AECOM

Waco Rapid Transit Corridor Feasibility Study

Evaluation of Alternatives

September 2018

Table of Contents

Figures

Tables

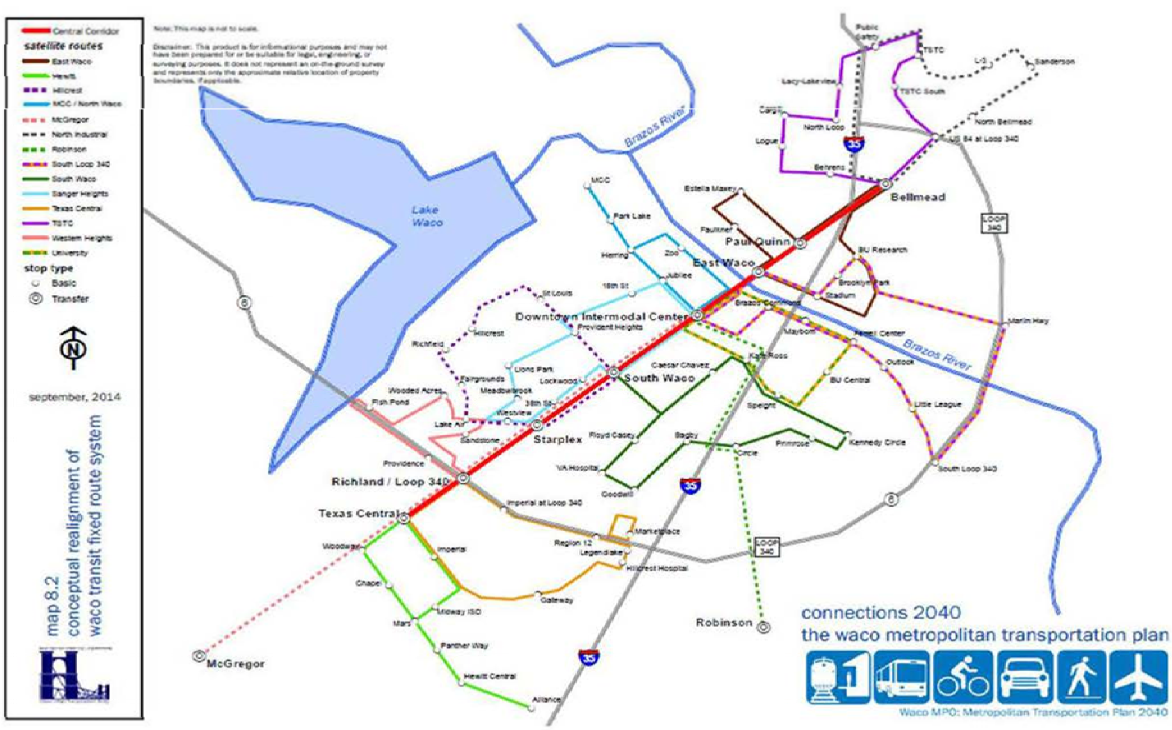
1. Executive Summary

1.1 Introduction

Waco Transit Systems (WTS) and the Waco Metropolitan Planning Organization (MPO) are conducting a study to analyze the feasibility of developing a rapid transit corridor and subsequent implementing bus service enhancements for the City of Waco. The current WTS network operates 10 fixed route bus lines with (average) 60-minute frequency in a traditional hub-and-spoke format. All local buses operate on long routes that wind their way into various neighborhoods and activity centers before looping back to the Downtown Transit Center, where most transfers occur. This operating system causes long 1-way travel times on each route and limits the opportunity for passengers to connect to other routes in order to get to their final destination. The result is a long and inefficient trip for most users, making transit the mobility option of last-resort for those who have little or no other choice.

The purpose for implementing a rapid transit corridor is to offer residents enhanced mobility and to provide improved access to jobs, medical and social services, and educational facilities. The proposed Rapid Transit Corridor (RTC) spans the north-south length of the City of Waco and connects to suburban communities on both ends of the corridor. The RTC travels from the northern limits in the Lacy Lakeview community, through downtown Waco, generally following the US Business Highway 77 (Business US 77) south to the Brazos River. Once south of the river, the corridor follows the alignment of Franklin Avenue and US Highway 84 (US 84) to the southern limits in the communities of Woodway and Hewitt, near the intersection of FM 1695.

Figure 1: Conceptual Realignment of Waco Transit Fixed Route System



The RTC would connect a diverse range of communities and regional activity centers and destinations such as Downtown Waco (including the Magnolia Market and Silos), area schools and universities (including Baylor University), health services (including the Baylor Scott & White Medical Center-Hillcrest and the McClinton Cancer Center), as well as commercial centers such as the Richland Mall and industrial parks.

The RTC study is following a three-step method to evaluate the rapid transit mode and alignment options to identify a preferred alternative.

1. **Assess Existing Conditions**: determine where people are coming from and where they are going, determine the primary travel corridors that are used, and understand how a RTC would support existing bus transit services.
2. **Develop Potential Solutions and Evaluation Metrics**: determine the right infrastructure, technology, and service components; determine the effects on riders, stakeholders, and transportation providers; and determine capital and operating costs.
3. **Select a Locally Preferred Alternative (LPA)**: Determine the solution that fits best with the community and determine how to pay for the improvements.

Alternatives considered for implementation within the RTC were defined such that they may meet application requirements for the Federal Transit Administration (FTA) Capital Improvement Grant (CIG) Program. (see *Final Interim Policy Guidance Federal Transit Administration Capital Investment Grant Program – June 2016*)

1.2 Public Involvement

The project team launched a rigorous public involvement process to bring the community into the conversation when developing draft alternatives, as well as discussion of evaluation results and recommendations. An RTC Steering Committee was formed to meet quarterly as guiding body for vetting of the study alternatives, analysis approach, evaluation results and recommendations. All Final technical documents and materials used in public presentations were uploaded to the Project website (http://www.aecomconnect.com/WacoRTC/).

The engagement process opened with a public charrette workshop (June 15, 2017) to introduce the project to the community, present preliminary vehicle (mode) technology recommendations and ask for feedback regarding potential RTC alignment, the types of destinations connected by the service, and station amenity options. The project team used the community responses (over 200) to identify three potential alignment alternatives for detailed evaluation as well as the preferred station amenities and important destinations served by transit.

Following the evaluation of alignment alternatives, the project team held multiple open houses community meetings, Webinars and a second public survey between November 2017 to March 2018.

1.3 Detailed Alternatives

Based on community feedback on preferred roadways for rapid transit service, the Project Team identified three (3) potential alignment alternatives for comparison (see **Table 1** and **Figure 2**). The detailed Alternatives developed and compared during Step 2 of the Waco RTC study will be combinations of right-sized service vehicles, stations, operating profiles and guideway assumptions.

Table 1: Detailed RTC Alternative Alignments

Alternative	Length (mi)	Alignment Description
Alignment 1	14.1	US 84 → New Rd → Franklin → Taylor / Hillsboro → B 77 to Crest (TSTC)
Alignment 2	13.3	US 84 → New Rd → Franklin → Taylor / Hillsboro → US 84 to Loop 340
Alignment 3	14.6	US 84 → Waco Dr → Taylor / Hillsboro → B 77 to Crest (TSTC)

Alternatives 2 and 3 also contain a routing option through downtown Waco along the 1-way pair of Franklin Ave / Washington Ave, or converting Franklin Ave to 2-way operations to run transit bi-directionally. This operating option was evaluated independently within the RTC study.

Service Operations

The service operating profile determines the amount of time vehicles are operating (span of service), how often vehicles stop at any given station (frequency) during different times of the day and the typical distance (spacing) between stations. When developing detailed service assumptions for each corridor, the existing conditions and challenges were also considered.

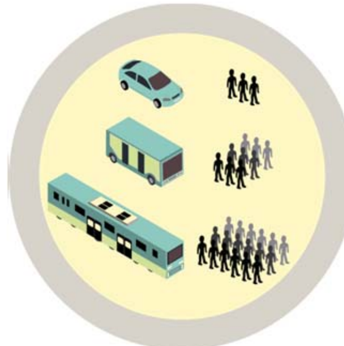
RTC Team Recommendation: The overwhelming feedback from public involvement participants and Waco Transit Systems staff identified needs for greater frequency, evening and weekend service. RTC corridor alternatives will be defined to operate until 8pm Monday through Wednesday and 10pm Thursday through Saturday, with a minimum 15-minute frequency for at least 14 hours on weekdays. Sunday RTC service will also be provided until 7pm. To compliment the RTC service, local bus routes may be subject to extended hours or days of service as well as realignment to improve overall transit system efficiency.

Infrastructure

The most visible element of the RTC will be branded station areas and vehicles. Stations and amenities must be designed and built to provide senses of comfort, security, accessibility, and connectivity for users. High capacity guideways are dedicated spaces in which the transit operates. The guideway may use space within an existing roadway, railroad right-of-way (property), or new right-of-way (property).

RTC Team Recommendation: Community feedback identified preferred station shelter types as well as priority safety and place making amenities that were included in conceptual station areas (see **Section 2.1**). Alternatives assume pursuing a dedicated transit guideway (reserved lanes) where achievable to allow for the most efficient transit trip time possible. However, roadways under the jurisdiction of the Texas Department of Transportation will not likely support conversion of existing traffic lanes or right-of-way to dedicated transit guideway. The study identified potential locations and where the greatest benefit can be realized from this investment.

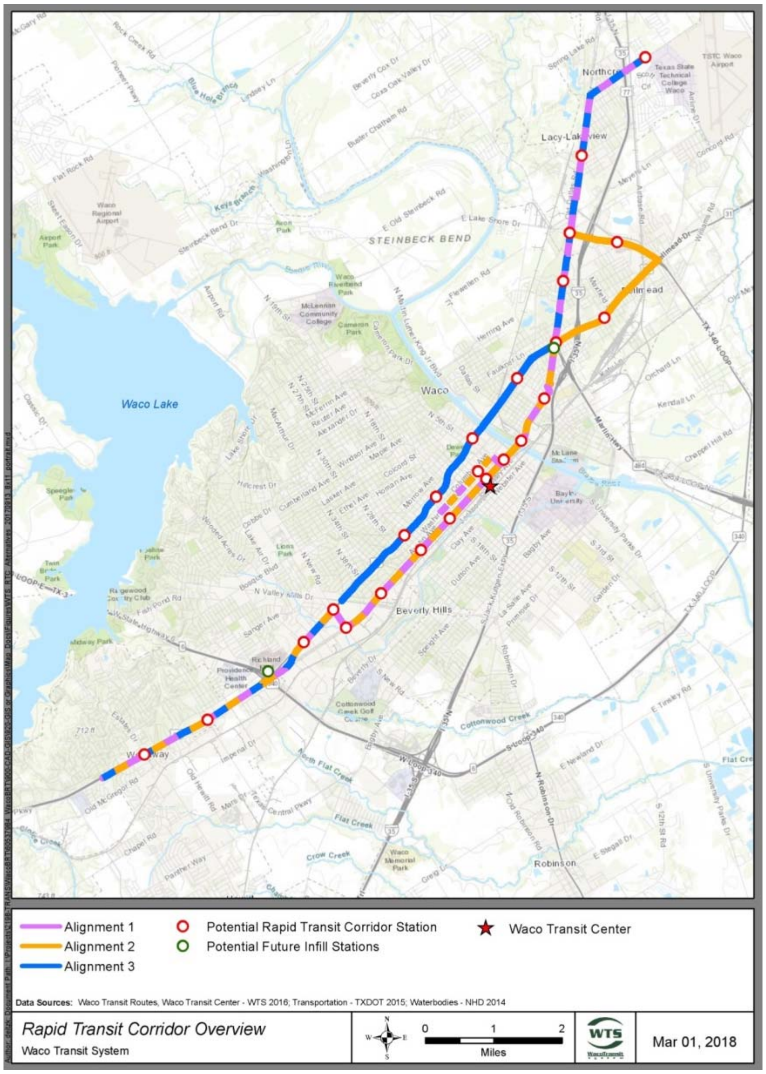
Technology



Transit ‘Modes’ are defined by the types of vehicles in operation and the propulsion (engine) technology that they use. They are typically some type of bus or rail vehicle. Different vehicle types can have a wide range of person-carrying capacity, but may also have different limitations on how much space is needed, operating speed or the type of guideway required. Additional technologies may be deployed to improve operating efficiency or user experience.

RTC Team Recommendation: Bus Rapid Transit is the preferred transit technology for higher-capacity transit in Waco (see the *Waco RTC Technology Assessment Executive Summary - August 2017)* for further information). Priority treatment at traffic signals to improve transit trip times, and at station areas to help inform passengers with real-time arrival signage or improve the off-board ticketing and fare collection process.

Figure 2: RTC Draft Alignment Alternatives



The detailed Alternatives were evaluated against the criteria shown in **Table 2**. These criteria are linked back to the project goals and objectives.

Table 2: Waco RTC Detailed Evaluation Criteria

Project Goals	Evaluation Criteria
Increase the efficiency of WTS operations and decrease overall transit travel times	• Mobility impacts (pedestrian, bicycle, parking and traffic) • 1-way travel time
Increase access to employment opportunities and critical services	• Ridership • Safety impacts
Leverage available local, state and Federal funding opportunities	• Economic development potential • Capital and operating & maintenance (O&M) costs • Community support

1.4 Evaluation Results

All three alternatives were analyzed independently and evaluated to compare the potential benefits and impacts among them. Several of the criteria identified in **Table 3** have multiple sub-categories that were analyzed individually and aggregated into the High/Medium/Low ratings shown. Alternative alignments may perform better or worse in the various sub-categories, but may not distinguish themselves as the clear best performer among the three options based on the aggregation of results (See **Section 3** through **Section 3.5** and **Appendix A** for further information).

Table 3: Draft Alignment Alternative Evaluation Results

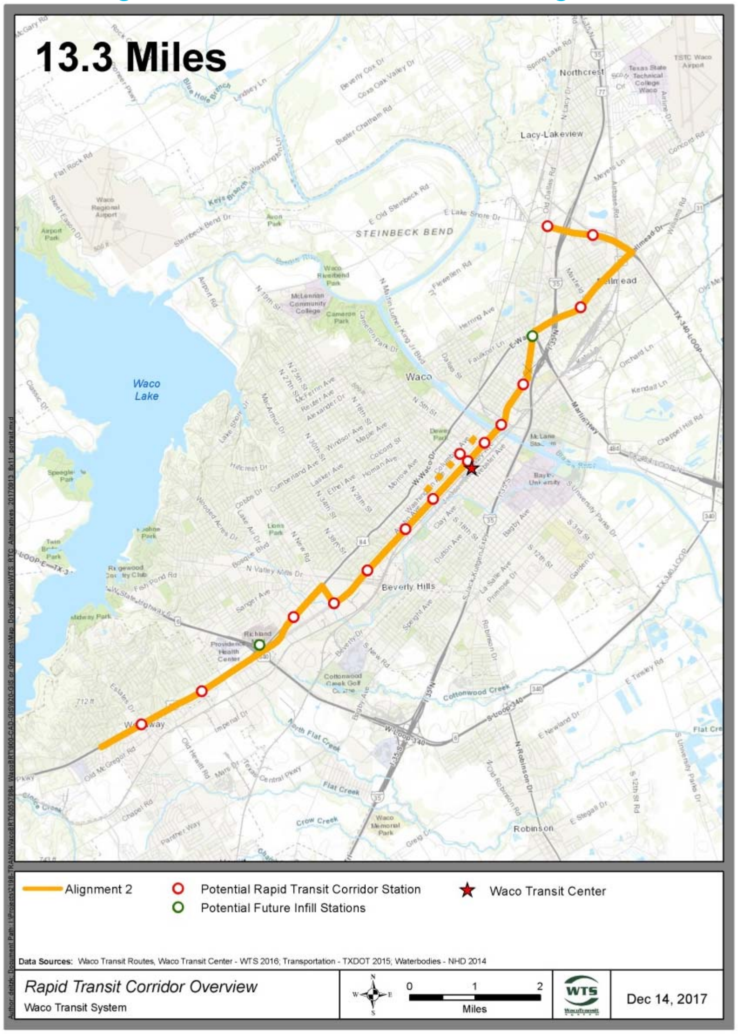
Criteria	Alignment 1	Alignment 2	Alignment 3
Mobility Impacts	**Medium**	**Medium**	**Medium**
1-way Travel Time	**60 min**	**65 min (NB) 50 min (SB)**	**45 min**
'System / RTC' Ridership (year)*	**4,030 / 870 (2023) 4,690 / 980 (2040)**	**3,990 / 900 (2023) 4,630 / 980 (2040)**	**4,080 / 900(2023) 4,730 / 1,000 (2040)**
Economic Development	**Medium**	**High**	**Low**
Safety	**High**	**High**	**Medium**
(Conceptual) Capital Cost	**$20.1 M – $20.8 M**	**$18.3 M – $19.4 M**	**$17.4 M – $18.5 M**
Overall Rating	**Medium**	**High**	**Medium**

* WTS fixed route bus service not optimized for RTC operations

All three alternatives are similar in length and operate as parallel alignments in providing rapid transit service to the Waco community. As a result, all three performed similarly in terms of potential Ridership, Mobility Impacts and Capital Cost. Criteria proving to be differentiators were Economic Development Potential and Safety. Alignments 1 and 2 would operate on the primarily commercial corridor of Franklin Ave / Washington Ave, while Alignment 3 is located on a residential corridor of Waco Dr. The higher speed limit and lack of pedestrian crossing protection near station locations on Waco Dr. also presented potential safety risks for potential transit users. The lower posted speeds and urban development along Franklin Ave / Washington Ave provide a more pedestrian friendly environment, as well as a greater concentration of existing transit destinations and under utilized land suitable for development or reinvestment. The potential operating & maintenance (O&M) cost of each of the Alignment Alternatives is estimated at approximately $3.5 to $4.5 million, annually.

Ultimately, Alignment 2 was identified as the Recommended Alternative. It should also be noted that the draft ridership projections assume existing local bus service, overlaid by RTC service and is not optimized for efficiency.

Figure 3: Recommended RTC Alignment



<u>Proposed RTC Station Locations</u>

US 84 (Woodway Dr) @ Hewitt Dr

US 84 (Woodway Dr)
@ Texas Central Pkwy

(Potential) US 84 (Woodway Dr)
@ Hwy 6

US 84 (Waco Dr) @ Lake Air Dr

New Rd @ Franklin Ave

Franklin Ave @ 35th St

Franklin Ave @ 26th St

Franklin Ave @ 18th St

Franklin Ave / Washington Ave
@ 8th St

Franklin Ave @ 3rd St

Franklin Ave @ MLK Jr Blvd

(Potential) Taylor St at Forrest St

Bellmead Dr @ Harrison St

TX Loop 340 @ Scroggins Dr

TX Loop 340 @ Business US 77

1.5 Franklin Two-Way Conversion vs Franklin/Washington Couplet

RTC Alignments 1 and 2 include an operational consideration to run along an existing pair of 1-way Northbound (Franklin Ave) / Southbound (Washington Ave) streets through downtown Waco. The City of Waco is currently considering conversion of Franklin Ave to a bi-directional arterial to improve traffic operations in the area. The RTC study considered the potential benefits and impacts of operating BRT service through downtown Waco using the existing 1-way couplet versus bi-directionally on Franklin only. Similar to the evaluation of alignment alternatives, the evaluation of 1-way vs 2-way operations through downtown may perform better or worse in the various sub-categories, but may not distinguish themselves as the clear best performer based on the aggregation of results.

Table 4: Draft Franklin / Washington Evaluation Results

Criteria	Franklin 2-way	Franklin / Washington Couplet
Mobility Impacts	Medium	Low
Economic Development	High	High
Safety	High	Medium
Cost	$$$	$$
Overall Rating	**High**	**Medium**

Converting Franklin Avenue to two-way traffic operations was identified as the preferred option to support RTC operations on Alignment 2.

- **Capacity on parallel streets**: 2-way conversion may impact more auto and parking lanes along the converted street, but may improve pedestrian safety with better crossing protection and induced traffic calming. Concentrating transit on a single street may also allow parallel streets to be designated for bike, pedestrian or auto focused uses.
- **Cost savings**: With fewer intersections required for the RTC to traverse (as buses would be focused only on Franklin Avenue), infrastructure costs would be less. A qualitative assessment was conducted, since detailed costs of 2-way conversion were not produced during this study and are the responsibility of others.
- **Efficient transit operations and passenger wayfinding**: Focusing rapid transit service on a two-way street is more efficient for the operation, as well as being easier for passengers to understand and navigate.
- **All day traffic vs peak only**: The two-way conversion would provide for an all-day traffic pattern rather than a peak period only pattern for buses operating in 1-way couplets. The development potential of properties along a 1-way pair may be negatively impacted by having less visibility during peak travel times of the day, when the travel flows are concentrated in a single direction.

1.6 RTC and Optimized Local Bus Service

The future 'No Build' condition (no RTC service) assumes a heightened level of investment in the local bus service to improve the average frequency from 60 minutes to 30 minutes. As previously mentioned, the potential daily ridership on the RTC Alignment Alternatives and WTS network was projected based on the existing hub-and-spoke local bus service, overlaid by the rapid transit service.

However, the frequency and speed of the RTC service provides an opportunity for WTS to re-route the local buses into a more efficient system of that local collector routes, connecting transit trip points of origin and destination to the RTC. The RTC is able to travel across town faster than the local bus routes and the robust RTC stations can function as transfer points to easily to interline with connector routes that get passengers to their final destination and instead of relying on making all transfers at the Downtown Transit Center. The reconfigured transit network proposed in support of RTC service is shown in **Figure 4.**

This reconfigured fixed-route system is meant to provide a more optimized future transit network where the RTC serves as the spine of the transit system that fixed-routes integrate with. The outcome is a transit system that provides improved access and more efficient travel for future system users. Special care was given to ensure that the reconfigured-system maintained coverage that exists today, improved coverage and maximized connectivity to key destinations and the recommended RTC alignment.

The benefits of the Optimized fixed-route network are illustrated by the improved RTC and system ridership in **Table 5**.

Table 5: RTC Alignment #2 and Optimized WTS System Ridership

Ridership Projections	No Build System		Optimized System	
	2023	2040	2023	2040
Total RTC Ridership*	900	980	1,480	1,610
Total System-wide Ridership**	3,990	4,630	4,960	5,700

*Table 4.03 – STOPS Model Output; **Table 10.01 – STOPS Model Output;

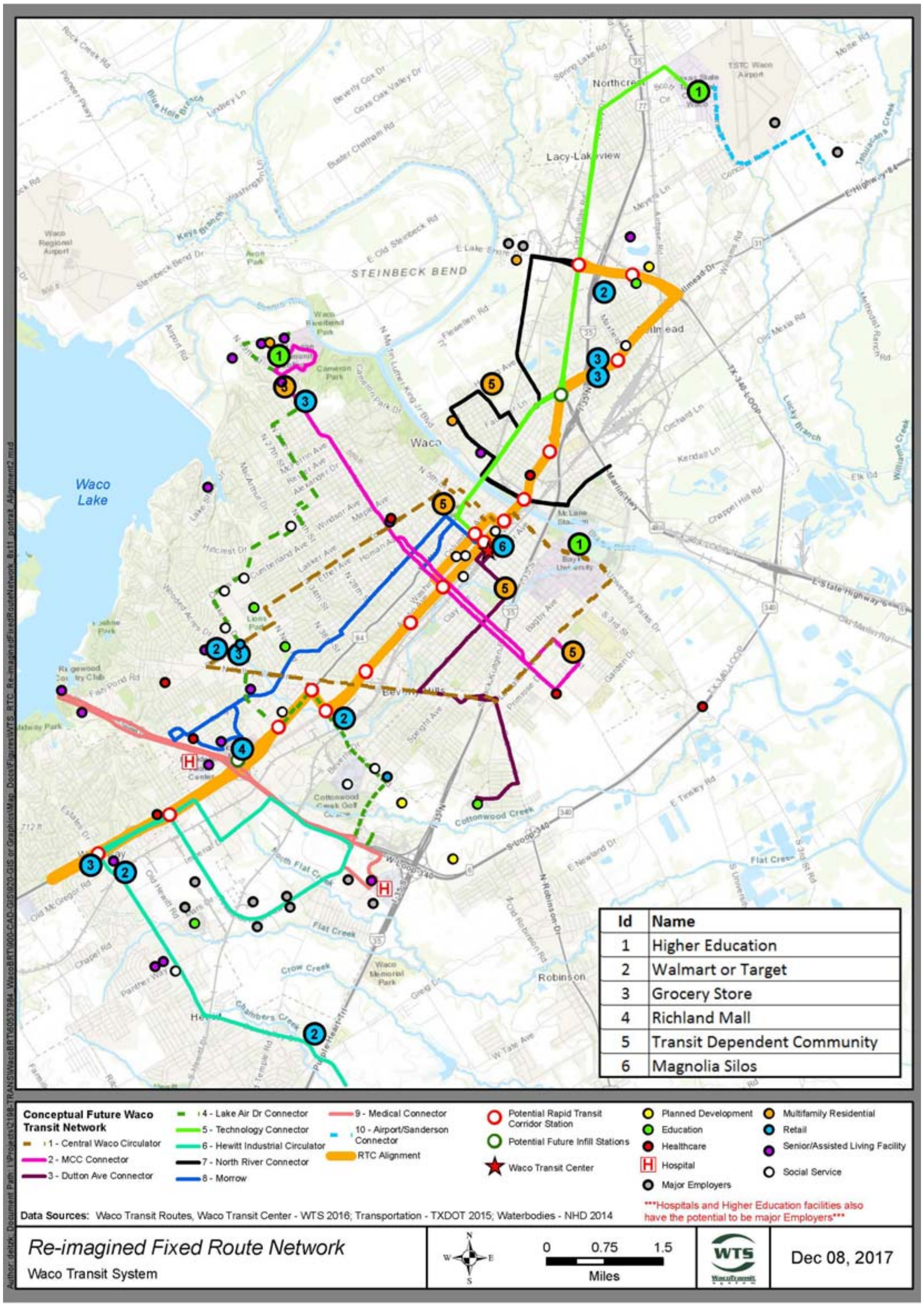
Optimized service changes include, but are not limited to (see **Section 6** for additional details):

- High frequency service consistent with the No Build option (average of 30 minutes)
- Shorter local bus routes (target 30-minute round trips or less), mitigating the need for additional vehicle purchases
- Rerouting local buses to maintain connectivity to activity centers (while allowing easy transfers to RTC spine)
- Extending hours of service to compliment RTC service

1.7 Next Steps

The RTC study recommendation (Alignment #2) and optimized network configuration will be presented to the RTC Steering Committee and appropriate approval bodies of WTS, Waco MPO and the City of Waco. Upon adoption, the proposed BRT project may be submitted to the Federal Transit Administration for potential entry into the Capital Investments Grant (CIG) Program to request federal funding for design and construction. The City of Waco and WTS may also continue to develop RTC solutions and fixed route optimization through additional planning studies or preliminary engineering activities.

Figure 4: Potential (Optimized) WTS Network with RTC Service



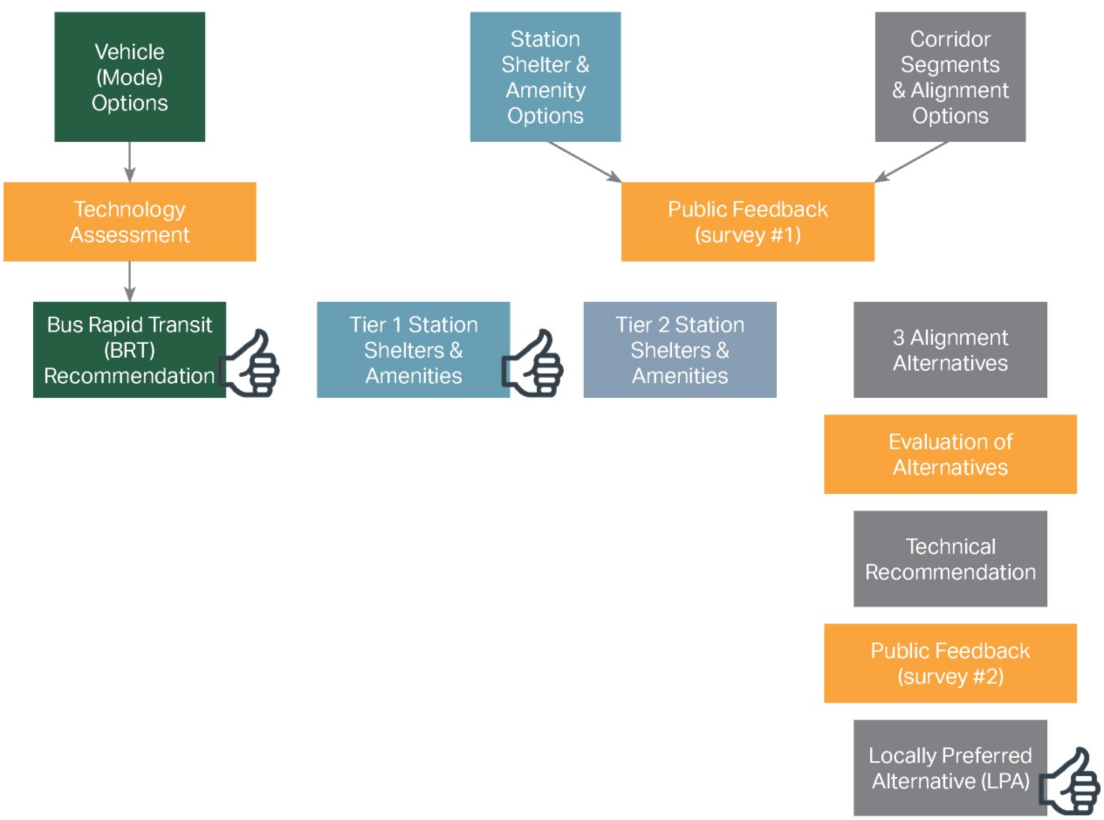
2. Alternatives Analysis Process

The objectives of Waco Rapid Transit Corridor (RTC) Feasibility Study is to identify and define a transit corridor to support proposed Bus Rapid Transit (BRT) service in the Waco community in order to improve transit accessibility, efficiency and trip times. The RTC study is following a three-step method to evaluate the rapid transit mode and alignment options to identify a preferred alternative.

1. **Assess Existing Conditions**: determine where people are coming from and where they are going, determine the primary travel corridors that are used, and understand how a RTC would support existing bus transit services.
2. **Develop Potential Solutions and Evaluation Metrics**: determine the right infrastructure, technology, and service components; determine the effects on riders, stakeholders, and transportation providers; and determine capital and operating costs.
3. **Select a Locally Preferred Alternative (LPA)**: Determine the solution that fits best with the community and determine how to pay for the improvements.

Alternatives considered for implementation within the RTC were defined such that they may meet application requirements for the Federal Transit Administration (FTA) Capital Improvement Grant (CIG) Program. (see *Final Interim Policy Guidance Federal Transit Administration Capital Investment Grant Program – June 2016*)

Figure 5: Waco Bus Rapid Transit Feasibility Study Process



2.1 Alternatives Overview

The study looked at existing conditions and public preferences to develop a set of transit priority treatments for rapid transit service and alignment (routing) alternatives. The study conducted a detailed evaluation of the alignment alternatives to compare potential benefits and impacts of transit priority treatments and identify a recommended solution. The study also developed a set of preliminary recommendations for changes to the existing Waco Transit System local bus network in order to optimize ridership on the system, as well as the BRT corridor. In November 2018 the RTC study unveiled the evaluation results and preliminary recommendations for public and stakeholder feedback before finalization and adoption of a locally preferred alternative (LPA). The LPA was approved by both the Waco Transit System Advisory Board and the Waco Metropolitan Planning Organization Policy Board on April 19, 2018. Waco City Council approved the LPA on May 1, 2018.

The public engagement process opened with a charrette workshop (June 15, 2017) to introduce the project to the community, preliminary vehicle (mode) technology recommendations and ask for feedback regarding potential RTC alignment, the types of destinations connected by the service, and station amenity options. The project team used the community responses (over 200) to identify three potential alignment alternatives for detailed evaluation as well as the preferred station amenities and important destinations served by transit.

2.1.1 Vehicle Technology

The consultant team conducted a high-level comparison of potential high capacity transit vehicle technologies in order to identify the most appropriate mode for rapid transit service in the Waco area. The team compared the conventional technologies of Bus Rapid Transit (BRT), Light Rail Transit (LRT), Modern Streetcar and Commuter Rail Transit options. (*see Waco RTC Technology Assessment Executive Summary – August 2017*)

As each mode option presents various benefits and challenges to operations, a common set of factors was used to compare the typical conditions under which the modes are deployed with the existing conditions of the Waco area. Considerations were given to corridor length, capital and operating costs, as well as potential ridership versus people carrying capacity. The Study Team recommended Bus Rapid Transit as the preferred transit technology for high capacity transit in Waco.

Bus Rapid Transit (or BRT) is premium bus service that is designed to improve capacity and travel time reliability over traditional local bus service by offering more frequent service, transit priority, additional passenger amenities, and specific branding. The main benefits to the Waco community are described below.

Limited Stops Results in Faster Operations: The current travel time between Bellmead and Woodway using the existing system can take up to up to 110 minutes. With the RTC this travel time would be cut to between 45 and 65 minutes depending on direction and alternative.

Greater Service Frequency: The current system provides for one bus per hour, on each route. This would be significantly improved with the RTC, which would provide one bus every 10 minutes during peak service and every 20 minutes during off-peak service.

Redevelopment Efforts at Stations: One of the benefits of high-capacity transit options like rail or BRT, beyond that of the traveling public, is the ability to attract development around stations, known as Transit Oriented Development (TOD). New development built around stations will in turn attract additional riders to the system. These redevelopment opportunities around the stations also attract other routes and help to provide convenient transfers to these other fixed routes or demand response services that serve them.

