

**RPTA Comprehensive Arterial  
Bus Rapid Transit  
Planning Study**

**Final Report**



September 2009

**RPTA Comprehensive Arterial Bus Rapid Transit Planning Study**

**Final Recommendations**

September 2009

**Submitted To:**  
Valley Metro/RPTA

**Submitted By:**





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## 1. INTRODUCTION

### *BRT Planning in the Valley*

The 2003 MAG High Capacity Transit Study identified a number of corridors for high-capacity transit improvements including light rail, dedicated bus rapid transit (BRT), and commuter rail. The Regional Transportation Plan (RTP), which was originally adopted in November of 2003, incorporated many of these corridors. In November 2004, Maricopa County voters passed Proposition 400, which reauthorized a county-wide half-cent sales tax originally approved in 1985, and provides funding for projects listed in the RTP. Eight arterial BRT corridors were identified in the RTP.

The 2007 RTP Evaluation examined the Transit Life Cycle Program to evaluate the planning and funding assumptions of the transit portion of the RTP. The 2007 RTP Evaluation found inconsistencies in the classification of arterial BRT services and recommended that “a comprehensive arterial BRT study be completed to determine the appropriate level of capital treatments by corridor within the constraint of the total capital budget for the Arterial BRT program.” The 2007 RTP Evaluation noted the total cost of BRT guideway improvements in \$2002 in the Transit Life Cycle Program, which was referenced as \$92,500,500 (\$113,764,900 in \$2009). As mentioned in the working paper for Tasks 4 and 6, the 2007 RTP Evaluation allocated arterial BRT capital funding proportionately along the corridors with dedicated BRT routes, but noted that actual implementation may differ.

Since approval of the RTP, the Main Street LINK arterial BRT service has begun passenger service operations, and planning for the Arizona Avenue BRT service is in the Final Design stage and will shortly be entering construction. In addition to the regional studies mentioned above, the City of Phoenix Public Transit Department undertook the “Plan for RAPID Central-South Mountain.” (Recommendations from this study are noted in the section on the South Central/Baseline corridors.)

Given the context for BRT planning in the Valley, this project, the Comprehensive Arterial Bus Rapid Transit Planning Study, is tasked with identifying demand for BRT and defining operational characteristics, capital infrastructure needs, and fleet requirements for the Arizona Avenue, Grand Avenue, Scottsdale Road/Rural Road, South Central Avenue/Baseline Road, and Chandler Boulevard arterial BRT lines. The study considers how operational characteristics and needs of the BRT corridors may change as the regional transit network develops over the life of the 20 year transit program. Finally, the study reviews prospects for Federal Very Small Starts funding for each of the corridors in the study. This study seeks to maintain consistency with previous and ongoing planning efforts while advancing the status of BRT planning in the Valley.

### ***Defining Bus Rapid Transit***

In the United States – as well as around the world – BRT does not have a single definition. The Transit Cooperative Research Program’s Report #90, titled “Bus Rapid Transit,” defined BRT as follows:

*“A flexible, rubber-tired rapid-transit mode that combines stations, vehicles, services, running ways, and Intelligent Transportation System (ITS) elements into an integrated system with a strong positive identity that evokes a unique image. BRT applications are designed to be appropriate to the market they serve and their physical surroundings, and they can be incrementally implemented in a variety of environments. In brief, BRT is an integrated system of facilities, services, and amenities that collectively improves the speed, reliability, and identity of bus transit.”*

Successive BRT planning guides have followed with this flexible approach to BRT. The definition of BRT is therefore flexible and adaptable to different operating environments. However, the overarching goal of a BRT system is to provide faster, more reliable travel for passengers in a high-quality environment with a strong identity.

Defining how BRT is implemented in the Valley is important in order to convey a consistent image and comprehensible system to current and prospective passengers. BRT is planned for a range of corridors, from more densely developed, higher-boardings corridors to areas where transit is not yet present. BRT is also planned for implementation over a number of years. Therefore, the BRT solution may differ somewhat from corridor to corridor, but should adhere to a set of requirements so that transit system characteristics are clear to existing and potential passengers.

In discussing the definition of BRT in the United States, the impact of the Federal Transit Administration’s (FTA) Very Small Starts program on BRT planning – which is described in greater detail in section 2.3 – must be mentioned. While Very Small Starts is a funding program, it describes a set of clear requirements for a transit system to be upgraded to a “lite” BRT system, or one without an exclusive guideway. Briefly, a corridor should already have at least 3,000 transit riders per day and BRT treatments must include transit stations, signal prioritization, low-floor/level boarding vehicles, branding, and specific service frequencies and service span. Costs are also a factor. While the PB team has not explicitly defined BRT in terms of Very Small Starts criteria, the boardings threshold was considered a good indicator of a corridor ready for higher-frequency BRT.

This report describes the vision for the Valley BRT system and each of the corridors planned for future implementation. In the first section, nine qualities of BRT are described in general, with a recommendation for implementation in the Valley’s BRT system. The second section of this paper describes a plan for each of the corridors, including a set of development tools for each. The final section evaluates each corridor’s likelihood of qualifying for federal Very Small Starts funding based on transit conditions today and future plans for the corridor.

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*Note: The current economic situation across the nation and particularly in the Valley has created uncertainty about the availability of funding for the BRT projects initially included in the RTP. Yet, whether additional BRT routes beyond the Main Street and Arizona Avenue/Country Club Drive corridors will be implemented in the next year or in ten years, cities and agencies can actively take steps today to ensure successful implementation and support once funding is identified.*

## 2. RECOMMENDATIONS

### 2.1. Elements of BRT<sup>1</sup>

The precise list of core BRT elements differ, depending on the source, while remaining fundamentally alike in the overall purpose of creating a high-quality transit system through improved travel times, a unique system identity, and by improving the customer experience. In this planning study, the elements of BRT are considered as follows:

- Running way & traffic signal priority
- Stations
- Vehicles
- Fare collection
- Real-time passenger information
- Service planning
- Branding
- Station access and transit-oriented development

The elements of BRT are not stand-alone elements; all are integrated into a seamless system and a decision on one component influences the configuration of other elements. This section describes each element in general and its application in each of the Valley arterial BRT corridors.

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<sup>1</sup> Definitions of some elements of BRT are based on the 2009 edition of FTA's "Characteristics of Bus Rapid Transit for Decision-Making."

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### *Running Way & Transit Signal Priority*

According to the 2009 edition of the Characteristics of Bus Rapid Transit for Decision-Making (“CBRT Manual”), “the running way defines where BRT vehicles travel and ... is analogous to tracks in rail transit systems.”

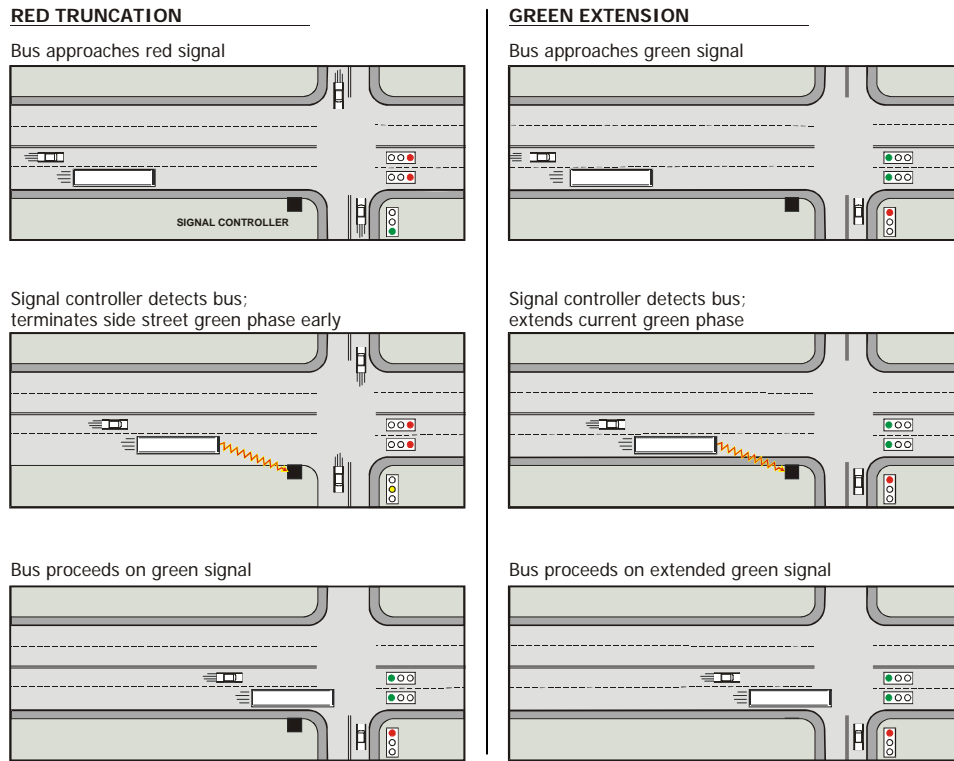
Running ways for BRT can range from mixed-flow roadway lanes; to striped, part-time bus lanes; to exclusive busways. The running way may run along the curb of a street; in the middle of a street; or be in its own right of way. Generally, the more exclusive and separate the lane, the faster and more reliable the BRT system will be; but the more exclusive and separate the lane, the more expensive it will be. Running ways interface with traffic signal systems that, by creating a “conversation” between transit vehicles and traffic signals, allow transit vehicles to be prioritized over other traffic at intersections.

BRT in the Valley is planned for corridors comprising – with some exceptions – six-lane arterial roadways with a median/left-turn lane and minimal shoulders or on-street parking. In other words, in the majority of the corridors, creating an exclusive transit lane would require removing a lane of traffic. However, many of the corridors in question are forecast to experience continued growth in traffic; thus, converting a traffic lane to a “transit-only” lane may lead to unacceptably poor levels of service in the other lanes. Perhaps more importantly, in general, the levels of transit demand estimated in the corridors can be served with lower-impact transit priority treatments. (It is important to consider that transit service in an exclusive lane must be frequent enough for the lane to be “self-policing;” otherwise other motorists will see an underused lane and begin to disregard its exclusivity.)

Intersection-based transit priority treatments are the cornerstone of BRT “lite” operations, that is, operations in mixed traffic (whether during the peak period only or all-day). Intersection-based priority is applied where most transit delays are associated with specific signals, whereas exclusive lanes are effective where there is more overall corridor congestion. Under higher bus volumes conditions, intersection priority treatments could supplement bus lane treatments in a corridor. Intersection-based priority can consist of:

- 1) Transit signal priority (green extension/red truncation) in the through traffic lanes (Figure 1).
- 2) A near side queue jump lane (either using a turn lane or developing a new lane) with signal (Figures 2 and 3). Note that a railroad style “bar” signal is recommended for transit signals to avoid signal confusion for motorists.
- 3) Near-side queue jump lane with far side bus stop and pullout (Figure 2); or
- 4) A curb extension (where the sidewalk is widened into a parking lane or shoulder so that the bus can stay in a traffic lane) (Figure 4).

**Figure 1 - Red Truncation/Green Extension TSP Concept**

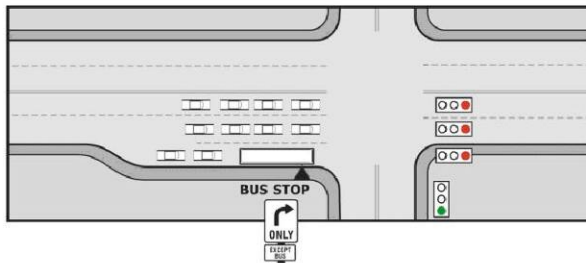


Source: *Transit Capacity and Quality of Service Manual, 3<sup>rd</sup> Edition, 2003*

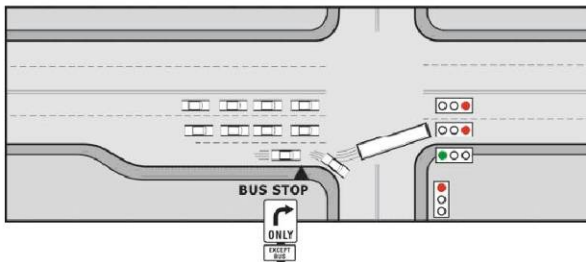
Figure 2 - Bus Queue Jump Signal/Bypass Lane Concept

### Bus Queue Jump Illustration

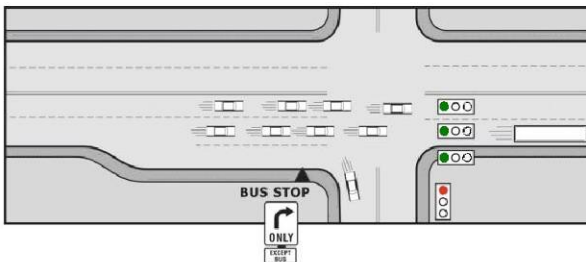
Bus pulls into near side turn lane; Passengers board during red



Bus receives green before other vehicles

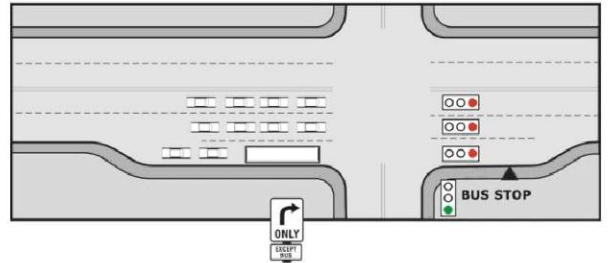


Other vehicles proceed a few seconds later

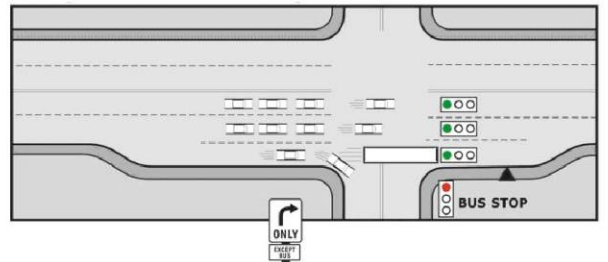


### Bus Queue Bypass Lane Illustration

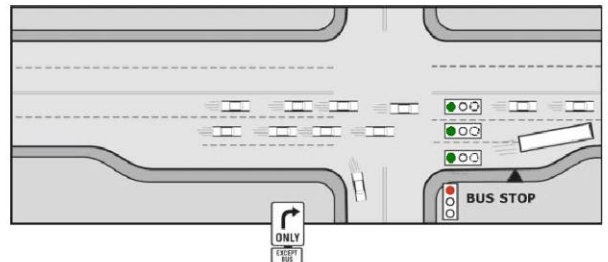
Bus pulls into near side turn lane



Bus pulls into far side station; Passengers board



Bus merges into general traffic



Source: *Transit Capacity and Quality of Service Manual, 3<sup>rd</sup> Edition, 2003*

Figure 3 - Queue Jump, Transit Signal, and Far-side Bus Stop in City of Chandler

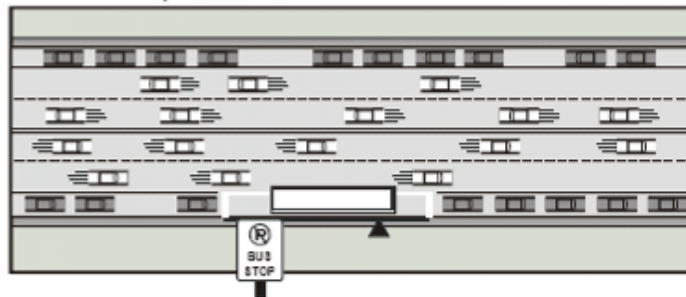


Source: City of Chandler

Figure 4 - Curb Extension for Transit Service

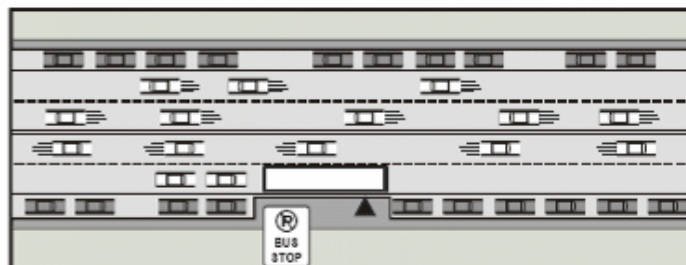
**Before**

Bus pulls to curb at bus stop: must wait for gap in traffic to proceed.



**After**

Curb extended into parking lane, bus stops in travel lane; more curbside parking available.



Source: Transit Capacity and Quality of Service Manual, 3rd Edition, 2003

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RECOMMENDATION:

The precise elements of running ways for each of the corridors in the Valley BRT system will vary based on the anticipated boardings and hence service levels for each corridor, as well as local traffic conditions. The following types of BRT running way and intersection priority treatments should serve as guidelines based on proposed peak hour, one-way bus volumes:

**Table 1 - BRT Running Ways and Intersection Priority Treatments**

<b>Type of Running Way</b>	<b>Peak Hour Bus Volumes (1-Way)<sup>2</sup></b>	<b>Demarcation</b>	<b>Applicable Intersection Priority Treatment</b>
Mixed-flow operation	<15	None	TSP, queue jump/bypass lanes, curb extensions (where shoulder or parking exist)
Business/Transit Access Lane (BAT)	15-40	Striped, signed lane	TSP
Exclusive lane/busway (buses only)	>40	Striped, signed lane exclusive at all times for transit/separate guideway	TSP

At the lower end bus volume scale, with buses operating in mixed-flow scenario, transit priority should be focused at the intersection level, with TSP, queue jump signals, bypass lanes and/or curb extensions. The upper volume threshold reflects priority being triggered (if unconditional priority) every other signal cycle (assuming an average 90-second cycle). Curb extensions would only be able in areas with on-street parking or shoulders.

With BAT lanes, BRT vehicles and local buses would share a curb lane with local access and right turn traffic. Through an area (such as a downtown) where on-street parking has been allowed, this lane designation could be only during peak periods, allowing for parking during off-periods where buses would have to operate in adjacent mixed-flow.

At the higher end of the bus volume scale (a condition not anticipated on the Valley area roadway system in the foreseeable future), an all-day use of lanes only by buses would be

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<sup>2</sup> Thresholds for peak-hour buses assume an average signal cycle length of 120 seconds. It is recommended that TSP be timed to allow transit priority every other signal cycle, with an intermediate cycle for recovery.

appropriate, along arterials most likely related to the development of median busway treatments, or separate side-of-road busway if under the rare condition right-of-way were available to provide sufficient separation between the arterial and busway facilities.

It is beyond the scope of this study to perform a traffic analysis to determine the precise level of treatment appropriate for each corridor. In developing an estimated capital budget for transit priority treatments in each corridor, PB has followed a general guideline that TSP is most effective at signalized intersections operating under level of service D and E conditions, with a volume-to-capacity ratio between 0.80 and 1.00.<sup>3</sup> BRT corridors facing implementation in the longer-term have the opportunity to incorporate space for queue jump/queue bypass lanes into interim roadway construction or widening projects, which can be restriped for relatively minimal cost once BRT implementation is imminent.

### *Stations*

Stations are key elements of BRT systems in several ways: First, as the gateway to the BRT network, the station influences the customer perception of the system. The station design and the amenities provided at the station simultaneously distinguish a BRT system from other transit services while providing a smooth transition between transit service types.

Second, BRT station placement affects how many stations are present along a route, impacting travel time. The more stations that are located along a BRT corridor, the more a BRT vehicle must stop and the longer the overall end-to-end travel time; therefore, station placement is a trade-off between the ability to serve more destinations and the ability to serve an entire corridor quickly. Station placement also depends on the means of access for passengers. Where passengers tend to arrive by foot, BRT stations should be more closely spaced than where passenger access is mainly through park-and-rides. A general rule of thumb for BRT station spacing is ½ to 1 mile, given that passengers probably will elect to walk a longer distance to access a BRT stop (1/4 to ½ mile). Longer station spacing is acceptable if underlying local bus service is provided with more frequent stops. (In the Valley, local arterial service generally stops every ¼ mile.)

Finally, station layout and curb design must be integrated with passenger vehicles for ease and speed of boarding.

The Main Street LINK and the planning for the Arizona Avenue BRT have established some precedents in amenities and design. (Figure 5 shows a Main Street LINK station under construction at the Alma School/Main stop; not all elements are yet present.) The following are considered essential elements of Main Street LINK and Arizona Avenue LINK stations:

- A placard or sign with the “LINK” logo
- Backlit green ‘halo’ sign band

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<sup>3</sup> Guidelines are based on those in TCRP Report #118, “The BRT Practitioner’s Guidelines”

- Real-time passenger information systems
- Fiberglass vertical shade screens
- Fare vending machines
- Trees

Artistic elements will be incorporated at signature BRT stations in downtown Chandler on Arizona Avenue.

**Figure 5 - Main Street LINK Station**



Source: PB

## RECOMMENDATION

### *Spacing*

BRT stations should be placed primarily at intersections of major arterials with intersecting bus routes or major trip generators/destinations. Stations should generally be about one mile apart, except in downtown areas, where closer spacing would be preferable. (Figure 6 - shows the simplified route structure of the Main Street LINK, in which stations are generally present only at major arterial intersections.)

### Amenities

BRT stations should be sized to respond to the anticipated level of demand. Minimally, a BRT station should incorporate shelter and shade, seating, trash facilities, real-time passenger information systems, static passenger information (maps, agency information, etc.), and landscaping. Where BRT vehicle dwell time is lengthy and/or passenger queues develop at the vehicle entrance, ticket vending machines should be incorporated into the design. All BRT stations should clearly incorporate Valley Metro and LINK logos. Park-and-ride facilities should be located at end-of-line BRT stations as well as at intermediate locations where access is primarily by car.

Figure 6 - Main Street LINK Route Structure



Source: Valley Metro/RPTA.

### Design

It is important to keep in mind the importance of station design in communicating the identity of the transit service. Especially in the Valley, where many BRT customers are new to transit, the station must clearly communicate the type of service that is present at the stop. Service branding elements, such as the LINK logo, must not be lost in the overall station design, and should be prominently displayed so that passengers do not board the wrong service type by mistake.

### Placement

At signalized intersections, BRT station placement should consider any transit priority treatments that are present. TSP is most effective when BRT stations are placed on the far side of the intersection, so that a vehicle activates priority, travels through the intersection, and then

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stops. Queue jumps are most effective paired with near-side stops (so that a vehicle stops to pick up passengers, then triggers the transit signal); and queue bypass lanes should be paired with far-side stations. Station placement will also depend on the availability of right-of-way.

## Vehicles

As the 2009 CBRT Manual notes, the transit vehicle is where BRT customers spend most of their time as they interact with the BRT system. The BRT vehicle is also very visible to non-customers as it travels along Valley roadways; therefore playing an important role in system branding and attracting new customers. BRT vehicles are usually configured in a specific way to decrease boarding times (through low-floor design and interior circulation).

The transit vehicle used on the Main Street LINK service (Figure 7) has responded to these important requirements for BRT vehicles. The New Flyer vehicle used on the LINK service is sleek and stylish. Using ultra low-sulfur diesel fuel for reduced emissions, the LINK vehicle is a low floor model and can be configured in a 45' or 63' articulated vehicle. A mix of 63' and 45' vehicles is planned for Arizona Avenue.

**Figure 7 - New Flyer LINK Vehicle**



Source: Valley Metro/RPTA

## RECOMMENDATION

Continued use of the New Flyer specialized BRT vehicle – or a similarly differentiated vehicle – on arterial BRT routes is recommended to clearly communicate to customers the distinctive service that arterial BRT service provides.

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### *Fare Collection*

Fare collection is an important element of BRT systems because it affects how quickly passengers are able to board, especially at very busy stops. Longer boarding times increase the overall travel time of a BRT vehicle in a given corridor. Fare collection itself can be divided into ticket purchase, validation, and enforcement stages. The discussion of fare collection and BRT systems sometimes includes the fare structure and type of media. The Valley Metro system currently utilizes an integrated fare structure and uses the same fare media across transit services, allowing for ease of transfers across service types.

In the Valley, the local bus system employs on-board fare collection and validation, whereby drivers check that each passenger has a valid ticket/pass as they board. Tickets can be purchased on board a bus although pre-purchase of tickets is encouraged. Off-vehicle fare collection is in place on the light rail system, which uses a proof-of-payment system. (Proof-of-payment indicates that there are no ticket gates at which customers simultaneously validate their ticket and enter a station; instead, anyone waiting within a designated area or on-board a vehicle must have a valid ticket or pass.) Light rail passengers purchase and activate their tickets before boarding a light rail vehicle. Fare enforcement officers conduct random, on-board checks to confirm that passengers have valid passes. Passengers who do not have a validated ticket or pass are fined. The Main Street LINK service will offer off-board fare collection at two stations.

### RECOMMENDATION

It is recommended that the integrated fare system that allows the use of the same fare media on Valley Metro local services, LINK services, and the METRO light rail system be continued.

In addition, the presence of ticket vending machines is recommended at stations where vehicle dwell time or passenger queuing at boarding doors is lengthy.

A future goal should be a transition to off-board fare collection on all arterial BRT routes to allow for all-door boardings. This will further reduce dwell times at stations since riders will be able to board at all doors, not just the front door.

### *Real-time Passenger Information*

Transit customers generally perceive time spent waiting as more onerous than time spent traveling. Studies have shown that knowing when a bus will arrive reduces customer anxiety and stress, and also reduces the perception of waiting times. Real-time passenger information allows passengers to know exactly when their bus will arrive by using intelligent transportation system (ITS) technology to display arrival information at BRT stations via dynamic message signs. A passenger who knows that they have five minutes before their bus arrives not only knows that they have not missed the bus but can also choose to make use of that time.

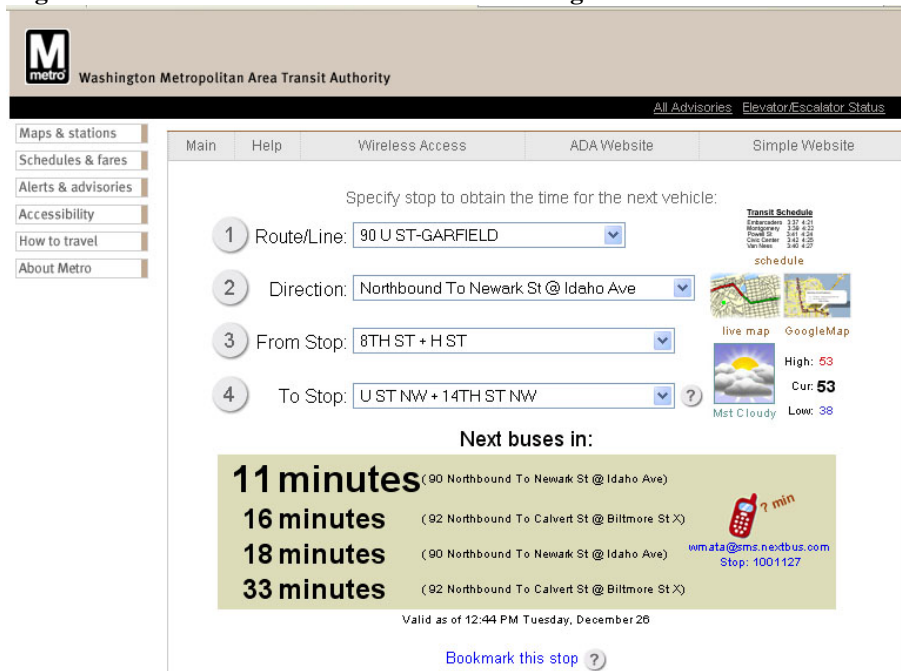
Real-time passenger information requires communications infrastructure on the transit vehicle and at the BRT station. In the Valley, real-time passenger information is already in place at City of Phoenix RAPID express bus stops and on the METRO light rail system.

RECOMMENDATION

Real-time passenger information is a key customer service upgrade on BRT systems and is recommended as a standard station amenity throughout the arterial BRT network.

Valley Metro currently provides a web-based trip planner configured for mobile devices; it is based on route schedules. Future upgrades to the system could allow passengers to obtain real-time information via a website or mobile device, such as a cell phone. This would allow passengers to time their arrival at a BRT station to match that of their bus; minimizing waiting time. This recommended upgrade would be especially significant during the hot summer months. Figure 8 shows a screen capture from the bus traveler information system applied in Washington, DC.

Figure 8 - Real-time Bus Information for Washington DC Metro Buses



Source: Washington Metro website. Note that customers can sign up to receive real-time information as text messages on their cell phones.

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### *Service Planning*

Operating plans for BRT systems include the route structure, service span (i.e., how many hours a day service is operated), and service frequency during times of day and on weekdays vs. weekends. BRT systems are generally recommended to have a simplified route structure (with a straight-forward route configuration with little deviation, less frequent stations than local service, and evenly spaced stops); frequent service; and minimum 16-18 hour service. The goal is for a service that is clearly differentiated from local service, mimics light rail frequencies and service spans, and produces faster end-to-end travel times by operating in a limited-stop manner. A ten-minute headway is generally considered the threshold at which schedules are no longer required.

Ideally, BRT service levels match anticipated boardings. If too much service is offered, resources are not fully utilized. If too little service is offered, BRT boardings may not reach full potential. BRT service many times overlays local bus service, which remains in a corridor but at a reduced service frequency.

### RECOMMENDATION

In general, the Valley BRT system is envisioned to have line-haul, trunk service along the targeted corridors. BRT will overlay local arterial service.

Several BRT corridors may not require the frequent service levels associated with BRT when they are first implemented. In these corridors, BRT service should be implemented at a lower frequency and coordinated with local service to provide maximum service in the corridor. Similarly, while BRT ideally operates 16-18 hours per day, BRT may be implemented in the Valley during peak commute hours only. The goal in providing lower levels of BRT service is to use limited funding in an efficient manner while providing additional service to help grow boardings. As boardings grow, in turn, additional BRT service can be implemented. Once boardings in the corridor reaches 3,000 per day, frequent all-day service should be in place.

Where BRT routes interact with light rail, schedules should be coordinated for minimum waiting time when transferring between modes. BRT and light rail stations should also be close together for minimal distance for transfers.

### **Branding Elements**

Distinctive branding elevates the image of BRT service and informs customers that they need to interact with the BRT system differently than with other bus services. A strong brand, consistently applied throughout the BRT network, serves as a communication to riders and other stakeholders that “transit has changed” in the service area. It ties together all of the elements of the BRT system so that customers easily understand when they are within the BRT system and when they are not. Branding considerations go beyond different color schemes and logos, but extends to service levels, fare policy, and so on.

The Valley Metro brand encompasses local arterial services, certain express bus routes, and dial-a-ride services. However, different brands are already in place. For example, light rail is branded with the METRO brand and logo. The City of Phoenix RAPID express bus system has also emerged as a highly successful service and clearly differentiated brand. (Note: the RAPID brand is copyrighted; LINK is not.) Local circulators in Tempe, Glendale, Phoenix, and Mesa also have their own branded services.

Valley Metro has responded to branding considerations for BRT with the “LINK” brand. LINK services evoke a rail-like transit system in terms of comfort, speed, and reliability. LINK routes achieve this goal through the use of stylized vehicles, upgraded stations, stations spaced roughly a mile apart, and the use of traffic signal priority. The matrix in Table 2 shows branding considerations for implementing arterial BRT services. As transit boardings grows in a corridor, LINK routes should approach rail-like trip frequencies. As previously mentioned, Valley Metro’s fare media is integrated across the local bus, LINK, and rail systems.

### **RECOMMENDATION**

PB recommends that the LINK brand in operation on Main Street in Mesa be extended to BRT corridors that meet these criteria; specifically, Arizona Avenue (as planned), Scottsdale/Rural, and Chandler Boulevard. Use of the LINK brand and should be evaluated for the South Central/Baseline corridor.<sup>4</sup> Where existing boardings levels cannot justify rail-like trip frequencies, service levels are recommended that will help grow boardings, with plans to increase frequencies over time.

Where an arterial BRT service connects with METRO light rail, and where many BRT customers can be expected to include rail as part of their overall trip, the BRT lines should integrate with light rail as a seamless network of higher quality public transit service. BRT trips should be timed for minimal waiting time between bus and rail services. Providing clear wayfinding to and from METRO light rail services is strongly recommended.

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<sup>4</sup> The City of Phoenix’ Transit 2000 referendum called for a RAPID service on the South Central/Baseline corridor.

**Table 2 - BRT Branding Service Outcomes Decision Matrix for Valley Metro Link BRT Services**

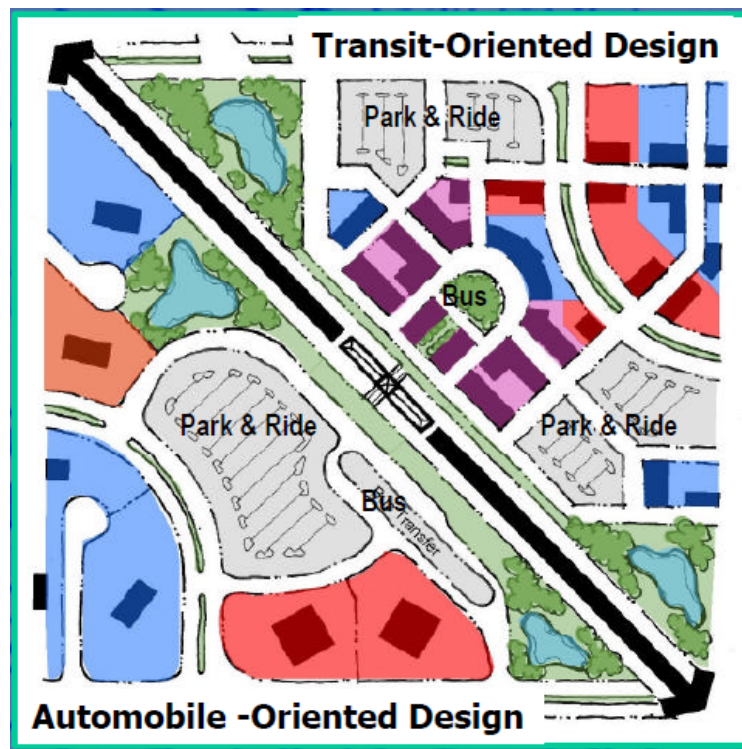
<b>Service Issue</b>	<b>Characteristic/criteria</b>	<b>Comments</b>
<b>Frequency of trips</b>	Same as rail services	METRO services operate on ten-minute frequencies
<b>Service hours</b>	Same as rail services	METRO currently operates approximately 20 hours per weekday
<b>Vehicle</b>	Articulated with livery and interiors similar to rail	Emulates the look and experience of rail as much as a road vehicle can
<b>Connection to other high-capacity transit</b>	Physical interconnections with mail stations and clear wayfinding between services	Ideally, passengers should feel “linked” to METRO as they transfer
<b>Passenger information</b>	Same as rail Marketing literature/signage same?	Use of real-time passenger displays on both LRT and BRT lines are very popular now, as they enhance the seamless network image and passenger convenience
<b>Fare media &amp; policies</b>	Same as rail No transfer fare	The use of the same fare media and integrated fare policy reinforces the idea of a network and enhances passenger convenience
<b>Coordinated schedules</b>	Transfer times coordinated with rail	When passenger demand on the BRT corridor cannot justify rail-like service frequencies, end-of-line transfers between METRO and BRT must be coordinated
<b>Logo/colors/identity</b>	Same or coordinated with rail	Enhances network identity and aids passenger way finding
<b>Station platform/level boarding</b>	Station locations, design, and amenities should all be considered part of the BRT brand (vs. allowance of design individuality to express local community identity)	Like logos, colors and signage, consistent station placement and use of certain design elements aid network identity and passenger way finding. Level/near-level boarding could also be a brand value, enhancing passenger convenience
<b>Cleanliness standards</b>	Same or similar to rail	Expectations of rail passengers will be high
<b>Reduced noise</b>	Same or similar to rail	Advanced propulsion systems on BRT vehicles can achieve lower noise levels
<b>Running way</b>	Convertible to light rail?	Depending on community expectations and goals, some BRT cities have stated that their systems preserve the option for future rail
<b>Parking</b>	Park-and-ride lots	The transit network’s cohesiveness and customer expectations of convenience and travel time savings are enhanced if similar parking provisions are applied to BRT as METRO
<b>Signage</b>	How is way finding for local routes described and portrayed – is it consistent?	Signage must be consistent, particularly in communities where there are many unfamiliar new/choice riders

### Station Access and Station-area Development

BRT systems and transit-supportive land use practices enjoy a mutually supportive relationship. Where transit investment provides more visibility to a given location, development may follow. Development – in turn – provides a built-in audience for transit riders. Design practices directly impact whether and how easily riders can access a station. The following is a set of overarching design principles that successful BRT corridors in the Valley should strive to address.<sup>5</sup>

- *Encourage direct connections to stations from surrounding development in order to promote pedestrian and non-motorized access.* Stations should be designed to allow access from many locations, including existing and future off-site development. Access should be provided on all sides of the station, where possible, and allow direct line-of-sight from drop-off areas to the station. Figure 9 - illustrates these principals and shows the difference between transit-oriented design and auto-oriented design.

**Figure 9 - Transit-Oriented Design vs. Auto-Oriented Design**



Source: PB PlaceMaking

<sup>5</sup> This section provides general guidelines on promoting transit-oriented development. For specific examples of where BRT has influenced station-area development, see *Benefits of BRT in Selected Case Study Cities* by Ian McNamara of the University of California, Berkeley. An electronic copy is located here: [http://path.berkeley.edu/informationclearinghouse/planning/case\\_benefits.html](http://path.berkeley.edu/informationclearinghouse/planning/case_benefits.html)

- **Enhance intersection crossings to promote walkability.** In the Valley, BRT stations will typically be located along arterials with wide streets and heavy traffic, which can be intimidating for some people to cross. Refuge islands are recommended in medians when pedestrians are required to cross three or more lanes of traffic. Crosswalks could also be marked with contrasting color or material.
- **Create inviting streetscapes.** People are more likely to walk longer distances to reach stations when the pedestrian environment is pleasurable. Shade can be provided by trees or building awnings. Planters can provide separation from the street and enhance the character of the street. Human-scaled sidewalk materials, including bricks and tiles, can be more inviting than large concrete slabs. Seating can provide resting areas along the street and accent lighting can create interest at night. Figure 10 illustrates such a streetscape treatment in the Verrado development in Buckeye.

**Figure 10 - Streetscape in Verrado (Buckeye)**



Source: PB PlaceMaking

- **Ensure safe lighting.** A lighting plan is recommended that locates sufficient lighting from all possible access locations. General lighting should be overhead, with lower elevation lighting to highlight changes in level or materials. Specifically, lighting should be located to illuminate the faces of people walking on paths and walkways. Overhead

lighting can be located at levels from 8 to 16 feet above ground. Lower level lights should be designed to be vandal resistant.

- **Encourage pedestrian services and uses.** The provision of pedestrian services could vary based on station size and could include amenities such as restrooms, information kiosks, emergency telephones, water fountains, security cameras and video screens, and wireless internet. Additional services could be provided in larger stations to allow vendor services for food and incidentals.

**Figure 11 - Residential and Office Uses Over Retail in Verrado (Buckeye)**



Source: PB PlaceMaking

- **Establish innovative zoning to allow a mix of uses.** A variety of land uses – residential and non-residential – can be viable at and adjacent to stations. A vibrant mix of uses can also create more activity at the stations, thereby making it a safer environment. A mix of uses can be provided through mixed-use zoning or a station overlay district policy. Figure 11 illustrates new mixed-use development in Verrado that could be developed next to BRT stations.
- **Provide meaningful open space.** A gathering of people tends to attract other people. Locating open spaces adjacent to stations can create safe and inviting environments. Open spaces can vary in size and include hardscaped plazas or landscaped parks. Open spaces can be extensions of the street and can organize other development including residential, commercial, institutional and retail uses.

- 
- *Create land use opportunities adjacent to stations.* Station area plans are recommended for each station location. In addition to identifying access to the station, the plan should identify adjacent land use opportunities that could benefit from the proposed station, and recommend the appropriate zoning for the surrounding land uses.

### **Ideal BRT Land Uses**

While many uses are compatible with BRT stations, some land uses provide more benefit than others:

- *Destination uses.* These uses include destinations where people travel daily, such as employment centers, multifamily housing and schools. Less frequent destinations include shopping malls, hospitals and public parks.
- *Neighborhood services.* These provide necessary services that people visit on their way to other destinations. These include grocery stores, Laundromat, dry cleaning, pharmacy and other types of uses.
- *Spontaneous and discretionary uses.* These uses offer convenience to the BRT rider and can include restaurants, coffee shops, book stores, magazine vendors, florists and other similar uses.

### **Development Practices and Strategies**

- *Public/Private Partnerships.* These partnerships are established when desired development may not be fully supported by the market or when there is public benefit that requires a public partnership. Private developers can team with public land owners to reduce risk to both parties and achieve results beyond what the market could provide. Mixed-use BRT and light rail stations are examples of where this strategy may be of benefit.
- *Vest entitlements for the time needed to realize desired development.* To encourage a desired development pattern, municipalities could vest entitlements without expiration if development is based on a previously approved development plan. This tool will allow a developer to focus on developing appropriately with market cycles and not be at risk for loss of entitlements. With this vesting, the municipality can also request high quality development based on rigorous standards and guidelines.
- *Land banking to preserve opportunities.* Municipalities can employ land banking with land leases to preserve a location until desired development is viable. If a municipality has identified a site to be a future BRT station, that municipality could purchase the site to control the use of the site. If the station is identified for construction in 10-20 years, the municipality could lease the site for temporary uses and use the lease payments to pay down the purchase price of the property.

## RECOMMENDATION

While the Valley has been hit hard by the current recession, the slowdown in development actually provides an opportunity for municipalities to carefully consider how their land use, zoning, and design practices can be shaped to support eventual BRT implementation. It is recommended that cities actively identify where transit-supportive land use and design elements can be incorporated into BRT corridors and station areas.

*Summary of BRT Elements and System Recommendations*

Table 3 summarizes how each BRT element affects travel time, system identity, and/or the customer experience.