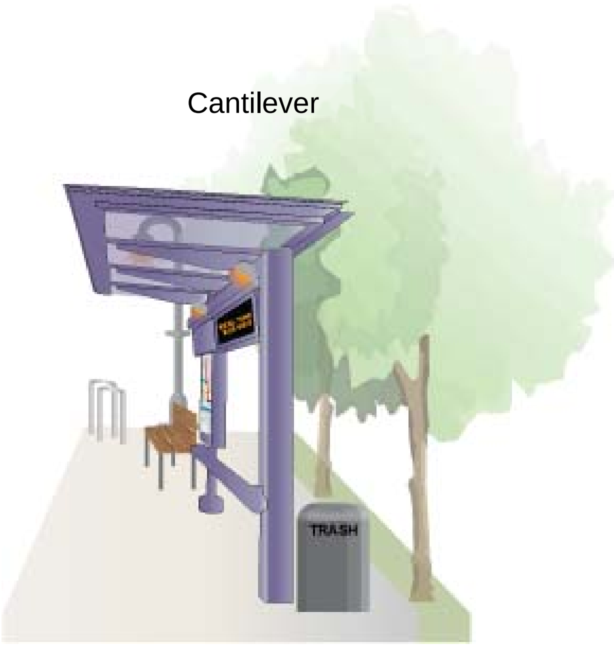
Provides Safer and More Accessible Service Options: Bus stops along BRT routes often provide mobility enhancements for bus riders. Stations are ADA accessible and they typically offer enhanced connections for bicycles/pedestrians through improvements made to crosswalks and curb bulb outs and bus pullout bays.

2.1.2 Station Options

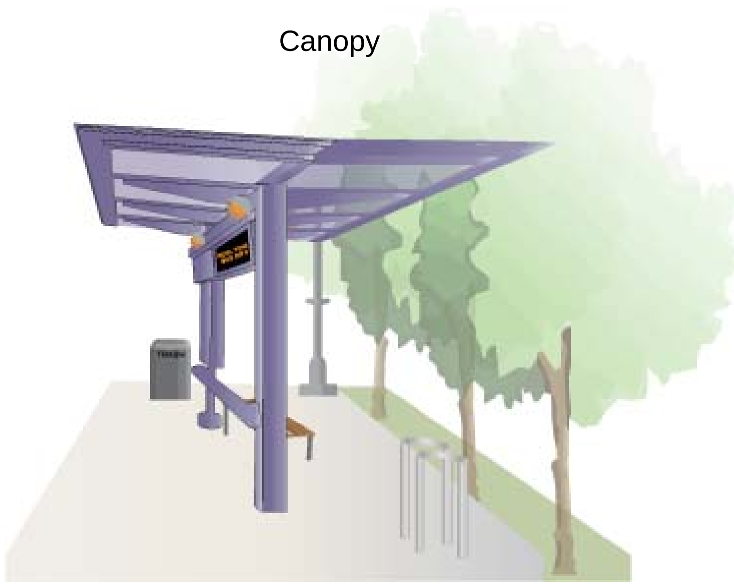
A visual preference survey was conducted through the online survey and a public workshop to determine the type of station shelter design was most favored for the potential RTC project. The survey showed four different types of bus shelters that could be used for the RTC project. The survey participants at the June 15 public workshop were provided additional descriptive information , including pros and cons, associated with each station shelter type that are likely to have affected their preferences. However, the options were only displayed visually in the online survey, with little discussion about pros and cons. Results from the workshop showed that respondents favored the Cantilever option, while most of the online responses favored the Pavilion.

The differing opinions between participants responses at the workshop versus online may suggest that the additional information provided to participants at the public workshop had a significant impact to the preferences.

Cantilever



Canopy



The visual preference survey also asked participants to select their top 3 preferred station area amenities. The Project Team received most responses for the following ‘Tier 1’ station area amenities:

Route Information/Way Finding Signs

Real Time Bus Arrival Times

Ticket Vending Machines

Free Public Wi-Fi

Pedestrian Access and Safety

Additionally, amenities like Trash Cans, Emergency Call Box and Device Charging also received significant responses. As a result, Project team classified these amenities as ‘Tier 2’ for selective installation based on potential budget and right-of-way constraints.

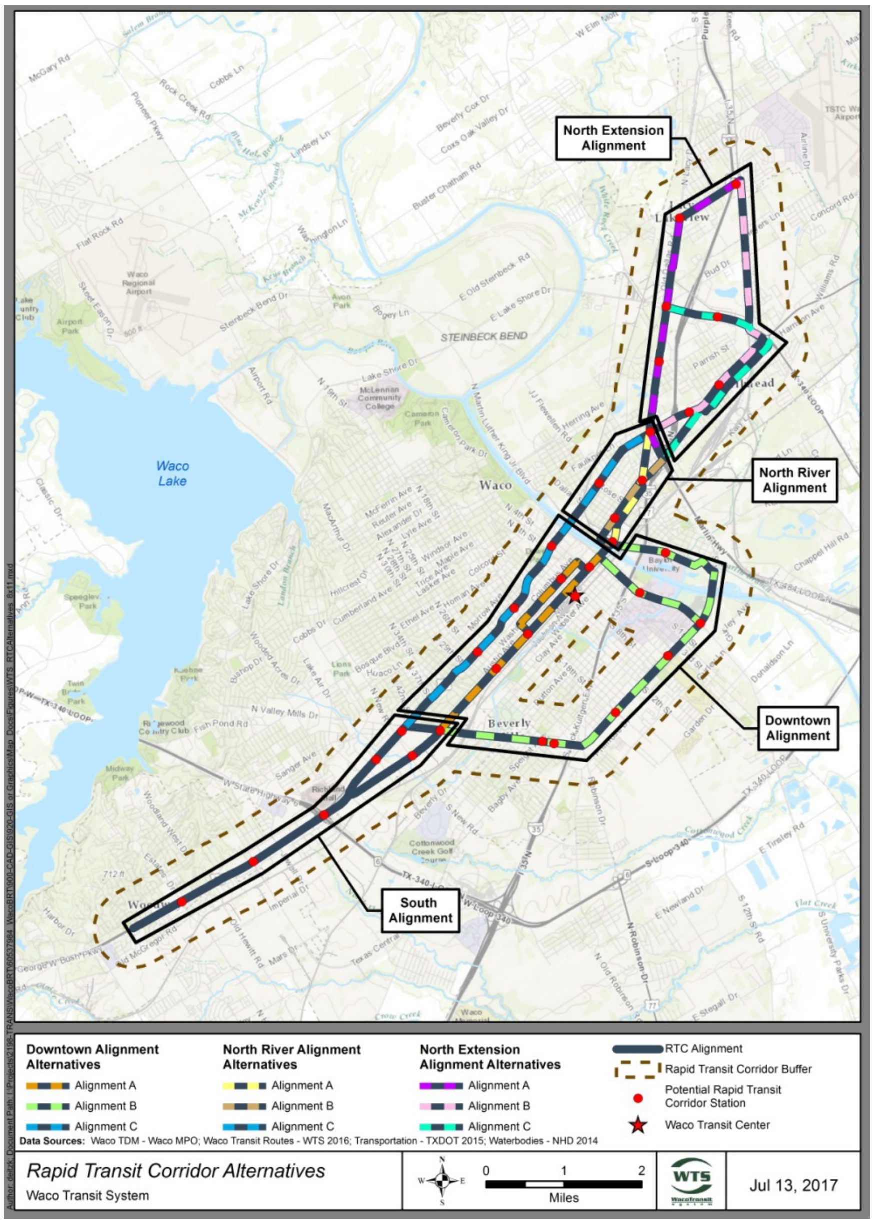
2.1.3 Service Operations

The service operating profile determines the amount of time vehicles are operating (span of service), how often vehicles stop at any given station (frequency) during different times of the day and the typical distance (spacing) between stations. When developing detailed service assumptions for each corridor, the existing conditions and challenges were also considered. Survey results and community feedback received during the first phase of this study indicated a strong desire for increased transit frequency and expansion of service hours into the late evening as well as offering Sunday service.

2.1.4 Alignment Options

The initial project area proposed a rapid transit solution that would operate between Bellmead, Waco, and Woodway, likely along one of the major travel corridors of Waco Drive or Franklin Avenue to connect downtown Waco to these north and south suburbs. For the purposes of this study, the rapid transit corridor (RTC) was segmented into four sub-areas based on existing infrastructure conditions and land uses in order to develop specific sets of corridor alignment options that could support rapid transit service in these areas. The RTC segments are: South, Downtown, North River, and North Extension, as shown in **Figure 6**.

Figure 6: Corridor Segments and Alignment Alternatives



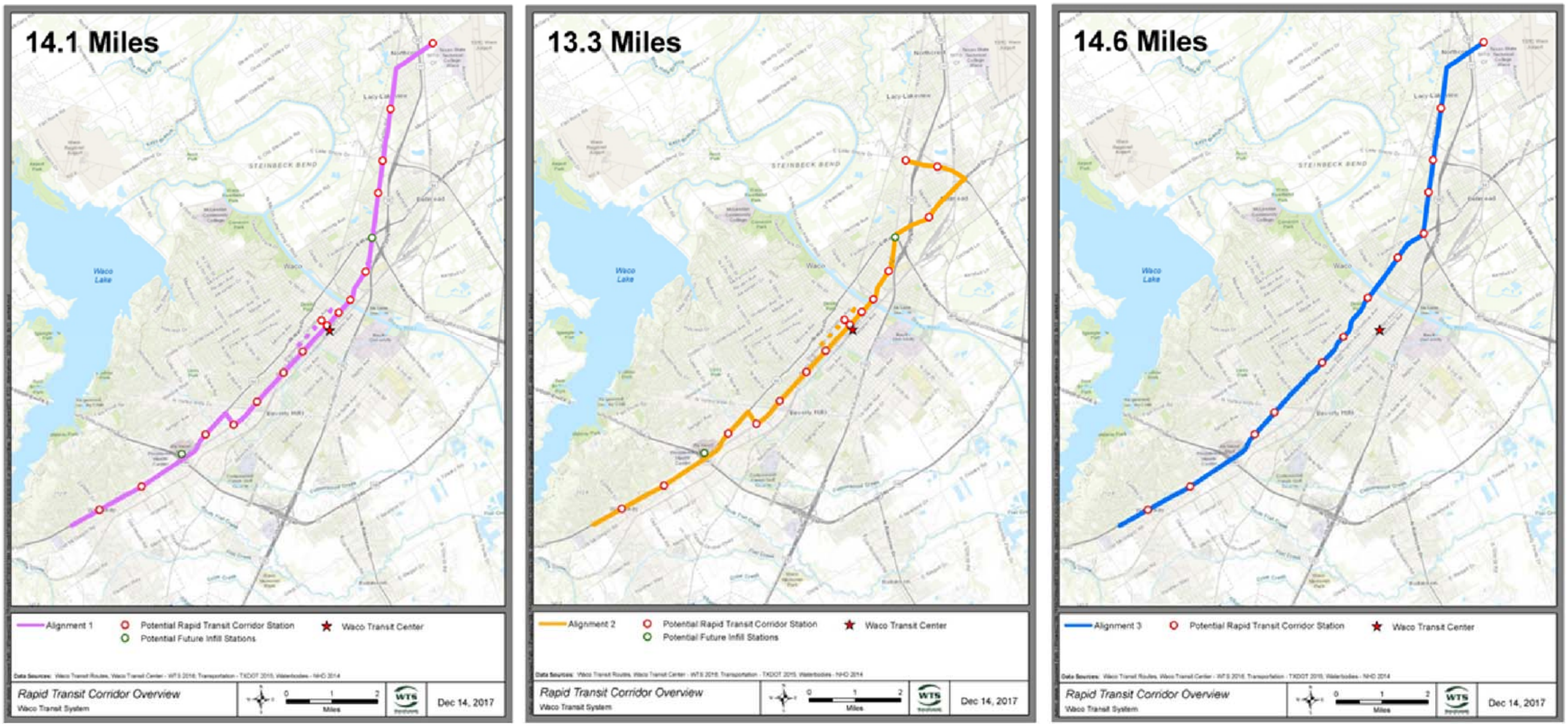
The information gathered at the public charrette, online, and during the passenger survey identified preferences that allowed the Waco MPO (Metropolitan Planning Organization), Waco Transit Systems (WTS) and consultant team to develop three detailed alignment alternatives. These alternatives were developed to provide the most efficient and logical operations of rapid transit service for detailed evaluation. The three alignment options and potential station area locations which were evaluated in detail are shown in **Figure 7**.

Alternative	Length (mi)	Alignment Description
Alignment 1	14.1	US 84 → New Rd → Franklin → Taylor / Hillsboro → Bus 77 to Crest Dr. → TSTC
Alignment 2	13.3	US 84 → New Rd → Franklin → Taylor / Hillsboro → US 84 to Loop 340 → Loop 340 @ Bus 77
Alignment 3	14.6	US 84 → Waco Dr → Taylor / Hillsboro → B 77 to Crest Dr. → TSTC

Alignment Alternatives 2 and 3 also contain a routing option through downtown Waco along the 1-way pair of Franklin Ave / Washington Ave, or converting Franklin Ave to 2-way operations to run transit bi-directionally. This operating option was evaluated independently within the RTC study.

Figure 7: Detailed RTC Alignment Alternatives

Alignment 1 **Alignment 2** **Alignment 3**



2.2 Evaluation Results Summary

2.2.1 Overview

The second phase of the Rapid Transit Feasibility Study compiled the results of the preliminary analysis and public feedback regarding potential vehicle, station, service operations, and alignment options into three Alternatives for comparative evaluation. The three alignments spanning the project area were compared against one another, while independent analyses were also conducted to address two specific considerations:

1. Which segments of roadway within each alignment alternative may be able to support a dedicated transit guideway?
2. Would BRT service most benefit from operating through downtown Waco on a couplet of existing 1-way streets (Franklin/Washington) or bi-directionally on Franklin, which would require conversion of travel lanes and signals to support 2-way operations?

The sections that follow summarize the overall results of these three evaluation efforts.

2.2.2 Alignment Alternative Evaluation Results

The detailed evaluation of alignment alternatives used combinations of criteria (shown in **Table 6**) to assess the degree to which each of the alignment alternatives met project goals. These criteria were measured through potential impacts and opportunities to mobility, development, ridership, ROW, cost, and safety within the project or station areas. These elements may also contain several sub-criteria that were calculated or quantified for evaluation.

Table 6: Waco RTC Detailed Evaluation Criteria

Project Goals	Evaluation Criteria
Increase the efficiency of WTS operations and decrease overall transit travel times	• Minimize conflicts with pedestrian, bicycle and auto facilities • 1-way RTC travel time
Increase access to employment opportunities and critical services	• Projected ridership • Maximize connectivity with pedestrian and bicycle facilities, as well as local bus routes • Minimize safety impacts for bicycles and pedestrians
Leverage available local, state and Federal funding opportunities	• Economic development potential • Capital and operating & maintenance (O&M) costs • Community support

Detailed Evaluation involved assigning different Ratings (High, Medium and Low) to each corridor alternative. By definition, a High is a definite positive rating, followed by a Medium which is a neutral/somewhat positive rating and a Low being none or negative rating. These ratings were derived based on a score given to each criterion used for the evaluation. The score was on a scale of 5, wherein 5 being the most desirable (Positive impact), 3 being neutral/somewhat positive, and 0 being the least desirable (None or Negative impact).

Based on the results of the detailed evaluation process, the design elements were examined to create one Preferred Alternative (as described in **Section 6**). The summary results are shown in **Table 7** through **Table 8** below.

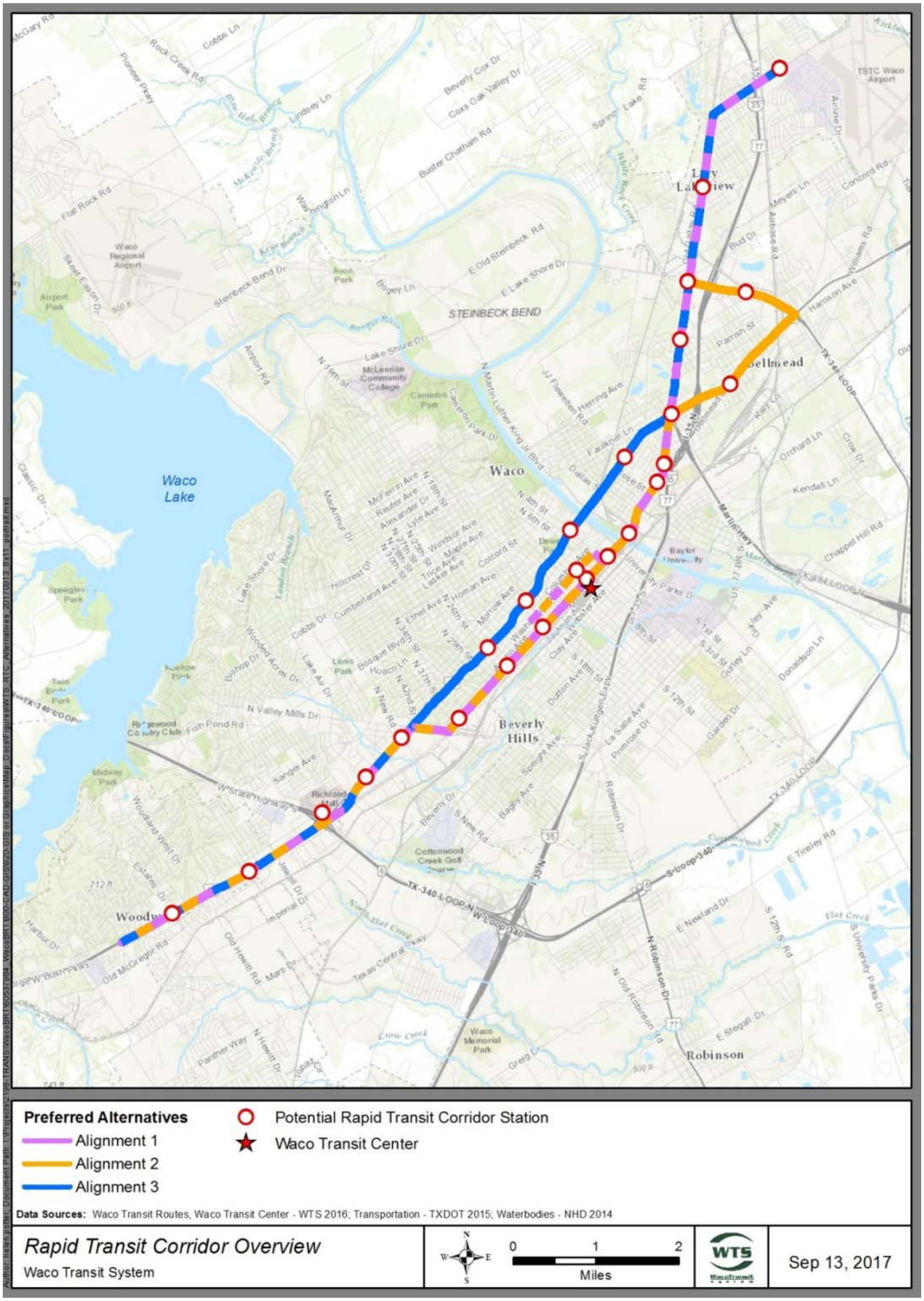
Table 7: Alternatives Evaluation Results

Criteria	Alignment 1	Alignment 2	Alignment 3
Mobility Impacts	Medium	Medium	Medium
1-way Travel Time	60 min	65 min (NB) 50 min (SB)	45 min
'System / RTC' Ridership (year)	4,030 / 870 (2023) 4,690 / 980 (2040)	3,990 / 900 (2023) 4,630 / 980 (2040)	4,080 / 900 (2023) 4,730 / 1,000 (2040)
Economic Development	Medium	High	Low
Safety	High	High	Medium
(Conceptual) Cost	\$20.1 M – \$20.8 M	\$18.3 M – \$19.4 M	\$17.4 M – \$18.5 M
Community Support	Ongoing	Ongoing	Ongoing
Overall Rating (Aggregate)	**Medium**	**High**	**Medium**

All three alternatives are similar in length and operate as parallel alignments in providing rapid transit service to the Waco community. As a result, all three performed similarly in terms of potential Ridership, Mobility Impacts and Capital Cost. Criteria proving to be differentiators were Economic Development Potential and Safety. Alignments 1 and 2 would operate on the primarily commercial corridor of Franklin Ave / Washington Ave, while Alignment 3 is located on a residential corridor of Waco Dr. The higher speed limit and lack of pedestrian crossing protection near station locations on Waco Dr. also presented potential safety risks for prospective transit users. The lower posted speeds and urban development along Franklin Ave / Washington Ave provide a more pedestrian friendly environment, as well as a greater concentration of existing transit destinations and under utilized land suitable for development or reinvestment. The potential operating & maintenance (O&M) cost of each of the Alignment Alternatives is estimated at approximately $3.5 to $4.5 million, annually.

Ultimately, Alignment 2 was identified as the Recommended Alternative which includes 13 initial stations and 2 potential additional stations as ridership and future development may justify. It should also be noted that the draft ridership projections shown previously in **Table 3** assumes existing local bus service, overlaid by RTC service and is not optimized for efficiency.

Figure 8: Station Location and Alignment Options



2.2.3 Franklin St and Washington St Operations Analysis

As previously mentioned, Alignments 2 & 3 contain a segment of Franklin Street in the downtown Waco area that is under consideration for conversion of 1-way traffic flows to bi-directional (2-way) operation.

Table 8: Downtown Alignment Analysis Results

Criteria	Franklin 2-way	Franklin / Washington Couplet
Mobility Impacts	Medium	Low
Economic Development	High	High
Safety	High	Medium
(Relative) Cost	$$$	$$
Community Support	TBD	TBD
Overall Rating (Aggregate)	High	Medium

2.2.4 Guideway Analysis

Simultaneously, the consultant team analyzed the conditions of each alignment to gauge whether the roadways may support dedicated transit guideways for BRT operations.

The detailed transit guideway alternatives, shown in **Table 9**, include the No Build, Mixed Traffic, Edge Running, and Center Running.

Table 9: Transit Guideway Characteristics

Mode	Detailed Mode Alternatives	Modal Description
No Build Alternative	The No Build Alternative maintains the same infrastructure and also assumes some expansion of existing transit services for future ridership growth.	
Mixed Traffic	RTC in Mixed Traffic includes substantial changes to the service plan, vehicles, technology, and infrastructure.	
Dedicated Guideway: Curb Running	The RTC Curb Running alternative would include the similar improvements identified in the Mixed Traffic alternative, but would operate in a curbside lane that is exclusively dedicated to transit service either at peak hour or 24 hours a day, seven days a week. This alternative offers many operational benefits, including reduced travel times, improved service reliability and reduced bus stacking.	
Dedicated Guideway: Center Running	Like the RTC Edge Running alternative, the RTC Center Running alternative will operated in a lane that is exclusively dedicated to transit service either at peak hour or 24 hours a day, seven days a week. However, the RTC Center Running will operate in a center (rather than edge running) lane which requires substantial infrastructure improvements.	

AECOM, 2017
NACTO, KCATA, WTS

3. Detailed Evaluation of Alternatives

3.1 Ridership Potential

3.2 Development Potential

3.3 Mobility Impacts

The alignment options were analyzed to determine how each alignment would fare against mobility impacts in the WTS service area. This section summarizes the existing and planned pedestrian and bicycle facilities along the corridor and near each potential station location.

Mobility impacts include an assessment of pedestrian and bicycle facilities near station areas, as well as considerations for the affect to auto traffic and operational needs within the corridor.

3.3.1 Bicycle and Pedestrian Mobility Impacts

Background and Methodology

Planned facilities were determined from the City of Waco and Waco MPO's most recent maps and adopted plans.

The evaluation of non-motorized impacts of the alternatives is based on the following criteria:

- **Impacts to existing pedestrian facilities and planned bicycle facilities** – Each of the alignment alternatives would incorporate changes to the street corridor that it operates on. While the mixed-traffic RTC would primarily include improvements outside the curbs of the roadway, the fixed-guideway would reconfigure the roadway itself. The only area where planned bicycle lanes would be affected by the fixed-guideway would be along Washington Avenue if Franklin Avenue does not become a two-way corridor. Ratings are provided for different areas of the corridor along the following scale: Low = no impact to network, Medium = some positive impacts for bicycles and pedestrians, High = definite positive impacts for both bicycles and pedestrian mobility.
- **Connectivity with planned Bicycle Routes / Lanes** – The alignment alternatives would provide connectivity to bicycle routes and lanes running adjacent or perpendicular to the RTC. Each alignment was evaluated based off the number of times bicycle routes and lanes running adjacent or perpendicular to the RTC. If Franklin Avenue became a two-way corridor, Alignment's 1 and 2 are ranked high while Alignment 3 is ranked Low. If Franklin Avenue and Washington Avenue remain one-way corridors, Alignment's 1 and 2 are ranked medium, while Alignment 3 is ranked low.
- **Station Connectivity using a Walk Score** – Walk score was evaluated using WalkScore.com to identify the most pedestrian friendly alignment based off station location.

Source

- Sidewalk information was obtained from the City of Waco, 2017
- Bicycle information was obtained from the City of Waco, 2017

- Walk score was determined using WalkScore.com

Evaluation Outcomes

The evaluation of results, shown in **Table 12**, suggest that the RTC options, which would include investments in pedestrian and bicycle access to and around potential station locations, are more supportive of non-motorized transportation than existing (No Build) scenario. In addition, all alternatives would generally be consistent with plans regarding bicycle and pedestrian infrastructure; however, some mitigation measures may be required where possible impacts to existing or planned bicycle corridors may occur.

3.3.2 Sidewalks

The existing sidewalks along the proposed RTC's are sparse and do not include continuous pedestrian access along either side of the road for each alternative. Sidewalk improvements will need to occur along proposed RTC's and near station locations in order to maintain proper accessibility to and from potential station locations. Based on the results identified during the evaluation process the proposed alignment with the least amount of sidewalk gap is Alignment 2, followed by Alignment 1 and Alignment 3. Overall, the alignment with the highest walk rating was Alignment 2, followed by Alignment 1 and Alignment 3. In addition, maintaining the Franklin Avenue and Washington Avenue corridors ranked higher in walk score and required the least amount of sidewalk improvements for pedestrian accessibility.

3.3.3 Bike Routes and Bike Lanes

The City of Waco has existing and planned bike routes and bike lanes that intersect and run parallel to the proposed RTC's. The impacts will depend on the final configuration selected. The Mixed Traffic configuration will have the least impact on any planned bicycle facilities. In isolated areas eliminating travel lanes with fixed-guideway options may impact planned bicycle lanes. If the selected RTC does impact planned bicycle facilities mitigation measures that can be used include, but are not limited to, an off street multi-use path, signing the route, or not marking the bicycle lane. Both Alignment 1 and Alignment 2 have the greatest impact to planned bicycle lanes, which would occur on Washington Avenue. However, if Franklin Avenue is converted to a two-way corridor no planned bicycle lane would be displaced, but if Washington Avenue and Franklin Avenue maintain the existing travel patterns then approximately 4,893 feet of planned bicycle lanes have the potential to become displaced. The RTC's provide connections to bicycle lanes and routes at different areas throughout Waco. However, the two alignments that provide the most connection are Alignments 1 and 2, primarily because they would provide service to the downtown core and offer more connections to passengers at potential station locations. Alignment 3 has six potential station locations which are located outside of the downtown core where the majority of bicycle routes and lanes are planned to be implemented.

Table 10: Pedestrian and Bicycle Mobility Impacts

Proposed Alignment	Mixed Traffic	Fixed-Guideway
Alignment Option 1	Medium	Medium
Alignment Option 2	Medium	Medium
Alignment Option 3	Medium	Medium

AECOM, 2017

3.3.4 Safety Impacts

Background and Methodology

The evaluation of Safety impacts of the alternatives is based on the following criteria:

- **Speed Limit** – The speed of a vehicle is a major determinant in the severity of a crash. In order to evaluate performance of each alignment alternatives in term of safety, posted speed limit were used. This data was obtained manually through google maps street view. Safety impacts were defined for different areas of the corridor based on the existing speed limit; with 30mph being most suitable for pedestrian and bicycle users and speed limit of more than 40mph being the least suitable. Ratings are provided along the following scale: Low = negative impact on pedestrian safety, Medium = some positive impacts for bicycles and pedestrian safety, High = definite positive impacts for both bicycles and pedestrian safety.
- **Presence of Sidewalks** – Presence of sidewalks enhances accessibility and induces a sense of safety among pedestrians and bicyclists. The data to evaluate this criterion was obtained through ArcGIS based spatial analysis of existing sidewalk coverage around 'proposed' station locations within each corridor alignment. Ratings are provided along the following scale: Low = lack of sidewalk coverage, Medium = presence of sidewalk in at least 1-2 direction, High = presence of sidewalks in all 4 directions (to and from the stations).
- **Proposed Bulb-outs locations** – Presence of Curb extensions or bulb-outs improve safety because they increase visibility, reduce speed of turning vehicles, encourage pedestrians to cross at designated locations, shorten the crossing distance, and prevent vehicles from parking at corners. The evaluation of each alignment was based on possible locations where bulb-outs can be constructed depending on the carrying capacity and ROW. Presence of bulb-outs within 200 ft. of station received High rating and a Medium rating was assigned if bulb-outs were located further than 200 ft. from station location. However, if there were no bulb-outs possible near to the station location on a particular stretch of corridor alignment, a Low rating was assigned.

Source

- Sidewalks data was obtained from WTS, 2017
- Proposed locations for Bulb-outs were obtained from ATG, 2017
- Speed limit data was obtained from Google Maps, 2017

Evaluation Outcomes

The evaluation of results, is show in **Table 13**, suggests that Alignment Option 1 and Option 2 have a definite positive impact on pedestrian and bicyclist's safety. Alignment Option 3 has somewhat positive impact but performs below par due to high posted speed limits. It is important to note that the guideway types of the proposed alignments (mixed traffic, dedicated center lane and dedicated curb lane) do not affect the results of safety evaluation.

Table 11: Safety Impacts

Proposed Alignment	Mixed Traffic	Fixed-Guideway
Alignment Option 1	High	High
Alignment Option 2	High	High
Alignment Option 3	Medium	Medium

AECOM, 2017

3.3.5 Traffic Impacts

Background and Methodology

At this level of alternative and project development, the traffic analysis was limited to high-level analysis to aid in narrowing down the detailed alignment alternative. The traffic impact evaluation measure analyzes the impact of various cross sections (mixed traffic, dedicated center lane, dedicated curb lane) on traffic within each RTC segment. Traffic analysis is based on a high-level review of potential impacts on V/C ratio along roadways. Station locations will be analyzed based on their impact on traffic at intersections. Different station types have different impacts on traffic (i.e. bulb-outs vs. in-traffic stops). Each segment requires different station types based on available ROW. Ratings for V/C ratio and impact on traffic at intersections are provided along the following scale:

- **Capacity (V/C Ratio) Score:** Scores were based off assigned ratings (high, medium, and low) to identify the impacts of traffic within each RTC segment. A rating was given a low if additional traffic is not likely to cause any additional queuing. A medium was given if there was traffic congestion due to bus travel/infrastructure that would likely increase que lengths and average delay through the corridor. In addition, a high rating was given if there would be an increase in traffic levels to the point where existing infrastructure is failing and queues are building faster than they can dissipate.
- **Number of Impacted Intersections Score:** Scores were based off assigned ratings (high, medium, and low) to identify the impacts of traffic within each RTC segment. A low rating was given to intersections where start-up level delay and stopping delay is not expected to increase due to bus traffic. A medium rating was given if the intersection received a moderate intersection delay. A medium rating was also given if the corridor will see impacts of buses frequently starting and stopping at intersections, but only minor queues will occur as a result. In addition, a high rating was given if the intersection sees a high intersection density. High ratings were also given if delays will increase due to numerous starting and stopping maneuvers from buses.

Source

- City of Waco
- TxDOT Statewide Planning Map AADT Data

Transportation Research Board, Highway Capacity Manual

Evaluation Outcomes

Due to existing and anticipated travel volumes along the potential rapid transit corridors, the impact of each alignment and potential cross section option was deemed to have low to medium impact on traffic along the corridor. In general, the mixed traffic cross section had a low impact on potential auto delay for all three alignments due to the bus traveling in a shared auto/bus lane. Some impacts would occur where curbside stations would be located, and a bus would be stopping within the travel lane to dwell while passengers board. Alignment 1 and 2 that go directly through the downtown area were the only two options to see a high impact to the volume to capacity ratio when a fixed guideway was considered. This is largely due to the removal of travel lanes for dedicated bus guideways in the downtown area, resulting in one traffic lane in each direction should Franklin Avenue be converted to two-way.

Table 12: Traffic Impacts

Alignment Option	Alignment Option 1		Alignment Option 2		Alignment Option 3	
	Mixed Traffic	Fixed-Guideway	Mixed Traffic	Fixed-Guideway	Mixed Traffic	Fixed-Guideway
Traffic Impacts	Low	Medium	Medium	Medium	Low	Medium
Capacity (V/C Ratio) Score	Low	High	Low	High	Low	Low
Number of Impacted Intersections Score	Medium	Low	Medium	Low	Medium	Medium

AECOM and ATG, 2017

3.3.6 Parking Impacts

Background and Methodology

Parking supply in proposed station areas was completed through desktop review and ArcGIS. Where applicable; measuring tools were used to determine approximate lengths of vehicles and lengths of parking zones. In addition, parking information was also obtained through City of Waco staff. Ratings for parking impacts are provided along the following scale:

- **Parking Impacts:** Scores were based off assigned ratings (high, medium, and low) to identify the impacts to parking along the proposed RTC. A low rating was given if the project required the removal of minimal to zero existing parking spaces. A medium rating was given if the project requires removal of moderate amounts of parking spaces, but additional parking is available in nearby locations. A medium was also given if the project will impact a moderate amount of parking lot spaces due to construction of bus pullout. In addition, a high rating was given if the project requires the removal of large on-street parking facilities. High ratings were also given if there was no available nearby parking or if it is already being used.

Source

- City of Waco

Evaluation Outcomes

In general, the impacts to parking along the rapid transit alignment alternatives is low, as there is not much on street parking throughout Waco, except for in the downtown area. The mixed traffic alignment options have little to no impact on parking, except in locations where a bus pullout may require removal of several spaces in the downtown area. If a fixed-guideway were to be constructed, there would be low to medium impact on parking along the three different corridor alignments. Alignment Option 2 showed the most impact due to the loss of parking in the Downtown and North River segments should a fixed guideway be implemented. **Table 15** shows the extent of on-street parking spaces that could be impacted by the three proposed alignment options.