Table 3 - Summary of BRT Elements

Element	Improved Trip Times	System Identity	Customer Experience
Running way & traffic signal priority	Prioritizes transit at intersections	Queue jumps increase visibility	Improves system reliability
Stations	Mile spacing reduces time spent at stops	Stations incorporate identity elements	Stations provide passenger amenities
Vehicles	Low-floor vehicles speed boarding	Vehicles have distinct design	Vehicles are spacious, quieter, with lower emissions
Fare collection	Ticket vending machines allow faster boarding/ lower dwell times	-	Integrated fares provide seamless travel throughout system
Real-time passenger information	-	Contributes to premium service feel	Lessens customer anxiety when waiting
Service planning	More efficient scheduling and running times	-	More transit service available
Branding	-	Identifies BRT as a distinct service	Different transit services are clear
Station Access/TOD	-	-	Better access to stations and destinations

In summary, arterial BRT systems in the Valley will be defined as:

- Limited-stop service, with stops at major arterials and/or major route destinations only.
- Transit priority treatments (such as signal priority and queue jumps) where local traffic conditions are favorable.
- Identity and branding treatments to stations, vehicles, and passenger information to identify the arterial BRT network as a distinct transit service.
- Incorporation of real-time passenger information at stations.

- 
- All-day service layered over local arterial service and coordinated with other high-capacity transit services, particularly light rail and other BRT routes.
  - Transit-supportive development and design policies in place throughout the BRT corridor.

The next section provides recommendations for each BRT corridor.

## 2.2. Route-Specific Recommendations

This section identifies recommendations for each of the BRT corridors included in the study, specifically focusing on service planning and costs. Where costs identified are greater than funding provided in the RTP and the 2007 RTP Evaluation, the goal is to provide agencies and municipalities involved in the implementation and provision of each BRT corridor an opportunity to identify additional funding sources. Additional considerations for corridor implementation are included where applicable. Within the recommendations for each corridor, a broad set of land use opportunities and strategies is identified to help leverage the implementation of BRT.

### *Arizona Avenue/Country Club Road - FY2011 (July 2010)*

Final design has been completed for the Arizona Avenue/Country Club Road BRT corridor and construction of right-of-way improvements are anticipated to begin in late 2009. Service on the BRT corridor is scheduled to begin in July of 2010. Current transit provision in the corridor is a weekday-only local service, with estimated corridor boardings of 1,800 per day. Boardings estimates indicated a strong response to BRT treatments, with a sizeable remaining demand for local services. The boardings estimates also predicted a strong audience for transfer activity to light rail at the northern terminus of the BRT route. Since the route has been branded as LINK service, it will be referred to as the “Arizona Avenue LINK” for the remainder of this document.

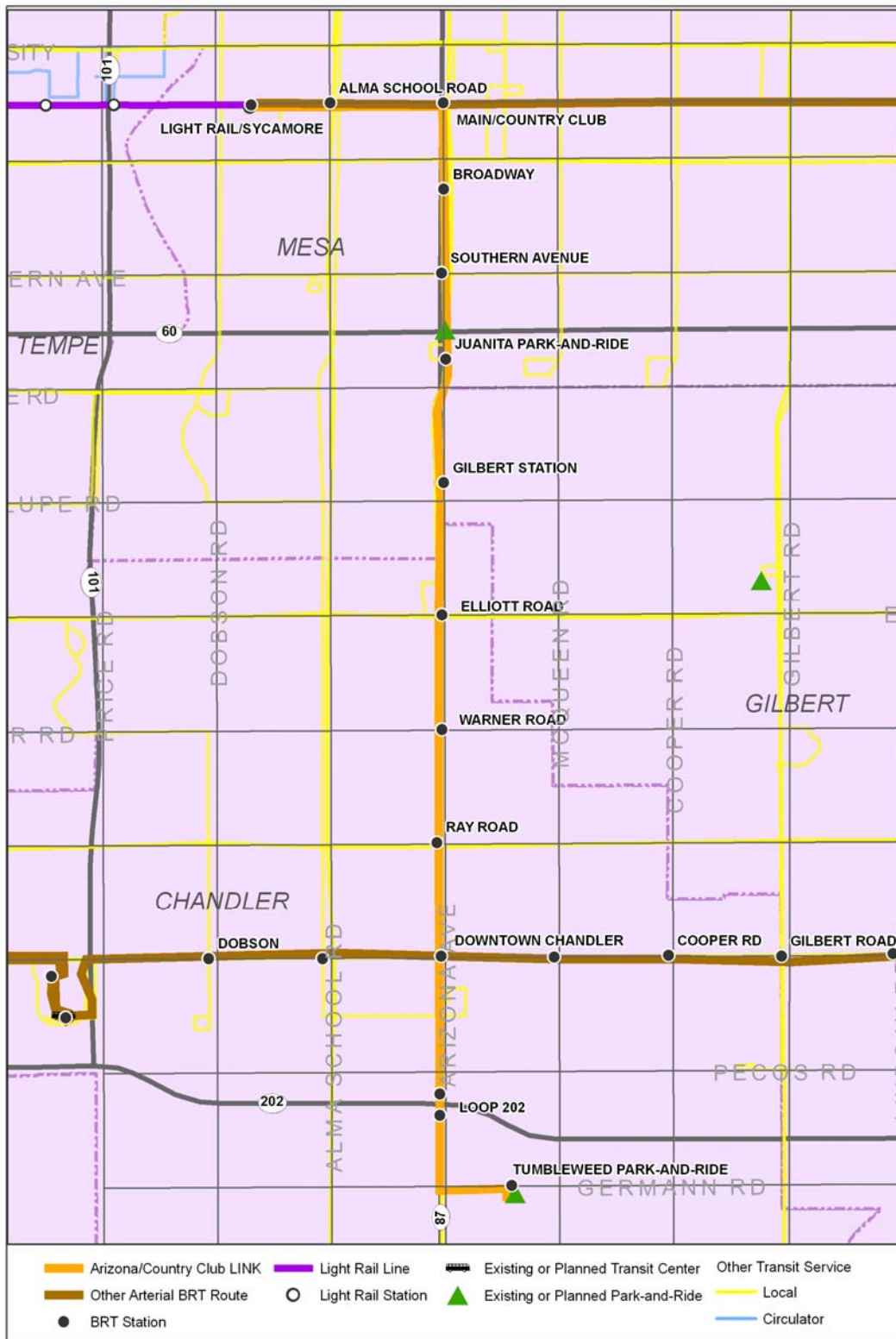
### **Running Way & Traffic Signal Priority**

The Arizona Avenue LINK will operate as a mixed-flow arterial service, with queue jumps and a transit signal at Elliot Road, Warner Road, and Ray Road in Chandler. Traffic signal priority treatment is present throughout the corridor at intersections with minor arterials. This treatment provides an early green light and an extended green light for the BRT vehicle if overall traffic flow permits. (Information on transit priority treatments is based on discussions with City of Chandler and City of Mesa representatives about the corridor’s final design.)

### **Stations**

Stations are planned for intersections of major arterials and downtown locations (see Figure 12). On average (throughout the corridor) stations are spaced every 0.86 miles. Park-and-ride facilities will be present at three stations: the Tumbleweed Park-and-ride in southern Chandler and the planned Juanita/Country Club park-and-ride in Mesa will be utilized by both LINK riders and express bus riders. The park-and-ride at the Main/Sycamore LRT station can be used by reverse commuters taking LINK into Chandler. Transfers between LINK and LRT will be available at the Main/Sycamore station. Transfers between LINK and local bus routes will be available at Main Street (Route 40), Broadway Road (Route 45), Southern Avenue (Route 61), Elliot Road (108), and Chandler Boulevard (Route 156). Transfers will be available to a new local service on Ray Road, planned for July 2014.

Figure 12 - Arizona Avenue/Country Club LINK Corridor



## Service Planning

Table 4 summarizes service level recommendations. Rather than defining near, mid, and long terms by years, boardings thresholds are suggested, with an estimated year of achievement.

**Table 4 - Arizona Avenue LINK Service Recommendations**

	Service span (hours)	Peak headway (minutes)	Off-peak headway (minutes)
<b>Near-term (existing boardings)</b>			
Weekday			
BRT service	18	15	30
Local service	18	30	30
Weekends*			
BRT service	17	n/a	30
Local service	17	n/a	30
*Weekend BRT service would start in 2011, when local weekend service is also scheduled to begin.**			
<b>Mid-term (2,500 daily riders in corridor; est. 2015)</b>			
Weekday			
BRT service	18	15	20
Local service	18	30	30
Weekends			
BRT service	18	30	30
Local service	18	30	30
<b>Long-term (3,000 daily riders; est. 2020)</b>			
Weekday			
BRT service	20	10	15
Local service	18	15	30
Weekends			
BRT service	18	30	30
Local service	18	30	30

\*\* 2009 update to TLCP moved the start year for regional funding of Arizona Avenue Supergrid Service to 2016. 2010 update to TLCP may also amend this start date. Weekend service on the LINK could be funded through a regional funding shift between Supergrid and the LINK once the former begins service.

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Given the existing boardings in the corridor, early years of LINK service should be planned at a lower frequency than required to match METRO service, which has 10-minute headways. Alternating service on local route 112 and LINK service can provide a more frequent headway in the early years of LINK service, as boardings grow. It will allow a choice for people while LINK service is introduced and service patterns are further established and understood.

When service is introduced in the early years, local and LINK service should have identical headways to provide the maximum service coverage for all riders. Average running speed was calculated at 12 mph for local service and 18 mph for LINK<sup>6</sup>. Based on these estimates, end-to-end travel times are 60 minutes for local service and 40 minutes for LINK service. Since the average speeds of LINK and local service differ, uniform headways between LINK and local trips cannot be maintained throughout the corridor. PB recommends that the two services be timed such that they provide an equal headway interval at the METRO station. Outbound routes originating at the Main/Sycamore station would be timed for departures every 15 minutes, but would arrive at Tumbleweed at intervals of five and 25 minutes.

In the mid-term, service levels on BRT should be increased to respond to anticipated growth in travel demand in the corridor. (Boardings estimates showed growth potential of about 12% between 2010 and 2015 on weekday trips, and depending on the service level, levels of boardings approaching the Very Small Starts threshold for frequent BRT service of 3,000 daily boardings.)

In the long term, estimated at 2020, boardings estimates showed daily corridor boardings exceeding 4,000 with frequent BRT layered over local services. Therefore, service levels are increased to a ten-minute peak headway and 15-minute off-peak headway.

#### *Coordination between LINK, METRO, and local service*

In the mid-term, weekday service levels on LINK and on arterial services would be enhanced to a degree that schedules would not have to be as closely coordinated as in the near term. PB recommends that weekend service be introduced with local arterial service in order to grow boardings before implementing weekend LINK services at a frequency of every 30 minutes.

In the long term, boardings in the corridor is expected to exceed the 3,000 threshold established by Very Small Starts guidelines. Once service frequencies are enhanced accordingly, Arizona Avenue LINK services will allow very little to waiting time between transfers to METRO. Implementation of weekend LINK services is recommended at this time, assuming local service is generating boardings.

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<sup>6</sup> Speed calculations for existing services are based on current schedules; estimate for LINK services is based on estimated speed by TranSystems, design consultants.

## **Costs**

### *Capital*

Capital requirements for improvements to the right-of-way and stations for the Arizona Avenue LINK route are estimated at \$28 million (in 2010\$) (including the cost of BRT vehicles).

### *Operations*

Annual operations costs (in 2010\$) for the recommended BRT service levels are the following:

- Near term (2010): \$1.94 million
- Mid-term (2015): \$2.75 million
- Long-term (2020): \$2.79 million

The planned costs in the 2007 RTP Evaluation showed annual funding for BRT operations in the Arizona Avenue corridor at \$777,000 (\$2010). (Detailed cost estimates are shown in Appendix II.)

## **Vehicle requirements**

Vehicle requirements for the recommended Arizona Avenue LINK service levels are the following:

- Near-term: 7 vehicles
- Mid-term: 7 vehicles
- Long-term: 11 vehicles

(Vehicle requirements assume 10% minimum layover/recovery time and 15% allowance for spares. Calculations are shown in Appendix IV)

## **Land Use and Development Opportunities**

The Arizona Avenue LINK corridor connects Downtown Mesa to Downtown Chandler and beyond to south Chandler and the Tumbleweed park-and-ride. This route includes the jurisdictions of Mesa, Gilbert and Chandler and passes through development at various stages and of various types.

Some specific development opportunities are identified below. Station locations that are not mentioned specifically should be integrated into the adjacent neighborhoods, providing pedestrian connectivity from the residential areas to the station and provide neighborhood serving uses when possible.

### *Main Street to US 60*

The northern portion of the corridor is adjacent to residential, commercial and retail development, including several vacant lots available for near-term development. Existing density along the corridor suggests compatibility for additional horizontal, mixed-use development contributing to neighborhood-center type development. The downtown area near

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Main Street could accommodate a public/private development with a transit station, which could be developed as an integrated focal point of downtown Mesa. The northwest and northeast corners of the Main Street/Country Club Road intersection are underutilized, with fast food development at corners and vacant land adjacent.

Broadway Road to Southern Avenue is characterized by medium and high-density residential uses and commercial and mixed-use development. Limited vacant land is present; however, key development opportunities exist if the stations are integrated into existing commercial development. Some vacant land exists at 10<sup>th</sup> Street.

A park & ride is planned at Country Club and Juanita. The park-and-ride could be integrated with commercial uses to support many neighborhood and regional services and accommodate daily services for transit users including: pharmacies, dry cleaners, auto service and many others.

#### *US 60 to Elliot Road*

Several smaller parcels are vacant near the potential station location at south of US 60. The parcels could provide opportunities for medium to high-density transit-related, mixed-use uses that could be influenced by their proximity to US 60 and Baseline Road, including shared use in the vicinity of the Wal-Mart at the northeast quadrant of the intersection, as well as at the business park to the southwest.

Between Baseline Road and Elliot Road, Arizona Avenue passes through the cities of Mesa and Gilbert. Current development includes a business park, medium and high density residential, light industrial, and neighborhood commercial at the major intersections. The many vacant parcels immediately adjacent to the LINK route could be encouraged for medium-density uses to support transit users. Several vacant parcels exist on the east side of Arizona Avenue between Guadalupe Road and Desert Street (the previous site of several car dealerships). Significant vacant land exists near Elliot Road, which can be developed to support medium-density mixed-use activities conducive to transit user needs.

#### *Warner Road to Germann Road*

This portion of the LINK corridor passes through the heart of historic Downtown Chandler. Though this is an older area of the City, significant revitalization and infill development has already taken place. A variety of uses including commercial, office, public, and residential of various densities is in place, providing a transit-supportive level of density and access environment. Commercial nodes at the intersections of Warner Road and Ray Road focus on neighborhood or community commercial. Vacant parcels near the Ray Road intersection could support significant development of community uses that support transit use.

The portion of Arizona Avenue from Pecos Road to Germann Road (extending to the Tumbleweed park-and-ride on Germann Road) is within the City of Chandler's designated Airpark Focus Area, which includes a mix of employment, commercial, residential and open space that must be compatible with aviation needs. The area between Pecos Road and Willis

Road is being developed as major regional commercial use. There are several vacant parcels existing around the stations identified between Pecos Road and Germann Road could be developed to support neighborhood and transit-friendly uses.

Medium density uses including general employment exist south of Willis Road to Germann Road and along Germann Road to the Tumbleweed Transit Center. New development near the transit center could support many neighborhood and regional services and accommodate daily services for transit users including pharmacies, dry cleaners, auto service (due to the proximity to the park-and-ride), among others.

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### ***Grand Avenue***

Grand Avenue is a partially access-controlled roadway, and is designated as U.S. Highway 60. Existing transit use in the corridor consists of peak-direction commuter services, with boardings of about 420 riders per day.<sup>7</sup> Development along Grand Avenue is sporadic. While the corridor is anchored by downtown Phoenix at its southeast end, development quickly transitions from vertical mixed uses to light and heavy industrial as one travels northwest. Although Grand Avenue passes through the downtown areas of Glendale and Peoria, it is grade-separated in these sections. Large patches of undeveloped areas are also present throughout the corridor. Finally, Grand Avenue is paralleled on the west side by the BNSF railway, an active freight corridor which acts as a further barrier to access.

For these reasons, Grand Avenue presents a better opportunity for continued commuter-oriented express bus services rather than for a Valley arterial BRT service. Funding for the Grand Avenue Limited in the 2007 RTP Evaluation assumed two-way service in the peak periods for the Grand Avenue Limited. Recent experience on bi-directional express bus routes suggests demand for service in the off-peak direction may still be limited, however. PB recommends that the Grand Avenue Limited continue to operate as a peak-period, peak-direction only, express bus service. No recommendations are made for right-of-way improvements for the Grand Avenue Limited.

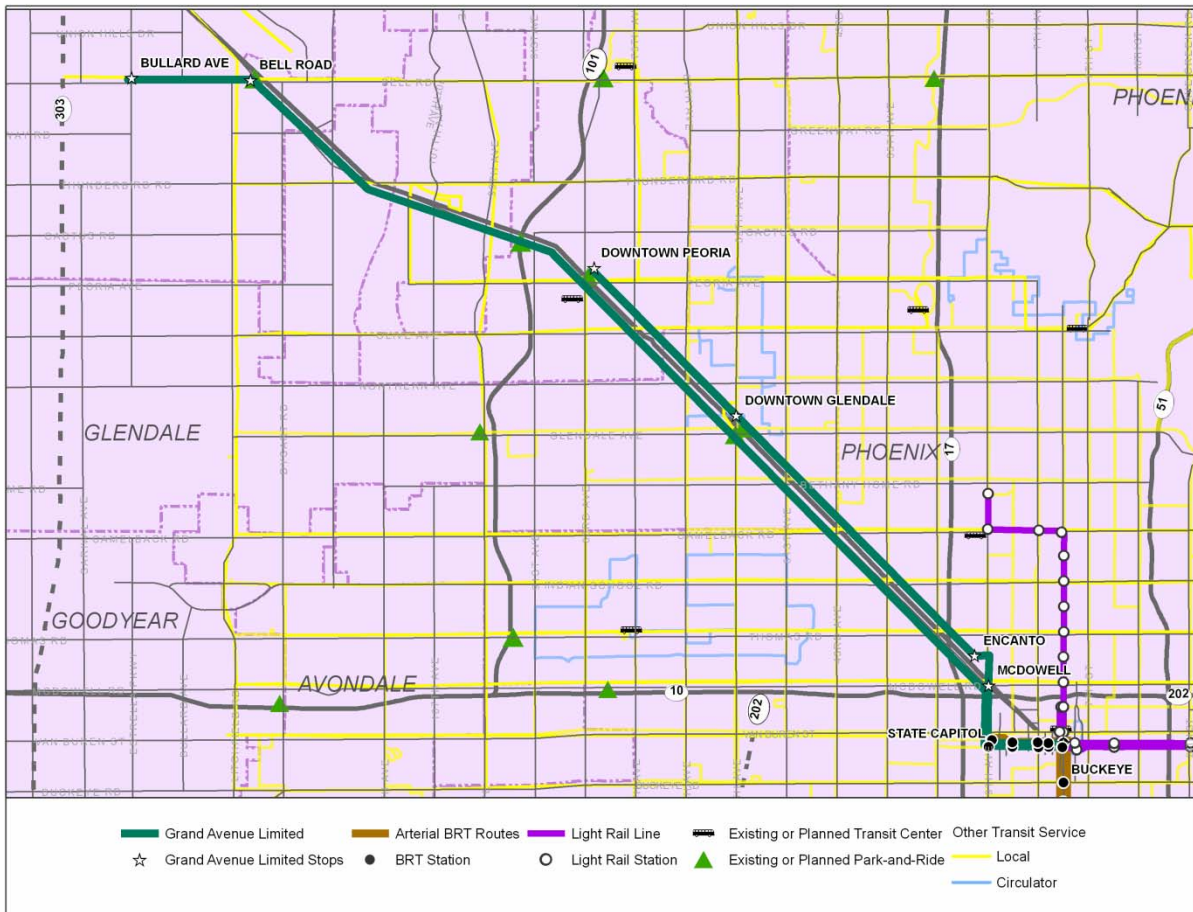
### **Service Planning**

Operational issues for the Grand Avenue Limited concern how stops are scheduled for each trip. Service between the Grand Avenue Limited and express route 571 (which originates in Surprise and travels non-stop to downtown Phoenix) should be coordinated and restructured to reflect traveler preference for non-stop travel between origins and destinations on long-distance routes. Under this restructuring, one route would follow the current service pattern of route 571, with origination at the planned Surprise Aquatic Center park-and-ride and a second stop on Greenway Road at Dysart in El Mirage before proceeding non-stop to downtown Phoenix. The second route would originate at the downtown Peoria park-and-ride, make stops at Peoria Avenue/84<sup>th</sup> Avenue, 67<sup>th</sup> Avenue/Northern Avenue, the planned downtown Glendale park-and-ride/transit center and then proceed to downtown Phoenix, as shown on Figure 13.

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<sup>7</sup> Valley Metro's June 2009 monthly ridership report showed a daily average of 159 passengers on express route 571 and 273 on the Grand Avenue Limited.

Figure 13 - Grand Avenue Limited Corridor



To maximize funding provided for the Grand Avenue Limited route, PB recommends gradual service increases paired with route restructuring such that some trips originate/terminate in Surprise, and others in Peoria. Service recommendations are summarized in Table 5. Because implementation is more than ten years out, specific year recommendations are not identified beyond near-term, mid-term, and long-term.