Table 13: Number of Parking Spaces Impacted

Proposed Alignment	Mixed Traffic	Fixed-Guideway
Alignment Option 1	Low	Medium
Alignment Option 2	Low	Medium
Alignment Option 3	Low	Low

AECOM and ATG, 2017

3.4 Guideway (Right of Way)

3.5 Capital, Operation & Maintenance Costs

3.5.1 Capital Cost

Background and Methodology

A high-level cost estimate was prepared for each different. Specific elements that impact the cost of each alternative include station costs, sidewalk improvements, vehicles, ROW acquisition, and resurfacing/striping to construct dedicated lanes. Variations in cost between the Alignment Options is largely due to length of potential dedicated lane segments, overall length of project and number of station areas.

Evaluation Outcomes

Alignment Option 1 was deemed to be the most expensive option, largely due to the increased station areas and length of the corridor/potential dedicated lanes. The lowest cost alternative is Alignment Option 2, which has fewer station areas. Alignment Option 2 was situated between Alignment Option 1 and 3 due to fewer station areas than Alignment 1 and more than Alignment 3 with shorter corridor length/potential dedicated lane segments.

Table 14: Cost Comparison

Proposed Alignment	Mixed Traffic	Fixed-Guideway
Alignment Option 1	$20.1M	$20.8M
Alignment Option 2	$18.3M	19.4M
Alignment Option 3	$17.4M	$18.5M

AECOM and ATG, 2017

Source

- Costs were developed by AECOM and ATG

3.5.2 Operating & Maintenance Costs

Service Options	Operation Hours	Fixed Route		BRT		Total
		Frequency	Annual Cost ($ millions)	Frequency	Annual Cost ($ millions)	Annual Cost ($ millions)
Current	M-F (6:00am – 7:00pm) Sat (7:00am – 8:00pm) No Sunday Service	60 min 60 min --	$4.2M	--	--	$4.2M
Proposed Mid-Level	M-F (6:00am – 8:00pm) Sat (7:00am – 8:00pm) No Sunday Service	30 min 30 min --	$4.5M Additional	15 min 30 min --	$2.4M Additional	$11.1M
Proposed Optimum	M-F (6:00am – 10:00pm) Sat (7:00am – 8:00pm) Sun (7:00am – 8:00pm)	30 min 30 min 60 min	$6.5M Additional	15 min 30 min 30 min	$2.8M Additional	$13.5M

4. Identifying the Preferred Alternative

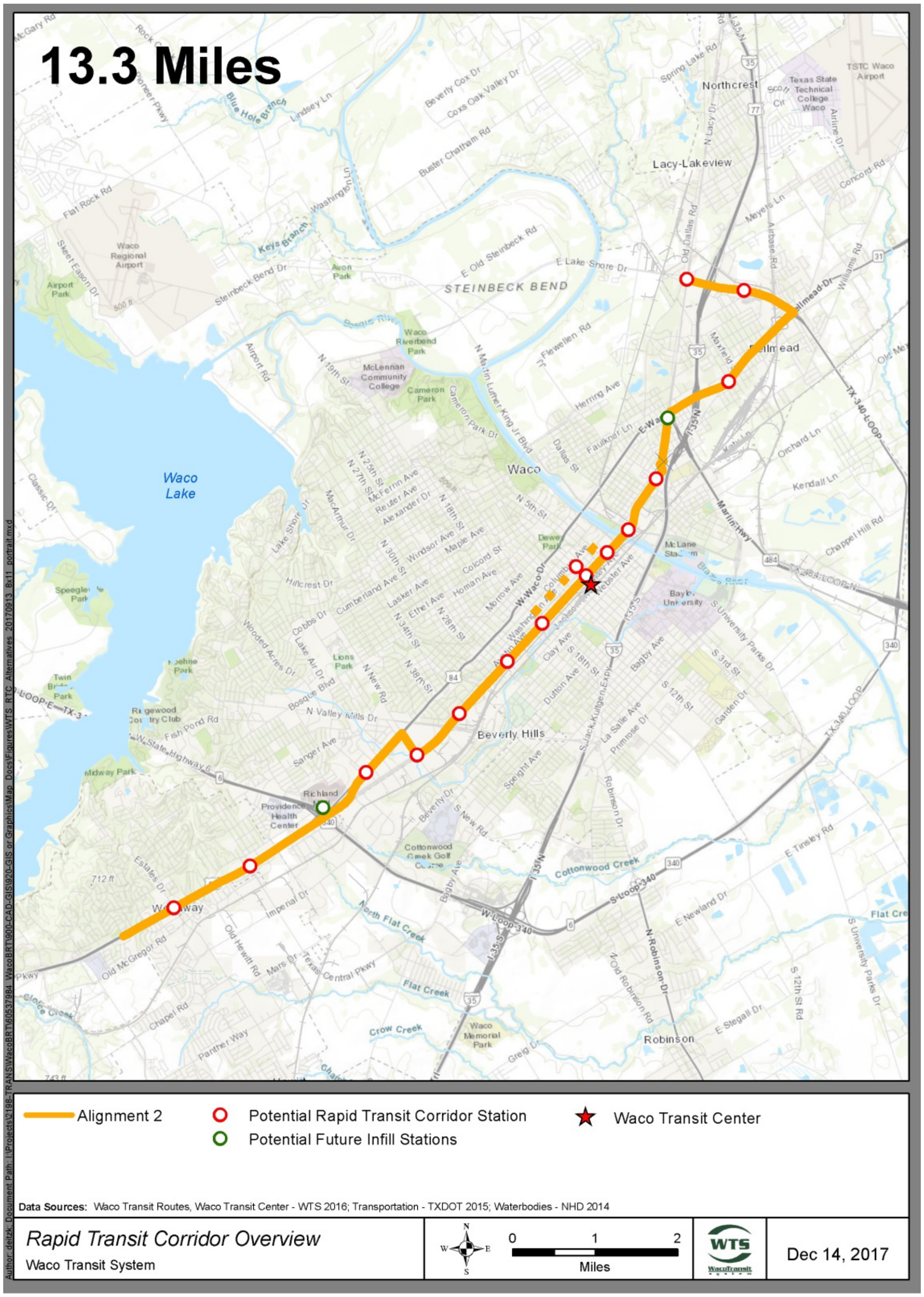
The Detailed Evaluation identified the RTC with the greatest potential to support higher capacity transit improvements throughout Waco. Multiple open houses, webinars, and popup engagement activities were held from November 2017 to March 2018 to inform the community about the results of the analysis process and garner feedback on public support for the recommendation. At the conclusion of the technical analysis and public input process, Alignment 2 was chosen as the Preferred Alternative due to a myriad of factors.

The Preferred Alternative, shown in **Figure 9**, would travel approximately 13.3 miles from north to south. Capital costs (including roadway infrastructure, design, and vehicle procurement, among others) are expected to range between $18.3 M and $19.4M. The annual operating cost is expected to be between $2.4M and $3M (depending on service hours and frequency). Ridership estimates for 2023 are 900 riders per day for the RTC and 3,990 for the system. In 2040, conservative estimates are 980 for the RTC and 4,630 for the fixed route. See Section 6 of this report for a review of transit optimization principles that would likely increase ridership further.

Key operational characteristics of the preferred alternative include two-way operation along Franklin Avenue. Two-way operation was found to provide better safety, connectivity, and overall service operations. This configuration also provides more future opportunities for transit oriented development along the RTC.

Recommended service characteristics of the preferred alternative include hours of operation until at least 10:00 pm on weekdays and the addition of Sunday service.

Figure 9: Preferred Alternative



5. Public Feedback Consideration

5.1 Second Public Survey

Seventeen surveys were completed during the second round of public feedback. Six questions were asked about the initial project recommendations, specifically how respondents expected to use the upgraded system.

Fifteen of the seventeen respondents agreed with the recommendations of the Locally Preferred Alternative. When asked if the future network would meet the needs of the respondents, fifteen responded that it would, while one response was left blank.

When asked which routes respondents envisioned using, several had higher response rates. These included the Central Waco Circulator, the MCC Connector, the Lake Air Drive Connector, the Hewitt Industrial Connector, the Morrow Connector, and the Airport/Sanderson Connector.

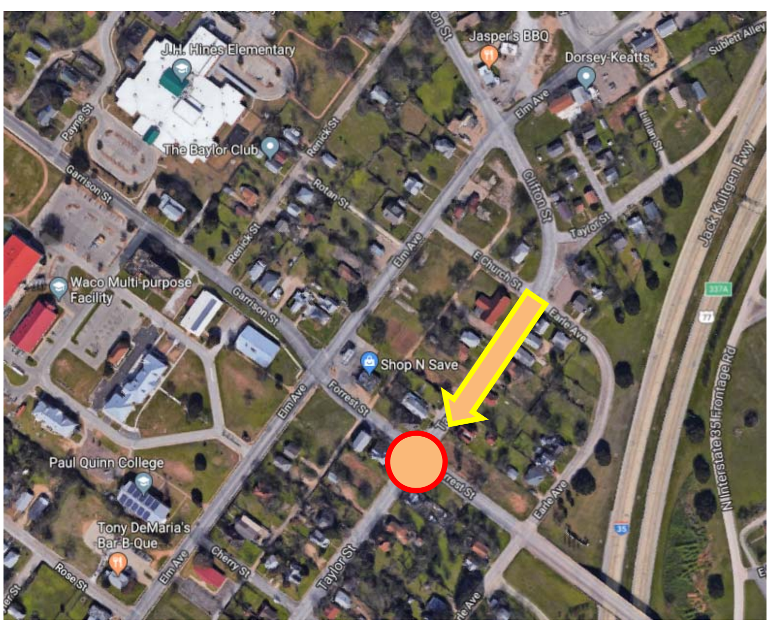
When asked about the types of destinations that respondents found to be the most important, responses included educational, healthcare, hospital, employment, and retail. Interestingly, the times of the day that respondents said that they would be most interested in using the service were from 7:00 a.m. to 10:00 a.m. and from 10:00 a.m. to 4:00 p.m.

Finally, all seventeen respondents said that they increased frequency would increase their likelihood to use the system more frequently.

The public showed excitement about the faster travel times and future changes to the local bus service. While the current system does not sufficiently meet the needs of existing riders, with the improvements that are proposed, the public noted that the future system seems much more likely to address the needs of the traveling public.

5.2 Changes to the Locally Preferred Alternative

Several changes were also made to the Locally Preferred Alternative. First the station originally located at the intersection of Taylor Street and Clifton Street was shifted to the intersection of Taylor Street and Forrest Street.



Second, the project team addressed some of the safety concerns at Franklin Avenue and Waco Drive.

Two potential future infill stations were also added to the Locally Preferred Alternative. These future stations are proposed at the Richland Mall located at Loop 340 and Waco Drive and at Hillsboro Drive and Waco Drive/US 84. Both future infill stations would provide additional access to the system as conditions in these areas change due to redevelopment opportunities.

The Locally Preferred Alternative is shown in **Figure 10**.

Figure 10: Locally Preferred Alternative

6. Transit Network Optimization

The LPA should be connected to an optimized local bus network in order to maximize the service and to support the transit network overall.

Keys to optimizing the fixed route network in Waco include both service operational changes and realignments of the fixed routes. Service operational changes include:

- Creating shorter routes (20-30 minute loops with transfer points along the Rapid Transit Corridor).
- Reroute the fixed routes to maintain connectivity to prime activity centers, while also allowing easy transfers along the Rapid Transit Corridor.
- Reroutes should be phased as changes are made.
- Mitigate the need for additional vehicle purchases.
- Extending the hours of service to compliment the Rapid Transit Corridor service.

These changes can result in multiple system time savings but would likely require an increase in operation funding.

Reroutes and scheduling changes to the fixed routes would exceed the current anticipated Rapid Transit Corridor ridership numbers. The current Waco system serves approximately 2,400 riders per day. By 2040, with an optimized transit network, the Rapid Transit Corridor could expect to serve 1,200 riders per day. The entire network, if optimized correctly, could expect to serve 5,900 riders per day.

Additional studies would be required prior to changes to the fixed route system.

7. Appendix A

7.1 Bicycle and Pedestrian Screening Criteria

7.1.1 Overview

Bicycle and pedestrian safety is an important measure when evaluating transit corridors and were evaluated as a part of the alternatives analysis.

7.1.2 Evaluation

The project team evaluated all three corridors based on impacts to non-motorized travel. Each corridor was given an overall range based on a combination of factors, including: an analysis of sidewalk gaps, the area's current walk score, impacts to bike lanes (either yes or no), bike lane displacements (in feet), and bike route and bike lane connectivity.

Table 15: Overall Alignment with Franklin/Washington Couplet

Alignment	Sidewalk Gap Alignment Rank	Walk Score. Com Rank	Bike Lane Impacts	Bike Lane Displaced	Bike Route and Bike Lane Connectivity	Average Rank Overall	Evaluation
Alignment 1	1.0	3.0	1.0	3.0	5.0	2.6	Low
Alignment 2	5.0	5.0	1.0	3.0	5.0	3.8	High
Alignment 3	3.0	1.0	5.0	5.0	1.0	3.0	Medium

Table 16: Overall Alignment without Washington Couplet (overall alignment Franklin 2-way)

Alignment	Sidewalk Gap Alignment Rank	Walk Score. Com Rank	Bike Lane Impacts	Bike Lane Displaced	Bike Route and Bike Lane Connectivity	Average Rank Overall	Evaluation
Alignment 1	1.0	3.0	3.0	5.0	3.0	3.0	Medium
Alignment 2	5.0	5.0	3.0	5.0	3.0	4.2	High
Alignment 3	3.0	1.0	5.0	5.0	1.0	3.0	Medium

7.2 Economic Development Screening Criteria

7.2.1 Overview

Economic development is an important measure when evaluating transit corridors, as development that is on-going or which occurs due to a public investment in the transit corridor provides opportunities for additional ridership for the transit agency and economic benefits for the city.

7.2.2 Evaluation

The project team evaluated all three corridors based on existing and future land uses. Corridor land uses that were transit supportive (multi-family residential and commercial) land uses, platted or vacant, or publicly owned scored highest for economic development. These land uses allow for more redevelopment opportunities compared to more stable land uses such as single family residential.

Table 17: Corridor Existing and Future Lane Use Compatibility

Alignment	Existing Land Use	Future Land Use	Evaluation
Alignment 1	3.0	3.0	Medium
Alignment 2	3.7	3.7	High
Alignment 3	2.3	2.3	Low

7.3 Safety Screening Criteria

7.3.1 Overview

Safety is also an important measure for new facilities of any kind. Transit improvements are more susceptible to safety concerns, as riders often arrive at stations by walking or bicycling. This often requires passengers to cross streets. Additionally, transit patrons also must stand at the station while waiting for the bus to arrive. Bus stations are often located next to busy streets, so passenger safety is paramount to ensure patrons arrive safely at their final destination.

7.3.2 Evaluation

The project team looked at three variables to assign a safety rating to each corridor including average speed limit, sidewalk score, and bulbout score.

- **Average Speed limit**: Speed limit data was obtained manually through google maps street view. High, Medium, and Low ratings were defined based on the existing speed limit on a particular corridor; with 30 mph being most suitable for pedestrian and bike users and more than 40 mph being the least suitable.
- **Sidewalk Score**: This data was obtained through ArcGIS based spatial analysis using the sidewalk shapefile provided by WTS. High, Medium, and Low ratings were defined based on the presence of sidewalks in and around the station area; with 5 stating that sidewalks are present in all directions, 3 being a medium coverage in/around the station location and 1 being the least.
- **Bulbout Score**: The data shows the proposed possible locations where bulbouts can be constructed based on carrying capacity and ROW. Presence of bulbouts within 200 feet of a station received High (5) rating and if bulbouts are located further than 200 feet from station location received Medium (3) rating. If there were no bulbouts possible near to the station location, a Low (1) rating was assigned.

Table 18: Safety Score Overall Ranking

Alignment	Safety Score Rank Overall	Evaluation
Alignment 1	3.2	High
Alignment 2	3.1	High
Alignment 3	2.9	Medium

8. Next Steps

8.1 FTA Project Justification

This section provides a brief summary of the process required for proposed transit design and construction projects to become eligible for discretionary Capital Investment Grant (CIG) funding from the Federal Transit Administration (FTA).

FTA requires transit agencies seeking funding to proceed through a multi-step, multi-year process to become eligible for federal funding. For projects with a total estimated capital cost of less than $300 million and seeking less than $100 million in Section 5309 CIG program funds the category is called Small Starts. The first phase of the Small Starts program is called Project Development and the second is a construction grant agreement.

Projects must be evaluated and rated by FTA in accordance with the defined criteria at various milestones in the development process and receive at least a “Medium” overall rating, in addition to other requirements.

Project Justification categories for rating:

- Mobility
- Environmental benefits
- Congestion relief
- Economic Development
- Land use
- Cost effectiveness (cost per trip)
- Local Financial Commitment

Source

- Final Interim Policy Guidance FTA CIG Program (June 2016)

8.2 Project Development

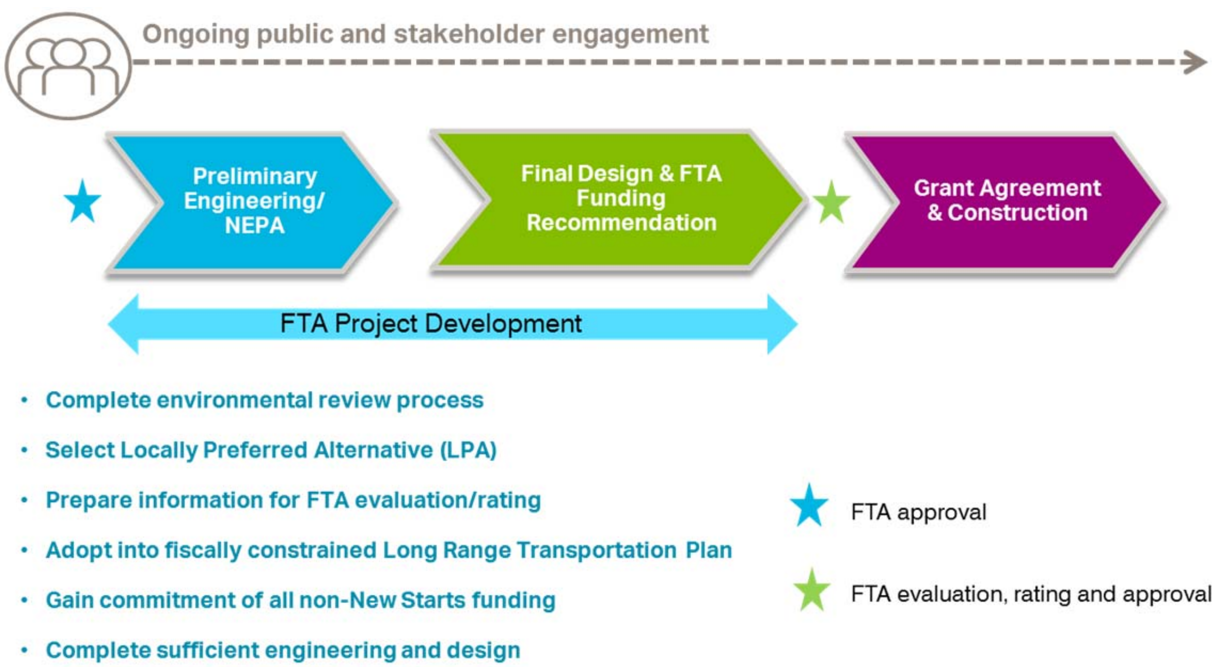
Project Development (PD) is the first phase of the project to qualify for funding in the CIG program. All activities undertaken prior to PD are not included should a construction grant be awarded in the future. FTA requires project sponsors to submit a letter to FTA as their application to enter PD. The application should include a summary of the justification of the project, including an executive summary of the Feasibility Study/Corridor Planning activity leading up to local selection of a rapid transit solution. It is also necessary to show commitment from local agencies, in this case City of Waco and Waco Transit Systems. The sponsor must also demonstrate the funding is available to perform the PD work which must be completed within 2 years.

Project activities required after being granted entry into PD are shown below:

- Sufficient engineering and design for reliable cost, scope and schedule estimates
- Environmental review process required under the National Environmental Policy Act (NEPA)
- Project Justification for rating
    - FTA PD Templates for mobility, environmental benefits, congestion relief, economic development, land use, capital cost and finance
- Local and Federal Actions
    - City of Waco & Waco Transit Systems
        - Execute critical agreements with key stakeholders
        - Secure all non-CIG funding for construction and continued operations
        - Complete NEPA process and CIG readiness requirements related to technical capacity, staffing, and oversight to be eligible for a construction grant agreement

FTA issues a CIG rating based on the evaluation of the PD requirements. A project requires a "medium" or higher rating to be eligible for a funding award. A construction grant agreement can be negotiated when a project is recommended for funding by FTA in the *Annual Report on Funding Recommendation.*

A summary of Project Development process to attain Small Starts funding is shown below:



Appendix B – WTS Conceptual Route Optimization

8.3 Route 1 – Central Waco Circulator

This will be a bidirectional loop route operating from the retail area located at Bosque Blvd and N Valley Mills Drive at the western most extent. From there it travels along Colcord Ave to 4th Street where it services downtown. After 4th Street it travels down Franklin where it connects with the RTC. It then travels down University Parks Drive where it serves Baylor. From University, it turns onto La Salle and then it has a slight deviation along 12th Street, Gurley Lane, and 18th Street. Once back on La Salle Avenue it travels to the Waco Traffic Circle and then up S Valley Mills Drive, serving retail along this segment. It turns from N Valley Mills Drive onto W Waco Drive to connect once again with the RTC. It then travels on N New Road and back onto N Valley Mills Drive to its origin. To accomplish a 30 minute frequency on this route, it will require bi-directional service, with two vehicles serving each direction.

	Weekday	Saturday	Sunday
Span	5:15 – 19:15	6:15 – 20:15	7:15 – 19:15
Frequency	30 min	30 min	60 min

8.4 Route 2 – McLennan Community College (MCC) Connector

This will be a bidirectional route operating as a crosstown connector from McLennan Community College on the northern extent and terminates at 12th Street and La Salle Avenue on the southern extent. It connects with the Central Waco Circulator on the southern extent at 12th Street and La Salle Avenue and on the northern extent at 18th Street and Colcord Avenue. It connects with the RTC at the station located at Franklin and 18th. From La Salle Avenue to West Avenue it will operate on the 17th and 18th Street couplet.

	Weekday	Saturday	Sunday
Span	6:15 – 19:15	7:15 – 20:15	7:15 – 19:15
Frequency	30 min	30 min	60 min

8.5 Route 3 – Dutton Avenue Connector

This will be a bidirectional route operating from the Downtown Transit Station on the northern extent and the University High School at the southern extent. It will serve the HEB located at Bagby Avenue and S Valley Mills Drive and make a connection with the Central Waco Circulator and the MCC Connector.

	Weekday	Saturday	Sunday
Span	6:15 – 19:15	7:15 – 20:15	7:15 – 19:15
Frequency	30 min	30 min	60 min

8.6 Route 4 – Lake Air Drive Connector

This will be a bidirectional route operating as a crosstown connector from MCC on the northern extent and will terminate at the Central Texas Market Place on the southern extent. This route will connect with the RTC at the stations located on W Waco Drive at Lake Air Dr. It will also serve the retail destinations located along Lake Air Drive, the Extraco Events Center, Heart of Texas Coliseum, Social Security Administration, and the Waco High School.

	Weekday	Saturday	Sunday
Span	6:15 – 19:15	7:15 – 20:15	7:15 – 19:15
Frequency	30 min	30 min	60 min

8.7 Route 5 – Technology Connector

This will be a bidirectional route in the North River area anchored at the Texas State Technical College on the northern extent. It will connect with the RTC at the station located on New Dallas Rd at Industrial Blvd. It will terminate at the Downtown Transit Center on the southern extent.

*This route will work in tandem or be interlined with a short connector route that connects the Texas State Technical College, the TSTC Waco Airport and Sanderson Farms (see route 10 – Airport/Sanderson Connector).

	Weekday	Saturday	Sunday
Span	6:15 – 19:15	7:15 – 20:15	7:15 – 19:15
Frequency	30 min	30 min	60 min

8.8 Route 6 – Hewitt Industrial Circulator

This will be a bidirectional route with a large turnaround loop in the clockwise direction in the industrial area that is anchored at the Hillcrest Medical center and connecting with the RTC transit stations at Estates Drive and Texas Central Pkwy on the northern extent and will terminate at the retail area located at Sun Valley Blvd and I-35 on the southern extent.

	Weekday	Saturday	Sunday
Span	6:45 – 19:15	7:45 – 20:15	7:45 – 19:15
Frequency	60 min	60 min	60 min

8.9 Route 7 – North River Connector

This will be a bidirectional route that circulates through the North River area. It will be anchored at the RTC station located on New Dallas Rd at Industrial Blvd on the northern extent. It will terminate at the Baylor Research and Innovation Collaborative on the southeastern extent.

	Weekday	Saturday	Sunday
Span	5:15 – 19:15	6:15 – 20:15	7:45 – 19:15
Frequency	60 min	60 min	60 min

8.10 Route 8 – Morrow Connector

This will be a bidirectional route anchored at the Downtown Waco Transit Center on the eastern extent and will terminate at the Richland Mall on the western extent.

	Weekday	Saturday	Sunday
Span	6:15 – 19:15	7:15 – 20:15	7:45 – 19:15
Frequency	30 min	30 min	60 min

8.11 Route 9 – Medical Connector

This will be a bidirectional route operating from the Hwy 6 turnaround near Waco Lake Shore on the northern extent and will terminate at the Hillcrest Baptist Hospital on the southern extent. This route will connect with the RTC at the Richland Mall station and it will also serve the Providence Health Center and the YMCA.

	Weekday	Saturday	Sunday
Span	6:45 – 19:15	7:45 – 20:15	7:45 – 19:15
Frequency	30 min	30 min	60 min

8.12 Route 10 – Airport/Sanderson Connector

This will be a short bidirectional route operating from the TSTC on the northern extent and will travel passed the L-3 Platform Integration building on the eastern extent and terminate at the Sanderson Farms entrance.

*This route will work in tandem or be interlined with the Route 5 – Technology Connector (Route 5 – Technology Connector).

	Weekday	Saturday	Sunday
Span	7:15 – 16:45	-	-
Frequency	3 round trips	-	-

About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A *Fortune* 500 firm, AECOM had revenue of approximately $17.4 billion during fiscal year 2016. See how we deliver what others can only imagine at aecom.com and @AECOM.

Contact

Andrew Ittigson

Project Manager

T +01 (214) 672-2858

E andrew.ittigson@aecom.com

aecom.com

Waco Rapid Transit Corridor Feasibility Study

Technology and Design Guidelines

Table of Contents

Tables

Figures

1. Introduction

The purpose of this document is to provide a high-level overview of the technology and design components required to implement bus rapid transit (BRT) in the City of Waco and the surrounding communities. This document builds off the initial Technology Assessment Executive Summary (August 2017). The elements throughout this document are a combination of best practices, publicly vetted concepts, and requirements for Small Starts FTA funding. This document includes the following components:

1. **Corridor Overview**
    - This section provides a brief overview of the Locally Preferred Alternative corridor that was selected through the Alternatives Analysis process.
2. **Communications and Technologies**
    - This section includes a high-level assessment of the technology components that are necessary to operate a bus rapid transit system, and their interaction with one another.
3. **Station Areas**
    - This section provides general guidance related to implementing bus rapid transit station areas at proposed locations throughout the corridor, including station siting and station amenities.
4. **Roadway Considerations**
    - This section outlines potential opportunities to restructure the existing Right of Way (ROW) to implement a bus rapid transit system along the preferred corridor.

It is important to note that the following sections are generalized and meant to provide guidance and key considerations that should be examined further. More detailed engineering and planning is required to implement bus rapid transit in Waco. This document provides a framework that was generally accepted by the community through the selection of a Locally Preferred Alternative.

2. Corridor Overview

The Waco Rapid Transit Corridor feasibility study process originally included three possible alignments for a BRT route through the city. Eventually, Alignment Two was selected as the preferred alignment based on the alternatives analysis process which included both technical assessments and a public outreach component.

Alignment Two is approximately 13 miles long, stretching from the intersection of US 84 at Hewitt Dr. at its southern terminus to the intersection of TX Loop 340 at Business 77 at its northern terminus. It travels along US 84/Waco Drive, New Rd, Franklin Avenue, Taylor Avenue, Clifton Street, Elm Avenue, Hillsboro Drive, and TX Loop 340. There are 14 proposed station locations distributed along the alignment, with the potential for additional “infill” stations that may be considered in future planning and engineering design phases. These stations not only function as the essential means of connecting passengers to the BRT service, but also provide passengers with service information and a safe, comfortable environment while waiting for a bus.

To the greatest extent practical, potential station locations were identified near signalized arterial intersections that would provide users access to areas with residential, commercial, educational, civic, park/recreational, medical, and industrial land uses -- including stations within a mile of important destinations such as the Mars Chocolate and Coca Cola Refreshments manufacturing facilities, Richland Mall, downtown Waco and Magnolia Market, Doris D. Miller Park and the Waco River Walk, and Eastgate Plaza Shopping Mall.

3. Communications and Technologies

3.1 General Overview and Relationship Between Them

Some of the aspects that distinguish BRT from other bus transportation services are also some of the most important characteristics to providing superior customer service and operating a successful BRT system. Technology and communications components support improved transit speed, efficiency, and reliability, as well as giving BRT some level of priority over other forms of automobile traffic. Communications are the systems that allow each vehicle to provide BRT service properly, interacting with traffic control and passenger information devices along the corridor. Various types of technologies are utilized to accomplish this communication. Non-communications technologies are also involved in the successful operation of BRT services. There are two primary types of communications and technologies components: on-board systems and devices and off-board systems and devices, both of which are discussed below.

3.2 On-Board Technologies

There are a variety of technologies available for use on-board transit vehicles. Among other capabilities, these technologies provide measures for activities such as: passenger information, trip planning, fare collection, data collection (automatic passenger counting), and monitoring (video surveillance), which all. These technologies contribute to a safer, more reliable, more efficient, and more successful BRT system

3.2.1 GPS

Global Positioning System (GPS) is a technology used in many different applications to track the location of a person, vehicle, or other object. GPS pinpoints location when a receiver device detects signals from three or more satellites. These receivers can be incorporated into transit vehicles to track their location in a process called Automatic Vehicle Location (AVL). When paired in communication with off-board receivers at stations, AVL can be used to calculate other important information like vehicle speed, direction, and distance from the station. Such information can then be displayed in real-time on digital signage, both on-board (showing riding passengers the next stop on the route) and off-board (showing waiting passengers when the bus is expected to arrive at the station).

Aside from digital signage, this real-time service information can also be incorporated into transit applications (web-based and smartphones) for users who are not yet at a station. Providing this type of information allows on-board passengers to better prepare to depart the bus at their desired stop and gives passengers waiting at stations (or elsewhere) better assurance of when to expect the next bus at a particular station. AVL communications are also important for transit operations centers because they transmit real-time information about buses to system employees who can use the information to plan service activities like maintaining route frequencies or react quickly when situations arise.

To transmit the location information from each bus to stations and operations centers, transit providers can use cellular or WIFI communications methods. With cellular communications, a bus has a cell modem that transmits location information and other data to a cellular tower, which can then transmit that information/data to off-board messaging signs for real-time display and operations centers for real-time evaluation or data storage. With WIFI communications, the same process would be accomplished using a WIFI modem with access to a wireless network which can relay information to desired messaging signs and other destinations.

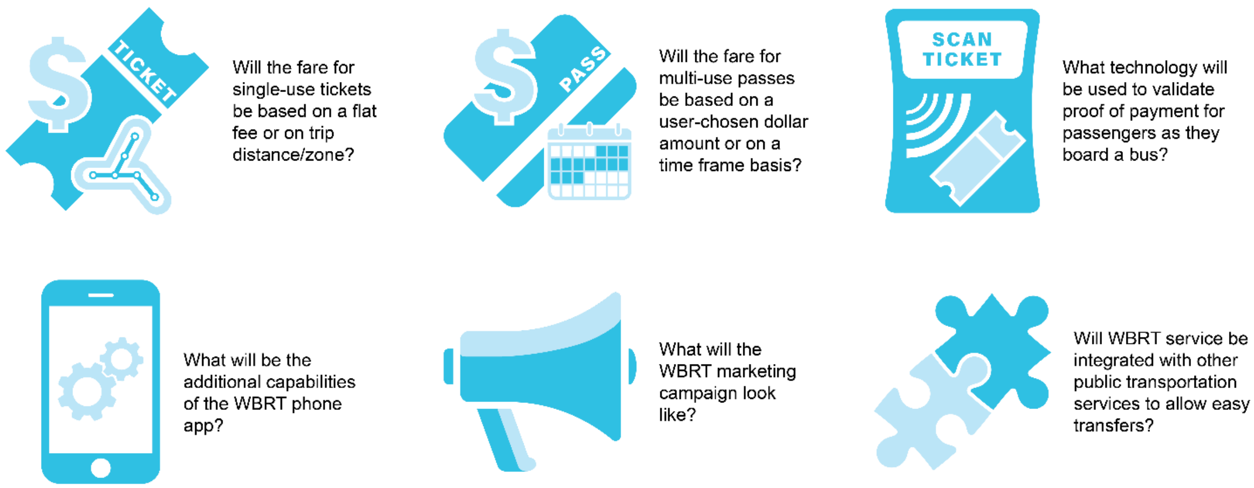
3.2.2 Fare Collection

Fare collection refers to the method of collecting passengers' payments for using a transit service. There are three primary aspects of fare collection:

- Fare media: The type of accepted payments.
- Fare collection process: The method for accepting and validating payment.
- Fare structure: The systemwide structure for fare collection, including elements such as the fares charged for different transit services, the coverage period (per ride, weekly, monthly, etc.) and discount rates.

Figure 1 below shows several necessary considerations for Waco Transit Systems (WTS) prior to implementing a new fare collection system.

Figure 1: Fare Collection Considerations



The combination of different fare collection processes, fare media, and fare structures that transit providers choose for their systems have a major impact on convenience, efficiency, and flexibility as it relates to passengers' interactions with the service. Transit providers generally choose the aspects of their fare collection system based on what works best for the service and what optimizes passenger interaction with the service. An important consideration is that not all populations have access to certain types of technologies, so flexibility and diversified options are crucial to ensuring that all potential users have access to the system.

3.2.2.1 Fare Media

Fare media refers to the types of accepted payments or payment proof that allow passengers to access transit services. For the purposes of WBRT service, proof of payment should come in the form of both single-use tickets and multi-use passes. These proof-of-payment types can come in either hard-copy form (paper tickets/receipts, plastic cards) or digital form (scannable codes on mobile device screens) and can be either inserted into or scanned by equipment on the bus to validate the payment. Payments in the form of cash or debit/credit cards will not be available for passengers as they board a WBRT bus.

3.2.2.2 Fare Collection Process

The fare collection process is the method for collecting and validating passenger payment for using the transit service. The fare collection process varies in how and when payments are received, their benefits to the transit system, and other considerations. As determined during the public involvement component of this study, the proof-of-payment fare collection system for Waco Bus Rapid Transit (WBRT) is recommended as the best option.

Local bus routes often utilize a pay-on-boarding method, which reduces the amount of equipment needed but often increases dwell time as each individual rider provides fare payment upon boarding. This can be further complicated if customers pay upon exiting and must negotiate a crowded bus to exit. One of the defining qualities of BRT is the ability to keep service "rapid," so a different fare collection method that avoids delays and allows buses to maintain their schedules should be implemented.

A proof-of-payment fare collection system, where passengers scan or insert their ticket/pass into on-board validation equipment, may be best suited for WBRT. This method requires passengers to pay to use the WBRT system ahead of boarding a bus which eliminates the delays associated with pay-on-boarding methods.

Proof-of-payment systems often utilize equipment that validates passenger payment at a station while they are waiting for a bus. Generally, this can be accomplished in two ways:

1) Closed system – where physical barriers channel all transit station access through a fare collection point (i.e. turnstiles).
2) Open system – where passengers pay upon boarding the vehicle or are held to an honor system of only using the service when they have a valid ticket or pass.

Proof-of-payment systems may employ inspectors from the transit service to occasionally check that passengers on board have valid proof of payment and give citations to those without validation. It is also important to note that local buses will still allow cash payments on board each vehicle.

Along many high capacity transit lines, ticket vending machines are provided at each bus/rail station for passengers to make on-site ticket purchases before boarding. However, the equipment can be expensive and difficult to maintain, and WBRT service will not offer this equipment except at the Waco Transit Center (WTC). As the WBRT service is expected to encourage more inline transfers with local buses at BRT stations away from the WTC, on site ticket purchases may not be conveniently accessible to potential transit users. Further, many transit users may not have access to smartphones or credit cards required for mobile app purchase of transit fares.

Given these challenges to implementing an exclusive proof-of-payment system, it may not be possible to eliminate pay-on-boarding equipment from the WBRT. However, WTS is encouraged to coordinate with potential commercial and retail partners near stations (i.e. – grocery stores, pharmacies, employers) to provide access to on-site ticket purchase. There will need to be a marketing campaign developed to formally notify the public that WBRT service will feature the use proof-of-payment options rather than the pay-on-boarding method used for the local bus service. This campaign process is critical for Waco given on-site ticket vending machines will not be installed except at WTC.

It is recommended that proof of payment for the WBRT service be made available in three ways: 1) Via a phone app that Waco Transit would develop, 2) directly from the Waco Transit Center, and 3) at local stores through a partnership with Waco Transit.

- <u>Phone app:</u> At a minimum, the phone app should provide passengers with the ability to purchase both single-use tickets and multi-use passes. Tickets and passes would be in digital form only and scanned from the passenger's phone screen as they board the bus. The app may also have broader capabilities such as providing passengers with service schedules and route information.
- <u>Waco Transit Center:</u> Tickets and passes purchased from the WTC would come in hard-copy form only. Single-use tickets can be printed on paper, while multi-use passes can be purchased as reusable plastic cards to ensure longevity. Waco Transit will decide how to structure the fare collection for reusable cards (i.e. loading a chosen dollar amount onto a card vs. paying to use the WBRT service for a set amount of time, such as a week, a month, or a year).

- Local stores: Waco Transit may choose to form partnerships with local businesses, such as a grocery store or shopping center, to sell tickets and passes on-site. Waco Transit may specifically choose to sell only multi-use passes at these stores to eliminate logistics for printing paper single-use tickets. This choice should depend on whether Waco Transit decides to charge differing amounts based on distance/zone-traveled for a single-use ticket – a decision which Waco Transit would make in the fare structure portion of the WBRT service plan. Similar to the WTC, tickets and passes sold in local stores would be in hard-copy format only.

3.2.2.3 Fare Structure

A WBRT service plan will need to be created to determine the details of the service's fare structure, which may include elements such as:

- Whether single-use ticket purchases come at a flat rate or whether the price should change based on trip distance/zone.
- Whether fares for BRT service should have a premium or be priced the same as local buses.
- Whether validated BRT fares can allow passengers to transfer to other public transportation services, and vice versa.

The current fare structure for Waco Transit permits daily and monthly passes access to all services. This may indicate what fare structure the public is familiar with and prefers, and, therefore, should be considered when determining the fare structure for the new service.

3.2.3 Automatic Passenger Counting

Automatic passenger counting (APC) uses counting devices on-board transit vehicles to collect data about the flow of passengers on and off the vehicle. APC devices can record data such as the number of passengers boarding or alighting (off-boarding) at a station, the date/time of the stop, the station location, and the time the vehicle doors open and close. This information can be transferred to computers or data storage systems by manual downloading, real-time reporting, or wireless transfer over a network.

These devices are usually placed at the doors of the vehicle and use infrared sensors to record how many people board and alight the vehicle at each station, as well as keep a running record of how many people are on the vehicle at a given point along a route. In addition to the benefits of obtaining this data, APC devices make the data collection process much easier and more accurate than traditional surveying and other collection methods. Waco Transit currently uses APC on existing transit services. Transferring this technology to the WBRT service will help Waco Transit continue to monitor the success of the service and make necessary changes based on ridership patterns.

3.2.4 Video Surveillance/CCTV

Video surveillance systems and equipment can be installed both for on-board and off-board purposes. The on-board surveillance system usually involves cameras (sometimes with audio capabilities) installed on and within a transit vehicle. These cameras can make recordings to be stored and referenced at later times or can send real-time footage to operations centers for monitoring. The primary purposes for on-board surveillance include promoting a safer passenger environment inside a bus and capturing interior incidents when they happen, monitoring bus driver behavior, and capturing the external environment around the bus while en route or when external incidents occur. This surveillance not only provides video accounts of incidents but also provides operations centers with the ability to respond appropriately to situations that are being monitored in real time.

3.3 Off-Board Technologies

Off-board technologies work in-tandem with the on-board technology addressed above to ensure the BRT system maintains reliability and ease-of-use. The off-board technologies described below are specific enhancements placed along the BRT route such as at station locations and intersections. While each technology brings a specific enhancement to the overall BRT system, they are the most effective when implemented together.

3.3.1 Station Technology

A key benefit of an AVL (automatic vehicle location) system includes the ability to distribute real-time information at transit stations to assist passenger experience and trip planning capabilities. Real-time information is made possible by the AVL system providing locations of transit vehicles, vehicle speed and direction, and schedule delays. In addition to the AVL information, real-time information may combine current and historical traffic conditions as well as real-time operations data to accurately predict the arrival of the next bus at a station. This information is often displayed to passengers on a dynamic message sign (DMS) at each station with information helpful for en route passengers such as current time and date, route number and destination of the vehicle, waiting time, and service disruptions. Implementing a real-time information system benefits the overall goals of a BRT system as it encourages a high level of confidence and comfort among passengers using the system.

If significant real time capabilities and dynamic messaging signs are provided at stations, it will be necessary for station areas to house communication technology and electronics within communications cabinets. Options exist to house communications cabinets inside of the shelter or outside of the shelter. The cabinet spatial requirements and potential impacts on shelter structure, as well as pedestrian and passenger operations should be considered during the design and implementation process. Accessibility to fiber/copper conduits are essential for these technologies to perform. Considerations should be made during the design process for wireless data transmission solutions. Wireless gateways and 4G/5G technology may allow for cost savings and reduced construction time to bury utility lines. Additional design considerations for communication boxes such as sizing and other requirements will also need to be made when incorporating these technologies.

Wifi hotspots should also be considered as a passenger amenity at stations. This feature allows passengers to easily connect to the internet while waiting for the next vehicle and may also be implemented on-board. WiFi hotspots have garnered support by the community and been noted as a preferred feature for the WBRT system. The mobile gateway for both AVL data transmission and passenger WiFi functions using a modem or cellular (4G/5G) solution.

3.3.2 Intersection Enhancements

Along most transit routes, traffic signals remain a major contributor to system delays. In places with high congestion, these delays can significantly contribute to the cost of running public transit. Intersection enhancements have the power to minimize person delay, reduce bus operating costs, and increase safety and reliability through the combination of signal enhancements and dedicated lanes. According to the National Association of City Transportation Officials, "traffic signal delay often accounts for one-quarter to one-third of a transit route's total trip time." This delay can be reduced by optimizing intersection design with the addition of three enhancement alternatives: 1) Transit Signal Priority, 2) Queue Jump, or 3) Bypass Lane. These three enhancements provide a variation of approaches to reduce transit delay at signals (See **Figure 2**). Waco Transit, in coordination with TxDOT and the City of Waco, should design a system compatible with the varying types of traffic signal enhancements, as each is applicable to different scenarios throughout the city and will ensure WBRT system's overall effectiveness.

3.3.2.1 Transit Signal Priority

Per FTA and FAST Act requirements to classify as a corridor-based BRT for Small Starts funding, traffic (transit) signal priority for public transportation vehicles is required. In addition, the "route must provide faster passenger travel times through congested intersections by using active signal priority in separated guideways, and either queue-jump or active signal priority in non-separated guideways." As such, the following section outlines different methods to improve transit speed and reliability along this corridor-based BRT.

The active form of Transit Signal Priority (TSP) advances or extends the traffic signal phase by holding a green signal for the transit vehicle to efficiently pass through the intersection for 3-5 more seconds or by truncating a red signal in the other direction. TSP operates as a special phase and once the transit vehicle is through the intersection the signal returns to the existing phase timing. TSP can be implemented as an active priority signal requiring the transit vehicle to communicate with the controller box as it approaches the intersection with the use of in-pavement induction loops, radio, or GPS or light-based detection (**Table 1**). These options allow for a range of cost alternatives.

Table 1: TSP Communication Technology

Technology Type	Function	Pros	Cons
Inductive Loops	Confirms location of a vehicle on the circuit and communicates with central system	• Compatible with commonly used look detectors • Relatively reliable • Does not require line of sight or visibility	• Requires in pavement loop detectors • Prone to failure due to pavement flexing
Radio Based Detection	Triggers street side beacons to communicate with signal to change	• Does not depend on line of sight or visibility	• Requires RD tag installation at upstream curbside • Non-directional vehicle information
GPS Based Detection	Device on the vehicle pinpoints vehicle location based on radio signals received from three or more satellites, communicates vehicle location to receiver connected to signal controller	• Does not depend on line of sight or visibility • Can easily notify controller when vehicle has cleared	• Slow automatic vehicle location polling rate • Low/no GPS reception in urban canyons
Light-based (Infrared) Detection	Emitter on the vehicle sends out infrared pulses at a specified frequency that are picked up by a receiver on the traffic signal	• Widely used in US for emergency vehicle pre-emption • Well tested for many years	• Requires line of sight clearance between emitter and detector

While active TSP requires the highest investment of the traffic enhancement options due to the signal technology enhancements necessary to communicate with vehicles, it has shown to have the highest return on investment (See **Table 2**). For example, the Bus Rapid Transit Practitioners Guide[1] provides a success story for the use of TSP:

> *Los Angeles MTA indicated before Wilshire-Whittier and Ventura BRT implementation, the average cost of operating a bus was $98 per hour. A traffic signal delay reduction of 4.5 minutes per hour translates into a cost savings of approximately $7.35 per hour per bus for the initial two BRT corridors. For a bus operating along these corridors for 15 hours a day, the cost savings would be approximately $110.25 per day. Assuming 100 buses per day for an average of 300 days per calendar year in two corridors, this translates into an approximately 3.3 million annual operating costs savings for the MTA. This savings does not include added benefit of travel time savings for the rapid ride bus passengers.*

To successfully implement active TSP, there must be a high level of coordination between the transit provider and any other agencies/departments that are in control of signal timing and traffic management for the streets that a BRT route follows. These groups must work together to effectively implement active TSP based on overall goals for transit and signal timing, transit service scheduling, the

[1] Bus Rapid Transit Practitioner's Guide – TCRP Report 118, Transit Cooperative Research Program

mechanical/electronic capabilities of the signal system, and any phasing needed for TSP integration due to equipment costs or time needed to make upgrades or gain approval.

Passive TSP is a lower-cost alternative to active TSP because it does not require special or additional equipment. Passive TSP does not directly give transit vehicles priority over other forms of traffic, however it uses practices that optimize traffic conditions for the presence of buses, such as coordination of traffic signals based on normal bus speeds and scheduling.

3.3.2.2 Queue Jump

A simplified alternative to TSP is the Queue Jump which requires a transit-only lane designated to the curb lane at an intersection. This enhancement allows a transit vehicle to access a transit station directly before (near-side of) a signal and when green the transit vehicles is given the first 3-5 seconds to pass through the intersection before general traffic lanes. This option is ideal to implement when a right turn lane is underutilized.

The TSP and Queue Jump intersection enhancements, while only requiring 3-5 seconds of green light time allocated to specific transit vehicles, have the potential to save time, money and ensure transit reliability and dependability for riders. However, if right turning traffic is high, bus time travel savings may be reduced due to right turn lane back-ups.

3.3.2.3 Bypass Lane

A Bypass Lane enhancement retains the same benefits as TSP and Queue Jump. The Bypass Lane allows the transit vehicle in the far-right turn lane to move through the intersection first allowing other auto vehicles to make their right turn. This alternative retains a transit-only lane through the intersection allowing the transit vehicle to move to a far-side transit station on the other side of the light. This enhancement is ideal at an intersection with heavy right turns. **Figure 2** further illustrates the differences between the three intersection enhancement alternatives.

Figure 2: Intersection Enhancement Alternatives

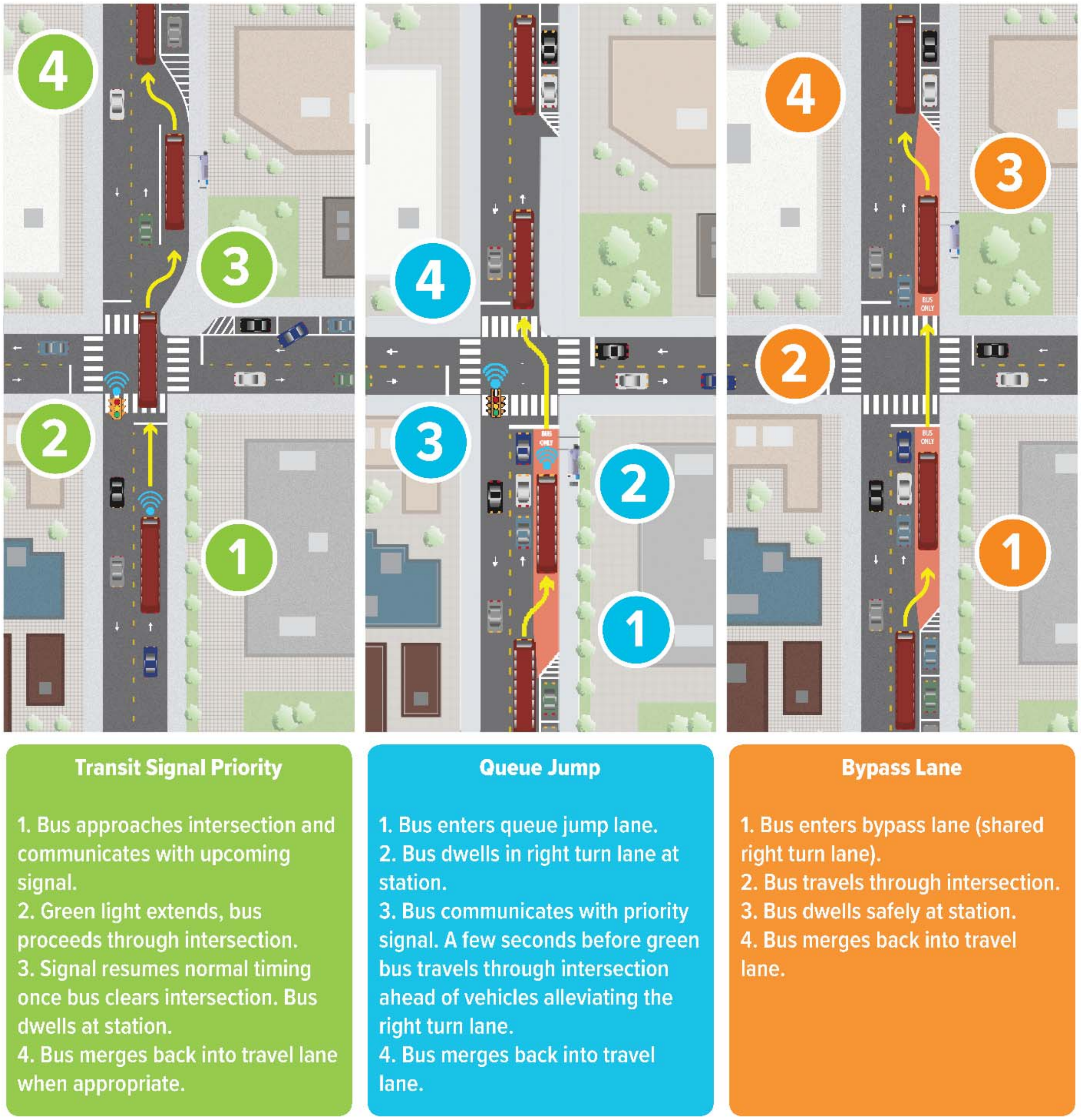


Table 2: Intersection Enhancements Comparison

	Transit Priority Signal	Transit Queue Jump	Transit Bypass Lane
Function	• Improved efficiency at congested intersections or intersections with long signal cycles using technology enhancements	• Improved safety and transit efficiency at non-congested intersections by dedicating transit facilities before signal with bus station and providing a green before other vehicles.	• Improved safety and transit efficiency at congested intersections that uses dedicated bus facilities • Preserves general vehicles right turning ability.
Benefits	• Reduces transit delay at intersections • Improves system reliability	• Reduces transit delay at intersections • Provides dedicated lane before signal for transit station.	• Reduces transit delay at intersections • Provides dedicated lane for transit to bypass congestion

	Transit Priority Signal	Transit Queue Jump	Transit Bypass Lane
Considerations	• May increase waiting times for autos/buses on cross streets • Not necessary at all intersections • Most effective at intersections with far side stop	• Not necessary at all intersections • Bus only lane may be shared right turn lane with auto traffic	• Not necessary at all intersections • Bus only lane may be shared right turn lane with auto traffic
Potential Costs	• Light based and radio technology approx. $18,500- 20,000 • Loop amplifier detector approx. $3000 • Signing and striping cost range $500-$2,000	• Bus Queue Jump signal cost is an estimated range of $5,000-$15,000 • Signing and striping cost range $500-$2,000	• Signing and striping cost range $500-$2,000

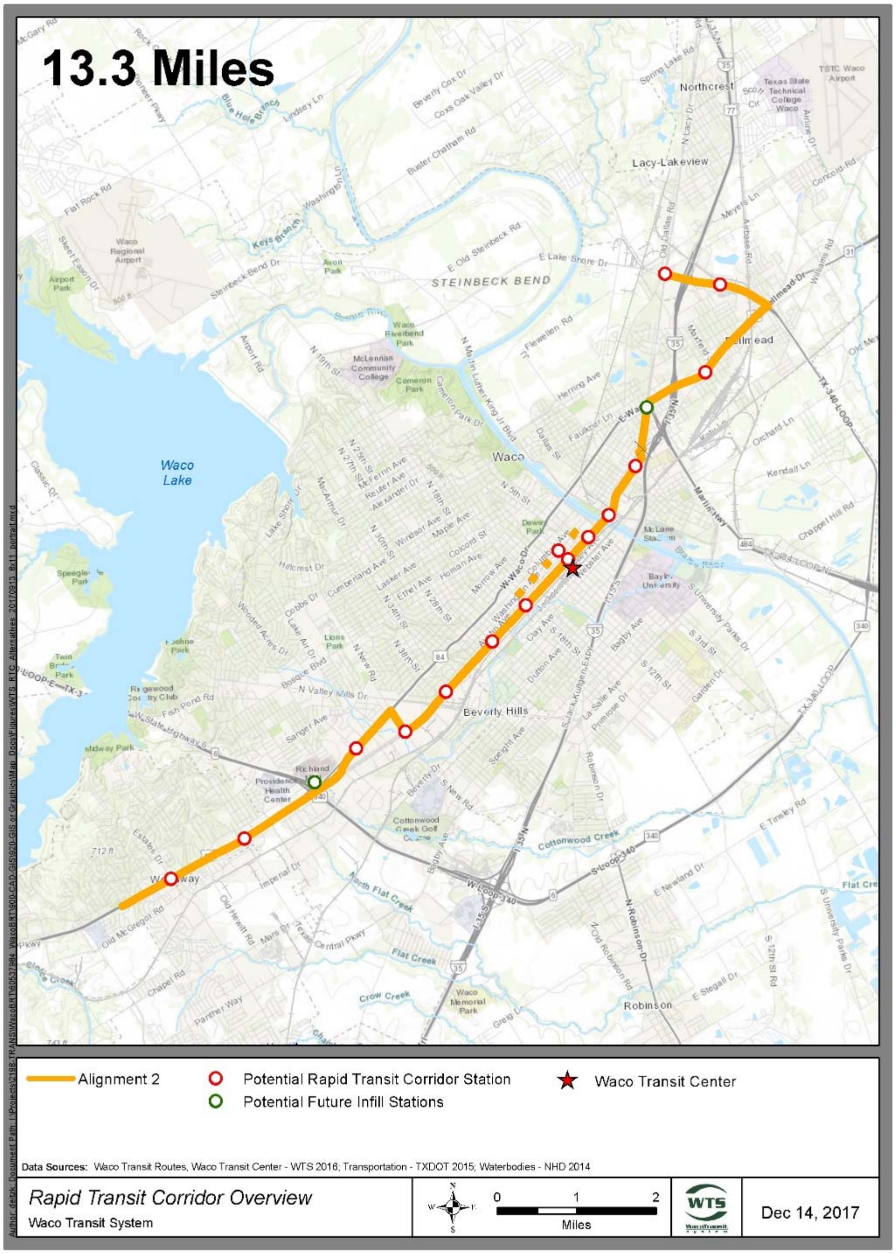
3.4 WTS Operations Center

A transit operations center is a hub where a transit provider monitors service operation, deploys changes to service, and reacts to situations as they arise. When transit providers integrate various communications and technologies into their system, they need a facility that acts as a nucleus for incoming data transmissions, video / audio streams, and phone calls. Waco Transit Center acts as the operations center for Waco Transit, and to properly accommodate a new BRT service and its associated communications / technologies, WTS may need additional investments that increase its capabilities for data storage, processing, and monitoring; especially the ability to receive and monitor data and streams in real time.

4. Station Areas

Station areas are a critical component of a BRT system, as passenger boarding and alighting activity occurs in these areas. Efforts should be made to create comfortable and safe environments that improve the attractiveness and accessibility of the BRT system. This section is broken into key elements of station areas, including general considerations, station siting considerations, station types, and station configurations. Generalized station areas are shown in **Figure 3.**

Figure 3: Waco BRT Station Areas



4.1 General Considerations

BRT stations should be developed in a way that minimizes the need for ROW acquisition. Waco Transit and the City of Waco will need to finalize station locations recommended through this phase of the feasibility assessment to consider whether reconstruction of roadways and sidewalks is necessary or if a retrofit of the existing conditions will meet the minimum requirements outlined in the following sections.

A key consideration at station locations is safety for all types of travelers, including people who drive, walk, bike, or take transit. Stations should be designed in a fashion that does not limit sight distance for people who drive, bus operators, and pedestrians. As the main access point for system users, stations should be accessible and comfortable. Station locations need to tie into the bicycle and pedestrian networks as most transit users reach boarding locations through those modes. A complete sidewalk network will help achieve better access to rapid transit services.

4.1.1 Operational Considerations at Station Locations

To ensure efficient operations at all station locations, WTS should be cognizant of: vehicle specifications and maintenance compatibility, platform boarding curb height to accommodate "near-level" boarding of BRT buses and local buses, and bus operations at shared BRT and local bus stations for parallel and perpendicular routes.

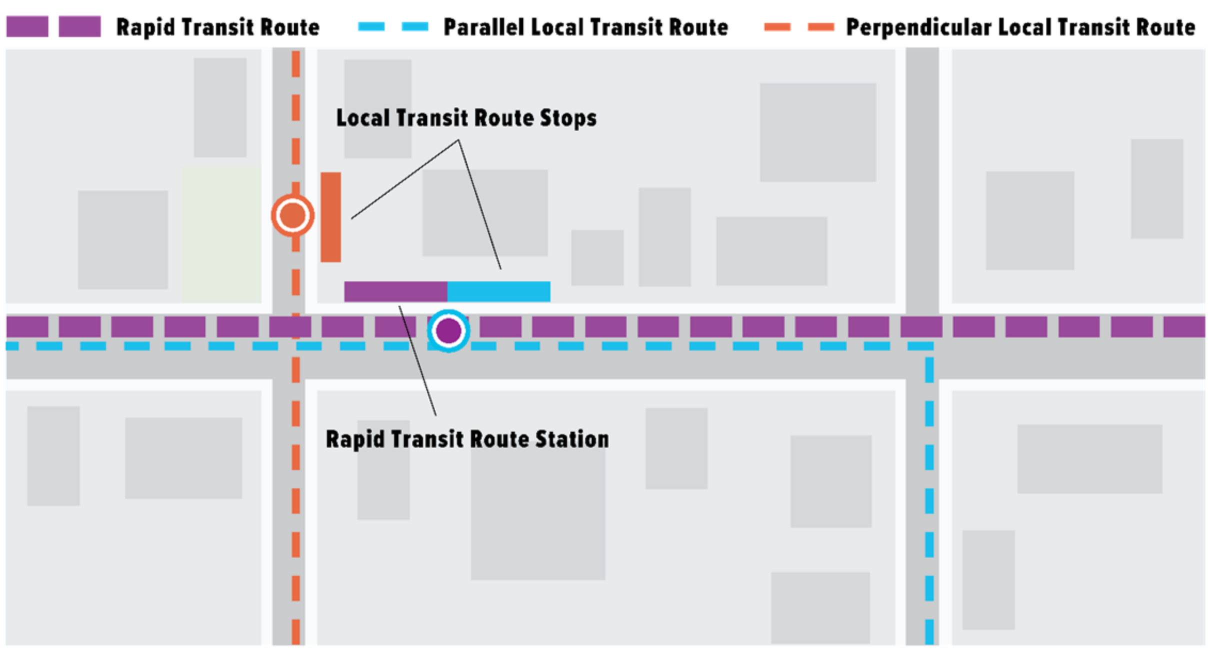
4.1.1.1 Bus Considerations

To ensure optimal operations at potential BRT station locations, buses with similar characteristics to the existing fleet will need to be utilized. The size and height of the bus doors in relation to the height of the curb is a key consideration that is often overlooked when operating BRT buses and local buses in the same environment. If different style buses are necessary, coordination with the City and WTS will need to occur to design station areas that have different curb heights to accommodate varying boarding heights.

4.1.1.2 Shared Stations

For the WBRT system to successfully move people between their starting and end points, transfers may be necessary in the future optimized system. To ensure a safe and efficient transfer process that minimizes overall travel time, station areas should serve as mobility hubs where the WBRT system, perpendicular local routes, and parallel local routes converge and foster connectivity between multiple transit routes. **Figure 4** illustrates how this can done at a BRT station location to limit the amount of travel between the different local bus stop locations. In addition to having nearby stop locations, it will be important for the local routes and the BRT to have similar timepoints where they converge on the same location to limit the wait time while transferring between routes and make trip planning more intuitive. Timepoints are locations along a route where users can be confident in arriving at on-time. Real-time arrival signage should include information on both the local bus and BRT to better inform passengers of the wait time.

Figure 4: Example of Shared Stop Interaction



4.2 Siting Station Locations

Rapid Transit Station location planning is important to the overall effectiveness of the transportation system. Rapid Transit Station location and design should be both considerate of the immediate built conditions and the transportation network at large. There are three general station location types – far-side, near-side, and mid-block – often used for bus station siting (See **Figure 5**). These location types designate where the bus stops in relation to an intersection and have specific guidelines to ensure rider-friendliness and minimize delays at intersections.

WBRT will likely include all three types of station locations. Each location type comes with advantages and disadvantages as well as best application (See **Table 3**, **Table 4, Table 5**). Bus stations are part of the overall transportation network, therefore pedestrian and bicycle accommodations should be a priority when siting and designing stations. These considerations will ensure WBRT station location implementation best supports a safe and efficient system.

Figure 5: Station Location Types

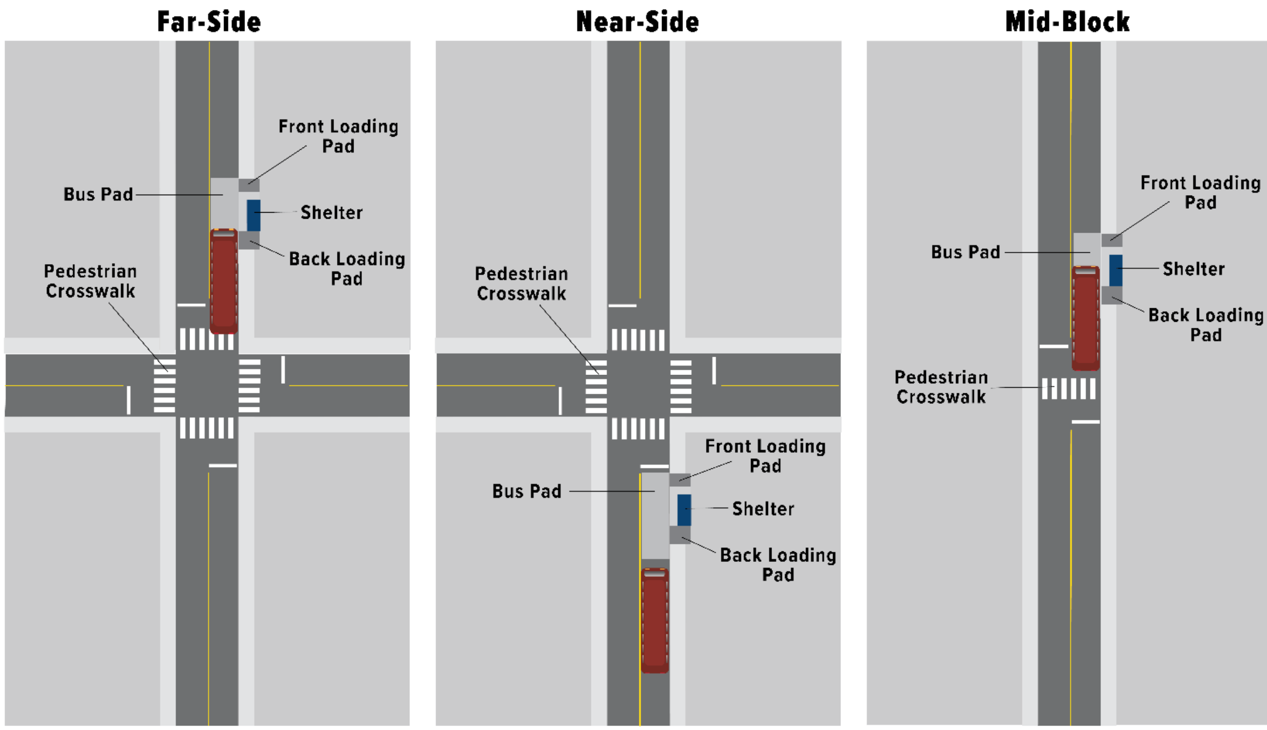


Table 3: Far-Side Station Location

Far-Side Station Location	
Description	A station located immediately after passing through an intersection.
Application	• High volume of right turning vehicles at near-side of intersection • Intersections where the transit vehicle turns onto different streets • Existing pedestrian conditions better on far side compared to near side (i.e. sidewalk/crosswalks) • Intersections with transit priority signaling • Complex intersections
Advantages	• Minimal conflicts between right turning vehicles in curb lane and buses. • Minimizes issues with sight distances for vehicles on the approach to an intersection • Reduces the likelihood of conflicts between pedestrians and buses • Reduces the required deceleration space that a bus needs when approaching a station • Bus drivers can leave the station more easily when vehicle traffic is stopped at a red light
Disadvantages	• Some sight distance issues with far-side stops. May obscure sight distances for crossing vehicles and pedestrians • Service times may be negatively affected if a bus must stop at a red light and then stop at the bus stop immediately afterward • Vehicles may not expect a bus to stop at a red light and then immediately stop again after passing through the intersection • May result in traffic backing up into the intersection when a bus is stopped in a travel lane
Other Considerations	• End of bus landing must clear pedestrian crossing by 10 feet to minimize intersection interference. • If bike facility is present, appropriate design accommodations for safe bike routing including signage and street markings are required • When curb extensions/pedestrian bulb-outs and on-street parking are present, transit vehicle merging space is required and dependent on size of vehicle for curbside pull-out stations • Additional transit merging space for bus pull-out stations should be considered when high speeds/high volumes are present • Additional intersection clearance may be needed if high turn volumes are present • Use of transit signaling may reduce delays and traffic queuing in intersection
Design Standards	• Bus Zone Length: In-lane 40’ bus – 45' 60’ bus – 65' Bus Zone Length: Pull-out 40’ bus – 90’ 60’ bus – 100’ Provide 5-10' between additional buses expected to dwell at platform • Back of bus must clear crosswalk by ten feet • Boarding areas must be a minimum of 8' wide and 5' long

Table 4: Near-Side Station Location

Near-Side Station Location	
Description	A station located immediately prior to passing through an intersection.
Application	• multiple travel lanes merging or significant driver lane change patterns on the far-side of intersection • Transit route continues straight through intersection • Higher volume of traffic on far-side • Better existing pedestrian accommodations than far-side (i.e. sidewalk/crosswalks)
Advantages	• Reduces the chances of a bus having to make a double stop (once for a red light and then again at the bus station) • Minimizes interferences when traffic is heavy on the far side of the intersection • Provides pedestrians/passengers with the closest access between crosswalks and the bus doors • Provides the bus driver with the full width of the intersection to pull away from the curb back into the travel lane • Provides bus drivers with the ability to check for oncoming traffic as well as other buses that may be carrying potential passengers
Disadvantages	• These types of stop locations create the possibility of conflicts with other vehicles trying to make right turns • Near-side stops can also create sight distance issues, including obscuring the view of curbside traffic control devices and crossing pedestrians. Crossing pedestrians may themselves have obscured sight distance • Depending on presence of TSP, buses could be queued several hundred feet prior to the station • The stopped buses might also block the view of cross traffic stopped at the intersection
Other Considerations	• Bus landing must give 10 feet clearance before pedestrian crossing to minimize intersection interference • If bike facility is present, appropriate design accommodations for safe bike routing including signage and street markings are required • When on street parking is present, transit vehicle merging space is required and dependent on size of vehicle for curbside pull-out stops • May be used as a queue jump • Use of transit signaling may reduce delays • Additional intersection clearance may be needed if high turn volumes are present
Design Standards	• Bus Zone Length: In-lane 40' bus – 35' 60' bus – 55' Bus Zone Length: Pull-out 40' bus – 100' 60' bus – 120' Provide additional 5-10' between additional buses expected to dwell at platform • Bus pad should be set back 10 feet from the crosswalk • Boarding areas must be a minimum of 8 feet wide and 5 feet long

Table 5: Mid-Block Station Location

Mid-Block Station Location	
Description	A station located somewhere near the middle of a block between two intersections.
Application	• High volume passenger destinations in proximity • Ability to accommodate mid-block pedestrian crossing protection • Traffic conditions unsupportive of stop at intersection
Advantages	• Minimizes sight distance issues for both vehicles and pedestrians. • Passenger waiting areas at mid-block stops may have less congestion
Disadvantages	• They require additional distance for restrictions on on-street parking • Pedestrians accessing or leaving the bus station may be more likely to jay walk instead of going out of their way to use a crosswalk at an intersection • Pedestrians who continue to properly use crosswalks to cross the street will have a further walking distance to or from the bus station • Mid-block signal warrants may be required in accordance with MUTCD at signalized pedestrian crossings
Other Considerations	• Must provide safe pedestrian crossing zone behind bus landing • If bike facility is present, appropriate design accommodations for safe bike routing including signage and street markings are required • When on street parking is present, transit vehicle merging space is required and dependent on size of vehicle for curbside pull-out stops
Design Standards	• Bus Zone Length: In-lane 40' bus – 35' 60' bus – 55' Bus Zone Length: Pull-out 40' bus – 120' 60' bus – 145' Provide additional 5-10' between additional buses expected to dwell at platform • Located at minimum 200 ft from intersection • A pedestrian crossing (signalized or traffic calming) is highly recommended and should be set behind the bus station • Back of bus must clear crosswalk by ten feet • Boarding areas must be a minimum of 8 feet wide and 5 feet long

4.3 Station Types

Station areas are the focal point of a bus rapid transit system. They are the key service access points for the system where boarding and alighting occurs. Per FTA and FAST Act requirements, corridor-based BRT requires separate and consistent brand identity at stations, accessible routes to stations, and information and route information at each station. The following section highlights key considerations for station areas.