**Table 5 - Service Recommendations for Grand Avenue Limited**

	<b>One-way Trips per day</b>	<b>Trips &amp; Direction</b>
<b>Near-term</b>		
Origination		(Peak direction only)
Surprise	8	4 inbound, 4 outbound
Peoria	10	5 inbound, 5 outbound
<b>Mid-term</b>		
Origination		(Peak direction only)
Surprise	10	5 inbound, 5 outbound
Peoria	12	6 inbound, 6 outbound
<b>Long-term</b>		
Origination		Two-way service
Surprise	14	AM: 5 inbound, 2 outbound PM: 5 outbound, 2 inbound
Peoria	16	AM: 6 inbound, 2 outbound PM: 6 outbound, 2 inbound

**Costs**

*Capital*

No right of way improvements are recommended for Grand Avenue. However, signal timing should be coordinated along the route to ensure efficient travel. The possibility of implementing transit signal priority at “choke points” along the route (19<sup>th</sup> Avenue, 35<sup>th</sup> Avenue, and Bethany Home Road) should be investigated but may be complicated by the presence of six-point intersections at each of these locations and by designation as a state highway.

*Operations*

Based on recommended service levels, annual operating costs would be the following:

Near term: \$570,000

Mid-term: \$694,000

Long-term: \$952,000

(Costs are in \$2010 and assume a contracted revenue mile rate of \$6.)

**Vehicle Requirements**

Based on the service recommendations, vehicle requirements would be as follows:

Near-term: 10 vehicles

Mid-term: 13 vehicles

Long-term: 14 vehicles

(Vehicle estimates assume 10% minimum layover/recovery time and 15% allowance for spares.)

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### ***Scottsdale/Rural***

The Scottsdale Road/Rural Road corridor is an existing transit corridor anchored by major employment centers and including downtown employment destinations and regional shopping centers.

An Alternatives Analysis (AA) is underway to evaluate the alignment and technology for a high-capacity form of transit in a corridor centered on Rural Road, south of the Loop 202. (Appendix I shows the study area.) The AA examines only the “Rural Road” portion of the corridor; the “Scottsdale Road” portion (north of the Loop 202) is not part of the analysis. At the time of this report, a final recommendation has not been identified for the South Rural corridor.

Boardings on the entire Scottsdale/ Rural corridor currently exceeds 6,000 riders per day, but the southern portion of the route accounts for about 60% of riders. The separation of the Scottsdale/Rural corridor into two sub-corridors allows greater flexibility and recognizes the differing boardings levels and travel patterns in the corridor. Therefore, the remainder of this section focuses on the Scottsdale Road portion of the corridor, between Scottsdale Airpark and Tempe Transit Center (as shown in Figure 14). Recommendations for the southern portion of the corridor will be completed by the South Tempe AA study.

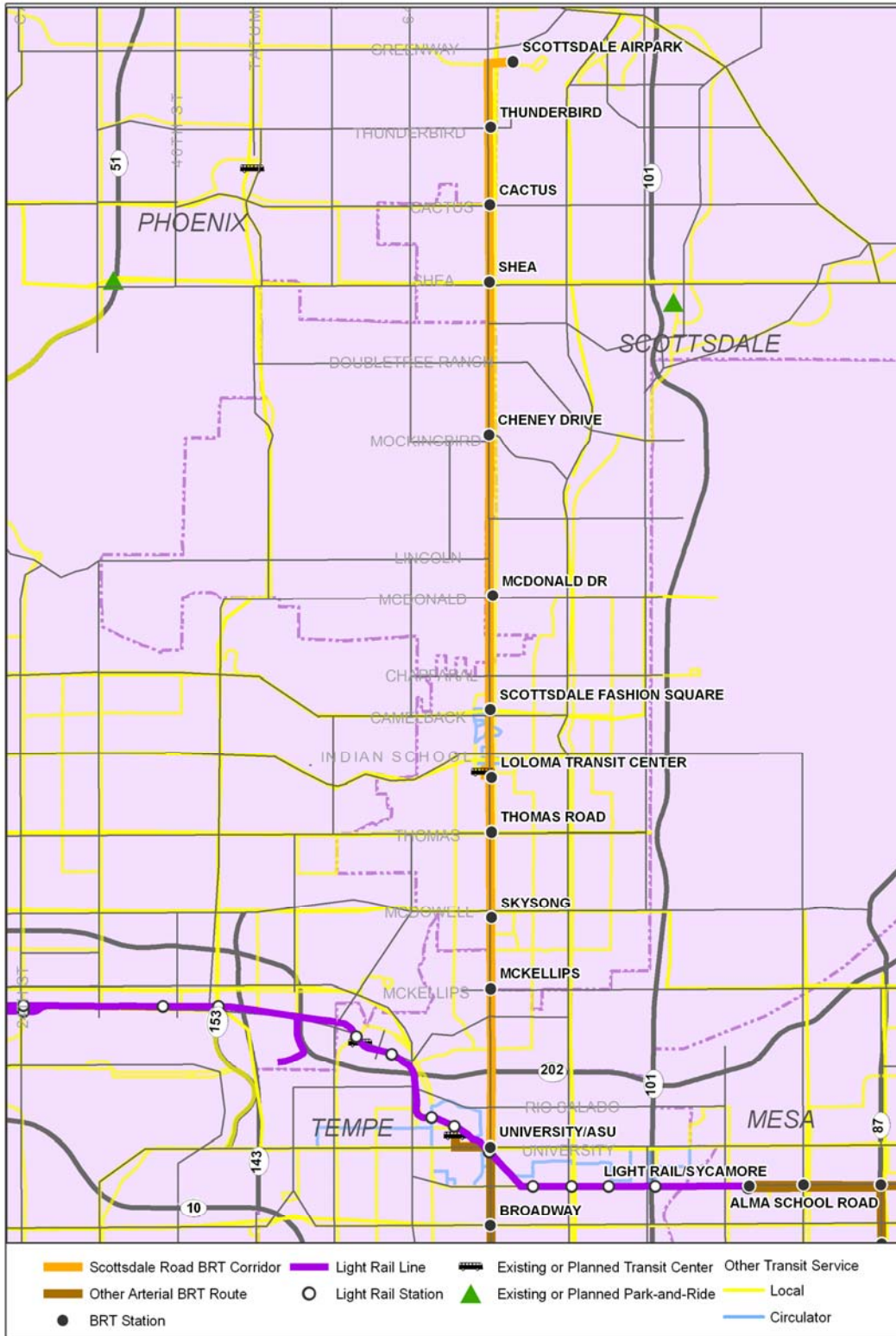
### **Stations**

Stations would be located roughly every mile along the Scottsdale Road corridor, at intersections of major arterials, as shown on the route map. In the portion of the corridor that borders the Town of Paradise Valley, stations are widely spaced given the very low density development in the area. A station is recommended to serve employees of resorts in the vicinity of Cheney Drive. BRT boardings estimates reflect an anticipated demand to the Scottsdale Airpark area; therefore, PB recommends extension of the Scottsdale Road BRT approximately 2.7 miles north of the originally-planned terminus at Shea Boulevard. On average throughout the corridor, stations would be spaced 1.2 miles apart, with the northern portion slightly farther apart at 1.4 miles.

While a joint-use park-and-ride is present at Dial Tech Center, dedicated park-and-ride locations along the corridor are not currently identified, but would ideally be placed near the northern and southern termini. Locations near Scottsdale Airpark, Shea Boulevard, and McKellips Road could all serve potential commuters. (The “Station Area Development” section discusses challenges and opportunities for park-and-rides along this corridor.)

Transfers to cross-town routes could be made at Greenway Road (Route 154), Shea Boulevard (Route 106), Camelback Road (Route 50), Indian School Road (Route 41), Thomas Road (Route 29), McDowell Road (Route 17), at Loloma Transit Center (Route 66) and University Avenue (Route 30).

Figure 14 - Scottsdale Road BRT Corridor



### Running Way/Transit Signal Priority

While traffic studies have not been completed for the Scottsdale Road portion of the corridor, existing boardings demand suggests service levels that could be accommodated by a “lite” BRT treatment on Scottsdale Road, with operations in mixed-flow arterial conditions, with transit signal priority, queue jumps, and curb extensions in downtown Scottsdale (where on-street parking is permitted) applied in the corridor if right-of-way is available.

### Service Planning

According to modeling estimates, transit boardings in the Scottsdale Road corridor currently approaches that of Very Small Starts requirements. A high service frequency is therefore recommended at time of implementation. As mentioned, BRT service is often paired with service reductions to local services; if this is an option then funding can be reallocated to the Scottsdale Road BRT. A slight reduction in weekday local service paired with high-frequency BRT is summarized in Table 6. (Because this service is recommended for long-term implementation, only an initial implementation level is provided.)

**Table 6 – Transit Service Recommendations for Scottsdale Road Corridor**

	Service span (hours)	Peak headway (minutes)	Off-peak headway (minutes)
Weekday			
BRT service	18	10	15
Local Service	17	20	20
Weekend			
BRT service	14	20	20
Local Service	(as planned)		

### *Additional Operational Considerations*

These recommendations address frequencies in the Scottsdale Road portion of the corridor only; however, service planning should be coordinated with service on the southern portion of the corridor. If lower frequency BRT service on the northern portion of the Scottsdale/Rural corridor than the southern portion is acceptable, operational considerations could influence how the corridor is presented. The entire corridor could be viewed as a single route, with lower frequencies on the northern portion; or the Scottsdale Road BRT could operate as an independent route operating between Scottsdale Airpark and downtown Tempe. Creating two separate routes could be clearer operationally, but would force through passengers to transfer. Space constraints at the downtown Tempe Transit Center could impact the ability of the Scottsdale Road BRT to stop and dwell at that station without facility expansion. Depending on

the structure of the Scottsdale Road and Rural Road BRT routes, use of the Rural/University Transit Center may be an alternative for end-of-line layovers.

The pros and cons of each approach should be examined in future corridor planning efforts.

## **Costs**

### *Capital*

Capital costs for improvements to the Scottsdale Road corridor (in 2010 \$) are as follows:

- \$22.4 million (including vehicles)
- \$1.531 million per mile (including vehicles)
- \$15.8 million (without vehicle cost)
- \$1.1 million per mile (without vehicle costs)

Detailed costs are shown in Table 7.

### *Operations*

At the high frequency levels recommended (and summarized in Table 6), annual BRT service operating costs would approach \$3.8 million; weekend services at the levels suggested in Table 6 would add a further \$800,000. (Costs are presented in \$2010, and assume a \$6/mile contract operating rate.)

## **Vehicle Requirements**

BRT service at the frequencies recommended would require 12 vehicles (including layover time and allowance for spares). Note: this recommendation applies only to the northern portion of the Scottsdale/Rural corridor and does not address interlining of services.

**Table 7 Capital Cost Estimates for Scottsdale Road Corridor**

		Unit cost	Number	Corridor cost
Standard BRT Station		\$ 334,000	20	\$ 6,680,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Standard shelter		\$ 205,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Artistic BRT Station		\$ 441,000	2	\$ 882,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Artistic Shelter		\$ 312,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Traffic Signal Priority	per mile	\$ 12,750	14.6	\$ 186,150
Queue bypass w/ farside stop pullout				
Major arterial	per queue jump	\$ 300,000	6	\$ 1,800,000
Curb Extension				
Downtown	per extension	\$ 40,000	4	\$ 500,000
<b>Capital subtotal</b>				<b>\$ 9,548,150</b>
Planning & Env. Clearance			15%	\$ 1,432,223
Final Design & Permitting			15%	\$ 1,432,223
Construction management			10%	\$ 954,815
Contingency			25%	\$ 2,387,038
Vehicles	per vehicle	\$ 550,000	12	\$ 6,600,000
<b>Total cost (including vehicles)</b>				<b>\$ 22,354,448</b>
<b>Cost per mile (including vehicles)</b>				<b>\$ 1,531,127</b>
<b>Total cost (NOT including vehicles)</b>				<b>\$ 15,754,448</b>
<b>Cost per mile (NOT including vehicles)</b>				<b>\$ 1,079,072</b>

## Station Access and Station Area Development

The current transit service along this corridor has high boardings due to a mix of origins and destinations along the route. Supportive station area developments would enhance the already successful transit corridor.

### *McKellips Road*

This location is envisioned as a potential station with primarily residential uses, some strip commercial uses and larger-scaled neighborhood serving uses on the southeast corner, anchored by Food City. Due to the proximity and large number of residential uses, additional neighborhood services may be supported. When redevelopment is viable for the southeast parcel, appropriate development could include medium to high density commercial mixed-use with support for transit uses.

### *Thomas Road*

This location is envisioned as a potential station with primarily low density non-residential uses to the north and limited neighborhood serving uses to the south. When redevelopment is viable, the north parcels could be assembled to create a larger site to support a medium-density mixed-use development including residential and additional neighborhood serving uses.

### *Camelback Road*

This location is envisioned as a potential station and contains primarily medium and high density residential, shopping and neighborhood serving uses and is intersected by the CSR canal. The northeast corner could provide additional redevelopment opportunities to build on the west side improvement efforts, and could integrate the station in the development.

### *Chaparral Road*

This location is envisioned as a potential station with primarily low density neighborhood serving uses and abandoned automotive uses surrounded by residential. The southwest parcel is approximately 34 acres and could support medium density mixed use development and transit user services. The northwest parcel contains primarily non-residential uses and the current site develop suggests that this corner could contain multiple land owners and would require verification. At the appropriate time, this corner could be assembled and developed with a medium-density mix of uses. The southwest and northeast corners contain similar shaped non-residential uses fronting the arterials with residential uses located behind. When redevelopment becomes viable, these corners could also support a medium-density mix of uses and provide direct access to the residential neighbors behind.

### *Cheney Drive*

This potential station is surrounded primarily by residential, hotel, and conference-support uses. Limited substantial redevelopment appears viable within a quarter mile distance.

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### *Shea Boulevard Park and Ride*

This location is envisioned as a potential station and park and ride. This intersection contains medium density commercial, with nearby multifamily and medical uses. At the appropriate time, the northeast 35 acre site, and the southeast site could be redeveloped to support a medium to high density mix of uses including residential, retail, and office. The west side parcels are comprised of smaller block patterns and could benefit from higher density development that accommodates better access than the east side. Due to the higher relative activity and density in this area, a park and ride station could benefit from multilevel parking with ground floor commercial and possibly office or residential above.

### *Cactus Road*

This location is envisioned as a potential station and contains primarily low density residential uses and Cactus Park, which is a desired location within the community due to the open space and recreational facilities offer at the park. Non-residential land does is not available within a quarter mile distance. Consequently redevelopment opportunities do not exist unless a zoning change is approved in the future. This station could provide services for recreational and transit users.

### *Greenway-Hayden Parkway*

The final station along the alignment is at the Scottsdale Airpark, which is a key employment center and offers shopping, office, and nearby multifamily uses. The station will be a destination for many and could also serve as a park and ride location to capture the southbound demand for residents in North Scottsdale. A park and ride at this location would need to be integrated into existing development since significant vacant land is not available in this area. With the Scottsdale Quarter under development, possibly the least utilized site would be located north of Greenway-Hayden Parkway. Further market demand and economic analysis would be required to identify the best locations to integrate a park and ride facility with redevelopment.

### ***South Central Avenue/Baseline Road Corridor***

Three routes included in the RTP comprise the BRT service envisioned for the South Central Avenue and Baseline Road corridors. The “South Central Express” would operate between Baseline Road and the Station Capitol; the “South Central BRT A” would operate between 59<sup>th</sup> Avenue and Central Station; and the “South Central BRT B” would operate between Arizona Mills Mall and Central Station. The routes and potential stations are shown in Figure 15.

### ***Planning Background & Previous Recommendations***

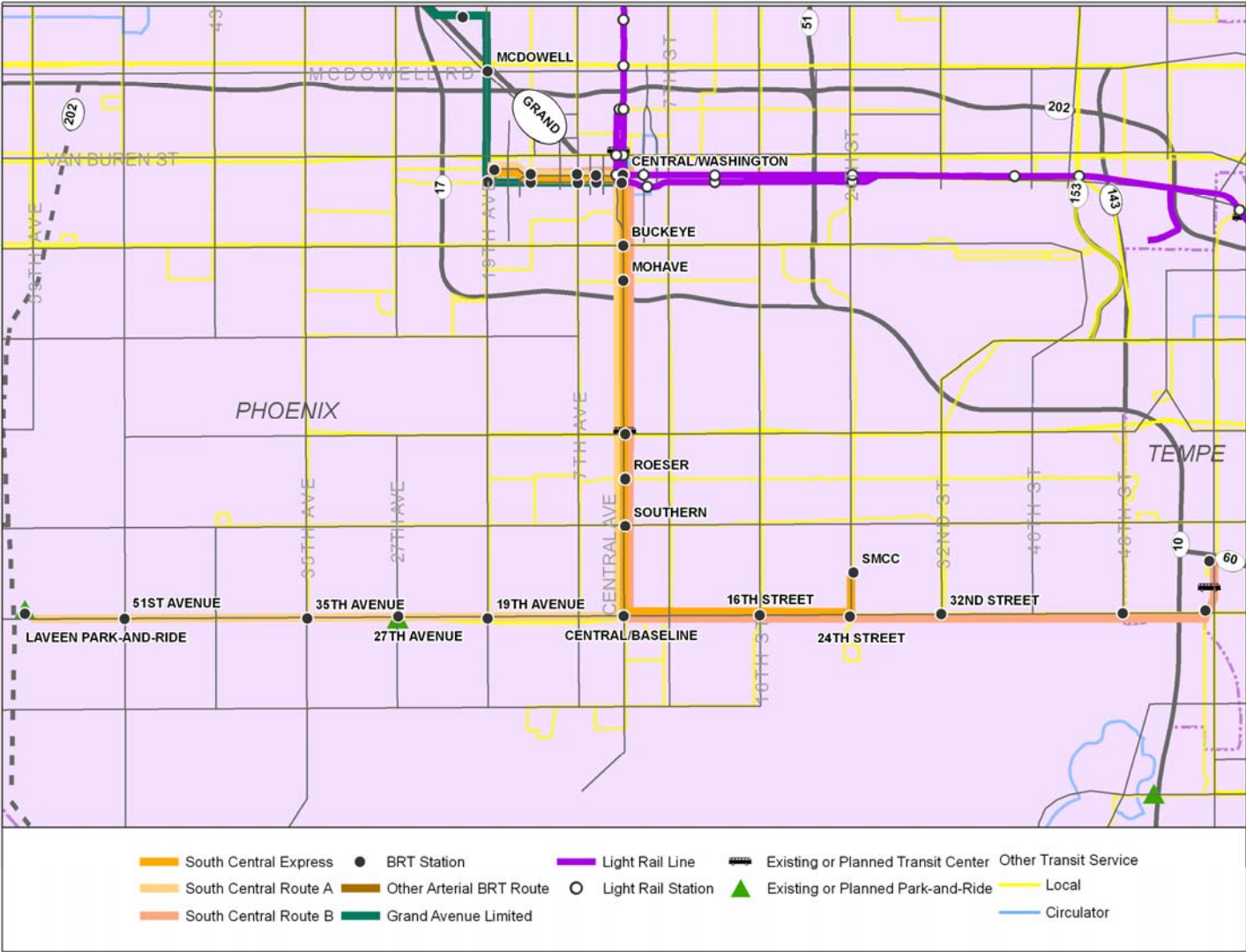
These three BRT routes were originally envisioned as part of the City of Phoenix RAPID express bus system and were included in the City’s *Transit 2000* sales tax approved by Phoenix voters. Whereas other RAPID express buses generally travel freeway corridors, the South Central Avenue/Baseline BRT routes would be the first on-street RAPID bus services. RAPID stations that would serve the routes were constructed on South Central Avenue at Buckeye, Broadway, Southern, and Baseline Roads as part of the initial RAPID rollout.

In 2004, the City of Phoenix Public Transit Department completed a study called the *Plan for RAPID Central-South Mountain*. This study recommended station location, routing, and operating plans for the corridor and recommended the name “Central-South Mountain RAPID.” Other recommendations included weekday peak-period only service, some reverse-commute trips, use of the RAPID-style vehicle and branding elements, and fares set at the express rate (at the time, the rate was \$1.75 each way; it is now \$2.75 each way). A two-phase approach to implementation was mentioned, with routes initially operating between 35<sup>th</sup> Avenue/Baseline Road to the State Capitol and from 24<sup>th</sup> Street/Baseline Road to the State Capitol. Extensions westward and eastward would be phased in as boardings grew and park-and-ride facilities were brought online. Although limited-stop service was considered key to creating fast service to downtown, no other transit priority treatments were mentioned.

Although the service has not yet been implemented, the City Public Transit Department is continuing to work with the community to plan the route. Planning – including purchase of land – continues for park-and-ride lots in the corridor. The City is planning on a 250-space facility in the vicinity of Baseline Road/27<sup>th</sup> Avenue and a facility at Baseline Road/54<sup>th</sup> Avenue (in Laveen). A park-and-ride at South Mountain Community College is also a possibility.

The PB team estimated existing boardings within the South Central Avenue/Baseline Road corridor at 11,000 boardings per day (several routes parallel routes the corridor within one-half mile, and riders from these routes may be attracted to BRT service; thus they were included in the boardings estimate). South Central Avenue in particular experiences high local service frequency, with 10-minute frequencies in the morning peak (6am to 9am) and all afternoon (1 pm to 6pm) and 20-minute frequencies at other times. Reflecting this intense existing transit service, the South Central Avenue portion has been identified as a potential extension of light rail.