4.3.1 Overview of Station Types

There are various types of transit stations which can be determined by an array of characteristics. For the purposes of Waco BRT, two typical station types were explored: the basic station and the enhanced station.

Base station size should depend on expected ridership. The more popular a station location is, the larger the station will need to be to accommodate the number of passengers likely to be waiting at the station. This is more likely to occur when stations are near or adjacent to popular destinations such as shopping centers, major employers, universities, entertainment districts, and other social amenities. A station that is likely to see fewer passengers can be smaller and simpler. Size and complexity of stations help determine the cost of building and maintaining them, so getting the station size right can help promote more efficient spending of funds. Ideally, the components of a station can be made modular and flexible to adjust to possible differences in existing conditions and changes in ridership levels.

The two station types (basic and enhanced) differ from each other by size and by provided amenities. The minimum amenities that should be incorporated into a basic station type include:

- <u>Service branding:</u> The branding for the transit service, usually seen on the transit vehicles and on signs/posters for the service, can also be incorporated into the design of station areas. Using coordinated and consistent branding helps people visually identify the association between a service and its facilities, as well as provides visual appeal.
- <u>Route and system information:</u> Information about the transit service is one of the most fundamental amenities that should be provided at stations. Even the most minimal of stations will provide service information at the route level, though ideally a station would provide route *and* system-level information (e.g. stop locations, schedules, maps). Though many passengers who use transit service frequently will likely not need this information while waiting at a station, providing service information is important for new users and for people who may not look up such information in advance of arriving at a station.
- <u>Real-time arrival information:</u> To provide waiting passengers with the most up-do-date and accurate route information, a real-time arrival sign should be placed at the station. These signs are digital and receive updates directly from en-route buses that notify passengers of the expected arrival time for each bus.
- <u>Passenger wayfinding:</u> This type of amenity is useful because it allows passengers to gain an understanding of their surroundings and can help put their current location (the station location) in context with the nearby urban or rural environment. Wayfinding resources usually include maps that show current location, nearby transit stops, the location of other destinations of interest, and how to reach these destinations.
- <u>Free WIFI:</u> Providing free WIFI at bus stations enables passengers to access the internet on their mobile devices (phones, tablets, laptops) for work and entertainment purposes while they wait for their bus.
- <u>Shelter structure:</u> Though some of the most minimal bus stations do not have a shelter structure, they are becoming more important to providing waiting passengers with a comfortable station experience. Shelters offer several benefits, including protecting people from weather conditions such as rain, snow, hail, and sun exposure. Shelters can also protect other amenities at the station from these same conditions. For the Waco BRT service, the shelter structures can have a modular design to allow for different station lengths to meet changes in surrounding area service conditions, such as alterations to route alignments or forecasted levels of ridership. Shelters come in a variety of shapes and sizes. **Figure 6** illustrates both pavilion and cantilever station structure designs, which were the preferred option per City of Waco residents. Both pavilion and cantilever structures offer ample seating and shade. A pavilion shelter is semi-enclosed while a cantilever structure has a simpler design comprised of one supporting element and a roof. When deciding between a pavilion or a cantilever shelter the following considerations should be made:
    - Pavilion:
        - Semi-enclosed design offers increased weather protection
        - May limit passenger or pedestrian maneuverability and can slow boarding times
        - Structures are more expensive than smaller, traditional designs
    - Cantilever:
        - Structures are cheaper than pavilions and are more maneuverable
        - Minimal design means minimal maintenance and expedited boarding times
        - Structure offers limited protection against weather
- <u>Covered seating:</u> Placing the provided station seating underneath the cover of the shelter structure can encourage more waiting passengers to use the seating. If the seating is in an exposed area of the station, people may choose to stand under the shelter instead of sitting on a bench or seating structure, particularly during adverse weather conditions.

- Waste bins: Waste bins help keep a station area clean and pathways clear for optimal use. This can cut down on maintenance costs and effort for the transit provider. Keeping the station area clear of potential obstacles is important for ADA compliance.
- Lighting: Lighting is especially important at a station area because it provides waiting passengers with a sense of safety and because it provides the necessary visibility when service continues after sundown.
- Safety call box: Safety call boxes provide another measure of security for passengers waiting at a station, particularly at night. Passengers can feel safer knowing that they have access to a communications line that calls the police directly. Most of these boxes provide authorities with a pinpointed location so that they can easily find the box when they reach the scene after a call has been made. These boxes also have emergency lighting that turns on at night to facilitate box visibility and a strobe that activates when an emergency call has been made.

The combination of these amenities provides passengers with adequate comfort and necessities while they wait at a station for their bus. It is also important to note that the longer the wait times are between buses (both for people starting their trips and people making transfers), the more passengers expect to be provided with station areas that feel safe and comfortable. This is especially true for passengers using the stations at the ends of a route because it is less likely that there are transfers or intersection routes at these stations.

The baseline amenities that should be incorporated into an enhanced station type include the same nine amenities as the basic station, plus:

- Additional covered seating: Overall, the enhanced station type is larger and includes more amenities. These stations are meant to accommodate larger numbers of waiting passengers, so they should include more covered seating than the basic station type.
- Larger shelter structure: Because this type of station is meant to accommodate larger numbers of waiting passengers, the enhanced shelter structure needs to be larger than the basic shelter structure, allowing more passengers to use it for cover. As with the basic station, the enhanced shelter structure can have a modular design to allow for flexible sizing in reaction to changes to service conditions.
- Bicycle racks: Some transit users choose to ride a bicycle to and from transit stations, and not all passengers will want or need to take their bicycles with them all the way to their final destination. Bicycle racks provide a secure storage method for such passengers.
- Streetscape and/or public art: To give a station area an elevated aesthetic, include streetscape and/or public art. This type of visual appeal can increase the level of enjoyment passengers experience while waiting at a station and provide a chance to bring local flavor to public spaces. Possible types of art could include sculptures, murals on nearby walls, painted pavement or sidewalks/crosswalks, and even temporary art installations. Ideally, these works would come from local artists.

Adding these amenities to the basic amenities creates an “enhanced” station area that will increase the likelihood that waiting passengers will have a positive experience at the station.

No matter the station type, all stations should comply with ADA laws for accessibility. To be ADA accessible, the following minimum requirements must be met:

- The station should be on a firm, stable surface.
- There must be a “stop pad” measuring 5 ft. wide by 8 ft. deep, at a minimum, and it must be kept clear for passengers boarding and alighting from a bus.
- There should be no less than 4 ft. of clear sidewalk area passing either in front of or behind the station to allow for continued pedestrian flow along the sidewalk.
- There must be a clear path from the station shelter to the stop pad.
- Amenities provided at the station must be accessible to persons with disabilities, with particular attention paid to the placement of the amenities at the station.

- The maximum slope of the station surface should be 2% for water drainage.
- The station should provide an accessible route to connect to sidewalks, paths, and streets.

The shelter for a basic station should be 10 ft. wide at a minimum. **Figure 6**: Station Structure Types

Figure 7 illustrates a basic station area along with its associated amenities. The shelter for an enhanced station should be at least 16 ft. wide. **Figure 8** illustrates an enhanced station area and its associated amenities.

Figure 6: Station Structure Types

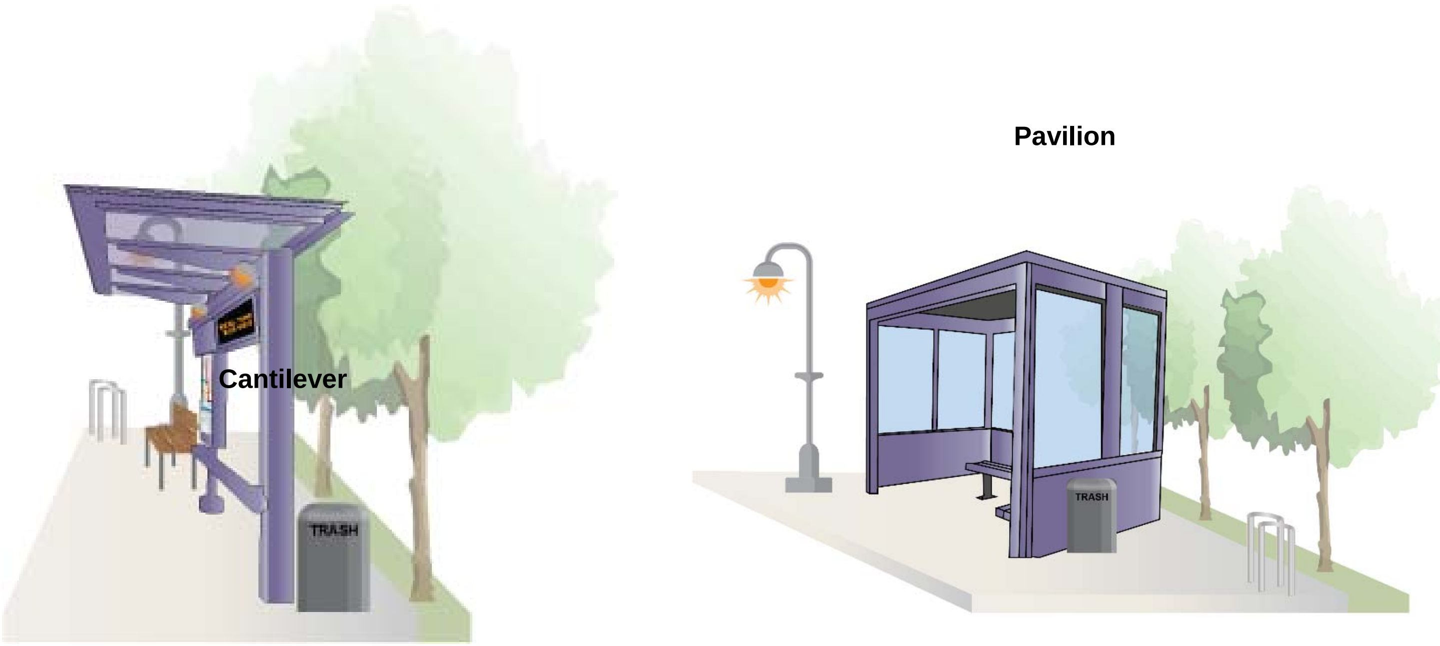


Figure 7: Basic Station

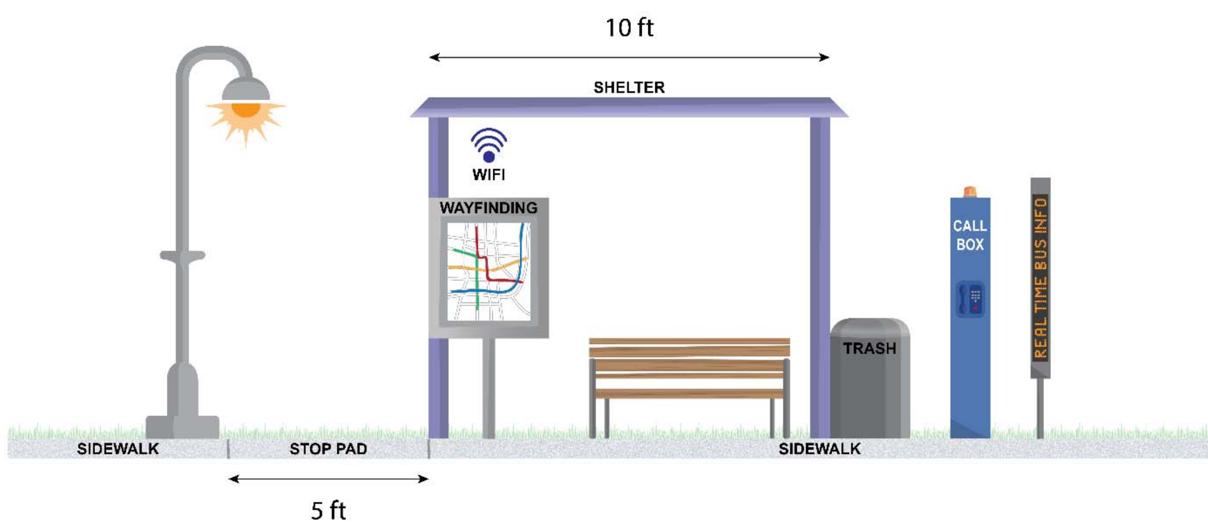
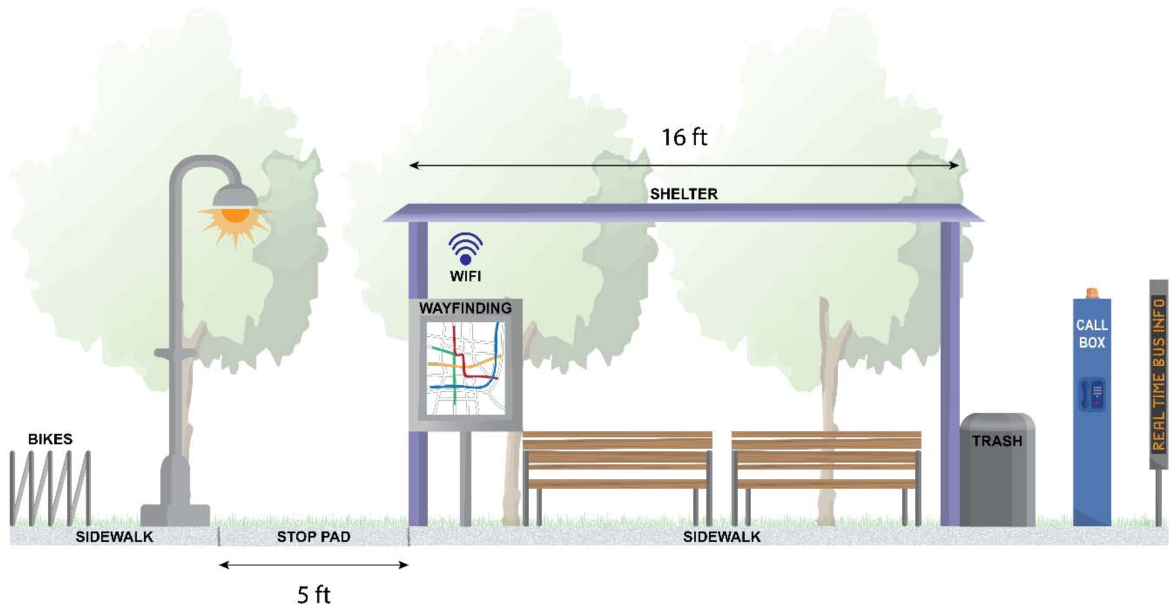


Figure 8: Enhanced Station



4.4 Station Configurations

Differing from station location, station configuration refers to how the station is physically built into the streetscape and how it relates to and interacts with other modes in the same transportation environment. Some station configurations remove the transit vehicle from the surrounding traffic while others keep the vehicle in mixed traffic flow. Some configurations prioritize transit, others prioritize the continued flow of automobile traffic. The primary differences in station configuration characteristics relate to safety, efficiency, cost, and right-of-way. During the design phase, Waco Transit will identify which configurations have the preferred characteristics for individual station locations after weighing and balancing priorities between transit and other modes of travel. **Table 6**, **Table 7**, **Table 8**, and

Table 9 provide a breakdown of the characteristics of each station configuration variation and

Table 6: Curbside Station Configuration

Curbside	
Description	Bus stops in a travel lane along the curb. Station amenities are incorporated into the sidewalk.
Application	• Low-speed streets with safer conditions to allow stopping in travel lanes
Advantages	• Minimal delays because buses do not need to merge back into traffic • Uses existing infrastructure without needing alterations to the roadway infrastructure • Easy and least expensive to implement
Disadvantages	• May cause traffic backup behind the bus • Unsafe car maneuvers to get around the stopped bus
Other Considerations, Effects on Bike/Pedestrian Environment	• May require new construction or reconstruction of sidewalks to ensure safe for pedestrians • May need to minimize conflicts between bicyclists and buses or bicyclists and pedestrians boarding or alighting the buses.

Table 7: Pullout Bay Station Configuration

Pullout Bay	
Description	Station is separated from the travel lanes which allows buses to pull into curb lane area to make a stop. Physically built into the curb or created by striping pavement in line with on-street parking.
Application	• High volume/high speed roadways • Areas with expected high passenger demand/volumes • Where bus dwell time is long • Where sight distances are poor for drivers approaching a bus from behind
Advantages	• Create a protected area for buses and passengers boarding/alighting • Allows through traffic to continue flowing in the travel lane while the bus is stopped.
Disadvantages	• Bus difficulty merging back into traffic • More expensive and more difficult to relocate
Other Considerations, Effects on Bike/Pedestrian Environment	• Along roadways where widening is already planned • Space for acceleration/deceleration inside the bay instead of in the travel lane • May require new construction or reconstruction of sidewalks to ensure safe pedestrian circulation

Table 8: Sidewalk/Station Bulbout Station Configuration

Sidewalk/Station Bulbout	
Description	Station is separated from the travel lanes which allows buses to pull into curb lane area to make a stop. Physically built into the curb or created by striping pavement in line with on-street parking.
Application	• High volume/high speed roadways • Areas with expected high passenger demand/volumes • Where bus dwell time is long • Where sight distances are poor for drivers approaching a bus from behind
Advantages	• Create a protected area for buses and passengers boarding/alighting • Allows through traffic to continue flowing in the travel lane while the bus is stopped.
Disadvantages	• Bus difficulty merging back into traffic • More expensive and more difficult to relocate

Sidewalk/Station Bulbout	
Other Considerations, Effects on Bike/Pedestrian Environment	• Along roadways where widening is already planned • Space for acceleration/deceleration inside the bay instead of in the travel lane • May require new construction or reconstruction of sidewalks to ensure safe pedestrian circulation

Table 9: Pedestrian Bulbout Station Configuration

Pedestrian Bulbout	
Description	Curb extensions generally at intersection locations, paired with on street parking to create a pullout area for bus dwelling.
Application	• Higher traffic and pedestrian volumes • Lower traffic speeds along urban corridors
Advantages	• Decreases the distance for pedestrian to cross the street at intersections near bus stations. • Allows through traffic to continue flowing • Minor impacts to the amount of on-street parking • Safer/shorter crossings for passengers crossing the street to/from the bus station
Disadvantages	• Bus difficulty merging back into traffic • Cars merging in and out of adjacent on-street parking spots may create conflict
Other Considerations, Effects on Bike/Pedestrian Environment	• Install along roadways where the existing ROW is adequate, or where widening is already planned • Required space for the bus to accelerate/decelerate inside the bay instead of in the travel lane • May require new construction or reconstruction of sidewalks to ensure safe and reasonable pedestrian circulation

Figure 9 provides aerial view illustrations of each.

Table 6: Curbside Station Configuration

Curbside	
Description	Bus stops in a travel lane along the curb. Station amenities are incorporated into the sidewalk.
Application	• Low-speed streets with safer conditions to allow stopping in travel lanes
Advantages	• Minimal delays because buses do not need to merge back into traffic • Uses existing infrastructure without needing alterations to the roadway infrastructure • Easy and least expensive to implement
Disadvantages	• May cause traffic backup behind the bus • Unsafe car maneuvers to get around the stopped bus
Other Considerations, Effects on Bike/Pedestrian Environment	• May require new construction or reconstruction of sidewalks to ensure safe for pedestrians • May need to minimize conflicts between bicyclists and buses or bicyclists and pedestrians boarding or alighting the buses.

Table 7: Pullout Bay Station Configuration

Pullout Bay	
Description	Station is separated from the travel lanes which allows buses to pull into curb lane area to make a stop. Physically built into the curb or created by striping pavement in line with on-street parking.
Application	• High volume/high speed roadways • Areas with expected high passenger demand/volumes • Where bus dwell time is long • Where sight distances are poor for drivers approaching a bus from behind
Advantages	• Create a protected area for buses and passengers boarding/alighting • Allows through traffic to continue flowing in the travel lane while the bus is stopped.

Pullout Bay	
Disadvantages	• Bus difficulty merging back into traffic • More expensive and more difficult to relocate
Other Considerations, Effects on Bike/Pedestrian Environment	• Along roadways where widening is already planned • Space for acceleration/deceleration inside the bay instead of in the travel lane • May require new construction or reconstruction of sidewalks to ensure safe pedestrian circulation

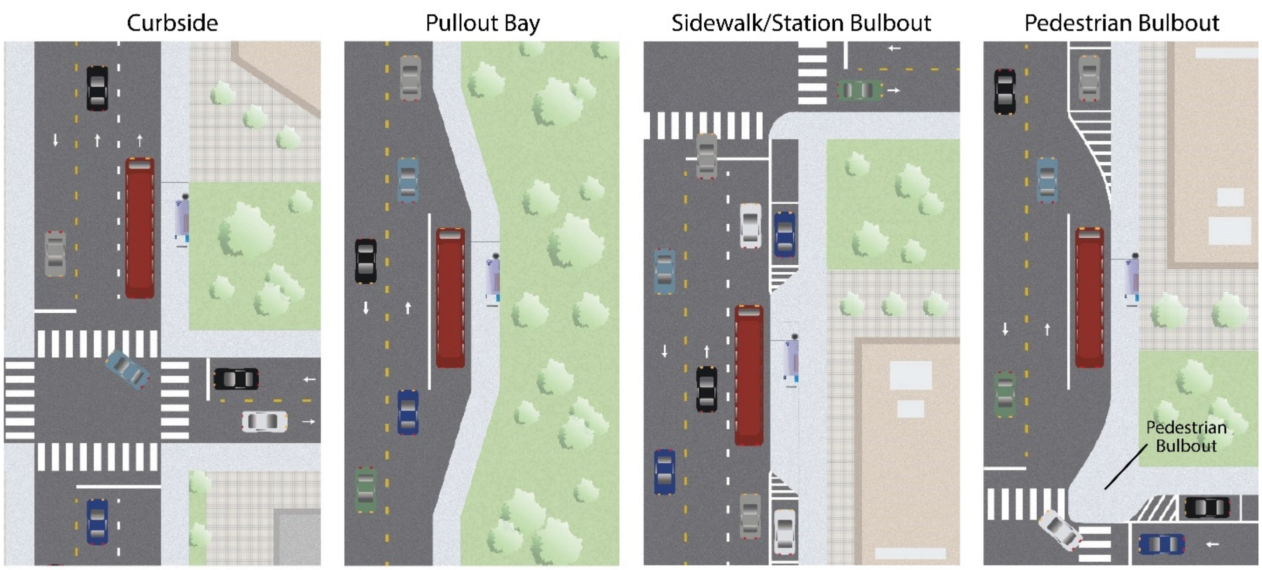
Table 8: Sidewalk/Station Bulbout Station Configuration

Sidewalk/Station Bulbout	
Description	Station is separated from the travel lanes which allows buses to pull into curb lane area to make a stop. Physically built into the curb or created by striping pavement in line with on-street parking.
Application	• High volume/high speed roadways • Areas with expected high passenger demand/volumes • Where bus dwell time is long • Where sight distances are poor for drivers approaching a bus from behind
Advantages	• Create a protected area for buses and passengers boarding/alighting • Allows through traffic to continue flowing in the travel lane while the bus is stopped.
Disadvantages	• Bus difficulty merging back into traffic • More expensive and more difficult to relocate
Other Considerations, Effects on Bike/Pedestrian Environment	• Along roadways where widening is already planned • Space for acceleration/deceleration inside the bay instead of in the travel lane • May require new construction or reconstruction of sidewalks to ensure safe pedestrian circulation

Table 9: Pedestrian Bulbout Station Configuration

Pedestrian Bulbout	
Description	Curb extensions generally at intersection locations, paired with on street parking to create a pullout area for bus dwelling.
Application	• Higher traffic and pedestrian volumes • Lower traffic speeds along urban corridors
Advantages	• Decreases the distance for pedestrian to cross the street at intersections near bus stations. • Allows through traffic to continue flowing • Minor impacts to the amount of on-street parking • Safer/shorter crossings for passengers crossing the street to/from the bus station
Disadvantages	• Bus difficulty merging back into traffic • Cars merging in and out of adjacent on-street parking spots may create conflict
Other Considerations, Effects on Bike/Pedestrian Environment	• Install along roadways where the existing ROW is adequate, or where widening is already planned • Required space for the bus to accelerate/decelerate inside the bay instead of in the travel lane • May require new construction or reconstruction of sidewalks to ensure safe and reasonable pedestrian circulation

Figure 9: Station Configurations



5. Roadway Considerations

5.1 Transit Roadway Operations

As its name indicates, BRT is a bus-based transportation service, so it utilizes the roadway network to maneuver along its routes. Therefore, it is important to consider the various roadway characteristics that will impact BRT service, particularly in terms of safety, efficiency, and accessibility. This includes roadway characteristics such as the configuration of the streetscape and how the BRT vehicle interacts with other types of traffic (including bicycles).

5.1.1 Dedicated vs. Mixed-Traffic Lanes

Bus lanes are an integral part of the overall bus rapid transit system. Bus lane design encourages system efficiencies and faster trip time to improve the passenger experience. There are three general configurations for bus rapid transit travel:

1) Mixed traffic lanes: Buses and personal vehicles share lane space along the rapid transit corridor.
2) Transit priority lanes: Allow mixed vehicular traffic under special conditions such as right-turn only or HOV operations.
3) Dedicated bus lanes: Can be configured offset, median running, or curbside. Dedicated bus lanes are confined to bus-only traffic and do not allow other vehicular traffic unless specified.

Curbside bus lanes run on the farthest right lane. When on-street parking is present, bus lanes run in between general traffic lanes and the parking lane, usually paired with a painted offset to provide buffer between parking. Choosing the best fit bus lane type often depends on ROW available and anticipated service volume. Additional considerations need to be given to the following:

- Street Markings and Signage: Lanes may be delineated by specific street markings, signage, and physical barriers to ensure road-user legibility. These are integral for maintaining system efficiency and safety.
- Transit Signal Priority (TSP): Implementing TSP at signalized intersections with bus lanes greatly improves reliability and travel times.
- Right-Turning Traffic: Bus lane design must consider right-turning traffic at intersections. Right-turn bays, street markings, signage, and TSP should all be considered to minimize service delays due to right-turning traffic.
- Bicycle Lanes: Special attention must be given to bike lanes when present on or aligned with bus lanes. Bike and bus lanes often share space and therefore need specific street markings and signage to delineate use and ensure safety and comfort.

A combination of mixed-traffic lanes, transit priority lanes, and limited dedicated bus lanes are preliminarily recommended for the Waco Bus Rapid Transit Corridor (See **Figure 10**). Preliminary recommendations were based on a review of traffic conditions and ROW availability. Further analysis is necessary to determine final recommendations along Waco roadways.

5.1.1.1 Dedicated Bus Lane

The dedicated bus lane best optimizes system reliability and travel times by separating bus traffic from other vehicular traffic, a key distinguishing feature of BRT systems. Dedicated bus lanes may be configured curbside, median running, or offset and delineated from vehicular traffic by lane markings, signage, and physical barriers. Curbside and offset lanes are recommended for the WBRT system where dedicated bus lanes are feasible/necessary. These lanes may be implemented by repurposing vehicle lanes and do not allow vehicular travel. A dedicated bus lane should not be ruled out simply due to high vehicle volume as it may alleviate congestion. It is highly recommended to incorporate transit priority elements such as TPS and queue jumps as they will best optimize the dedicated bus lane and system efficiency. Right-turning traffic should be given special attention when implementing a dedicated bus lane and defined using appropriate signage and markings. **Figure 10** shows a map of the BRT alignment and identifies which roadway segments could potentially have dedicated transit lanes without major reconstruction or investment in ROW acquisition.

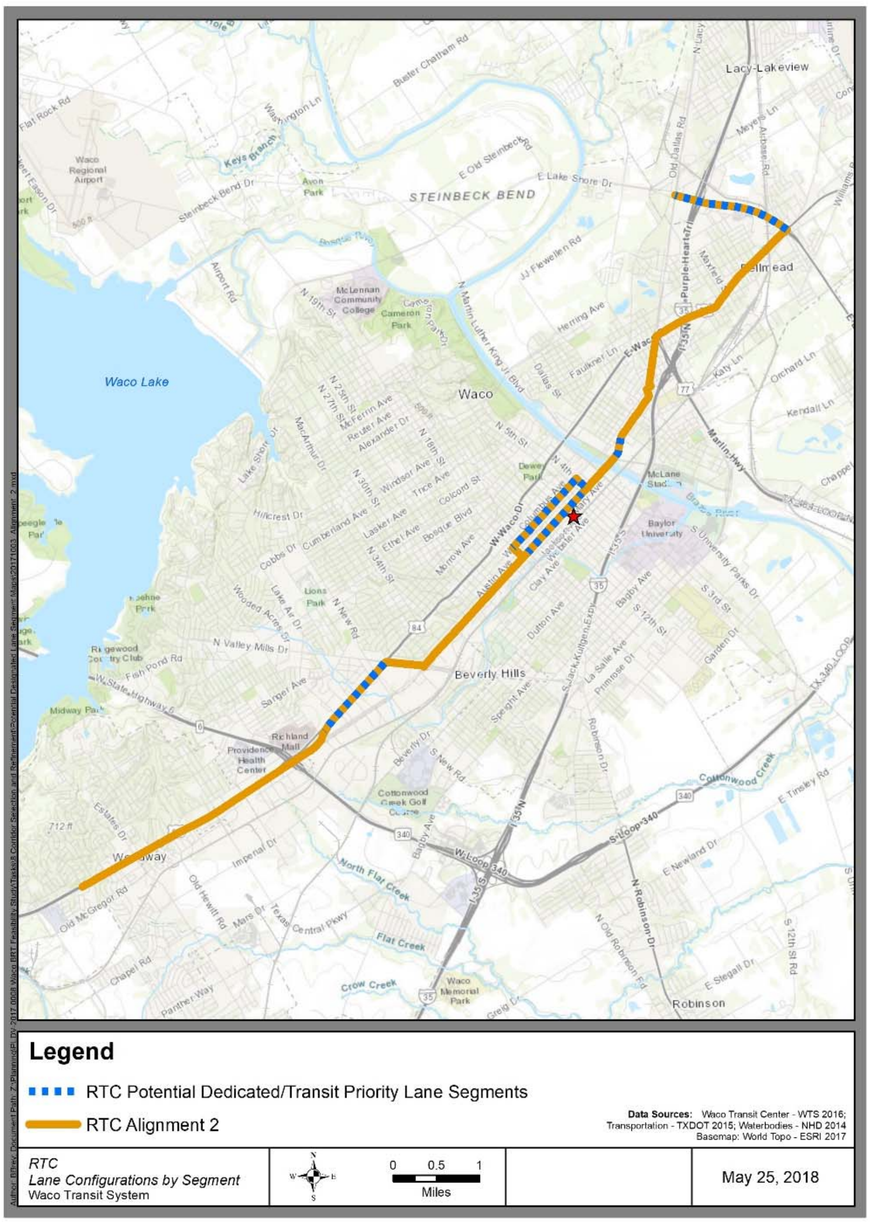
5.1.1.2 Transit Priority Lane

A transit priority lane is similar to a dedicated bus lane except that it allows vehicular traffic where specified along the route. These lanes may be flexible and dynamic depending on need and time of day. For instance, transit priority lanes often allow right turning vehicular traffic to enter the bus lane at intersections. Transit priority lanes may also be flexible depending on time of day or day of the week. For example, vehicular traffic may be allowed to travel in the transit priority lane during off-peak hours. Like the dedicated bus lane, street markings, signage, TSP and right-turn bays all help to manage bus and right-turning vehicular traffic**.**

5.1.1.3 Mixed-Traffic Lane

Mixed-traffic lanes should be used for Waco Bus Rapid Transit when the ROW does not allow for a dedicated bus lane. Incorporating transit priority elements into intersections where mixed-traffic lanes are present will be critical for service reliability and travel times. Additionally, service reliability and travel times will also depend on right-turning traffic design considerations. When bike lanes are present, the appropriate street markings and signings must be used to delineate the shared space.

Figure 10: Potential Transit Priority and Dedicated Lane Segments



5.2 Potential Cross Sections

This section details the existing roadway cross section configurations and potential future cross sections at some of the locations along the BRT alignment that could potentially be re-configured to better accommodate BRT service. Descriptions of the surrounding areas are also provided to help give context to these locations. As part of the BRT feasibility study, it is important to assess existing roadway configurations and decide if there are any areas along the BRT alignment that need to be updated to allow the BRT service to function optimally.

The locations discussed below (shown in **Figure 11**) were selected based on their unique roadway characteristics. They are meant to illustrate varying conditions along Waco roadways along the BRT route and how BRT could change the streetscape to provide fast and reliable rapid transit service. The potential future cross sections identified for these locations were created based on a review of current roadway dimensions, available ROW and an analysis of traffic conditions that may necessitate a dedicated lane, transit priority lane, or a mixed traffic and bus lane. The potential future configurations are not definitive but show possibilities for altering the streetscape to better accommodate BRT service. It is important to note that the exhibits presented are potential cross sections. Further engineering and coordination will be required to develop final cross sections throughout the corridor.

Figure 11: Corridor Locations for Potential Roadway Re-Configurations

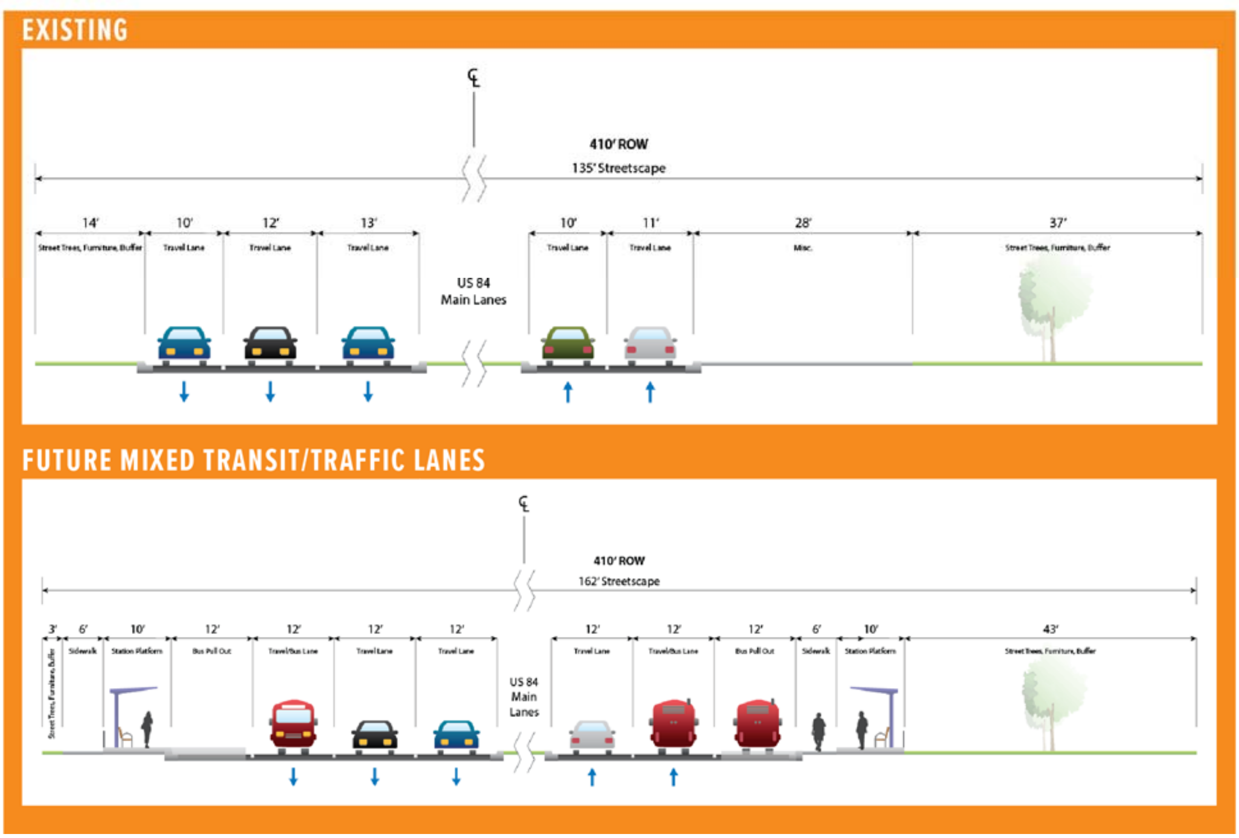
During the feasibility study engagement process, several locations along the corridor were identified that may be impacted by future construction projects nearby. Coordination with potential future roadway reconstruction/reconfiguration or land redevelopment opportunities may offer opportunities to preserve right-of-way for transit priority treatments or station areas to improve future RTC operations. The areas near Richland Mall (US 84 and Hwy 6/Loop 340) and the US 77 interchange with US 84, for example, are prime examples where an opportunity exists to incorporate transit priority treatments and accessibility to support RTC service.

5.2.1 US 84 Frontage @ Hewitt Dr.

This area along the preferred route alternative is the only location where the BRT route would travel along a frontage road. The area immediately adjacent to the US 84 frontage at Hewitt Dr./Estates Dr. is occupied by commercial land uses such as grocery stores, restaurants, and other service businesses such as pharmacies, banks, and medical facilities. However, just beyond these parcels the existing land use is primarily single-family neighborhoods, especially on the north side of US 84. There is also a commercial/industrial business area to the southeast of US 84.

The existing cross section for the US 84 Frontage @ Hewitt Dr. contains three travel lanes running on the southbound frontage and two travel lanes running on the northbound frontage. There are large vegetated median/buffer areas separating the frontages and the US 84 main lanes (two lanes running southbound and two lanes running northbound), as well as between the frontages and the adjacent businesses. The current speed limit on the frontages is 40 mph. The potential future cross section would create mixed transit/traffic lanes to accommodate the BRT. One existing lane in each direction of the frontage would be converted to be a mixed transit/traffic lane, and bus pull outs would be created at the station locations so that buses can safely pull over to load and unload passengers. Though there are no sidewalks in the existing cross section, the potential future configuration would add sidewalks to accommodate access to the BRT stations. These cross sections are illustrated in **Figure 12** below.

Figure 12: 8 US 84 Frontage @ Hewitt Dr.

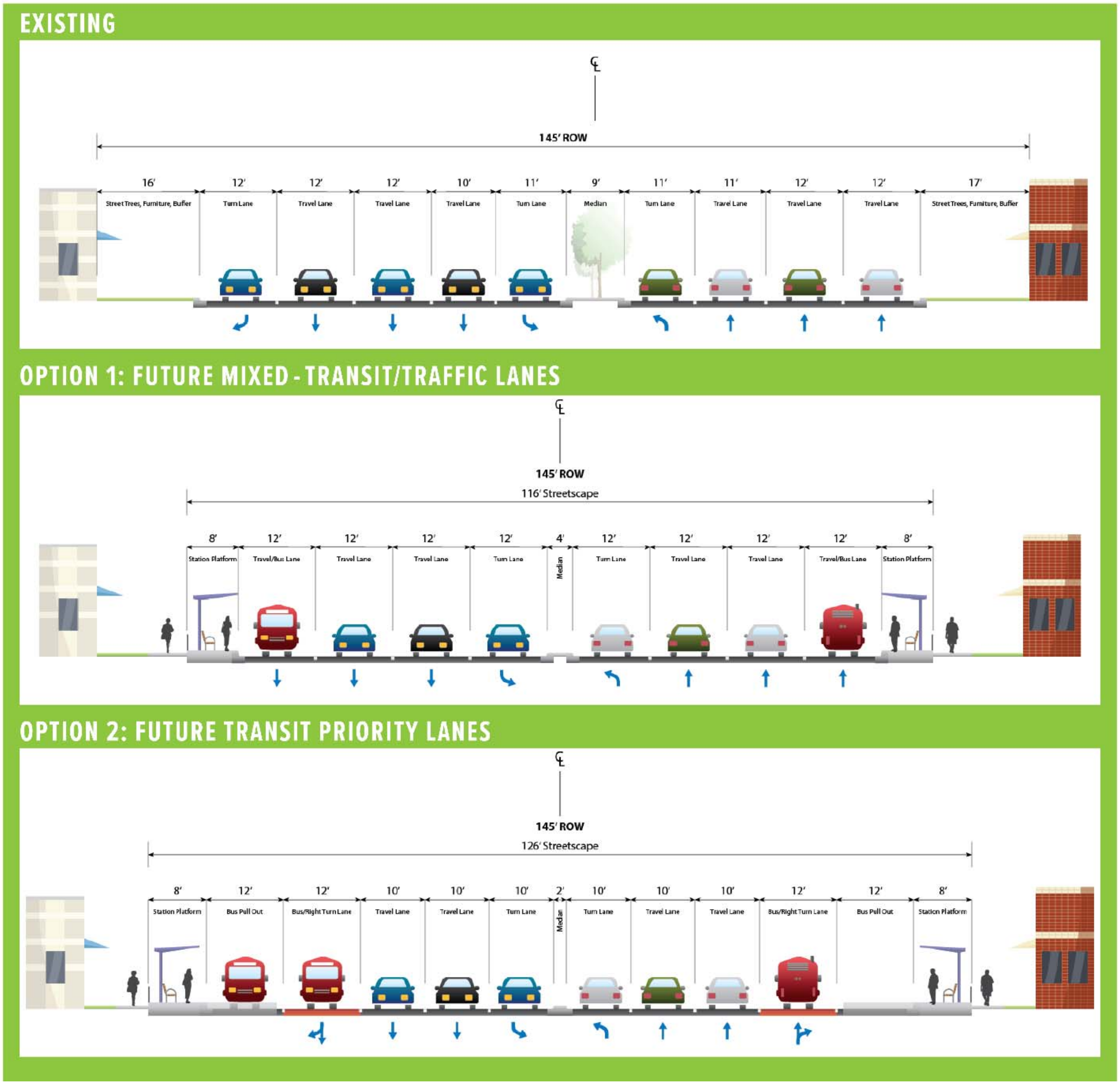


5.2.2 US 84 @ Lake Air Dr.

The land uses surrounding the US 84 (aka W. Waco Dr.) @ Lake Air Dr. area is a mixture of commercial and industrial, including a mixture of businesses such as big box retail stores (Home Depot, Barnes & Noble, Big Lots), auto-oriented service businesses, and construction/supply/tech-industrial businesses. Beyond this, single-family neighborhoods stretch to the west, Richland Mall sits to the southwest, and a forested, undeveloped swath of land with Waco Creek transecting it sits to the southeast.

The existing cross section for this location includes three through-travel lanes in each direction. The northbound direction has a left turn lane and the southbound direction has a left turn lane and a right turn lane. A median exists between the two travel directions and there are landscaped buffers between the travel lanes and the adjacent businesses. The current speed limit for this area is 45 – 55 mph. US 84 @ Lake Air Dr. has two potential future cross sections; the first uses the outermost lane in each direction for mixed transit/traffic and leaves the other lanes in their existing configuration, and the second uses the outermost lanes in each direction for dedicated transit lanes which can only be used by cars when making right turns at intersections and also leaves the other lanes in their existing configuration. In the mixed transit/traffic future scenario, bus stations are made in-lane when loading or unloading passengers at a station, while in the dedicated transit lane future scenario the buses use pull outs to make their stops. Though the existing cross section does not have sidewalks, both potential future configurations incorporate sidewalks to accommodate access to the BRT stations. These cross sections are illustrated in **Figure 13** below.

Figure 13: US 84 @ Lake Air Dr.

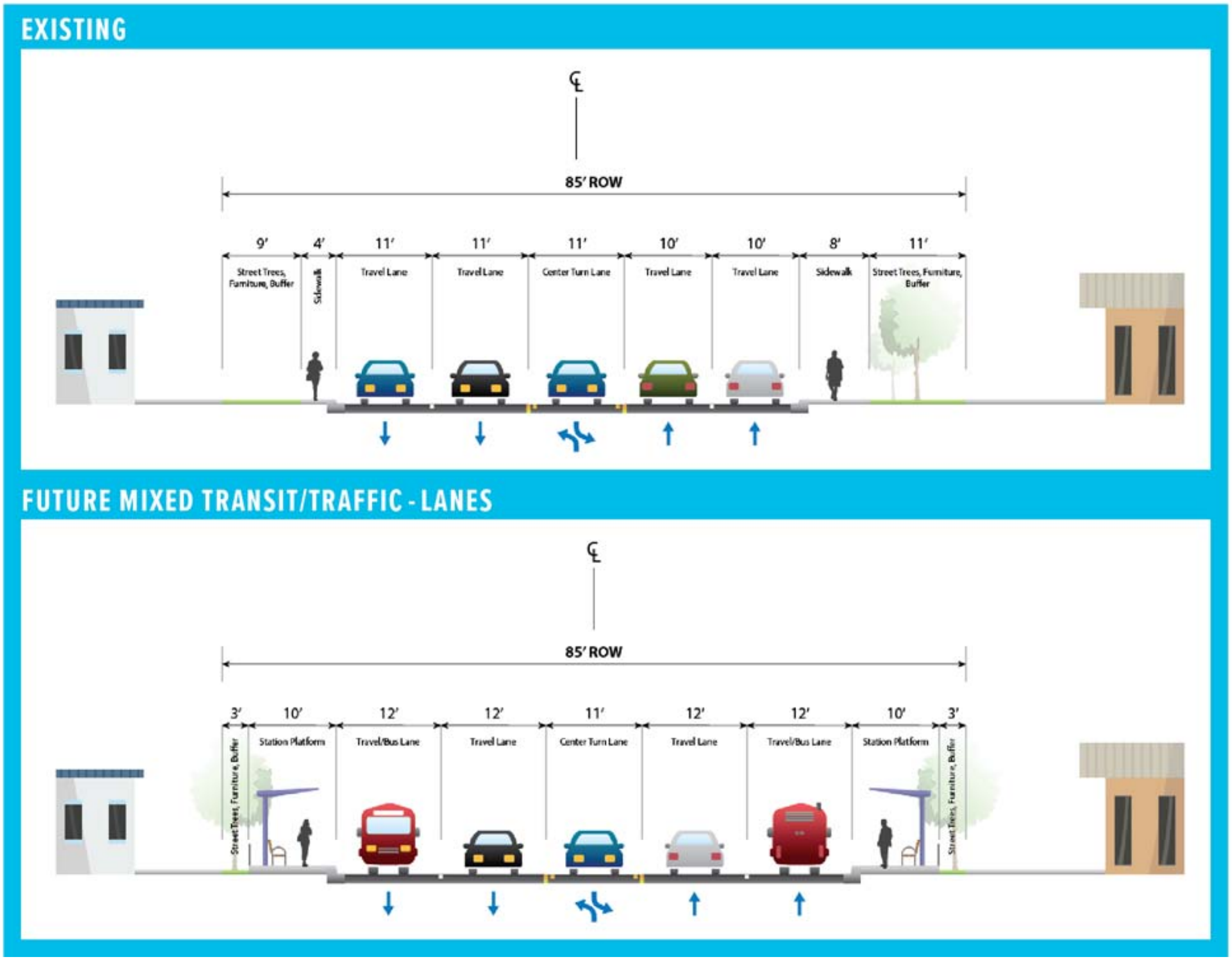


5.2.3 Franklin Ave. @ 38th St.

Similar to the two US 84 locations, the Franklin Ave. @ 38th St. area is immediately surrounded by commercial and light industrial land uses. A large single-family neighborhood area extends to the north and west of the intersection, and not far to the east are Floyd Casey Stadium and the old Hart-Patterson Track & Field Complex, both of which were Baylor University facilities prior to the construction of a new athletic complex north of the Brazos River.

At this location, a median which extends south along Franklin Ave. ends right at the intersection of Franklin and 38th. Moving north from the intersection the median becomes a center turn lane. Both the northbound and southbound directions currently have two travel lanes on both sides of the center turn lane. The existing speed limit for the area is 35 to 40 mph. Franklin Ave. @ 38th St. has one potential future cross section, which would maintain the existing configuration apart from turning the outermost travel lane in both directions into mixed transit/traffic lanes due to restricted ROW in the area. This also means that the buses would have to make in-lane stops to load/unload passengers because there is not enough ROW to choose a bus pull out station configuration. These cross sections are illustrated in **Figure 14** below.

Figure 14: Franklin Ave. @ 38th St.

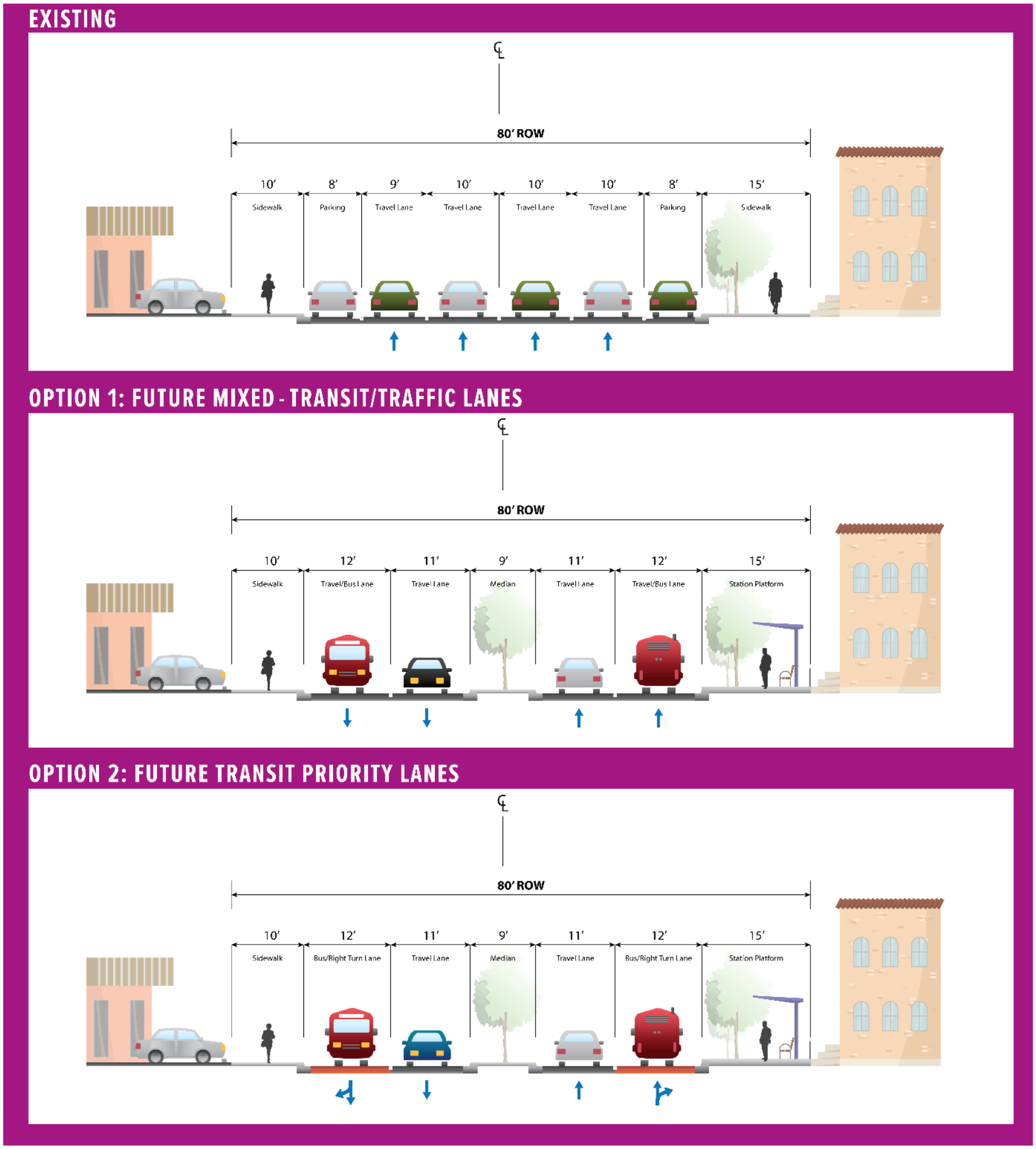


5.2.4 Franklin Ave. @ 8th St.

Franklin Ave. @ 8th St. is part of Waco's downtown area, and as such the adjacent land uses are mostly commercial and governmental/civic. Outside of these land uses, single-family neighborhoods begin to crop up to the northwest and the southeast. The U.S. courthouse, Texas State Office Building and the Waco Hippodrome Theatre are some of the notable destinations in the immediate vicinity of the intersection. The Magnolia Market at the Silos is also 1/4 mile away and is one of the largest tourist attractions in Waco.

Franklin Ave. is a one-way street running northbound from 17th St. to 4th St. This segment is part of a one-way couplet with Washington Ave., which runs southbound. Franklin Ave. @ 8th St. is part of this one-way segment, with an existing cross section of four lanes running northbound and one on-street parking lane on both the east and west extents of the pavement. There are also sidewalks on both sides of the street. The current speed limit in the area is 30 mph. There are two potential future cross sections for this area which provide options like those for the US 84 @ Lake Air Dr. location. The first option would convert the street into a two-way, four-lane travel way with a median separating the travel directions. The outermost lane in each direction would be a mixed transit/traffic lane. All on-street parking is removed from this option. The second potential future cross section option is the same as the first, except that instead of mixed transit/traffic lanes, the outermost lane in each direction would be a dedicated transit lane. For both options, in-lane stops would be made to load and unload passengers at stations. These cross sections are illustrated in **Figure 15** below.

Figure 15: Franklin Ave. @ 8th St.

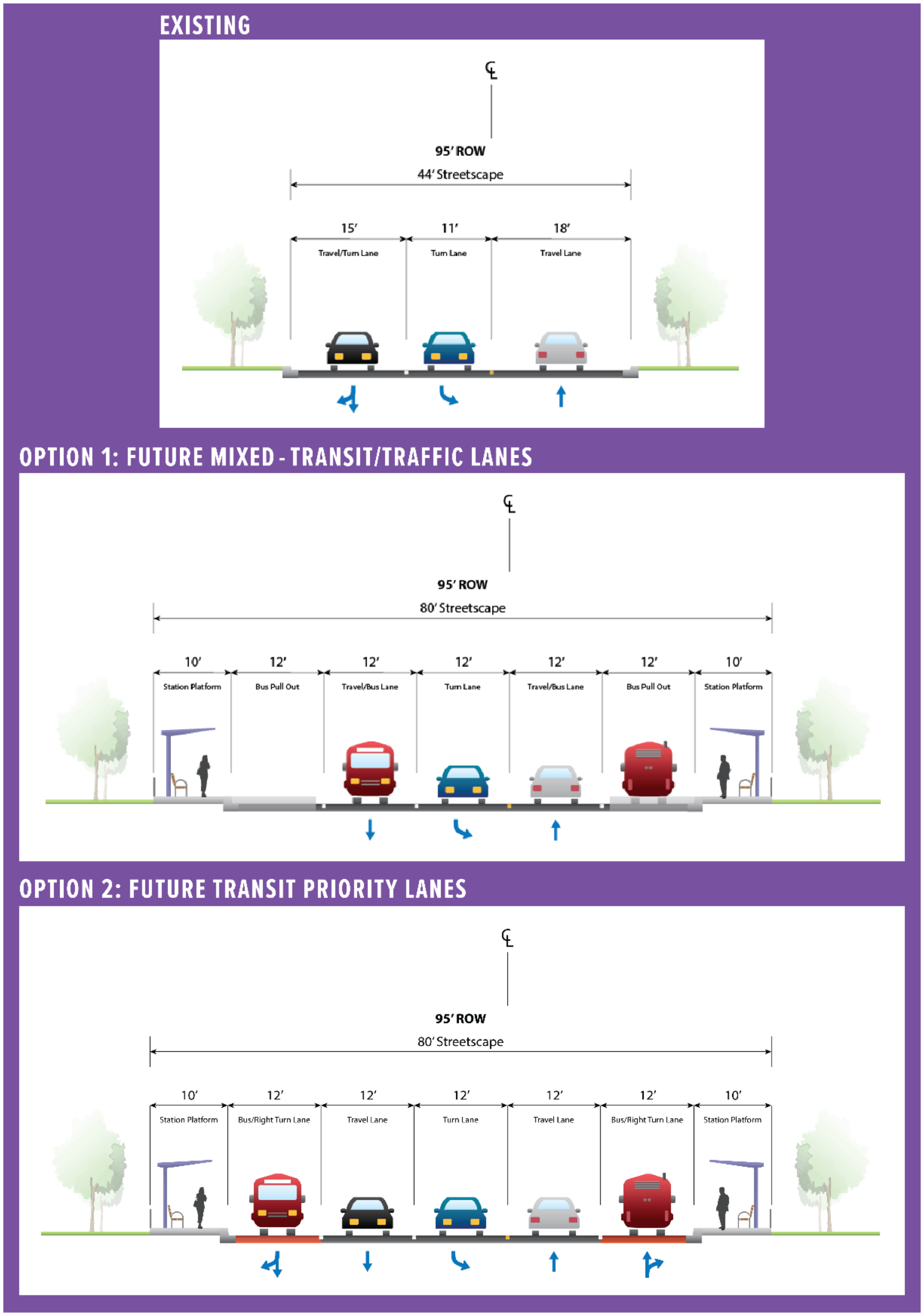


5.2.5 Taylor Ave. @ MLK Jr. Blvd.

The intersection of Taylor Ave. @ MLK Jr. Blvd. is just north of the Brazos River, and the land immediately adjacent to this location is vegetated, undeveloped land. The south side of the intersection is next to the riverbank and Doris D. Miller Park, the East Riverwalk extension, and the Waco Riverwalk. Nearby on the north side are primarily industrial land uses followed by the start of single-family neighborhoods. There is also a handful of commercial and civic/government land uses close by. This intersection is the first after Franklin Ave. crosses the river, and it becomes Taylors St. at the intersection with MLK Jr. Blvd.

The existing cross section for this area is three lanes undivided buffered by vegetated land with no sidewalks. Taylor St. is a two-way street with two southbound lanes and one wide northbound lane. The two southbound lanes only exist at the intersection to allow for turning movements and moving farther north on Taylor St. there is only one wide lane in each direction. The current speed limit for this area is 30 mph. There are two potential future cross sections for this area, both of which require widening the paved area to some degree. Because this location is surrounded by undeveloped land, ROW here is less constrained than it is in the other locations previously discussed. The first potential future cross section would only need pavement widening next to BRT stations to create bus pullouts where buses load and unload passengers. The one northbound lane would become a mixed transit/traffic lane, the southbound left turn lane would be maintained, and the outermost southbound lane would become a mixed transit/traffic lane. The second potential future cross section would keep the same basic configuration as the existing cross section, except that one dedicated transit lane would be added in each direction and car traffic right turn movements would be made from these lanes. Buses would stop in the dedicated lanes to load/unload passengers at stations. Both potential future options would require the addition of sidewalks in some configuration to accommodate access to the BRT stations. These cross sections are illustrated in **Figure 16** below.

Figure 16: Taylor Ave. @ MLK Jr. Blvd.

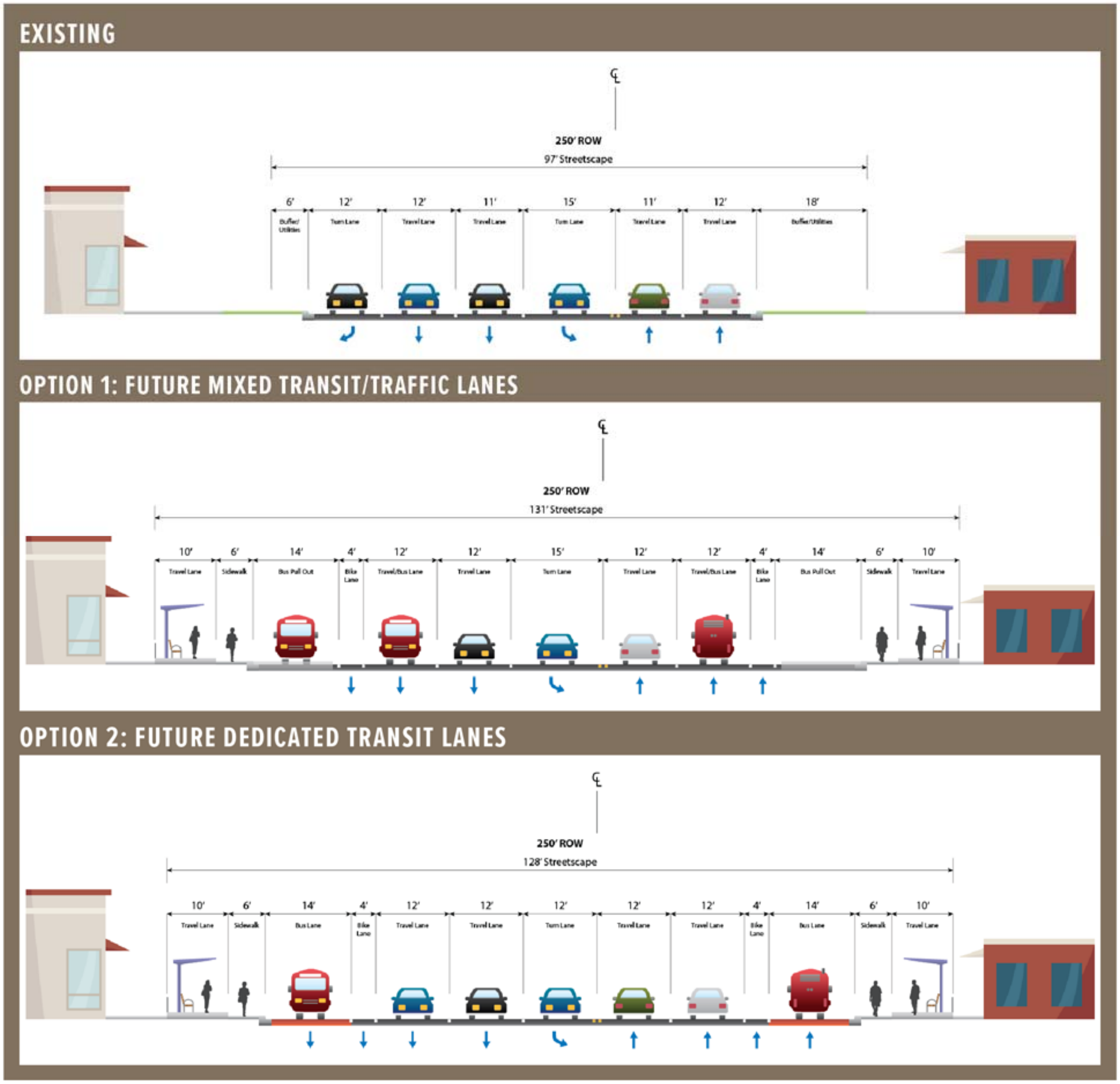


5.2.6 TX Loop 340 @ Scroggins Dr.

Similar to many of the other locations previously discussed, the TX Loop 340 @ Scroggins Dr. area is surrounded by commercial land uses, as is common with many highways in Texas as they cross through urban areas. The Walmart Supercenter, the Home Depot, and the American Bank are some of the notable nearby commercial properties. La Vega High School is immediately adjacent to the intersection. To the north of this location, just behind the commercial properties lies a large undeveloped swath of land with a body of water, and just beyond the commercial properties on the south side is the beginning of a large residential area with some multi-family use on the periphery and single-family stretching south. This area is proposed as the site for a new minor league baseball park.

The existing cross section at this location is six lanes undivided, with two through-travel lanes in the northbound direction and four lanes (two through, one left turn, and one right turn) in the southbound direction. There is some shoulder space on the edges of the road, but no sidewalks, and there is vegetated buffer space on both sides between the roadway and the adjacent commercial businesses. The current speed limit in the area is 40 – 50 mph. Like some of the areas discussed previously, there are two potential future cross sections for TX Loop 340 @ Scroggins Dr., both of which would require a widened streetscape. The first would maintain the existing cross section but would transform the outermost travel lane in each direction into mixed transit/traffic lanes, would add a bike lane in each direction outside of the mixed lane, and would create a bus pull out at stations on both sides. The second potential future option would maintain the existing configuration, except that the southbound right turn lane would become a through lane. A bike lane would be added in each direction outside the outermost car lanes, and outside the bike lanes, a dedicated transit lane would be added in each direction. Right-turning cars would make their turns from these dedicated lanes, and BRT buses would make in-lane stops to load and unload passengers at stations. Sidewalks would be added to both future options to accommodate bus station accessibility. These cross sections are illustrated in **Figure 17** below.

Figure 17: TX Loop 340 @ Scroggins Dr.