Figure 15 - Proposed South Central Avenue/Baseline Road BRT Routes and Station Locations



The City of Phoenix has already performed a great deal of study on this corridor, including extensive public outreach. PB supports previous recommendations, but would suggest the some further considerations as planning and implementation efforts continue.

### **Running Way & Transit Signal Priority**

The 2004 City of Phoenix study addressed the limited-stop nature of the South Central Avenue/Baseline corridor BRT service as a means of creating faster travel times. The use of transit signal priority and queue jumps/bypass lanes should be examined in further corridor planning studies. Baseline Road west of 43<sup>rd</sup> Avenue appears to have shoulders which could be dedicated for transit needs; in addition, where widening projects take place, space for queue jumps or bypass lanes could be allocated for future growth of transit service. Portions of the corridor without such easily convertible excess roadway width should be examined for benefits from TSP treatment.

### **Branding**

The City of Phoenix has developed the South Central Avenue/Baseline corridor routes as part of the City's RAPID network. RAPID is a highly visible and successful transit brand in the Valley, and it clearly conveys a premium transit service that Central-South Mountain communities are clamoring for. However, other BRT routes in the network are being implemented under the LINK brand. Whether any customer confusion may result from RAPID branding on BRT routes in the City of Phoenix and LINK branding on other BRT routes in the Valley Metro network should be considered.

### **Fare Structure**

The City of Phoenix recommended charging an express fare for its Central-South Mountain RAPID service given the faster travel speeds and upgraded amenities of the RAPID service. However, Valley LINK BRT services charge a regular local/light rail fare. Again, whether these conflicting policies may cause any confusion on the part of passengers should be discussed.

### **Operating Plan**

Previous planning efforts have recommended service only in the peak commute times. Given existing boardings in the corridor and the already frequent service on South Central Avenue, PB recommends that all-day service spanning 18 hours be considered along South Central Avenue, approaching the levels recommended in Very Small Starts program. Along Baseline Road, peak-only service with some reverse-commute trips would be implemented as planned.

Service schedules between the three South Central/Baseline BRT service could be coordinated to create 10-minute headways in the peak hours along the South Central Avenue portion. To create 15-minute BRT headways in the off-peak hours, local services could be reduced slightly from existing levels. Weekend service on the South Central Avenue portion should also be considered. Table 8 summarizes the service level recommendations.

**Table 8 - Recommended Service Levels for South Central Avenue/Baseline Road BRT Routes**

	Service span (hours)	Peak headway (minutes)	Off-peak headway (minutes)
<b>South Central Express</b>			
Weekday			
BRT service	18	10*	15
Local service	17	20	20
		<i>*10-minute peak service when combined with A and B BRT routes</i>	
Weekend		All-day headway	
BRT service	14	30	
Local service	17	30	
	Service span (hours)	Peak-hour trips	Off-peak trips
<b>South Central BRT A</b>			
BRT service	Peak-hour only	6 inbound, 4 outbound	-
<b>South Central BRT B</b>			
BRT service	Peak-hour only	6 inbound, 4 outbound	-

**Costs**

*Capital*

Costs to implement improvements in the right-of-way for each of routes in the corridor are presented in tables 9 through 11 and are summarized as follows:

South Central Express:

- \$7.2 million (including vehicles)
- \$1.12 million per mile (including vehicles)
- \$0.77 million per mile (not including vehicles)

South Central BRT A:

- \$4.2 million (including vehicles)
- \$1.77 million per mile (including vehicles)
- \$1.16 million per mile (not including vehicles)

South Central BRT B:

- \$5.2 million (including vehicles)
- 2.01 million per mile (including vehicles)
- \$1.41 million per mile (not including vehicles)

(Capital costs shown above are in \$2010.)

Table 9 South Central Express Capital Cost Estimates

		Unit cost	Number	Corridor cost
Standard BRT Station		\$ 334,000	10	\$ 3,340,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Standard shelter		\$ 205,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Artistic BRT Station		\$ 441,000	0	\$ -
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Artistic Shelter		\$ 312,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Traffic Signal Priority	per mile	\$ 12,750	9.4	\$ 119,850
Queue bypass w/ farside stop pullout				
Major arterial	per queue jump	\$ 300,000	4	\$ 1,200,000
Other				
Upgrades to shared stations	Passenger inform	\$ 2,000	5	\$ 10,000
<b>Capital subtotal</b>				<b>\$ 4,669,850</b>
Planning & Env. Clearance			15%	<b>\$ 700,478</b>
Final Design & Permitting			15%	<b>\$ 700,478</b>
Contingency			25%	<b>\$ 1,167,463</b>
Vehicles	per vehicle	\$ 550,000	6	\$ 3,300,000
<b>Total cost (including vehicles)</b>				<b>\$ 10,538,268</b>
<b>Cost per mile (including vehicles)</b>				<b>\$ 1,121,092</b>
<b>Total cost (NOT including vehicles)</b>				<b>\$ 7,238,268</b>
<b>Cost per mile (NOT including vehicles)</b>				<b>\$ 770,028</b>

**Table 10 South Central BRT A Capital Cost Estimate**

		Unit cost	Number	Corridor cost
Standard BRT Station		\$ 334,000	6	\$ 2,004,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Standard shelter		\$ 205,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Artistic BRT Station		\$ 441,000	0	\$ -
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Artistic Shelter		\$ 312,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Traffic Signal Priority	per mile	\$ 12,750	3.6	\$ 45,900
Queue bypass w/ farside stop pullout				
Major arterial	per queue jump	\$ 300,000	2	\$ 600,000
Other				
Upgrades to shared stations	Passenger information	\$ 2,000	22	\$ 44,000
<b>Capital subtotal</b>				
				<b>\$ 2,693,900</b>
Planning & Env. Clearance			15%	<b>\$ 404,085</b>
Final Design & Permitting			15%	<b>\$ 404,085</b>
Contingency			25%	<b>\$ 673,475</b>
Vehicles	per vehicle	\$ 550,000	4	\$ 2,200,000
<b>Total cost (including vehicles)</b>				<b>\$ 6,375,545</b>
<b>Cost per mile (including vehicles)</b>				<b>\$ 1,770,985</b>
<b>Total cost (NOT including vehicles)</b>				<b>\$ 4,175,545</b>
<b>Cost per mile (NOT including vehicles)</b>				<b>\$ 1,159,874</b>

Table 11 South Central BRT B Capital Cost Estimate

South Central BRT B				
		Unit cost	Number	Corridor cost
Standard BRT Station		\$ 334,000	8	\$ 2,672,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Standard shelter		\$ 205,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Artistic BRT Station		\$ 441,000	0	\$ -
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Artistic Shelter		\$ 312,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Traffic Signal Priority	per mile	\$ 12,750	3.7	\$ 47,175
Queue bypass w/ farside stop pullout				
Major arterial	per queue jump	\$ 300,000	2	\$ 600,000
Other				
Upgrades to shared stations	Passenger inform	\$ 2,000	26	\$ 52,000
<b>Capital subtotal</b>				<b>\$ 3,371,175</b>
Planning & Env. Clearance			15%	<b>\$ 505,676</b>
Final Design & Permitting			15%	<b>\$ 505,676</b>
Contingency			25%	<b>\$ 842,794</b>
Vehicles	per vehicle	\$ 550,000	4	\$ 2,200,000
<b>Total cost (including vehicles)</b>				<b>\$ 7,425,321</b>
<b>Cost per mile (including vehicles)</b>				<b>\$ 2,006,844</b>
<b>Total cost (NOT including vehicles)</b>				<b>\$ 5,225,321</b>
<b>Cost per mile (NOT including vehicles)</b>				<b>\$ 1,412,249</b>

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### *Operations*

Operational costs for South Central Express operations as recommended above are \$1,840,000 annually. South Central BRT A services would incur \$239,000 annually and South Central BRT B would cost \$481,000 per year to operate. Total operational costs for BRT service in the South Central Avenue/Baseline Road corridor would be \$3,156,000. All costs are in \$2010 and assume a \$6/mile operating cost.

### **Vehicle Requirements**

Based on the service planning recommended above, the South Central Express route would require 6 vehicles for maximum peak operations; and each of the other routes would require 4 (including an allowance for layovers and spares).

### **Station Access and Station-area Development**

The South Central Avenue/Baseline Road Corridor is a developing area with potential to incorporate transit supportive development. The BRT routes will serve employment destinations along Baseline Road as well as downtown Phoenix and can also act as a feeder route to light rail.

#### *Baseline Road: 59th Avenue to Central Avenue*

Vacant land near the stations along Baseline Road between Central Avenue and 59<sup>th</sup> Avenue hold potential for station areas specifically designed for commuters. Large parcels of land available at 35<sup>th</sup> Avenue and 59<sup>th</sup> Avenue allow for larger station areas, and the accommodation of an end of the line park-and-ride. These planned stations are adjacent to medium density residential and local commercial and retail services, thus lending themselves to neighborhood type stations. They should be integrated into the neighborhood, providing connectivity and permeability, primarily serving commuters.

Due to the low-density development in this area, it could be difficult to develop an integrated mixed use facility with supporting commercial and service uses transit users. However, as this area intensifies this type of development would be possible. It is recommended that land be secured for future growth and development around this park & ride location. The City of Phoenix could lease land to provide interim public uses.

#### *Central Avenue: Washington Street to Rio Salado*

The corridor between Buckeye Road and I-17 contains a range of service and industrial uses. Some parcels appear to be underutilized. Further economic analysis could indicate the land value ratio to the cost of improvements on each parcel thereby quantifying the comparative level of utilization. Underutilized sites could support neighborhood services for the residences on each side of Central Avenue and for transit users along the corridor.

*Central Avenue: Rio Salado to Baseline Road*

A focused area of development along the South Central BRT Corridor should be the integration of station design at the three potential stations between Southern Avenue and Broadway Road along Central Avenue, designated as the South Mountain Village Core. Stations along this section should be integrated into the emerging Village to create a focal point of development activity and neighborhood amenity. This area has vacant and underutilized land adjacent to medium and high density residential, and has been designated as a redevelopment area to create a Village Center. The design of these stations should be integrated into the neighborhood, with public space, high level of pedestrian permeability and street connection to facilitate movement between the station area and village core. Integrated developed could include retail and commercial services to the surrounding residential neighborhood and provide for transit user needs.

*Baseline Road: Central Avenue to Priest Drive*

As the eastern portion of the South Central corridor develops, the station areas can be incorporated into new development, integrating transit into the emerging South Mountain Employment Center, which is designated as employment and retail uses along Baseline Road between 24<sup>th</sup> Street and 48<sup>th</sup> Street. Vacant and underutilized land is currently available at a minimum of one quadrant at each of the station intersection locations in this area. The type of development along this corridor could provide activities and amenities oriented towards employment and retail services.

Stations should be developed on one or both sides of Baseline Road as detailed in the specific intersection area recommendations below.

*48th Street*

Specific locations include at the northeast corner of 48<sup>th</sup> Street and Baseline Road, where underutilized commercial development exists, as well as at the southwest quadrant adjacent to an existing gas station, where a vacant parcel could provide transit related development opportunities.

*32nd Street*

At the 32<sup>nd</sup> Street intersection significant vacant land exists along the south side of the corridor, which may be developed for medium density transit supportive development.

*24th Street*

The route extends north to connect with South Mountain Community College, where a station should be integrated into the south side of the campus to allow access to the commercial development at 24<sup>th</sup> Street.

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*16th Street*

Existing vacant land is currently planned and platted for mixed use development. Additional vacant land which can be used for transit supportive uses is located along the south side of intersection.

*Central Avenue*

The northwest corner of the intersection with Central Avenue has narrow vacant parcel between Baseline Road and the canal which provides a unique station area opportunity for integrated station operation and mixed-use transit supportive development.

### **Chandler Boulevard**

The Chandler Boulevard BRT corridor currently experiences a varied level of development. The western portion of the corridor serves large employers, a regional mall, and downtown Chandler. The eastern terminus is anchored by the ASU Polytechnic Campus and the Phoenix-Mesa Gateway Airport (formerly the Williams Gateway Airport), which is planned for aggressive development. Another regional shopping area is present in the vicinity of the Loop 202. In between these major destinations is light residential development along with patches of farmland.

Transit service along Chandler Boulevard currently generates about 1,200 boardings per weekday. Transit service is also present on the weekends. Long-term boardings estimates were not performed, but the corridor serves the combined ASU Polytechnic and Phoenix-Mesa Gateway Airport, where total trip-making is forecast almost to triple by the year 2030. Boardings can therefore also be expected to grow as the corridor reaches its development potential.

With BRT implementation planned for more than ten years out, there is ample time for transit boardings to continue to grow. BRT improvements can be incorporated with planned roadway improvements, and transit-supportive development policies and design principals can be put in place around identified station locations.

### **Running Way/Transit Signal Priority**

Boardings demand suggests service levels that could be accommodated by a “lite” BRT treatment on Chandler Boulevard, with operations in mixed-flow arterial conditions, and transit signal priority and queue jump/bypass lanes applied in the corridor.

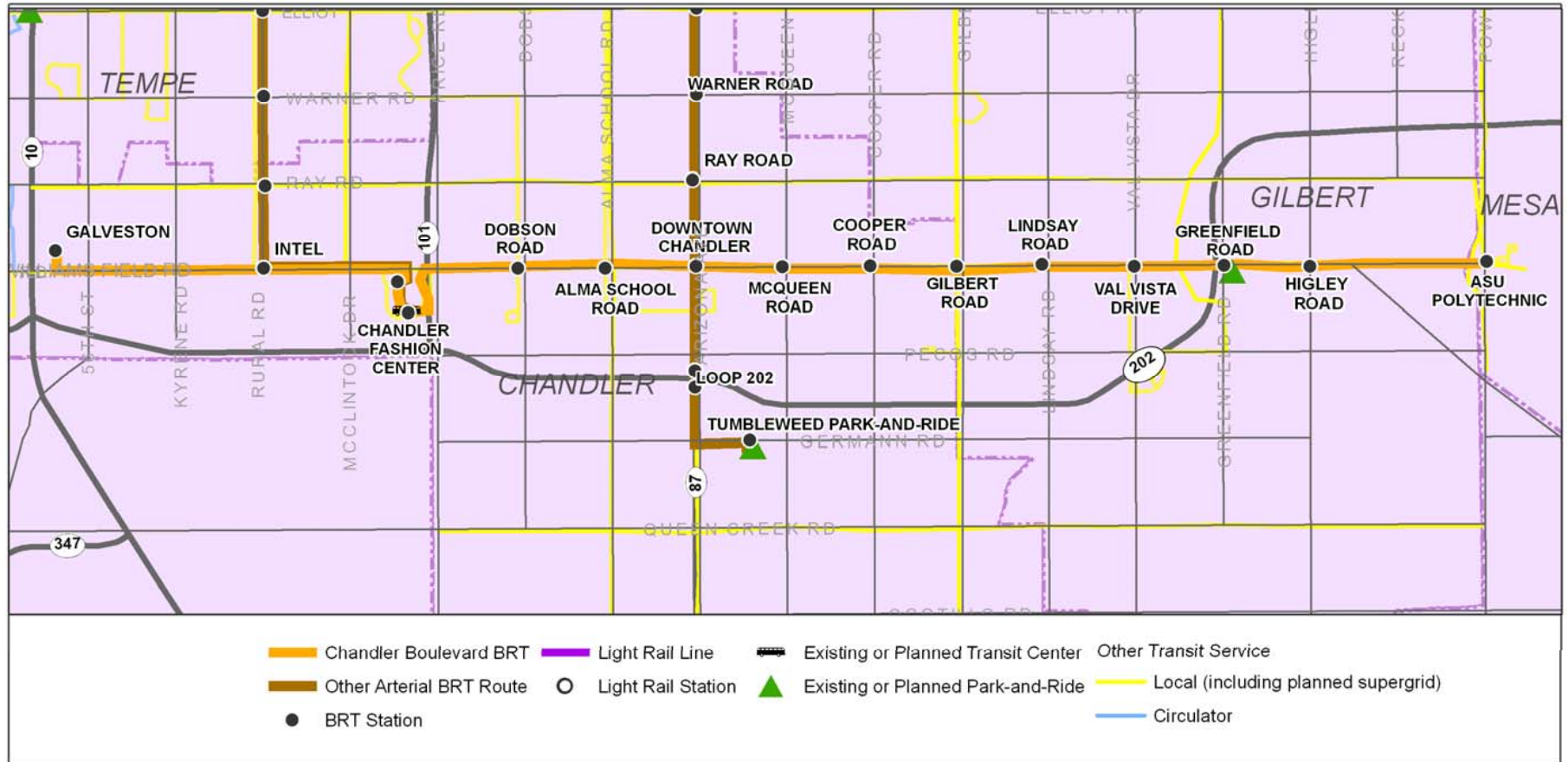
### **Stations**

Stations would be located roughly every mile along the corridor, at intersections of major arterials, as shown on the route map. A regional park-and-ride in the vicinity of Loop 202 and Val Vista is planned, which will server both the Chandler Boulevard BRT and express bus routes. Transfers to other BRT services will be present at Arizona Avenue and Rural Road. Transfers to local services will be available at 56<sup>th</sup> Street (Route 56), Kyrene Road (Route 65), Rural Road (Route 72), Dobson Road (Route 96), Alma School Road (Route 104), Arizona Avenue (Route 112), and Gilbert Road (Route 136), at Chandler Fashion Center (Route 81), along with new local services to be implemented on Power Road and Greenfield Road.

### **Service Planning**

For planning purposes, PB recommends similar service levels and boardings thresholds to those recommended for the Arizona Avenue LINK service, with the addition of weekend service at the lower threshold of boardings since weekend service is already present. As the date of implementation nears, the appropriate service level should be selected based on existing boardings at that time.

Figure 16 - Proposed Chandler Boulevard BRT Corridor and Station Locations



**Table 12 - Chandler Boulevard BRT Service Level Recommendations**

	Service span (hours)	Peak headway (minutes)	Off-peak headway (minutes)
<b>Minimum frequency: under 2,000 riders/day</b>			
Weekday			
BRT service	16	30	30
Local service	16	30	30
Saturday			
BRT service	15	30	30
Sunday			
BRT service	15	30	30
	Service span (hours)	Peak headway (minutes)	Off-peak headway (minutes)
<b>Moderate frequency: 2,500 riders/day</b>			
Weekday			
BRT service	18	15	20
Saturday			
BRT service	16	30	30
Sunday			
BRT service	15	30	30
	Service span (hours)	Peak headway (minutes)	Off-peak headway (minutes)
<b>High frequency: over 3,000 riders/day</b>			
Weekday			
BRT service	18	10	15
Saturday			
BRT service	16	20	20
Sunday			
BRT service	16	20	20

**Costs**

*Capital*

Capital costs for Chandler Boulevard corridor infrastructure improvements are as follows:

- \$19.4 million (including vehicle costs)
- \$1.1 million per mile (including vehicles)
- \$944, 000 per mile (without vehicles)

A detailed cost estimate is presented in Table 12.

**Table 13 Chandler Boulevard Capital Cost Estimate**

		Unit cost	Number	Corridor cost
Standard BRT Station		\$ 334,000	20	\$ 6,680,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Standard shelter		\$ 205,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Artistic BRT Station		\$ 441,000	2	\$ 882,000
<i>Component costs:</i>				
Right-of-way	@ \$10/sq. ft	\$ 3,000		
Temp. Const. Easement	@ \$4/sq. ft	\$ 4,000		
Artistic Shelter		\$ 312,000		
Ticket vending machine		\$ 100,000		
Dynamic Message Signage		\$ 12,000		
Curbway	Build to 14"	\$ 10,000		
Traffic Signal Priority	per mile	\$ 12,750	17.7	\$ 225,675
Queue bypass w/ farside stop pullout				
Major arterial	per queue jump	\$ 300,000	10	\$ 3,000,000
<b>Capital subtotal</b>				<b>\$ 10,787,675</b>
Planning & Env. Clearance			15%	\$ 1,618,151
Final Design & Permitting			15%	\$ 1,618,151
Contingency			25%	\$ 2,696,919
Vehicles	per vehicle	\$ 550,000	5	\$ 2,750,000
<b>Total cost (including vehicles)</b>				<b>\$ 19,470,896</b>
<b>Cost per mile (including vehicles)</b>				<b>\$ 1,100,051</b>
<b>Total cost (NOT including vehicles)</b>				<b>\$ 16,720,896</b>
<b>Cost per mile (not including vehicles)</b>				<b>\$ 944,683</b>

*Operations*

Annual operating costs for the service levels recommended above are estimated as follows:

Minimum frequency service: \$1.55 million

Moderate frequency service: \$2.7 million

High frequency service: \$4.5 million

## Vehicle Requirements

Vehicle requirements for the service levels recommended above are as follows:

Early years: 10

Mid-term: 10

Long-term: 14

## Station Access and Station Area Development

The Chandler Boulevard corridor currently holds potential for future transit development with significant vacant land along the corridor. Because BRT service is planned for the long-term, the Chandler Boulevard corridor has many opportunities to implement BRT-friendly policies and influence development patterns today.

Significant vacant land is currently available and can be preserved at the intersections east of McQueen Road. These vacant parcels can be developed to accommodate future station needs, such as pedestrian connectivity to residential neighborhoods, amenities accommodating commuters as well as destinations utilizing the location along the transit line. Sufficient land for future park-and-rides can also be identified and preserved for future needs, specifically immediately east of Greenfield Road. In the immediate vicinity of Loop 202, significant commercial, retail, and employment development is already occurring which can serve as a key activity node along the route. This route also provides access to the Williams Gateway Airport area, which is an emerging employment center. As this area is developing, future station area should be integrated into the development as this will be an important destination along the corridor.

West of McQueen Road there is limited development opportunity along Chandler Boulevard with smaller parcels of vacant land available, however existing employment, commercial and retail development exists and can accommodate small integrated stations located at or near the development. The key will be to integrate features supporting transit needs, such as pedestrian connectivity, while enhancing commercial and retail amenities exist along this portion of the corridor. Residential development and major employment centers adjacent to the western portion of the corridor provides a boardings base for the route but accessibility from stations to neighborhoods will be needed while ensuring safety and security of the users.

From McClintock Drive to Gilbert Road the Chandler Boulevard corridor is primarily residential with a concentration of commercial and employment focused extending from the Loop 101 vicinity to Dobson Road. The City of Chandler has placed an emphasis on growth and expansion between Loop 101 and Dobson Road, which includes commercial, employment, and residential development. Pedestrian connectivity and station integration will be vital to ensure the safety and security of the users in this area, as this will be a key destination.

Additionally, this corridor passes through the heart of Downtown Chandler, in the vicinity of Arizona Avenue and McQueen Road. In this downtown area, the City has placed an emphasis on revitalization and infill growth. As the city pursues its revitalization efforts, stations can be

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integrated into the downtown fabric, creating a focal point to anchor the spaces. Potential development types in the downtown include station area plazas with integrated mixed use development to encourage various levels of activity. In this region, the corridor also crosses a canal/recreational trail near Cooper Road, which enhances bicycle and pedestrian connectivity to the transit corridor. A station near this location would be optimal.

#### *54th Street*

This potential station would be located near the I-10 and Loop 202 interchange and contains primarily low density non-residential uses including hotels, employment and industrial uses adjacent to the rail line. There is vacant land available at 56<sup>th</sup> Street that could be identified for a future park and ride.

#### *Rural Road*

This station will connect with the BRT alignment along Rural Road. A vacant parcel exists on the northeast corner of the intersection. The Intel complex is located at the northwest corner, which will be a major destination along the alignment. As such a station should be integrated at or near the Intel complex.

#### *McClintock Drive*

This location is not envisioned as a potential station but contains vacant parcels to the northwest and northeast which could provide opportunities for future mixed use development, with the northwest parcel accommodating access to Desert Breeze Park.

#### *Loop 101 – Chandler Fashion Center*

This location is envisioned as a potential station and contains the Chandler Fashion Center and is surrounded by medium density housing and other commercial uses. Vacant land west of the Chandler Fashion Center could be developed as medium to high density residential and provide access to Price Park. The vacant parcel south of the Chandler Fashion Center could be developed as mixed-use with retail adjacent to Frye Road with office located behind with frontage onto Loop 101 and Loop 202 for advertising purposes.

#### *Dobson Road*

This location is envisioned as a potential station and contains primarily low density neighborhood serving commercial uses surrounded by residential. Some opportunity exists to provide complementary neighborhood and transit user services along the corridor as vacant parcels are developed, while the underutilized existing development can be integrated into the station area as well.

#### *Alma School Road*

This location is envisioned as a potential station and contains primarily low density commercial and multifamily surrounded by mixed-density residential uses. There exist few vacant parcels,

specifically at the northeast corner of Chandler Boulevard and Alma School Road. The site west of Pleasant Drive could be viable for multifamily.

*Arizona Avenue*

This location is envisioned as a potential station and will connect with the BRT alignment along Arizona Avenue. The Chandler Center for the Arts is located on the northwest corner with commercial infill opportunities for the vacant sites on the southwest and southeast corners. Due to the small block pattern of these southern sites, development will likely contain small scaled neighborhood uses.

*McQueen Road*

This location is envisioned as a potential station and contains primarily low density multifamily uses to the west with a gas station and vacant lot to the east. The vacant lot on the southeast and northeast corner could provide neighborhood servicing uses for the surrounding residential uses.

*Cooper Road*

This location is envisioned as a potential station and contains primarily vacant land with a few small scale service uses surrounded by low and medium density residential. More neighborhood serving uses could be viable in this location due to the large quantity of residential uses in this area. With significant vacant land parcels on each corner of this intersection, a community plan could be prepared to encourage the proper public policies for this area.

*Gilbert Road*

This location is envisioned as a potential station and contains primarily low density residential with a vacant lot on the northwest corner, neighborhood commercial on the southeast corner, a modular home community on the southwest corner, and large lot residential to the northeast with a pharmacy on the corner. There could be future opportunities for additional neighborhood service uses. The vacant lot could provide additional commercial uses to complement the existing uses on the southeast corner. The modular home community could be redeveloped in the future to support additional neighborhood services.

*Lindsay Road*

This location is envisioned as a potential station and contains primarily large lot residential to the west, small scale neighborhood commercial to the northeast and a vacant parcel to the south west.

*Val Vista Road*

This location is envisioned as a potential station and contains neighborhood serving commercial and vacant parcels surrounded by single family residential. There are future opportunities to

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develop the southeast vacant parcels as neighborhood serving uses due to the large quantity of residential uses in the area and to complement the uses in Santan Village.

*Loop 202 Road Park and Ride*

This location is envisioned as a potential park and ride and station and is developing as a regional shopping area. Land for a future park and ride should be identified now and consideration should be given to securing this land with a plan for revenue generation. When the BRT is implemented a station could be integrated with other commercial uses at the San Tan Village west of the interchange.

*Higley Road*

This location is envisioned as a potential station and contains primarily non-residential uses on all four corners. Future opportunities could include neighborhood serving commercial uses or medium density residential.

*Power Road at William Gateway*

This location is envisioned as a potential station and contains primarily employment uses. This location could provide park and ride facilities. Land for a park and ride should be identified now and consideration should be given to securing this land with a plan for revenue generation. A BRT station could be integrated with other commercial uses.

### 2.3. Prospects for Very Small Starts Funding

Federal funding for BRT under the Section 5309 Capital Investment Grant program includes a category called “Very Small Starts.” Very Small Starts projects are considered simple and low-risk, and are thereby subject to a simplified evaluation and rating process by FTA.<sup>8</sup>

To qualify for Very Small Starts’ streamlined evaluation and an automatic “medium” rating, a BRT project must meet the following criteria:

- The corridor in which BRT is to be implemented must have:
  - Existing corridor boardings exceeding 3,000/day of riders who would benefit from the service
- The completed BRT project must have all of the following elements:
  - Transit Stations
  - Signal Priority/Pre-emption
  - Low Floor / Level Boarding Vehicles
  - Special Branding of Service
  - Frequent Service - 10 min peak/15 min off peak
  - Service offered at least 14 hours per day
- The cost of the BRT project must be:
  - Less than \$50 million total cost
  - Less than \$3 million per mile (excluding vehicles)<sup>9</sup>

If one of the first four elements listed above is already in place, funding can be sought for the remaining three project elements to create a “whole” BRT project. (For example, if signal priority systems have already been implemented using local funding, Very Small Starts funding can be requested for the remaining elements of the BRT project.) If two of the first four elements are already in place, however, the project is considered ineligible for Very Small Starts.

Table 2 compares each of the corridors in the arterial BRT system against Very Small Starts criteria. (Grand Avenue is not included in the table as it is not recommended for inclusion as an arterial BRT route.) As the table shows, only South Central/Baseline corridor currently meet the existing boardings requirement of Very Small Starts, while the Scottsdale Road corridor almost meets the boardings requirement. The related service levels on these corridors are closest to the Very Small Starts requirements. However, the use of transit priority treatments, substantial stations, level boarding/low-floor vehicles, and branding treatments are recommended for each of the corridors.

It should be noted that with federal transportation reauthorization pending, the Very Small Starts program may be dramatically overhauled in the future, if not eliminated altogether. Nonetheless, in the BRT industry, the criteria associated with Very Small Starts have become the *de facto* definition of a “lite” BRT system and will likely impact BRT planning for some time.

<sup>8</sup> See “Very Small Starts Fact Sheet” at:

[http://www.fta.dot.gov/documents/Very\\_Small\\_Starts\\_Fact\\_Sheet\\_Feb\\_7th.doc](http://www.fta.dot.gov/documents/Very_Small_Starts_Fact_Sheet_Feb_7th.doc)

<sup>9</sup> Criteria identified in “Very Small Starts Fact Sheet” identified in previous footnote; dated July 6, 2009.

**Table 14 - Very Small Starts and Valley Metro Arterial BRT Routes**

<b>Very Small Starts Criteria</b>									
Requirement	Stations	Traffic signal priority	Boarding	Branding	Service frequency and span	Existing boardings	Capital costs		
Description	Substantial transit stations	Traffic signal priority or pre-emption if there are traffic signals on the corridor	Low-floor vehicles or level boarding	Branding of the proposed service	Ten-minute peak/15-minute off-peak headways or better 14 hours per weekday (equates to 136 one-way trips/day; applies only to BRT service)	Existing weekday average boardings exceeds 3,000 per day	Total capital cost less than \$50 million (including all project elements)	Less than \$3 million per mile (exclusive of rolling stock) capital budget	
<b>Routes</b>									
Arizona Avenue BRT	Yes - recommended	Portion	Yes (near-level)	Yes - "LINK" brand, vehicle type	No – recommended 30-min peak/30-min off-peak frequency at service start	No – Approx. 1,200 – 1,800 avg. daily boardings in 2010	Yes - \$28 million budgeted	Yes - \$1.72 million per mile	
Scottsdale Road (north of Loop 202)	Yes - recommended	Yes - recommended	Yes – recommended	Yes – recommended "LINK" brand, vehicle type	Yes - recommended 10-minute peak/15-min off-peak frequency at start	No – approximately 2,900 daily boardings in 2010	Yes - \$22.4 million	Yes - \$1.1 million per mile	
South Central Express	Yes - recommended	Yes - recommended	Depends on vehicle used. (RAPID vehicles are not low-floor)	Yes – may be RAPID brand, vehicle type	Yes - recommended 10-minute peak/15-minute off-peak service for South Central Avenue Corridor	Yes – Approx. 11,200 avg. daily boardings (5,200 in South Central Avenue corridor) in 2010	Yes - estimated \$24.3 million for all corridors	\$996,000/mile	
South Central BRT A									
South Central BRT A									
Chandler Blvd BRT	Yes - recommended	Yes - recommended	Yes - recommended	Yes - "LINK" brand, vehicle type	Unknown; will require evaluation of existing boardings at time	No- Approx. 1,200 to 1,500 avg. daily boardings in 2010	Yes - \$19.4 million	Yes - \$944,000 per mile	

Note: Findings from the Tempe South Corridor AA indicate that Rural Road would meet Very Small Starts criteria.

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### 3. CONCLUSION

The Comprehensive Arterial BRT Planning Study was tasked with identifying characteristics of the arterial BRT network identified in the Regional Transportation Plan and funded by Proposition 400. Capital and operating costs for each BRT corridor were also identified.

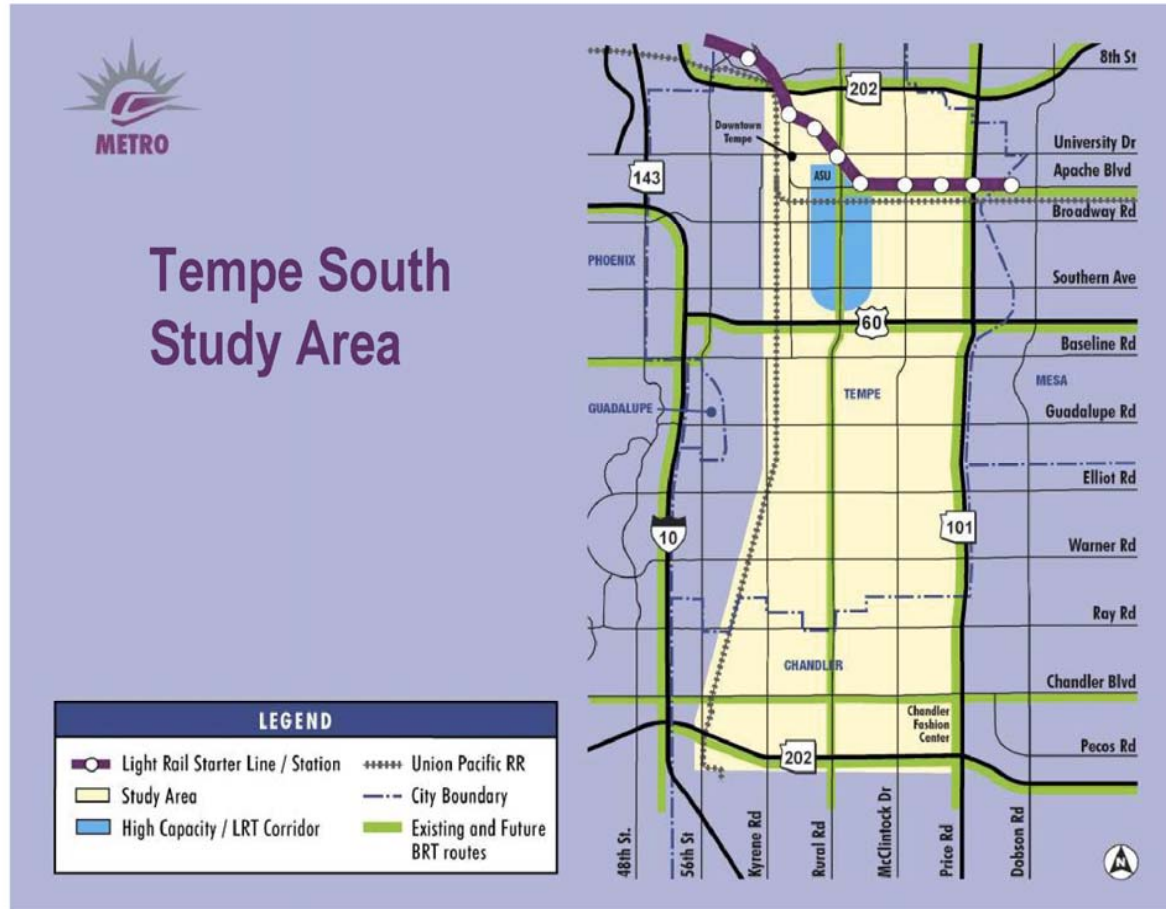
While funding for the arterial BRT system is uncertain at this point, Valley agencies involved in the provision of transit services can be actively taking steps to anticipate capital improvements in each corridor and ensure that transit supportive land use and design measures are in place.



## APPENDICES



Tempe South High Capacity Transit Study (Alternatives Analysis) Study Area



Source: METRO



## APPENDIX II: Detailed Operating Cost Estimates



### Arizona Avenue LINK Operating Cost Estimates (2010 \$)

	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annual, BRT only)
<b>Near-term</b>												
<b>Weekday</b>												
BRT service	11.9	18	5.00	15	30	40	52	92	1,095	\$ 6	\$ 6,569	\$ 1,675,044
Local service	16.3	18	6.00	30	30	24	48	72	1,170	\$ 6	\$ 7,020	
<b>Daily totals</b>											<b>\$ 13,589</b>	
<b>Saturday*</b>												
BRT service	11.9	17	17.00	60	60	34	-	34	405	\$ 6	\$ 2,428	\$ 133,518
Local service	16.3	17	17.00	60	60	34	-	34	553	\$ 6	\$ 3,315	
<b>Daily totals</b>						<b>Total for corridor - Saturday</b>		<b>68.0</b>	<b>957</b>		<b>\$ 5,743</b>	
<b>Sunday*</b>												
BRT service	11.9	17	17.00	60	60	34	-	34	405	\$ 6	\$ 2,428	\$ 133,518
Local service	16.3	17	17.00	60	60	34	-	34	553	\$ 6	\$ 3,315	
<b>Daily totals</b>						<b>Total for corridor - Sunday</b>		<b>68.0</b>	<b>957</b>		<b>\$ 5,743</b>	
											<b>\$ 1,942,080</b>	
*Weekend BRT service would start in 2011, when local weekend service is also scheduled to begin.												
<b>Mid-term</b>												
<b>Weekday</b>												
BRT service	11.9	18	6.00	15	20	48	72	120	1,428	\$ 6	\$ 8,568	\$ 2,184,840
Local service	16.3	18	6.00	15	30	48	48	96	1,560	\$ 6	\$ 9,360	
<b>Daily totals</b>						<b>Total for corridor - weekday</b>		<b>216.0</b>	<b>2,988</b>		<b>\$ 17,928</b>	
<b>Saturday</b>												
BRT service	11.9	18	18.00	30	30	72	-	72	857	\$ 6	\$ 5,141	\$ 282,744
Local service	16.3	18	18.00	30	30	72	-	72	1,170	\$ 6	\$ 7,020	
<b>Daily totals</b>						<b>Total for corridor - Saturday</b>		<b>144.0</b>	<b>2,027</b>		<b>\$ 12,161</b>	
<b>Sunday</b>												
BRT service	11.9	18	18.00	30	30	72	-	72	857	\$ 6	\$ 5,141	\$ 282,744
Local service	16.3	18	18.00	30	30	72	-	72	1,170	\$ 6	\$ 7,020	
<b>Daily totals</b>						<b>Total for corridor - Sunday</b>		<b>144.0</b>	<b>2,027</b>		<b>\$ 12,161</b>	
											<b>\$ 2,750,328</b>	

	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annual, BRT only)
Long-term												
Weekday												
BRT service	11.9	20	6.00	10	15	36	112	148	1,761	\$ 6	\$ 10,567	\$ 2,694,636
Local service	16.3	18	6.00	15	30	24	48	72	1,170	\$ 6	\$ 7,020	
<b>Daily totals</b>						<b>Total for corridor - weekday</b>		<b>220.0</b>	<b>2,931</b>		<b>\$ 17,587</b>	
Saturday												
BRT service	11.9	18	18.00	30	30	12	-	12	143	\$ 6	\$ 857	\$ 47,124
Local service	16.3	18	18.00	30	30	12	-	12	195	\$ 6	\$ 1,170	
<b>Daily totals</b>						<b>Total for corridor - Saturday</b>		<b>24.0</b>	<b>338</b>		<b>\$ 2,027</b>	
Sunday												
BRT service	11.9	18	18.00	30	30	12	-	12	143	\$ 6	\$ 857	\$ 47,124
Local service	16.3	18	18.00	30	30	12	-	12	195	\$ 6	\$ 1,170	
<b>Daily totals</b>						<b>Total for corridor - Sunday</b>		<b>24.0</b>	<b>338</b>		<b>\$ 2,027</b>	
												<b>\$ 2,788,884</b>

**Grand Avenue Limited Operating Cost Estimates (2010 \$)**

	One-way Bus Trip Length (miles)	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annually)
<b>Near-term</b>						
Origination						
Surprise	25.9	8	207	\$ 6	\$ 1,243	\$ 316,894
Peoria	16.3	10	163	\$ 6	\$ 975	\$ 248,625
					<b>\$ 2,218</b>	<b>\$ 565,519</b>
<b>Mid-term</b>						
Origination						
Surprise	25.9	10	259	\$ 6	\$ 1,553	\$ 396,117
Peoria	16.3	12	195	\$ 6	\$ 1,170	\$ 298,350
					<b>\$ 2,723</b>	<b>\$ 694,467</b>
<b>Long term</b>						
Origination						
Surprise	25.9	14	362	\$ 6	\$ 2,175	\$ 554,564
Peoria	16.3	16	260	\$ 6	\$ 1,560	\$ 397,800
					<b>\$ 3,735</b>	<b>\$ 952,364</b>

**Scottsdale Road BRT Operating Cost Estimates (2010 \$)**

	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annually)
<b>Weekday</b>												
BRT service	14.6	18	6.00	10	15	72	96	168	2,453	\$ 6	\$ 14,717	\$ 3,752,784
Local Service	14.6	17	6.00	20	20	36	66	102	1,489	\$ 6	\$ 8,935	\$ 2,278,476
<b>Saturday</b>												
BRT service	14.6	14	14.00	20	20	84	-	84	1,226	\$ 6	\$ 7,358	\$ 404,712
<b>Sunday</b>												
BRT service	14.6	14	14.00	20	20	84	-	84	1,226	\$ 6	\$ 7,358	\$ 404,712

**South Central Avenue/Baseline Road BRT Operating Cost Estimates (2010 \$)**

	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost	Total Annual Cost
<b>South Central Express</b>												
<b>Weekday</b>												
BRT service	9.4	15	6.00	20	15	32	72	104	978	\$ 7.88	\$ 7,703	\$ 1,964,389
Local service	9.4	17	6.00	20	20	36	66	102	959	\$ 8	\$ 7,555	
<b>Weekend</b>												
BRT service	9.4	14	-	30	30	32	56	88	827	\$ 7.88	\$ 6,518	\$ 717,017
Local service	9.4	17	6.00	30	30	12	44	56	526	\$ 6	\$ 3,158	
<b>South Central BRT A</b>												
BRT service	13.0	6	6.00	30	30	12	-	12	156	\$ 7.88	\$ 1,229	\$ 313,466
<b>South Central BRT B</b>												
BRT service	13.1	6	6.00	15	30	24	-	24	314	\$ 7.88	\$ 2,477	\$ 631,755
<b>Total service on Central Avenue</b>								242			\$	3,626,628