6. Conclusion

The guidance and considerations outlined in the plan are merely conceptual. Additional engineering, planning, and coordination is necessary to better define the Waco BRT operational and physical characteristics.

About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A *Fortune* 500 firm, AECOM had revenue of approximately $17.4 billion during fiscal year 2016. See how we deliver what others can only imagine at aecom.com and @AECOM.

Contact

Andrew Ittigson

Project Manager

T +01 (214) 672-2858

E andrew.ittigson@aecom.com

aecom.com

AECOM

Waco Rapid Transit Corridor Feasibility Study

STOPS Model Memo

Table of Contents

Figures

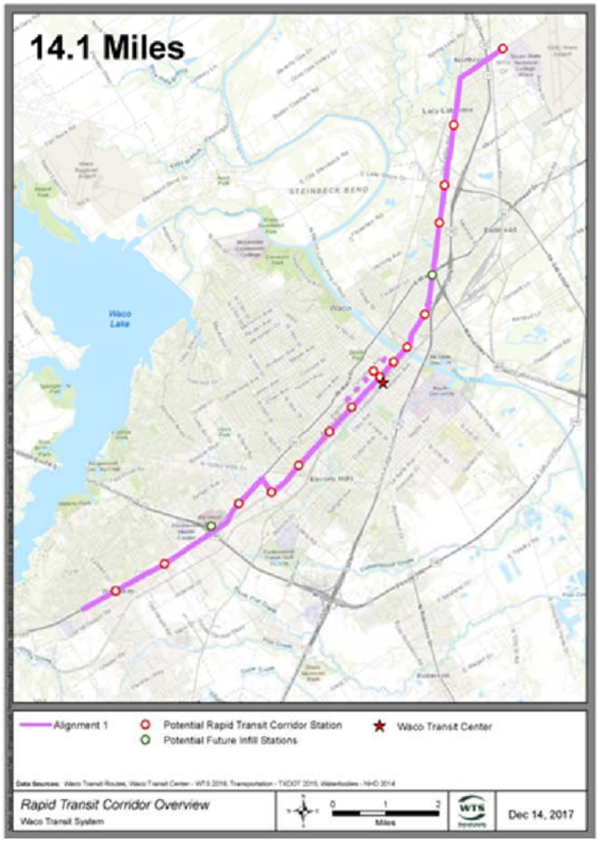
Tables

1. Introduction

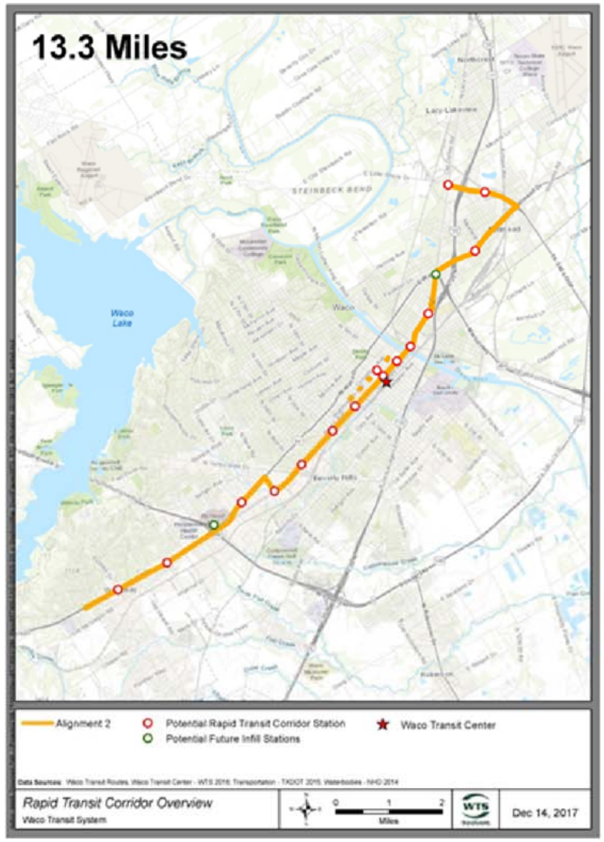
This technical memorandum describes how the Waco Rapid Transit Corridor (RTC) Feasibility Study used the Federal Transit Administration (FTA) Simplified Trips-on-Project Software (STOPS) to evaluate service alignment options for the RTC and determine potential ridership that the RTC could generate throughout the system. STOPS is a sketch planning tool that forecasts ridership for fixed guideway transit service using Census Transportation Planning Products (CTPP) Journey-to-Work (JTW) and General Transit Feed Specification (GTFS) data. The model was also used to evaluate the potential ridership results from the Locally Preferred Alternative (LPA) and a reconfigured underlying local fixed-route system designed to provide improved service linked with the RTC. Utilizing this tool, the project team evaluated three proposed RTC options for the Waco area shown in **Figure 1**.

Figure 1: Detailed Alignment Alternatives

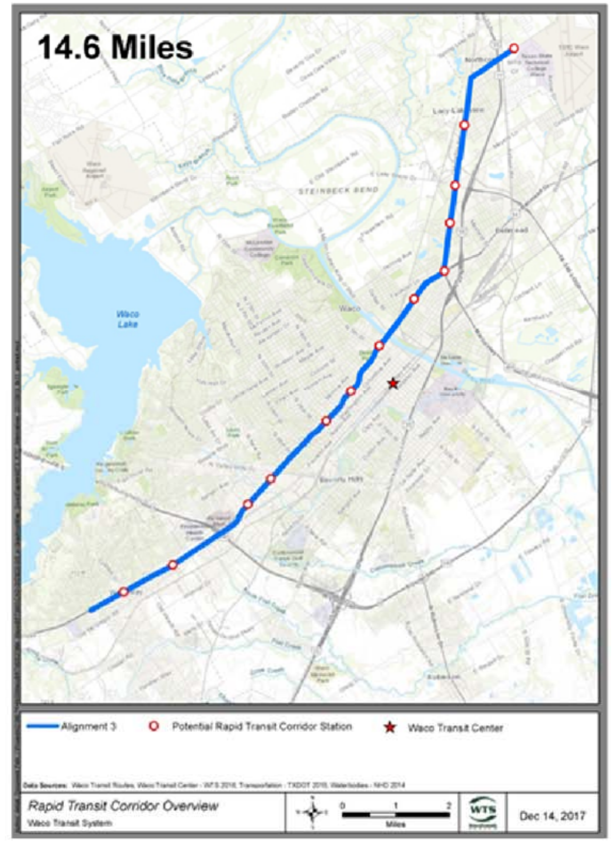
Alignment 1



Alignment 2



Alignment 3



2. Data Inputs

Data inputs for the STOPS Model include operational characteristics for modeled fixed guideway service and demographic information. The use of standardized data sources – the CTPP worker flows and the GTFS transit descriptions – means that STOPS has consistent information across all metro areas regarding travel patterns and transit services. The following section describes the various data inputs used for this project.

2.1 Census Data

The STOPS model uses CTPP 2000 Journey-to-Work (JTW) data that provides worker flows and transit shares. STOPS also uses 2010 census-block boundary data to inform the model about the current development density and pedestrian environment throughout the study area.

Census data was downloaded from the FTA website: https://www.transit.dot.gov/funding/grant-programs/capital-investments/stops-data-census

2.2 GTFS

Waco Transit provided GTFS data. This informs the model about the levels of service and existing conditions of the fixed-route transit system. Waco Transit operates a flag-stop system, where passengers can board and alight anywhere along the route that the operator determines to be safe. However, STOPS software does not currently provide a setting for this type of service, an additional step was needed to prepare the GTFS data. Therefore, fixed-route bus stops were created every quarter mile along local routes to simulate the flag-stop system. While an agency would normally not space their stops with such close spacing, this configuration helped model service access that is provided through the flag-stop service.

2.3 Ridership Data

The STOPS model can be calibrated automatically based on daily boarding counts at the station-level. The project team used ridership provided by Waco Transit from the 2016 Random Survey and expanded it using the 2017 Farebox Data. The ridership data were geocoded and then attributed to the closest stop from where boarding activity occurred.

2.4 Waco MPO Traffic Analysis Zone (TAZ) data

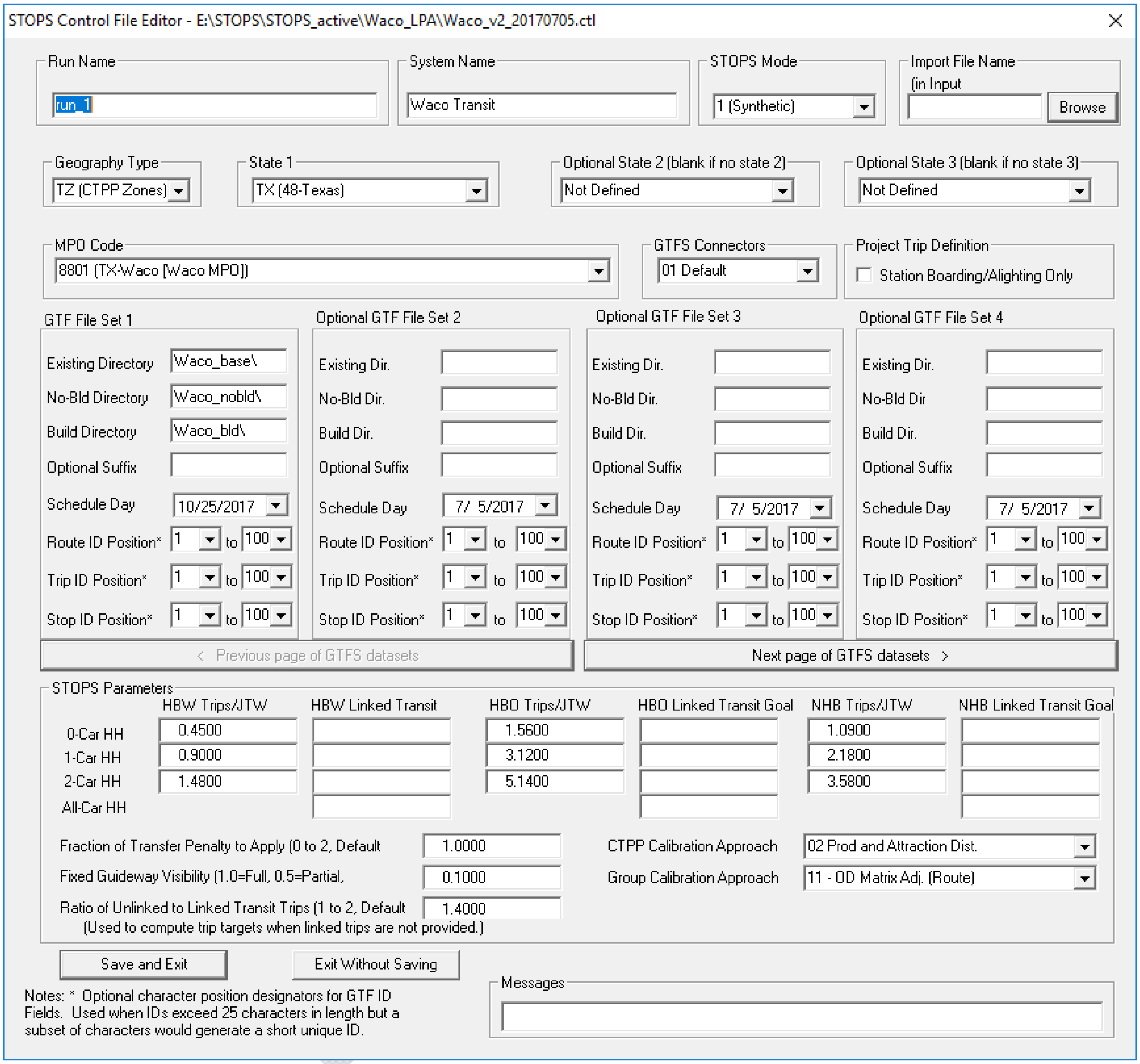
The project team used the TAZs from the local Travel Demand Model (TDM) that used the Census block geography as a guide to provide a representation of the local land use and geography.

3. Model Calibration

Before running the STOPS model, several parameters must be determined to ensure the model provide the best possible results given the available data. We can choose to use either STOPS default values or values estimated based on locally available information. For this study the project team used parameters that were the product of an analysis performed on the 2007 – 2008 Waco Household Travel Survey, as it was the most recent study available. The parameters were estimated and calibrated during development of the Waco Travel Demand Model.

Figure 2 shows the interface for the Parameter file that must be populated with either STOPS default values or manually entered data that came from the sources outlined in Section 2. Many of the fields in the STOPS Parameters file show the model where to navigate to find the necessary files to successfully run the STOPS model.

Figure 2: STOPS Parameters



3.1 Calibration

For this study, multiple versions of the STOPS model were tested in order to calibrate the model. This is a critical step in the model development process as it establishes a calibrated model to serve as a point of comparison for all of the subsequent model runs. **Table 1** below is an explanation of the steps taken to achieve a calibrated model:

Table 1: STOPS Calibration

Version	Action	Description	Observations
1	Initial STOPS Model Calibration	All parameters were left in 'Default' mode except for the linked transit person trips by purpose.	Base year (2017) Ridership was too high.
2	Default STOPS Model Calibration	Used default STOPS parameters.	This model run produced even higher ridership results.
3	Define Unlinked Transit Trips	The 'linked transit person trips by purpose' options were reset to the locally defined numbers. The Weekday Unlinked Transit Trips were defined based on the most recent ridership data.	By better defining the total number of Unlinked Transit Trips we were able to achieve more realistic ridership estimates in this model run.
4	CTPP Calibration Approach	The 'CTPP Calibration Approach' field was changed to '02 Prod and Attraction Dist.'	Since the RTC corridor is in a more stable area where the nature of travel is less likely to change, except in response to the project, itself, this setting was determined to be more appropriate for the model.
5	Group Calibration Approach	The 'Group Calibration Approach' field was changed to '11 – DD Matrix Adj. (Route)'.	This parameter was recommended for model runs where full bus and fixed guideway stop/station count data are not available. While some stop level ridership counts were available there was not a complete set due to the nature of the flag-stop system. This change kept the ridership estimates at a realistic level for this model run.

3.2 Districts and Station Groups

In the STOPS model, districts are defined as areas with levels of walk and drive accessibility to stations. Stations within a district are located relatively close to one another and share similar levels of transit service. The study area covers several different and distinct areas that are defined by neighborhood patterns, land use and major destinations. For example, there are major schools such as Baylor University, McLennan Community College and Texas State Technical College that are contained within one district to ensure that the specific travel patterns associated with that land use are reflected in the model. The districts were developed to be smaller and more distinct along the proposed RTC and become larger the further away from the RTC to improve sensitivity and accuracy along the corridor. **Table 2** shows all the defined districts for the model, **Figure 3** illustrates the existing WTS fixed-route bus network, and **Figure 4** shows a map of the STOPS districts.

The potential to improve access along the RTC still exists. To illustrate, the planning team identified two potential infill station locations that were not included in the ridership estimates documented in this memo. (see locations at Forrest/Taylor and Hwy 6/US 84 in **Figure 1**) There may be latent demand or increased transit travel time benefits in these areas should WTS wish to consider implementing stations as these locations.

Table 2: STOPS District Details

District ID	District Name	Number of TAZs	Number of RTC Stations	Number of Bus Stops	District Population	District Employment
1	Baylor	1	0	12	4,214	2,559
2	West Waco	10	0	17	10,093	1,224
3	Central	12	6	98	8,624	5,639
4	Tech Village	1	0	31	1,755	2,945
5	MCC	2	0	19	814	1,493
6	South	6	0	8	4,798	1,195
7	Southeast	7	0	2	3,301	498
8	East Waco	6	0	8	917	745
9	N I-35 Corridor	17	5	75	11,992	3,940
10	Lake Waco	10	0	0	4,279	1,272
11	Woodway	10	4	37	12,316	6,196
12	Southwest	19	3	118	24,352	17,727
13	South New Rd	5	0	20	1,942	780
14	La Salle Corridor	17	0	67	13,992	2,945
15	Timbercrest	8	2	16	3,902	1,103
16	South Central	11	2	87	7,385	6,602
17	CBD	6	4	68	2,316	6,689
18	Richland Hills	6	3	67	6,296	13,493
19	North Waco	13	0	3	7,497	1,414
20	Parkdale	6	0	42	5,590	4,283
21	North River	16	5	133	9,560	3,569
22	North Central	35	0	196	34,352	9,053
23	East River	5	0	27	2,270	856
24	Rural McLennan	54	0	1	51,124	9,301
25	Rural	189	0	4		

Figure 3: Existing WTS Fixed-Route Bus Network

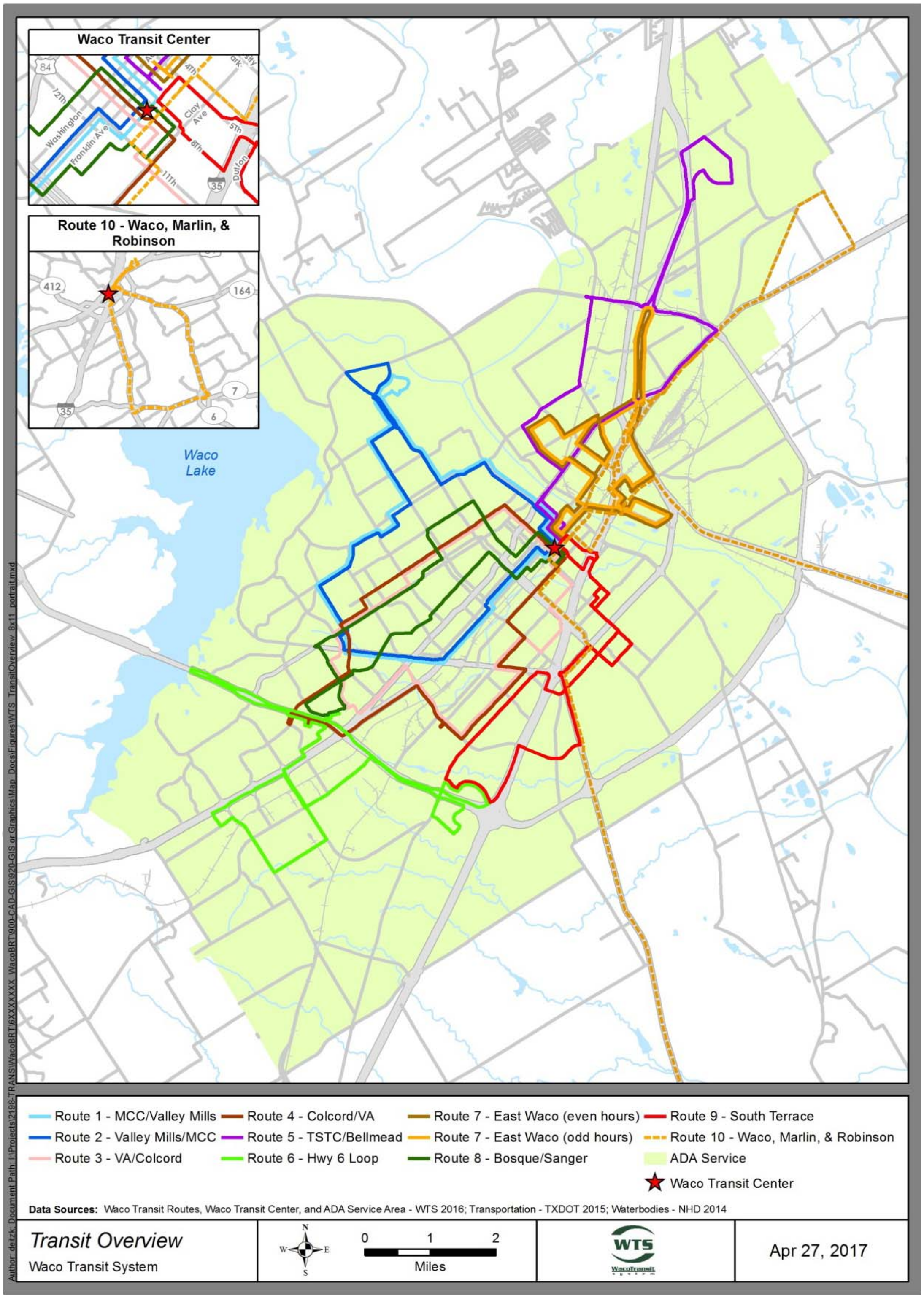
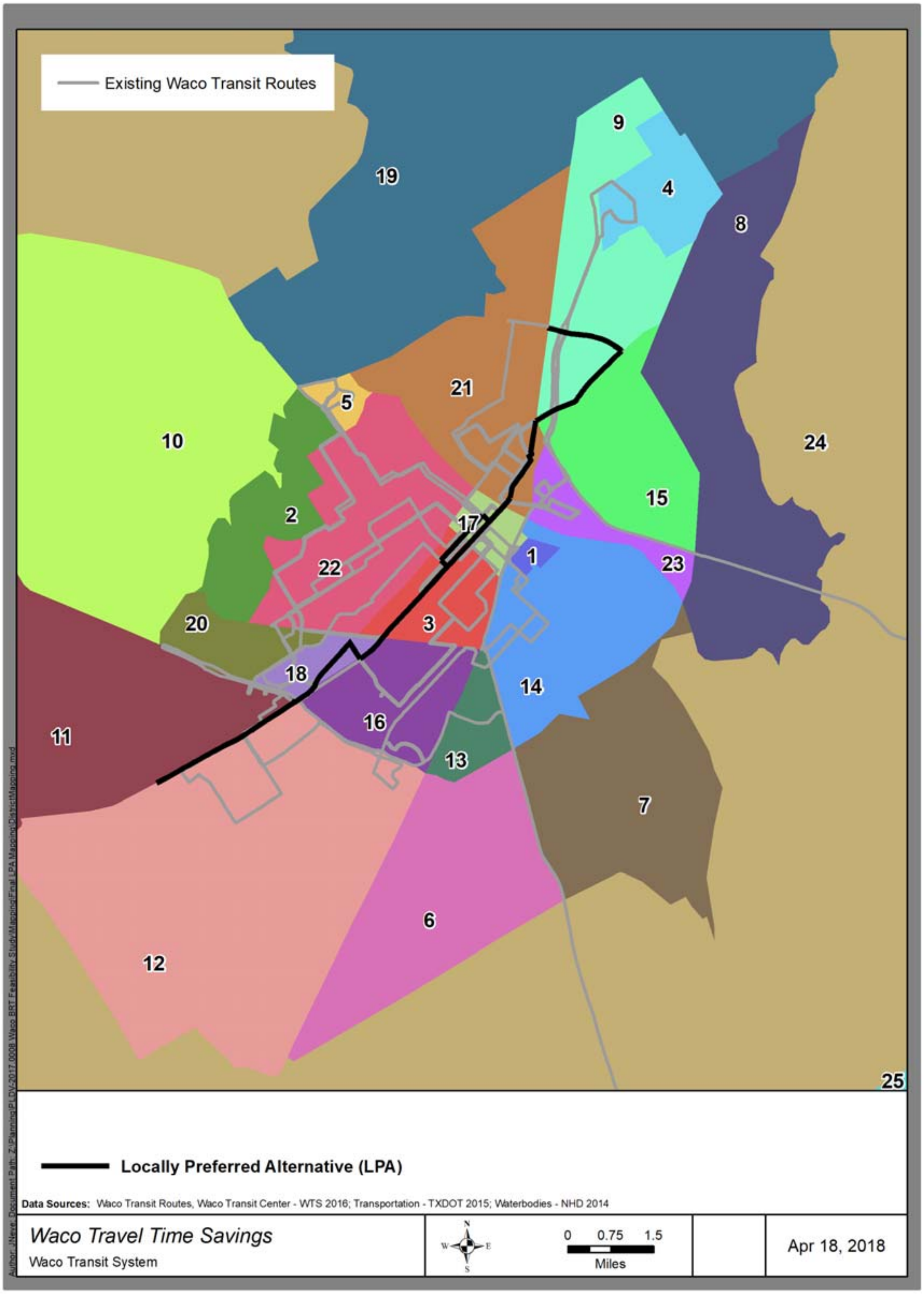


Figure 4: STOPS Districts



4. Model Run and Results

Completion of the model calibration and setup allowed the project team to complete model runs for each of the proposed RTC alignment options. Each of the three proposed RTC alignments was modeled on top of the fixed-route system as it is currently configured.

For this project, the following scenarios were analyzed for each of the three RTC alignment options:

2017 Current Year – Base year service

2023 Opening Year – Proposed year for RTC implementation

2027 Build – 10-year forecast of improved fixed-route service and RTC service

2040 Build – 20-year forecast of improved fixed-route service and RTC service

Table 3 shows the results of the 2023 and 2040 scenarios for each of the RTC alignment options.

Table 3: STOPS Ridership Evaluation

Ridership Projections	Alignment Option 1	Alignment Option 2	Alignment Option 3
Total RTC Ridership (year)*	870 (2023) 980 (2040)	900 (2023) 980 (2040)	900 (2023) 1,000 (2040)
Total Systemwide Ridership**	4,030 (2023) 4,690 (2040)	3,990 (2023) 4,630 (2040)	4,080 (2023) 4,730 (2040)
RTC Ridership by Transit Dependents***	80 (2023) 90 (2040)	65 (2023) 70 (2040)	75 (2023) 75 (2040)
Systemwide Ridership by Transit Dependents ****	445 (2023) 490 (2040)	435 (2023) 480 (2040)	445 (2023) 490 (2040)

*Table 4.03 – STOPS Model Output

**Table 10.01 – STOPS Model Output

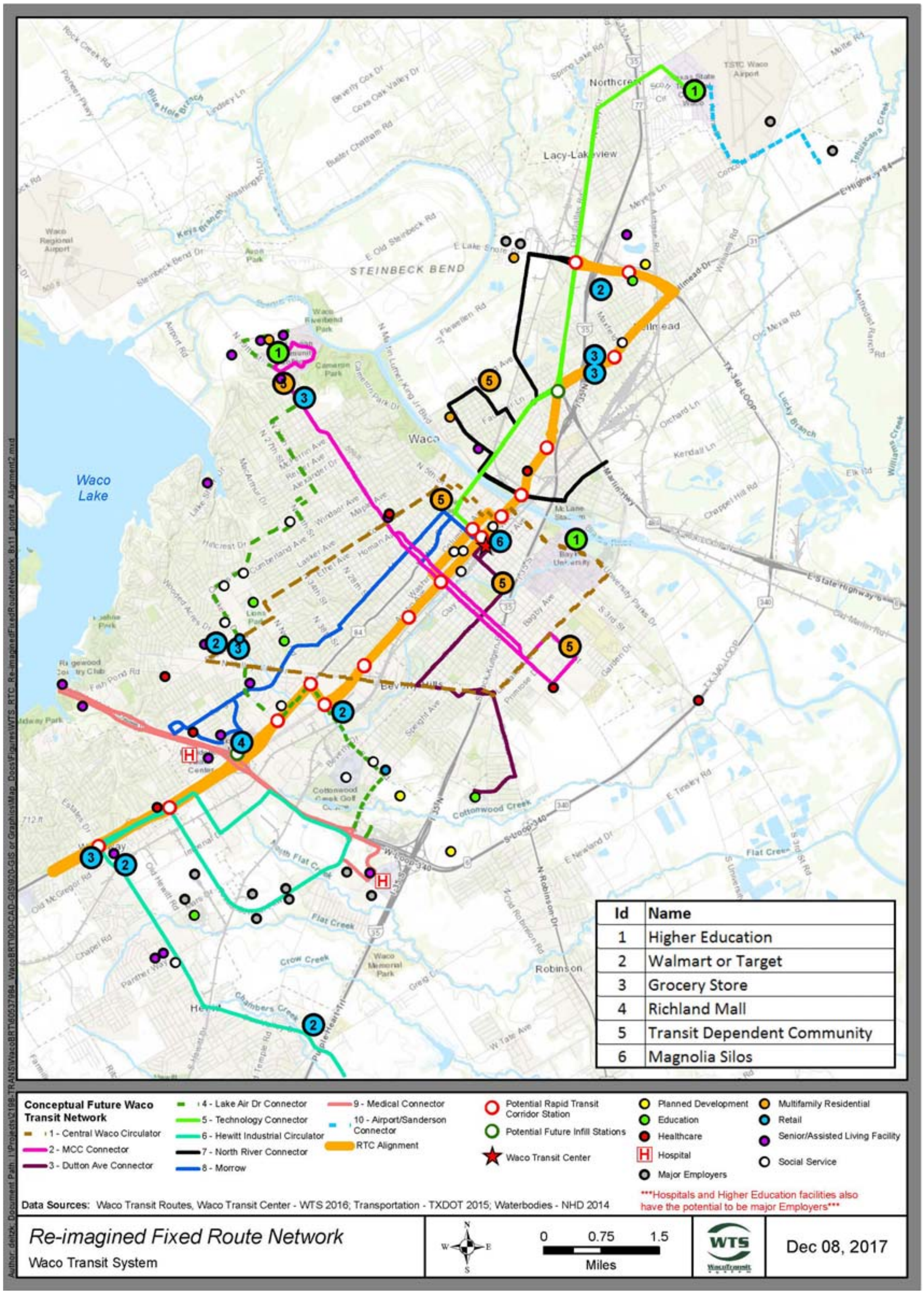
***Table 6.03 – STOPS Model Output

****Table 6.01 – STOPS Model Output

Based on the results shown in **Table 3,** along with all the other screening criteria and public involvement, a Locally Preferred Alignment (LPA) -- Option 2 was selected (See Evaluation of Alternatives Memo). To better understand the potential ridership associated with the LPA, additional model runs were conducted.

To strengthen the model, the underlying fixed-route network was reconfigured using input from the public, Waco Transit Operational staff, Waco MPO staff and key stakeholders. This reconfigured fixed-route system is meant to provide a more optimized future transit network where the RTC serves as the spine of the transit system with transfer points to fixed-route connectors at RTC stations along the corridor. The outcome is a transit system that provides improved access, connectivity and more efficient travel for future system users. Special care was given to ensure that the reconfigured-system maintained or expanded coverage that exists today and maximize connectivity to key destinations and the LPA RTC alignment.

Figure 5: RTC Alignment #2 with Reconfigured Fixed Route Network



In addition to reconfiguring the underlying fixed-route bus network, service level parameters for operational hours and frequency were enhanced based on identified projects in the Regional Coordination Plan and Waco's goal to continually grow and improve service as the needs of the community continue to grow. In order to demonstrate potentially incremental, sustainable ways to implement the service, two LPA scenarios were developed. A Mid-Level Build Scenario and an Optimized Build Scenario provided the stakeholders with the insights towards taking steps in growing and building out their optimized system and to understand and compare costs associated with the two scenarios. Below are the operating parameters used for each scenario:

Mid-Level Build Scenario (RTC w/realigned fixed route network):

- Local Bus
  - 'Optimal' re-aligned routes
  - Improve weekday/Saturday frequency to 30 min average
  - Operational hours from 6:00 a.m. – 8:00 p.m.
  - NO Sunday service
- RTC
  - 15 min all day frequency from 6:00 a.m. - 8:00 p.m.
  - Saturday service at 30 min frequency from 6:00 a.m. to 8:00 p.m.
  - NO Sunday service

Optimized Build Scenario (RTC w/realigned fixed route network):

- Local Bus
  - 'Optimal' re-aligned routes
  - Improve weekday/Saturday frequency to 30 min average
  - Operational hours from 6:00 a.m. – 10:00 p.m. weekdays and Saturdays
  - Sunday service at 60 min frequency from 7:00 a.m. – 7:00 p.m.
- RTC
  - 15 min frequency from 6:00 a.m. – 8:00 p.m. and 30 min frequency from 8:00 p.m. – 10:00 p.m. on weekdays
  - Saturday service at 30 min frequency from 6:00 a.m. – 10:00 p.m.
  - Sunday service at 30 min frequency from 7:00 a.m. – 7:00 p.m.

Table 4 displays the STOPS LPA ridership model results for the reconfigured system. The low ridership numbers by transit dependents could be due to the limitations of the model to capture this type of ridership since it is based on journey to work data.

Table 4: STOPS LPA Ridership Results – Reconfigured System

Ridership Projections	2017	2023	2027	2040
Total RTC Ridership*	1,390	1,550	1,530	1,700
Total Systemwide Ridership**	4,750	5,160	5,250	5,910
RTC Ridership by Transit Dependents***	70	80	80	90
Systemwide Ridership by Transit Dependents ****	430	440	460	490

*Table 4.03 – STOPS Model Output
**Table 10.01 – STOPS Model Output
***Table 6.03 – STOPS Model Output
****Table 6.01 – STOPS Model Output

Figure 6 shows the ridership by station location along the LPA with the reimagined fixed-route system. This map also reveals where transfer opportunities exist between the reconfigured fixed-route network and the LPA and the result is a significant projected ridership at those potential transfer opportunities.

One of the most significant improvements that can be realized from the investment in the RTC and the reimagined fixed-route network is the travel time savings. Travel time savings can be thought of as the difference in time it would take to travel via transit between the Optimized RTC and No-Build Scenarios. **Figure 7**, **Figure 8**, and **Figure 9** show the significant travel time savings to various key locations (Downtown Waco, Bellmead retail center and Woodway employment center) from all the surrounding TAZs in the service area. You may notice many TAZ do not show any travel time savings. This does not indicate that there would not be any travel time savings for users within those TAZs, only that the model did not have any existing trips to model from this zone to the key locations.

As previously identified, there may also be opportunities to capture latent transit demand, improve transit access, or increased travel time benefits to the greater Waco community by refining local bus connectivity or implementing infill stations at strategic locations. Additional study and refinement is recommended during the RTC design and construction process.