### Chandler Boulevard BRT Operating Cost Estimates (2010 \$)

	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annually)
Minimum service frequency (under 2,000 riders/day)												
Weekday												
BRT service	17.7	16	6.00	30	30	12	40	52	920	\$ 6	\$ 5,522	\$ 1,408,212
Local service	17.7	16	6.00	30	30	12	40	52	920	\$ 6	\$ 5,522	
Saturday												
BRT service	17.7	15	15.00	30	30	12	-	12	212	\$ 6	\$ 1,274	\$ 70,092
Sunday												
BRT service	17.7	15	15.00	30	30	12	-	12	212	\$ 6	\$ 1,274	\$ 70,092
												<b>\$ 1,548,396</b>
	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annually)
Moderate frequency (2,500 riders/day)												
Weekday												
BRT service	17.7	18	6.00	15	20	24	72	96	1,699	\$ 6	\$ 10,195	\$ 2,599,776
Saturday												
BRT service	17.7	16	16.00	30	30	12	-	12	212	\$ 6	\$ 1,274	\$ 70,092
Sunday												
BRT service	17.7	15	15.00	30	30	12	-	12	212	\$ 6	\$ 1,274	\$ 70,092
												<b>\$ 2,739,960</b>
	One-way Bus Trip Length (miles)	Service span (hours)	Number of peak hours	Peak headway (minutes)	Off-peak headway (minutes)	Number of trips in peak	Number of trips off-peak	Total trips per day	Total mileage	Cost per mile	Total cost (daily)	Total cost (annually)
High frequency (over 3,000 riders/day)												
Weekday												
BRT service	17.7	18	6.00	10	15	36	96	132	2,336	\$ 6	\$ 14,018	\$ 3,574,692
Saturday												
BRT service	17.7	16	6.00	20	20	18	60	78	1,381	\$ 6	\$ 8,284	\$ 455,598
Sunday												
BRT service	17.7	16	6.00	20	20	18	60	78	1,381	\$ 6	\$ 8,284	\$ 455,598
												<b>\$ 4,485,888</b>

## APPENDIX III: Calculations for Vehicle Requirements







**RPTA Comprehensive Arterial Bus Rapid Transit Planning Study**

**Working Paper for Task 3: Review of Studies**

**Analysis of Industry BRT Studies and Regional  
Transit Studies Relevant to Valley Metro Arterial  
BRT Development**

September 2008

**Submitted To:**  
Valley Metro/RPTA

**Submitted By:**  
Parsons Brinckerhoff



Following as noted in the subject Scope of Work is a review of studies relevant to the development of the Arterial BRT network. The goals of this task are (1) to allow the planning process to benefit from industry-wide studies and policies; and (2) to ensure that any recommendations in the Comprehensive Arterial BRT planning study are consistent with other transit-related studies in the Valley. This working paper includes summaries of several industry studies and their relevance to the RPTA Comprehensive Arterial BRT study; and brief descriptions of local and regional studies that include transit findings and recommendations only as they are relevant to development of Valley Metro's arterial BRT network. A complete list of the documents reviewed is included in Appendix I.



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## **APPENDIX I LIST OF STUDIES/REPORTS REVIEWED**

## **APPENDIX II BRIEF SUMMARY OF NON-RELEVANT LOCAL/REGIONAL STUDIES**



## 1. NATIONAL/INTERNATIONAL INDUSTRY STUDIES

### 1.1. FTA Characteristics of BRT for Decision Makers (CBRT) (2004)

Published in 2004, the CBRT identified six “major elements” of any basic BRT system:

- Vehicles
- Running Ways
- Stations
- Service and Operating Plan
- Intelligent Transportation System Technologies (such as Traffic Signal Priority and Real-Time Traffic Information Systems)
- Fare Policy

These elements should work together as a system to achieve the following performance outcomes: improved travel times, greater schedule reliability, an identity and image distinct from other transit services (especially traditional bus service), enhanced safety and greater corridor capacity. These characteristics in turn achieve the following benefits: higher ridership, better capital cost-effectiveness when compared with alternative transit investments, improved operating cost-efficiency (again vs. other investments), transit-supportive land development (although it is arguable whether this benefit is greater for other fixed guideway modes) and environmental benefits.

For RPTA, the study has the following importance to the arterial BRT systems in Phoenix:

- CBRT was the first major federally released technical document that helped to define BRT for policy makers and others responsible for implementation of such systems.
- The CBRT document first characterized arterial BRT as part of the mode and not simply a transportation system management improvement to existing bus service if it addresses the above six elements in a system approach.
- These improvements do result in increased ridership, as demonstrated by cities that adopted BRT (and as corroborated by other BRT deployments that have occurred since the CBRT was published).
- CBRT documented a range of successes in the various performance measures above, although it was left to future studies to refine the linkages between various levels of investments in BRT and these outcomes (e.g., what quantities of travel time savings and ridership gains can be expected from exclusive vs. mixed traffic running ways).

### 1.2. TCRP Report #118: BRT Practitioner’s Guide<sup>1</sup>

Report #118 from the Transit Cooperative Research Program (TCRP) of the Transportation Research Board (TRB) provides more details in the issues addressed and updates data that was provided in the CBRT document. Particularly useful are updated unit costs for various BRT elements. In addition, the following applicable findings are worth noting:

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<sup>1</sup> Information on factors influencing ridership will be included in the working paper for Task 6.

- Because BRT can operate on arterial streets, in freeway medians, on freeway shoulders, and alongside freeways; in railroad and other separate rights-of-way; and in tunnels or on elevated structures, careful planning is needed. The mode is especially desirable in large urban areas where peak-period and all-day passenger flows are sufficient to warrant frequent service and there is a sufficient presence of buses to justify dedicated running ways.
- Current experience suggests that, in the United States or Canada, urbanized area population generally should exceed 750,000 and central business district (CBD) employment should be at least 50,000 (TCRP Report 90). However, a large university or other outlying major activity center could also support a BRT route or system. The following good practices are suggested based on industry BRT experience to date:
  - Trunk line BRT headways should be 8 to 10 minutes or shorter during peak periods and not more than 12 to 15 minutes during off-peak periods.
  - Ideally, there should be at least one BRT (and local) bus per traffic signal cycle where buses operate in a dedicated arterial street BRT lane.
  - BRT systems should focus on at least one major activity center, preferably with limited and/or expensive parking.
  - Communities contemplating BRT should have a clear vision of BRT needs and opportunities. BRT lines should be planned as an interconnected system of routes and incrementally developed, with the most promising links built first.
- BRT should be planned and developed through a process that stresses solving demonstrated current and forecast future problems and needs. Planning requires a realistic assessment of demands, costs, benefits, and impacts for a range of alternatives that includes a “base case” and may include one or more rail rapid transit options. Continuous community and decision-maker support is essential.
- BRT should be planned to realize the following objectives:
  - Serve demonstrated current and forecast future transit demand and needs
  - Provide reserve capacity for future growth
  - Attract automobile drivers to transit
  - Relate to and reinforce transit and pedestrian-oriented development
  - Have affordable initial implementation and ongoing operating and maintenance costs
  - Take advantage of incremental development opportunities, and promote complementary “Transit First” policies
  - Avoid vigorously any “deconstruction” of a BRT system by removing elements critical to its success to cut costs or bow to interests of competing modes

BRT should also be developed as a permanently integrated system of facilities, services, and amenities; i.e., providing the key attributes of rail transit to the maximum extent possible. It should operate on separate rights-of-way wherever possible and on wide, continuous, free-

flowing streets if separate rights-of-way are unavailable. If in-street operation is required, preferential treatments such as exclusive bus lanes, transit signal priority (TSP), queue jumps/bypass lanes, and curb extensions are desirable. Wide station spacing (except in downtown areas) is also desirable.

BRT systems should be reasonable in their costs to the community, urban travelers (especially transit riders), and the transit agency. Investments should be balanced with present and likely future ridership. Systems should be designed to increase transportation capacity in heavily traveled corridors, reduce travel times for riders, and minimize total person delay in the corridors served. A basic goal should be to maximize person flow with the minimum net total person delay over the long run.

Particularly noteworthy for the Comprehensive Arterial BRT study, streets and corridors with existing long, heavily-traveled bus routes are likely candidates for BRT. Often, BRT development will involve restructuring existing bus routes to provide sufficient service frequency along the BRT route. That does not mean that local service should cease; rather, it must be reconfigured to complement the new BRT service and thereby enhance total capacity and quality of transit service in the corridor.

Finally, BRT should have a consistent, appealing image that communicates this different service quality to the rider and community. BRT vehicles, stations, and marketing materials should convey the image of BRT as a rapid, easy-to-use, and socially beneficial service.

### **1.3. International Transport Development Program Bus Rapid Transit Planning Guide**

The International Transport Development Program BRT Planning Guide (June 2007) summarizes the international experience with BRT, particularly the well-known systems such as those in Curitiba, Brazil and Bogota, Columbia. It takes a slightly different approach to describing BRT decision-making, listing six major activities that must be considered in any sound BRT planning. These include:

- Project preparation, including evaluation of alternatives, market studies and consideration of competing technologies
- Operational planning, including type of network (e.g., trunk-only line vs. with feeders and express service as well) and the institutional coordination that enables many international systems to operate with little or no public subsidies due to the use of private operators<sup>2</sup> (further investigation of which may be of interest to RPTA planners)
- Physical design, including stations, running ways, etc.; as well as cost estimates (international experience suggests that BRT in the U.S. is roughly double the average costs of comparable systems elsewhere)

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<sup>2</sup> Note, however, that deficit-free transit of any kind generally is possible only under economic and development conditions that favor the use of public transportation rather than private vehicles.

- Integration issues, meaning both the interconnection of BRT with other modes (and related issues such as fare policies, passenger information, service timing etc.) as well as land use policies that support larger transit investments including BRT
- Business planning, including financial planning, contracting with providers (again, the common practice outside the U.S.) and, particularly important, marketing and branding
- Evaluation and implementation, which includes continuous follow-up monitoring of environmental and economic impacts of the investments as well the ridership and cost effectiveness of the operations

This document also defines BRT differently from the way it is defined in the U.S. Here, it includes only those systems with reserved bus lanes or segregated busways, plus at least two of the following characteristics: integrated route network; enhanced stations; level boarding and alighting; median platforms; prepaid fare collection; intermodal terminals in strategic locations; seamless fare integration with feeder buses and other transit modes; distinctive branding and identity; rationalization of operations in the corridor through regulation, concession agreements or operations plan (the last case if a single organization); low-emission/advanced propulsion vehicles; use of intelligent transportation systems; accessibility for the mobility challenged; and easy-to-understand signage and other passenger information systems.

#### **1.4. APTA Draft Industry Standards Developed To Date for BRT**

Although no industry standard has been adopted, there are several standards in various states of development by the FTA- and APTA-funded BRT standards development process. The most relevant of these to the RPTA's arterial corridors include:

- Service Design draft completed 2/14/2008
- ITS Communications draft completed 2/19/2008
- Vehicle Doors and Platform Interface draft completed 2/14/2008
- Stations draft completed 2/19/2008
- BRT Branding draft completed 2/14/2008 and distributed for ballot to industry for adoption
- ITS draft completed 2/19/2008

Final versions of the standards will be reviewed and incorporated as appropriate to the Comprehensive Arterial BRT project.

#### **1.5. Documentation on Branding and Ridership Outcomes**

Several recent documents discuss the importance of branding and image to stimulating ridership on BRT systems. These documents include National BRT Institute: Quantifying the Importance of Image and Perception to BRT (Cain and Flynn, 2007) and other relevant Branding/Ridership reports and presentations (Henke 2007, Failbel et al, 2006)

Cain and Flynn reported early findings of a study showing a relationship between stronger BRT branding and image and ridership gains but have yet to report findings that quantify the

relationship. Henke cited Failbel and others showing that as much as 20 percent of BRT ridership increases cannot be explained by any other factor (e.g., travel time savings, frequency etc.) and speculated that at least half could be from stronger branding and image. This speculation understates some recent industry experience. For example, although Eugene, Oregon's new BRT did not achieve the expected average travel speed, ridership is nearly double its projections.

#### **1.6. CALSTART's *Bus Rapid Transit Ridership Analysis***

This 2004 meta-analysis of ridership studies examined ridership results in six early-adopter BRT cities, including two that are arterial-based (Los Angeles, Oakland), two with mostly exclusive bus lane segments (Las Vegas, Boston), one with arterial and HOV segments (Phoenix), and one busway (Miami). The study found that the median corridor ridership increase was 41 percent with the highest posted by the system with an exclusive lane and strong branding and image for the BRT system (Boston, 96 percent).

NOTE: Information from this report and its source reports will be examined in more depth in Task 6: Modeling.

#### **1.7. Very Small Starts Funding Process and Eligibility Criteria**

The FTA administers the Section 5309 Capital Investment Grant program, which provides capital funds for major transit investment projects. As a result of the Safe, Accountable, Flexible Efficient Transportation Equity Act of 2005, A Legacy for Users (SAFETEA-LU), the Section 5309 Capital Investment Grants program now includes a new project category called "Small Starts." In issuing regulations and guidance that implements this new category, the FTA created a sub-category called "Very Small Starts." This category has the most relevance to the Arterial BRT program contemplated by RPTA; indeed, several similar projects have already received Very Small Starts (VSS) funding in other cities.

VSS projects are simple, low-risk projects that qualify for a highly simplified project evaluation and rating process by the FTA. In order to qualify, a project must be a bus, rail or ferry project with a cost less than \$50 million (total, i.e., combined federal and local contributions) and contain the following features:

- Ten-minute peak/15-minute off-peak headways or better while operating at least 14 hours per weekday (not required for commuter rail or ferries)
- Located in corridors with 3,000 or more existing average weekday riders who will benefit from the proposed project, and
- Have a total capital cost less than \$50 million (including all project elements) and less than \$3 million per mile, exclusive of rolling stock.

- Three of the following four elements<sup>3</sup>
  - Substantial transit stations
  - Traffic signal priority or pre-emption if there are traffic signals on the corridor
  - Low-floor vehicles or level boarding
  - Branding of the proposed service

(If a project does not meet all of these criteria, it will be evaluated as a Small Starts project.)

To prove the proposed project qualifies as a VSS, project sponsors shall submit:

- A detailed definition of the locally preferred alternative, describing the project elements demonstrating eligibility under this section.
- Documentation demonstrating that existing transit riders in the project corridor that will demonstrably benefit from the proposed Small Starts project exceed 3,000 per average weekday. This documentation will include the following:
  - Raw data on transit vehicle loadings in the corridor based on ride checks of ons and offs for existing services for three days of typical ridership and service
  - Description of the methods used to count riders in the corridor
  - Grantee verification of reliable data collection practices
- A transit operating plan that documents the transit services to be impacted by the proposed VSS project. The operating plan should document the number of existing riders on each affected bus or rail line whose passengers will directly benefit from the proposed project. The operating plan must demonstrate the manner in which existing riders will benefit in terms of reduced travel time, added frequency, or improved passenger amenities.

### *Very Small Starts Project Evaluation Process*

The project rating process and evaluation criteria are much less difficult for VSS projects than for other Small Starts or “big” New Starts. For example, the FTA automatically grants a medium rating for Project Justification, Cost Effectiveness and Land Use and Economic Development.

Projects will also receive a medium rating for Local Financial Commitment if they can demonstrate:

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<sup>3</sup> In its Federal register notice of August 8, 2008, the FTA eliminated the requirement that all four project elements (low-floor buses, traffic signal priority/pre-emption, significant stations, and branding) must be part of the project, and instead now allows a project to be eligible if it includes at least three of these four elements. This change was made because the agency said it was concerned about how minor improvements already made in a corridor, such as the existence of one of the four required elements, prevented projects from being eligible for Small Starts funding. Previously, small starts projects that did not include a fixed guideway (i.e., exclusive or mostly-exclusive BRT running way or track for rail projects) were not eligible for Small Starts funding if any of the four elements listed above already existed in the corridor.

- Funds are available for the local share
- The additional operating and maintenance costs of the project are less than 5 percent of the agency's operating budget
- The agency is in reasonably good financial condition

The project development process is also streamlined for VSS. During the planning and project development process, FTA evaluates the project's justification and local financial commitment and the project sponsor must address any remaining planning, environmental, engineering, and design issues and requirements. SAFETEA-LU requires FTA to approve the projects at two critical stages: 1) after alternatives analysis (AA) for entry into project development; and 2) to make funding recommendations through a Project Construction Agreement after project development has been completed.

Projects that are VSS may utilize a very simple project definition-based AA process. The key elements of the highly simplified alternatives analysis report are:

- A clear description and assessment of the transportation problem or opportunity to improve transportation service in the corridor.
- A clear description of the project designed to solve the problem or take advantage of the opportunity to improve transit service in the corridor. This section should include a clearly defined scope, list of project elements, their associated costs, and the expected effect on transit service in the corridor.
- A comparison of the VSS to conditions today, including an assessment of the effectiveness of the proposed project in solving the problem or taking advantage of the opportunity in the corridor.
- A determination of whether or not the project sponsor can afford the capital and operating costs of the alternatives.
- A well supported explanation for the choice of a proposed project that includes an analysis of the likelihood of the proposed project to achieve the project goals and any uncertainties associated with achieving the project goals.
- A plan for implementing and operating the proposed project that addresses the project sponsor's technical capability to build, operate and maintain the proposed project.

The above description of an AA for VSS applies only if the FTA has determined that the project qualifies as a NEPA categorical exclusion. (See 23 CFR 771.117.) If the project will require an Environmental Assessment (EA) or an Environmental Impact Statement (EIS), and the AA is not being combined with the NEPA document, then the requirements of the FHWA/FTA guidance on [Linking Planning and NEPA](#) would apply in order for the AA to have standing in the subsequent NEPA document. If the project is not a categorical exclusion and the AA is being combined with the EIS or EA, then the NEPA requirements of the EIS or EA (whichever the FTA has determined appropriate) would also apply, in addition to the AA requirements listed above.

For VSS projects, preliminary engineering and final design work is combined into one phase referred to as Project Development. This phase is also accelerated and more simplified than for larger Small Starts and certainly more streamlined than for New Starts.

### ***Project Construction Grant Agreement***

Financial assistance under Section 5309 for construction of a VSS project is provided through a Project Construction Grant Agreement (PCGA) that is negotiated during project development.

### ***Recommendation for Very Small Starts funding***

VSS projects that meet the following conditions may be recommended for funding in the President's budget, subject to funding availability:

- The project must have been approved to enter into project development.
- The project must be "ready" to be implemented.
- The project must be rated at least "medium."

As with all Section 5309 Capital Investment Grants, the rating process is separate from the budget decisions. Projects that achieve a "medium" or better rating will be eligible to receive Section 5309 Capital Investment Grant funds, but are not guaranteed to receive any funding in the President's Budget.

It is important to understand that the expedited rating process of VSS only promises a "medium" rating, and if competition for the limited amount of Small Starts money grows, a "medium" may not be good enough to assure funding. RPTA should closely monitor the demand for funding under the Very Small Starts program, because it may make sense to advance BRT projects as Small Starts rather than Very Small Starts if it appears that a higher rating is needed.

## **2. LOCAL/REGIONAL STUDIES<sup>4</sup>**

### **2.1. Mesa Main Street BRT Corridor Study**

The Mesa Main Street BRT Corridor Study is relevant to the Comprehensive Arterial BRT study because it established several policies and technologies that may apply to other BRT routes.

The purpose of the Mesa Main Street BRT Corridor Study was to develop the configuration and design concepts to enable early implementation of the proposed Mesa Main Street BRT line from Sycamore (the east end of the Central Phoenix/East Valley line) to Power Road. The study also considered selected routing variations, such as a possible extension to Superstition Springs Mall along either Main Street or Southern Avenue. The project goals are as follows:

- Provide transit that attracts choice riders
- Enhance local access and mobility

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<sup>4</sup> Studies in this section are generally listed in order of relevance to the current study, from most relevant to less relevant.

- Reduce bus travel times in the Main Street corridor
- Connect with other high-capacity and high-speed services
- Use existing rights-of-way as much as possible
- Promote transit-oriented development

The study is the first phase of a coordinated effort to plan high-capacity transit in the Main Street corridor.