Figure 6: LPA Ridership by Station Location

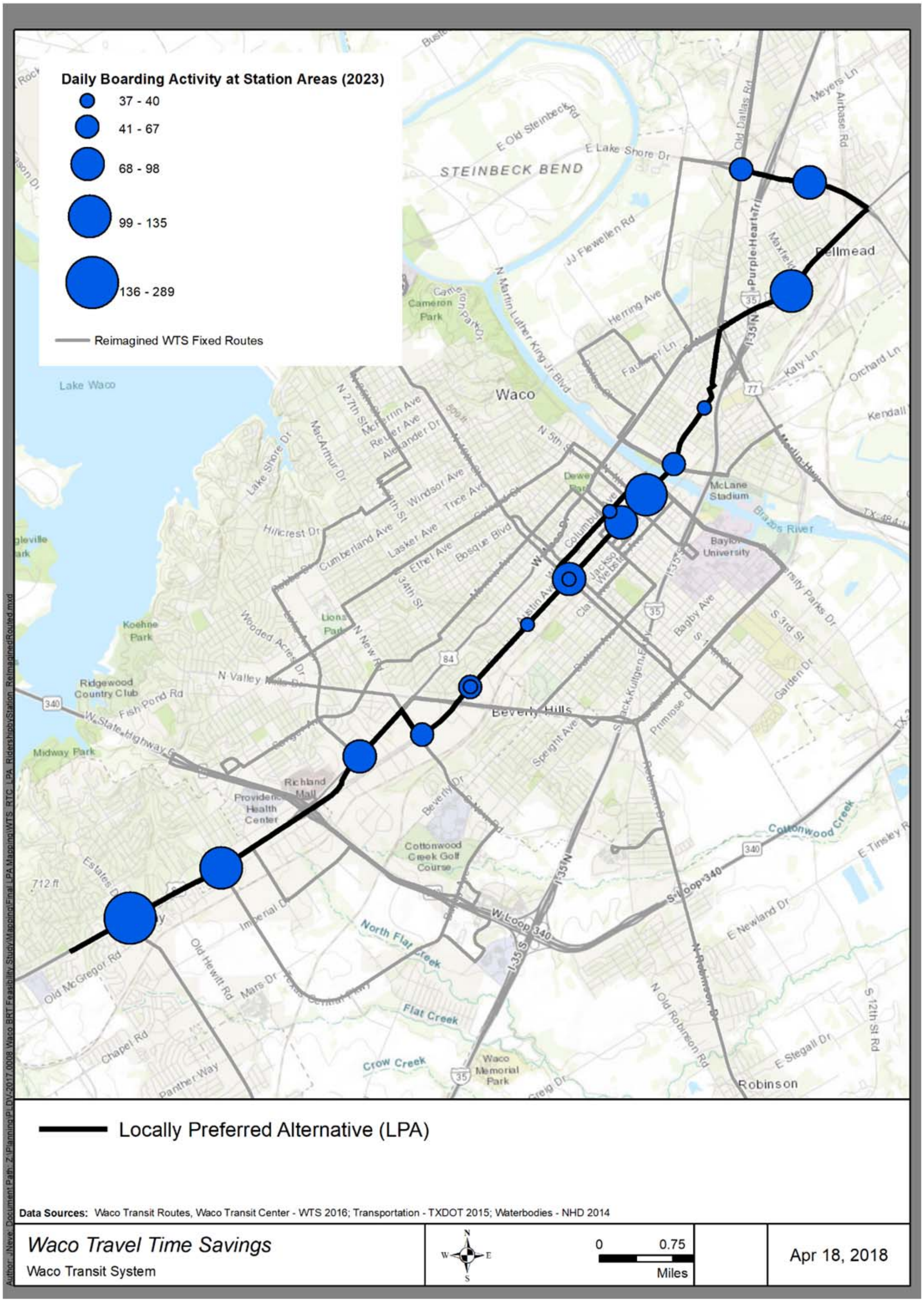


Figure 7: Estimated Travel Time Savings to Waco Central Business District (CBD)

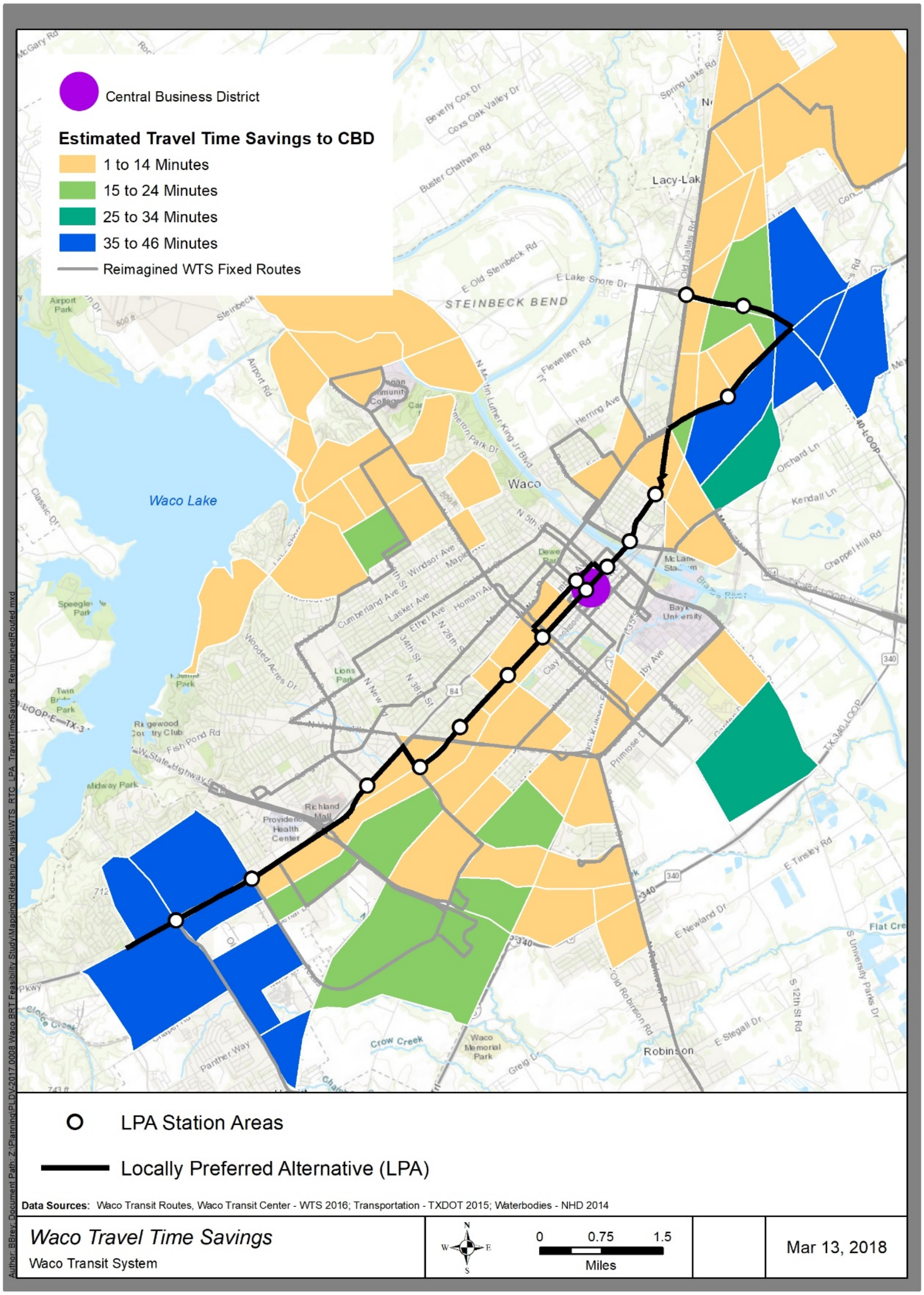


Figure 8: Estimated Travel Time Savings to Bellmead

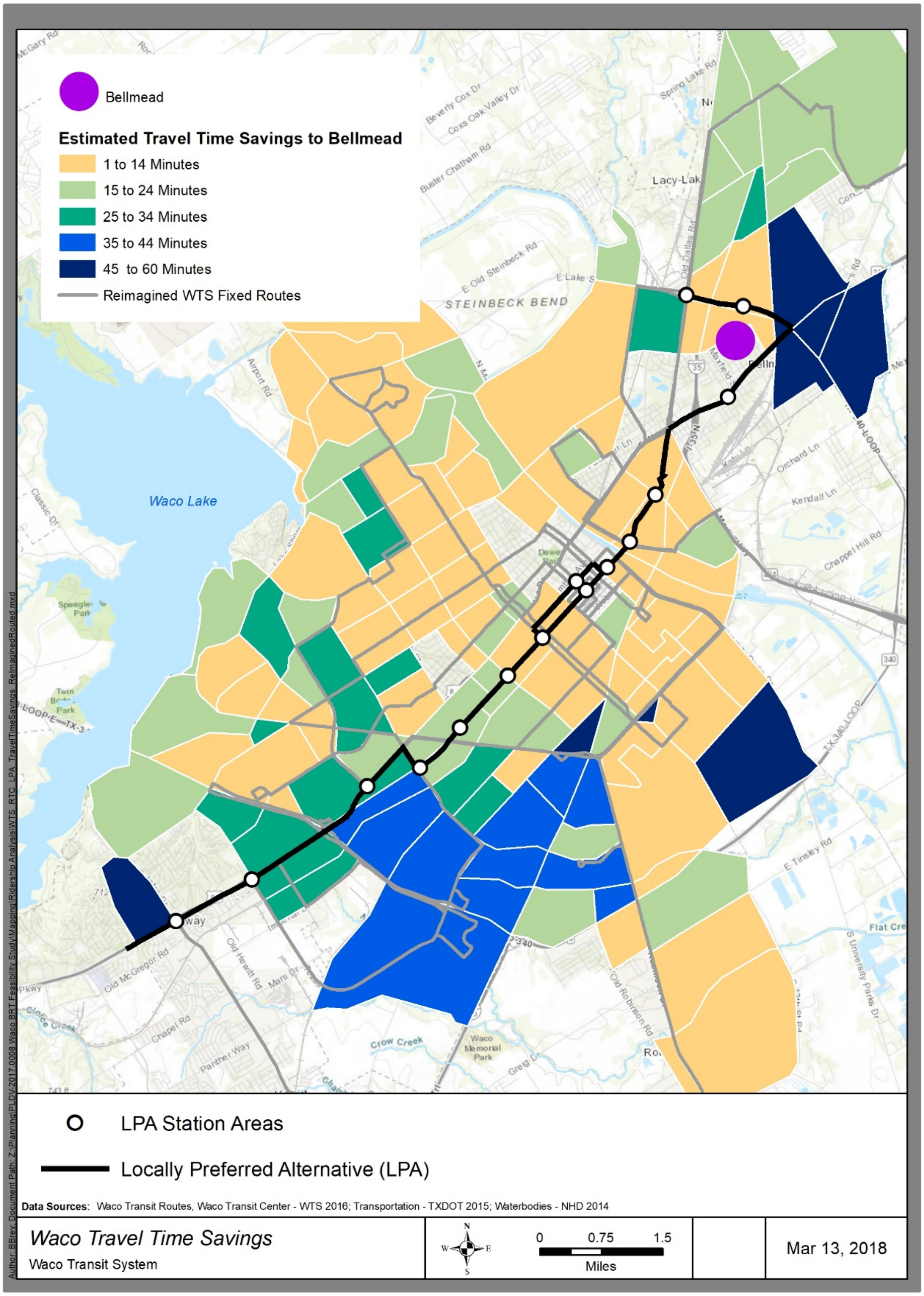
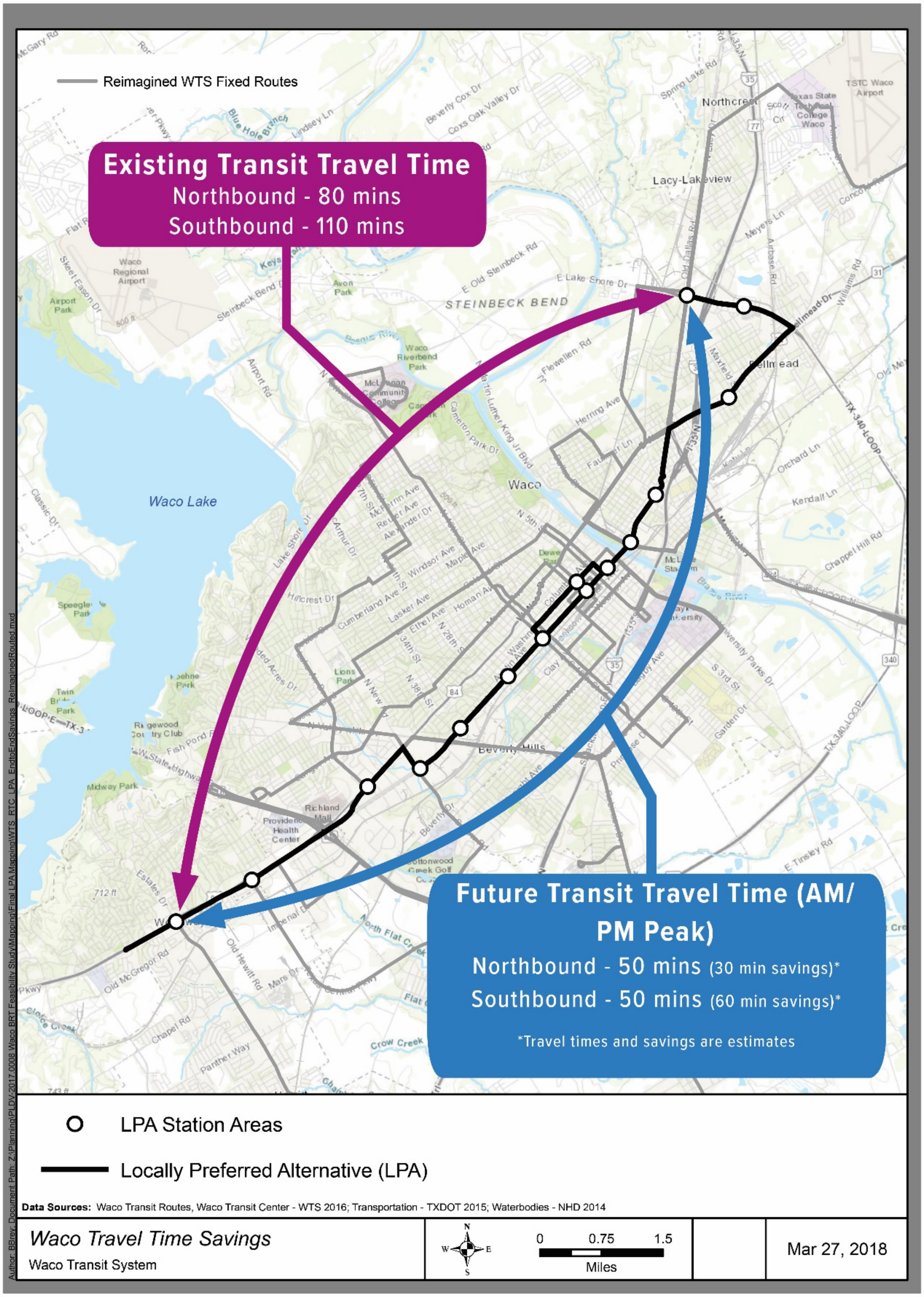


Figure 9: Estimated End to End Travel Time Savings



About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A *Fortune* 500 firm, AECOM had revenue of approximately $17.4 billion during fiscal year 2016. See how we deliver what others can only imagine at aecom.com and @AECOM.

Contact

Andrew Ittigson

Project Manager

T +01 (214) 672-2858

E andrew.ittigson@aecom.com

aecom.com

9/17/2018

Sherry Riklin, Acting Associate Administrator for Planning and Environment
Federal Transit Administration
U.S. Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

RE: Waco, TX – Rapid Transit Corridor (RTC) Project Development Justification Request

Dear Ms. Riklin:

The purpose of this letter is to formally request entry into Project Development of the FTA Capital Improvement Grant (CIG) Program for the Waco Rapid Transit Corridor preferred alternative.

The City of Waco, Texas is proposing a Rapid Transit Corridor (RTC) operating branded buses in mixed traffic along a route that travels approximately 13.3 miles, serving industrial and commercial employment centers, the Central Business District, as well as important retail centers for residents and visitors. It is oriented in a north-south direction, connecting Waco with the adjacent communities of Woodway, Beverly Hills, Bellmead and Lacy-Lakeview. The Rapid Transit Corridor will feature branded stations, with real time arrival information and elevated platforms for near-level boarding at up to 17 key locations. The rapid transit service would operate on 15-minute frequencies along the centralized corridor. The capital cost of the project may range from approximately $18.3M to $19.4M. This estimate will be refined during Project Development. Detailed technical reports of this Feasibility Study and supporting documentation may be found at the Project website:
http://www.aecomconnect.com/WacoRTC/about/

Study Sponsor and Partner Roles and Responsibilities

Waco Transit System (WTS) and the Waco Metropolitan Planning Organization (MPO) are the study sponsors for the RTC Project. The roles and responsibilities of Waco Transit System's partners in the development of the Project are listed below:

- Federal Transit Administration (FTA)– *Lead Agency*
- City of Waco – *Local Funding Partner*
- Waco MPO – *Technical and Planning Assistance*
- Federal Highway Administration (FHWA)
- United States Army Corp of Engineers (USACE)
- Environmental Protection Agency (EPA)
- TxDOT

Project Manager and Other Key Staff

Allen Hunter, Waco Transit System General Manager, will manage the RTC Project. Other key staff who will perform the Project Development work include:

- Waco Metropolitan Planning Organization:
  Christopher Evilia, AICP, MPO Director
  Annette Shepherd, Senior Transportation Planner

- Waco Transit System:
  Serena Stevenson, Assistant General Manager
  Joseph Dvorsky, Director of Service Development
  Diana Le, Management Assistant
  Charles Parham, Director of Operations

- RATP Dev USA:
  Allen Hunter, Waco Transit System General Manager
  John Hendrickson, Senior Vice President

Existing Waco Transit System

The current WTS operates nine fixed routes on a flag stop basis, covering approximately 90 square miles with an average frequency of 60 minutes (see **Figure 2**). The fixed route network operates on a pulse out of the Downtown Transit Terminal. The hub and spoke system operates as a circulator, which makes traveling to multiple destinations inconvenient and can take up to 2 hours for transit users as nearly all transfers occur at the Downtown Transit Terminal. Fixed route service operates from approximately 6am to 7pm Monday through Friday, and 7am to 8pm on Saturday. Sunday service is not currently offered.

Reimagining Waco Transit Service

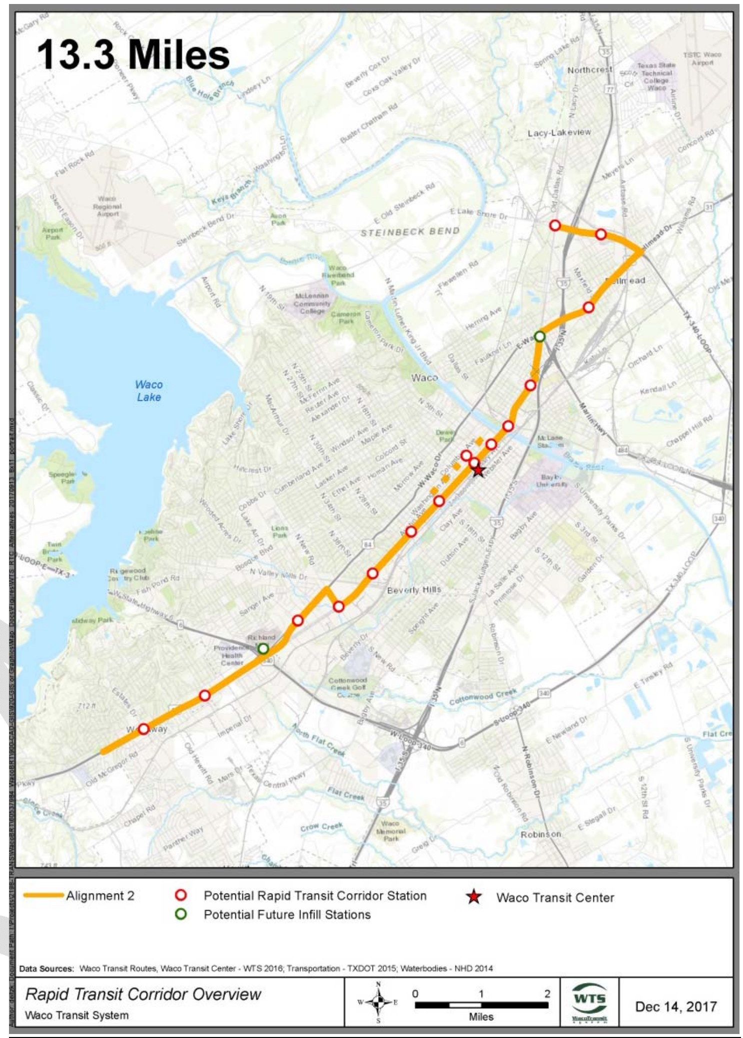
The conceptual recommendation for an RTC was identified in *Connections 2040: The Waco Metropolitan Transportation Plan* (MTP) as well as *The City Plan: Waco Comprehensive Plan 2040*, September 2015. The concept recommended in the MTP would provide a central Rapid Transit Corridor (RTC) service upon which all other routes would feed into at various transfer locations throughout Waco. Regional growth, development and travel patterns documented in supporting regional plans such as: *Waco Downtown Transportation Study*, and the *FY17 Heart of Texas Regionally Coordinated Transportation Plan* confirm the need for an augmented transit network and improved efficiency.

The RTC will serve as a catalyst project that would allow realignment of the current hub-and-spoke system to increase fixed route efficiency and decrease overall transit travel times for system users. Realignment of local buses would facilitate transition of the network to a branch-and-stem operation, allowing inline transfers between routes at the RTC stations for faster trip times to destinations. The shorter fixed routes would also result in improved transit accessibility for local residents and rural transit users looking to access regional institutions for higher education, healthcare services and retail centers in Waco.

RTC Operating Profile

The RTC would complement the existing fixed route service and add an hour to the weekday span of service, operating at a 15-minute frequency Monday – Friday between the hours of 6am and 8pm; as well as every 30 minutes on Saturdays between 7am and 8pm. On an existing fixed route system that currently serves approximately 2,400 riders per day, an average of over 900 riders are projected on the RTC project. By optimizing and realigning the fixed route network to better tie in with the RTC, the system-wide ridership is estimated to grow to over 4,500 daily users with approximately 1,200 on the RTC project. The projected annual operating cost of the RTC service may range from approximately $2.4M to $3M. WTS will determine final weekday and weekend operating spans through the Project Development phase

Figure 1: Waco RTC Recommended Alignment



Local Adoption

The feasibility study technical analysis concluded in the winter of 2017/2018 and identified the preferred RTC alignment shown in **Figure 1**. Multiple open houses, webinars, and popup engagement activities were held from November 2017 to March 2018 to inform the community about the results of the analysis process and garner feedback on public support for the recommendation. The RTC study's Steering Committee and WTS Transit Advisory Board endorsed the recommendation on March 20, 2018, followed suit by the Waco MPO Technical Committee and Policy Board on April 5th and 19th, respectively. The Waco City Council voted to approve the recommended BRT alignment and service profile at the Council meeting of May 1, 2018.

Cost Estimate and Project Development Funding

The conceptual capital cost range estimated during the study identified approximately $2.7M to $3M in soft costs for professional services and management through design and construction, with approximately $1.2M of that total directed towards Project Development activities for preliminary engineering and NEPA review. The City of Waco is in the process of finalizing their FY 19 budget, which includes a line item allocation for RTC Project Development fees. (*see City of Waco Proposed 2018-2019 Budget*)

Capital Cost Category	Approx. Cost ($ millions)
Roadway infrastructure, stations, IT/communications	$6.8 – $7.4
Vehicles	$4.5
Design, management, right of way, legal, etc…	$2.7 - $3.0
Contingency	$4.2 - $4.5
Project Total	**$18.3 - $19.4**

Governance and Next Steps

The Waco MPO provides management and oversight for several planning initiatives and capital projects with regional significance. WTS is a wholly owned subsidiary of service provider RATPDev, under contract to the City of Waco to operate and maintain transit service for the Waco Urbanized Area. The Waco BRT Feasibility Study was procured and managed jointly by the Waco MPO and WTS acting through the City of Waco. Professional services to support proposed Waco RTC Project Development activities would be procured and managed by the City of Waco, with support from WTS as well as the Waco MPO, City of Waco Planning & Zoning, Public Works, and Traffic Departments.

Assuming acceptance into the FTA CIG Project Development phase in Fall 2018, the potential milestone timeline towards RTC service operations is shown below:

Draft Milestone Schedule Activity	Begin	End
FTA Justification Letter / Pre-Award Authority	June 2018	August 2018
Professional Service (PE/NEPA) Procurement	Fall 2018	December 2018
Preliminary Engineering and NEPA	January 2019	August 2019
Selection of a Locally Preferred Alternative (LPA)	February, 2018	May, 2018
LPA in Long Range Transportation Plans	October, 2018	January, 2019
FTA CIG Application and Funding Recommendation	Fall 2019	Spring 2020
Request Entry into Engineering		
Final Design	Spring 2020	Fall 2020
Full Funding Grant Agreement (FFGA)		
Construction and Vehicle Procurement	Fall 2020	December 2020
Construction	Spring 2021	Spring 2022
Revenue Service	Spring 2022	

**begin/end dates as of September 2018*

The community of Waco is excited for the opportunity to discuss the proposed Rapid Transit Corridor with the Federal Transit Administration and the many potential benefits to local residents, employers and service providers. We are happy to address any questions that you may have regarding the results of the feasibility study, proposed project, or provide additional information in order to demonstrate the region's commitment to implementation.

Respectfully Submitted,

[Name]
[Title/position]

[Name]
[Title/position]

Enclosures

- Exhibits of existing (**Figure 2**) and proposed (**Figure 3**) WTS transit network
- Waco MPO resolution #2018-5 supporting BRT Feasibility Study recommendations (4/19/18)
- Waco City Council resolution #2018-484 approving BRT Feasibility Study recommendations (5/1/18)
- City of Waco Proposed Budget 2018-2019
- Community Letters of Support

Figure 2: Existing Waco Transit System Fixed Route Network

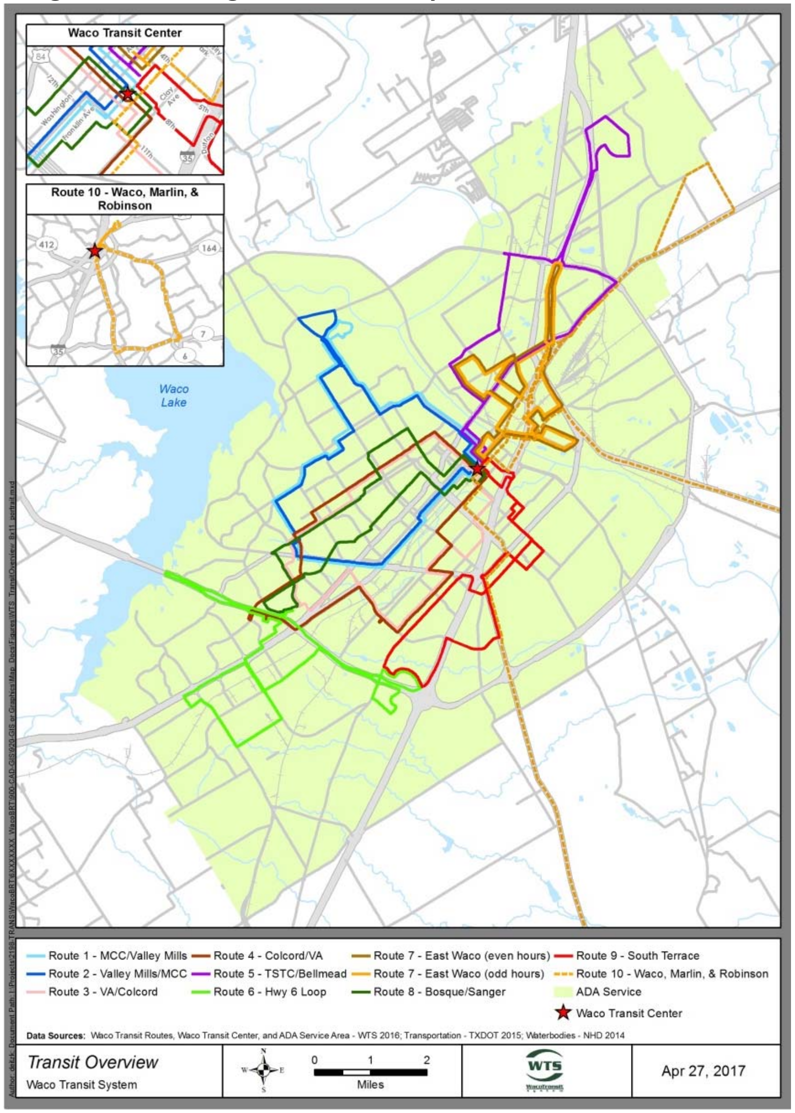
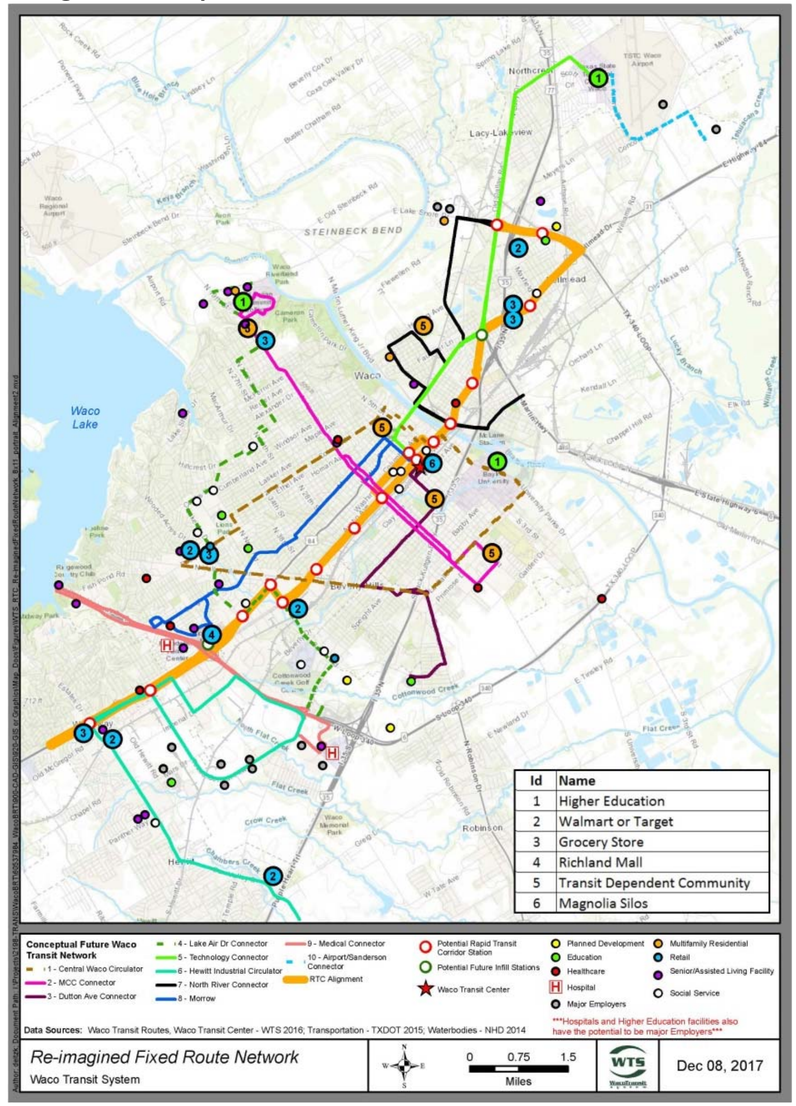


Figure 3: Proposed RTC and Potential Fixed Route Network



Waco Metropolitan Planning Organization

RESOLUTION 2018-5

WHEREAS, the Waco Metropolitan Planning Organization was established to identify and support the implementation of regionally significant transportation projects to address future mobility needs of the Waco Region; and,

WHEREAS, the Waco Metropolitan Planning Organization Policy Board is composed of representatives appointed by the elected City Councils and Counties located within the jurisdiction of the MPO as well as the Texas Department of Transportation; and,

WHEREAS, the Waco MPO has jointly funded with Waco Transit a feasibility study for future bus rapid transit services; and,

WHEREAS, the Waco MPO and Waco Transit procured the services of AECOM to perform said study; and,

WHEREAS, the staff of AECOM have studied several different transit service alternatives and several different potential alignments and have also studied a no-build alternative; and,

WHEREAS, the staff of AECOM, the Waco MPO and Waco Transit have solicited feedback from interested citizens and stakeholder interests regarding these different service and alignment options; and,

WHEREAS, the staff of AECOM recommends as the locally preferred alternative the implementation of Bus Rapid Transit service with 13 initial stations and 2 potential additional stations beginning in the vicinity of the Texas Central Industrial Park and terminating near North Loop 340 & IH-35 in Bellmead; and,

WHEREAS, the staff of AECOM further recommends that the BRT generally follow and alignment of US 84, Franklin Ave, Taylor Ave, Hillsboro Dr, Bellmead Dr and North Loop 340 with Franklin Ave being converted to two-way operations; and,

WHEREAS, the staff of AECOM additionally recommends that the remaining fixed routes services be realigned to optimize connection to the BRT service; and,

WHEREAS, the staff of AECOM recommends that the entire Waco Transit system operate until at least 8:00pm but preferably until 10:00pm during weekdays and also operate on Sundays.

NOW, THEREFORE, BE IT RESOLVED BY THE POLICY BOARD OF THE WACO METROPOLITAN PLANNING ORGANIZATION:

That the Waco MPO Policy Board hereby accepts the recommendations of the staff of AECOM and expresses its support for implementation of the locally preferred alternative.

That the Waco MPO Policy Board requests the City of Waco, as the authorizing agent for Waco Transit, to submit these recommendations to the Federal Transit Administration (FTA) for potential entry into the Capital Improvement Grant Program (CIG) and pursue funding for the engineering and design study

That it is hereby officially found and determined that the meeting at which this resolution is passed is open to the public and that public notice of the time, place and purpose of said meeting was given as required by law.

That all public participation requirements identified within the Waco MPO Public Participation Plan related to this action by the Policy Board were met and completed.

PASSED AND APPROVED this the 19th day of April, 2018.

Dillon Meek
Council Member – City of Waco
Chair – Waco MPO Policy Board

ATTEST:

Christopher Evilia, AICP
Director

P.O. Box 2570, Waco, TX 76702-2570
(254) 750-5651
www.waco-texas.com/cms-mpo
mpo@wacotx.gov