**TABLE 1: SUMMARY OF THE MAIN STREET BRT RECOMMENDATIONS**

Alignment	Main Street from Sycamore to Power Road; then Power Road from Main Street to Superstition Springs Mall. (Possible deviation via 1 <sup>st</sup> Street between Country Club Drive and Mesa Drive if found during corridor planning to be needed.)
Initial stations	Sycamore (LRT transfer), Alma School Road, Country Club Drive, Center Street, Mesa Drive, Stapley Drive, Gilbert Road, Lindsay Road, Greenfield Road, Main Street/Power Road, Power Road/Baywood, Superstition Springs Center (12 stations)
Possible Future Stations	Val Vista Drive, Higley Road, Recker Road
Days of Operation	Monday through Sunday
Hours of Operation	Weekdays: 4:30 am to 10:35 pm Weekends: 5:00 am to 10:35 pm
Frequency of Service*	Weekdays: 15 min peak service, 30 min off-peak (peak services 6 am to 8:30 am and 3:15 pm til 6:35 pm) Weekends: 60 min service
Running Way Features	Curbside in mixed traffic, with future potential for dedicated lanes in some areas; curbside stations
Vehicle Length	60-foot buses with 30-minute peak service
Vehicle Floor Height	Low-floor design; either 70 percent low floor with raised section and step up behind center door, or full-length flat floor. Will provide near-level boarding.
Fuel	Compressed natural gas
Doors	Right side only; three on articulated buses, two on standard-length bus
Door Width	Maximum available (estimated to be 42 inches)
Seating Capacity	55 on articulated buses
Wheelchair Berths	Two
ITS	Communication through variable message sign and voice annunciator; Global Positioning System; on-board devices as part of signal priority treatment; Wi-Fi (optional extra cost item)
Enhanced Interior Treatments	Yes
Enhanced Exterior with Appropriate Branding	Yes
Bicycle Accommodation	Yes
Transit Priority Treatments	Varies by segment but limited signal priority is an objective along most of the route
Fare Collection	Hybrid, with farebox on each bus and ticket vending machines at Sycamore, Downtown, and Superstition Springs (Could eventually evolve into a fully off-board or proof-of-payment system, with ticket vending at each station.)
Station Design Features and Amenities	All stations will include benches, trash cans, shade treatments, schedule information, and other enhancements. Sycamore, Downtown, and Superstition Springs will have ticket vending machines.

Sources: *HDR Report on Mesa Main Street Operations Alternatives (Sept 2007)*; *IBI/DMJM Harris Final Report of the Mesa Main Street BRT Study (April 2007)*

\*Note: BRT service schedule is coordinated with local service schedule to provide 30-min frequencies on weekends.

## 2.2. Metro Rail Extension Studies

### *Central Mesa Alternatives Analysis/Environmental Impact Statement (AA/EIS)*

The Central Mesa AA/EIS is an ongoing study through February 2009; relevant findings will be updated throughout the process of the Comprehensive Arterial BRT project. The study may establish additional technologies or policies on BRT that would be relevant to the Comprehensive Arterial BRT project.

In February 2007, METRO Rail and the City of Mesa began a 24-month study (Alternatives Analysis) to analyze potential high capacity transit corridors in the Downtown Mesa area and east to Power Road. The study area begins in west Mesa at the eastern end of the line for the 20-mile starter Light Rail Transit (LRT) project at Sycamore and Main streets. The study area is bounded by Sycamore to the west, Power Road to the east, between University Drive and the Superstition Freeway (US 60). This study is the first part of the federally sponsored transit planning process which looks at a variety of potential transit technologies and alignments that may be built in the study area.

According to future travel trends, daily freeway congestions in the Mesa study corridor is expected to exceed congestion levels in other areas, such as the Downtown Phoenix area. In 2030, daily congestion is expected on 93 percent of lane miles on roadways in the Mesa project corridor; a growth of 66 percent over current levels. Areas located west of the immediate project corridor are expected to generate the highest growth in vehicular travel. In addition, several attractions of regional significance are being planned throughout the City. These attractions will provide significant employment, commercial, entertainment and retail resources, and are expected to generate even greater demand for travel and access.

The Alternatives Analysis also outlined priorities for the use of transit technologies such as BRT and Light Rail. Below is a list of priorities:

- Increase access to regional employment areas for City of Mesa residents
- Provide improved travel times over local bus
- Identify transit technology and route to connect with the Central Phoenix/East Valley Light Rail Transit System
- Facilitate continued development of a regional, seamless transportation system
- Attract new transit riders onto the growing regional system
- Support economic development

### ***Tempe South AA/EIS***

The Tempe South AA/EIS is an ongoing, 24-month study; relevant findings will be updated throughout the process of the Comprehensive Arterial BRT project. The study may establish additional technologies or policies on BRT that would be relevant to the Comprehensive Arterial BRT project. In addition, the study area overlaps with a portion of the Scottsdale/Rural arterial BRT route, and any recommendations regarding the two routes should be coordinated.

METRO, in cooperation with the Federal Transit Administration (FTA), is conducting a 24-month AA/EIS in the southern Tempe/western Chandler area to analyze a potential high-capacity transit connection to the 20-mile METRO Central Phoenix/East Valley light rail starter line. As with the Central Mesa AA/EIS, the Tempe South AA/EIS is the first stage of the federally sponsored transit planning process, and looks at a variety of potential alignments and transit technologies (including bus rapid transit, light rail transit, modern streetcar and/or commuter rail) that could be built in the study area.

### ***METRO Transit System Configuration Study***

The METRO Transit System Configuration Study was the first phase of a comprehensive system study for the 57-mile high-capacity transit system. The technologies established in the Transit System Configuration Study may affect which technologies are used in the BRT system or the efficiency of the BRT system.

The METRO Transit System Configuration Study is a technical report assessing additional important issues not specifically addressed in earlier documents. The issues are listed below:

- The capacity and constraints of the North Central Avenue LRT Corridor
- Impacts to traffic due to LRT branching
- Express Operations
- Additional Maintenance location
- The layout and operation of the Downtown Phoenix Junction

During the preliminary stages of LRT design, a traffic system operating strategy was proposed and evaluated by the local jurisdictions that control the street system in which the LRT project is located. (This was tested as part of the light rail design effort.) The system to be used is referred to as “Predictive Priority.” Predictive priority is a system wherein LRT trains operate with traffic signal priority that recognizes approaching LRT trains as well as traffic on adjacent streets and adjusts traffic signals accordingly. The predictive priority system was developed after an analysis of the entire 20-mile light rail alignment and approximately 350 adjacent intersections. As a result, predictive priority treats intersections differently depending on conditions at that specific locations; predictive priority may also respond differently depending on the time of day. The signal prioritization will continue to evolve once the light rail is in operation and as traffic patterns change over time.

### 2.3. City of Chandler High Capacity Transit Study

This 2003 report from the City of Chandler and RPTA evaluated the need for high-capacity transit services on Chandler Boulevard and Arizona Avenue. The study recommended a phased approach to transit improvements on both roadways; each phase of improvements sets the foundation for the next. In phase 1, queue jumper lanes, traffic signal system upgrades, bus stop improvements, and fiber optic cables are recommended for use by the local bus transit network and to enable communications for the future BRT system. In phase 2, mixed-flow BRT is envisioned for Chandler Boulevard, Arizona Avenue, Rural Road, and Williams Field Road. (Williams Field Road BRT is envisioned for the longer term.) Phase 3 incorporates light rail on the Arizona Avenue and Rural Road corridors, but only in the longer term.

NOTE: Any BRT recommendations from the current project should recognize the long-term plans for both Arizona Avenue and Rural Road to permit convertibility to light rail.

### 2.4. Valley Metro/RPTA Efficiency and Effectiveness Study

The purpose of the Efficiency and Effectiveness Study was to develop a reporting framework of quantifiable measures to evaluate bus and rail transit service performance, at both the route and system-wide levels, in support of Proposition 400. The Arizona statutes concerning the Proposition 400 law call for performance audits starting in 2010. The measures developed will be used to complete the audits. Below are the performance targets for fixed route buses at the route level:

**TABLE 2: PERFORMANCE TARGETS FOR FIXED ROUTE BUSES AT THE ROUTE LEVEL**

Fixed Route Bus, Route Level	Target
<b>Cost Efficiency/Effectiveness</b>	
Farebox Recovery Ratio	25%
Operating Cost Per Boarding	\$2.32
Subsidy (Net Operating Cost) Per Boarding	\$1.75
Cost Per Revenue Mile	\$4.96
<b>Service Effectiveness</b>	
Total Boardings	3%*
Boardings Avg. Weekday, Sat. Sun.	3%*
Boardings Per Revenue Mile	2.1
Boardings Per Revenue Hour (Express Bus)	TBD
On-time Performance	90%
Miles Between Mechanical Failures	23,400

\* Items: Financial Plan assumptions; subject to service level increases.

Note: The performance measures for “Total Boardings” and “Boardings Avg. Weekday, Sat., Sun.” refer to an increase in boardings on the route in question versus general population growth. In other words, a goal for each route is a 3% increase in ridership over whatever increase would be expected due to population growth.

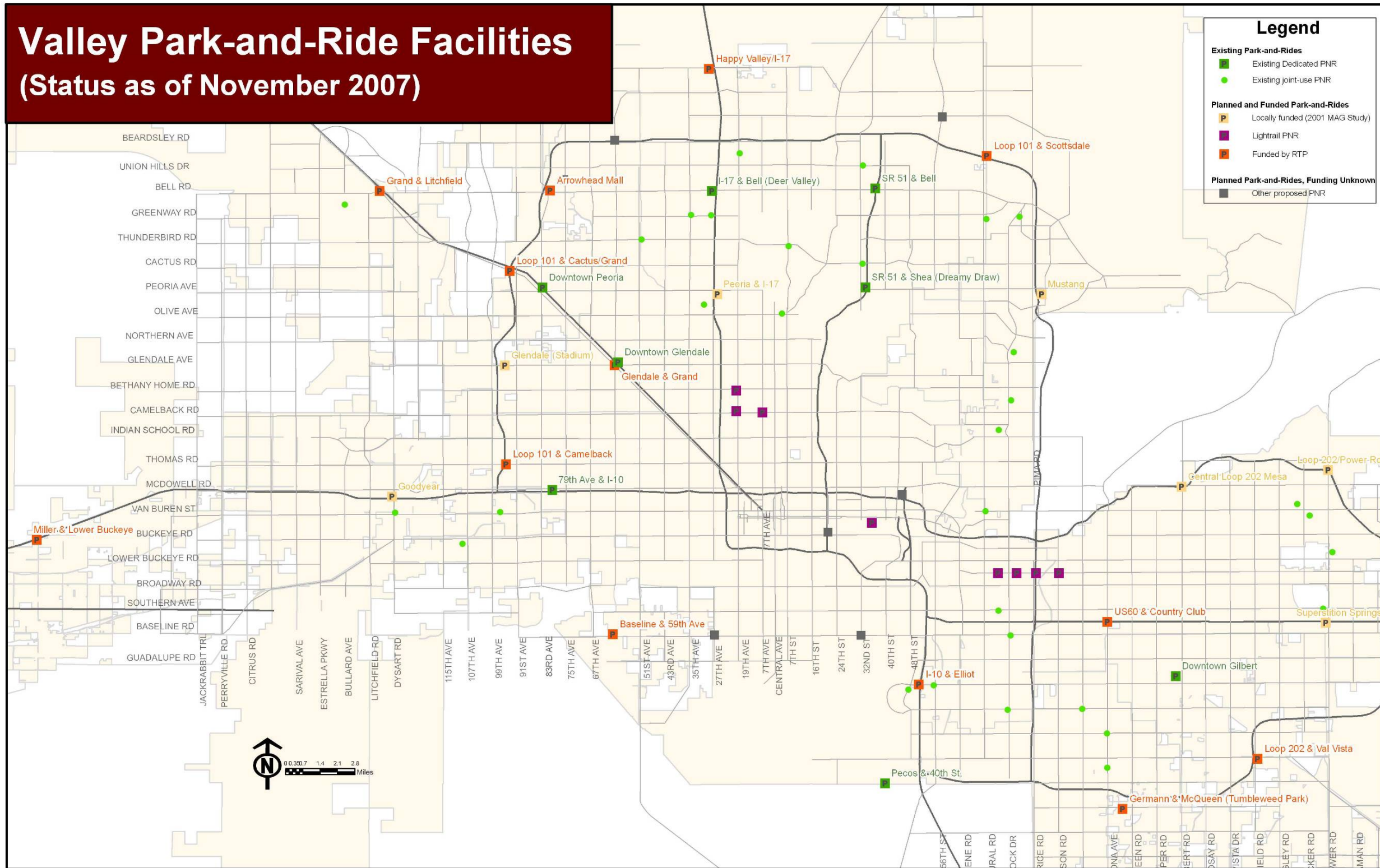
The study also discussed expectations for implementing new routes. A phased service approach was recommended for areas where population and employment density are significantly low or supporting passenger facilities are unavailable. (However, no methodology was formally recommended.) Routes are granted a two-year maturation period before they are subject to the performance measures. The study also recommended that routes be measured by subsidy per boarding, and that the RPTA identify a lifeline network that “would be maintained over time serve Title VI markets or other policy requirements even if its performance fell below the systemwide average.”

The Arterial BRT Planning Study will consider these performance measures for the arterial BRT network and propose additional measurements if applicable.

## **2.5. MAG Park-and-Ride Study & RPTA Park-and-Ride Reprioritization Study**

Park-and-ride facilities will support the arterial BRT system in appropriate locations. The 2001 MAG Park-and-Ride Study established a regional network of park-and-ride facilities to support the commute-oriented express bus system. The 2008 Park-and-Ride Reprioritization Study refined the construction schedule of 13 park-and-ride facilities (funded by proposition 400) to ensure alignment with operational start dates. A map of the envisioned park-and-ride network is shown on the next page.

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Source: RPTA Park-and-Ride Reprioritization Study

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## **2.6. Regional Transportation Plan, Annual Updates, and 2007 Transit LifeCycle Program Review**

The 2003 Regional Transportation Plan (RTP) established a set of projects funded by Proposition 400 sales tax revenues. Among the transit projects included in the RTP is the arterial BRT system. (Much of this system was developed in previous reports such as the Regional Transit System Study and the MAG High-Capacity Transit Study.) The RTP is updated each year to reflect the status of projects and update any changes. The 2007 Transit LifeCycle Program Review refined the operating and financial assumptions for transit projects included in the RTP to evaluate the financial feasibility of transit projects given rising costs and changing expectations. Although many previous documents have contributed to the formation of the arterial BRT system, findings from the 2007 TLCP Review and the latest RTP Update serve as the basis for mileage, funding, and start-date assumptions of this current study.



## **APPENDIX I**

### **List of Studies/Reports Reviewed**



## **NATIONAL AND INDUSTRY STUDIES AND REPORTS**

- FTA Characteristics of BRT for Decision Makers
- TCRP Report #118: BRT Practitioner's Guide (include web-only document 39: Appendices to the BRT Practitioner's Guide & A90 as needed)
- ITDP Bus Rapid Transit Planning Guide (June 2007)
- APTA draft industry standards for BRT
- National BRT Institute's (CUTR) "Quantifying the Importance of Image and Perception to BRT" and other relevant branding/ridership reports and presentations
- CALSTART's "Bus Rapid Transit Ridership Analysis" report
- Review of Federal Very Small Starts funding process and eligibility criteria

## **COMPLETED LOCAL/REGIONAL STUDIES**

- Mesa Main Street BRT Corridor Study
- Regional Transportation Plan (/Prop. 400) & 2007 Annual Review (HDR/SR Beard Study), Regional Transit System Study (2003)
- METRO Transit System Configuration Study (Phase I)
- Bus Stop Program and Standards
- Five-year Transportation Improvement Program (TIP)
- MAG Park-and-ride Study
- RPTA Park-and-Ride Reprioritization Study
- RPTA Freeway Express/BRT Operating Study
- MAG High Capacity Transit Study
- MAG Commuter Rail Study
- City of Chandler High Capacity Transit Study
- RPTA Service Effectiveness and Efficiency Study

## **ONGOING LOCAL/REGIONAL STUDIES**

The PB Team will monitor the following studies to ensure findings and recommendations are incorporated as appropriate to the current study

- Main Street Alternatives Analysis/Environmental Impact Statement
- Valley Metro Rail (VMR) on-going corridor & planning studies
- Arizona Avenue BRT Design Concept Report Study
- RPTA Branding/Identity Study & development
- City of Glendale Light Rail Corridor Study

## **STUDIES NOT AVAILABLE FOR REVIEW**

- City of Phoenix Bus Stop Study
- City of Surprise Transit Plan

## **APPENDIX II**

### **Brief Summary of Non-Relevant Local/Regional Studies**



## **MARICOPA ASSOCIATION OF GOVERNMENTS TRANSPORTATION IMPROVEMENT PROGRAM – JULY 2007**

The Maricopa Association of Governments (MAG) Transportation Improvement Program (TIP) comprises a technical report and a list of funded projects. The TIP includes street, freeway, transit, Intelligent Transportation System, travel demand management, trip reduction, bicycle, pedestrian, and telecommunication projects of the MAG member agencies, ADOT, the RPTA/Valley Metro, and the Indian Communities. The technical report provides a detailed explanation of the transportation planning process and also includes an analysis of the funding that is incorporated. The final volume contains the full listing of projects.

This study does not provide Bus Rapid Transit (BRT) characteristics and factors impacting route efficiency and connectivity.

## **MARICOPA ASSOCIATION OF GOVERNMENTS COMMUTER RAIL STRATEGIC PLAN (DRAFT)**

The Maricopa Association of Governments has been actively exploring potential options for enhancing the longer-term economic vitality of the county and the mobility and well-being of its citizens. MAG recognized that commuter rail corridors may serve a critical function in addressing future travel needs in the region. The Commuter Rail Strategic Plan provides a framework on how commuter rail could be implemented in the MAG region and northern Pinal County. Three core elements build the foundation for the plan:

- A framework of goals, objectives, and action items to implement commuter rail
- A series of implementation steps for commuter rail investment
- A consensus agreement of a large and diverse group of stakeholders

The contents of the study do not provide any BRT system characteristics and factors impacting route efficiency and connectivity. However, any BRT or commuter rail plans should identify potential transfer points and understand the other system's potential impact on operations.

## **RPTA BUS STOP PROGRAM AND STANDARDS**

The Regional Transportation Plan designated \$26.4 million for bus stop improvements over the 20-year life of the program. The goals of the Bus Stop Program and Standards project were to understand the data maintenance and management practices of RPTA member agencies; understand the needs and objectives of member agencies in providing amenities at bus stops; develop reasonable levels of investment (funding) for bus stop amenities; design a program of objective criteria to prioritize RTP funding for bus stops across the region; provide best practices and design standard construction requirements to RPTA member cities to meet RPTA's goals as well as newer requirements from the Americans with Disabilities Act (ADA); and prepare a coordinated implementation program for bus stop investments.

The RTP established a separate pool of funding for capital improvements to the arterial BRT network.

### **RPTA FREEWAY EXPRESS BUS/BRT OPERATING PLAN**

The RTP established a network of freeway-based, commuter-oriented express bus routes. These routes, referred to as Freeway Express Bus/BRT are distinguished from the arterial BRT network in that they travel almost exclusively on the freeway network, generally travel inbound in the morning and outbound in the evening, and operate only during the peak commute periods.

**RPTA Comprehensive Arterial Bus Rapid Transit Planning Study**

**Working Paper for Task 5: Peer City Review**

**Analysis of Peer Cities' Experience Relevant to  
Valley Metro Arterial BRT Development**

September 2008

**Submitted To:**  
Valley Metro/RPTA

**Submitted By:**  
Parsons Brinckerhoff



Following as noted in the subject Scope of Work is a review of peer city experiences relevant to the development of the Arterial BRT network. This information includes a description of the peer networks' administrative and operational structure, funding, equipment and technological resources, level of service compared to demand, how the peer system identified the needs and trip requirements of user groups, routing, fare structure, and performance indicators (i.e. cost per trip, mile, and hour), as available for each peer city.



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## **APPENDIX: SYSTEM MAPS**



## **1. INTRODUCTION**

Although Bus Rapid Transit (BRT) has received major attention in the United States only relatively recently, there are now examples of BRT systems in many US cities and around the world. As each new BRT system is developed, additional knowledge is gained about the ways in which BRT systems can and should be implemented. In order to facilitate application of lessons learned as the Valley's arterial BRT network is implemented, the goal of Task 5 is to provide a brief examination of the experience of several cities with arterial BRT.

Three peer cities, providing a diverse mix of arterial BRT and other transit services, were selected for the review. Los Angeles was chosen for its diverse network, branding of types of BRT and other transit services, and incremental system development. Las Vegas demonstrates an incremental approach, has similarities to the Valley in geography, climate, and urban development patterns, and provides an example of use of private contract operators. York, Ontario is also an example of incremental BRT development, displays interconnection with other transit modes, and has strong branding strategies. These peer cities are presented below in this order. To provide context for the understanding of each city's BRT system, this report includes background information on the service area and the overall transit system in each case. To the extent available, information on funding, ridership metrics, administrative and operational structure, and BRT planning criteria for each system are presented.

## **2. EXAMINATION OF PEER CITY EXPERIENCES**

### **2.1. Technical Advisory Group Specific Inquiries**

The study's Technical Advisory Group (TAG) members asked the consultant team to address specific questions in the peer city review. These issues are presented in Table 1, with a summary of experiences from the peer cities. Following the table is an extensive description of the experience with BRT in Los Angeles (the Los Angeles County Mass Transit Authority, or LACMTA), Las Vegas (the Regional Transportation Commission of Southern Nevada, or RTC), and York (York Region Transit, or YRT).

TABLE 1: SUMMARY OF EXPERIENCE ON RELEVANT ISSUES

	Los Angeles, CA	Las Vegas, NV	York, Ontario
Cross-jurisdictional technology issues	<ul style="list-style-type: none"> <li>Traffic signal priority (TSP) present only in Los Angeles City, but discussions with other cities regarding more compatible radio-frequency-based (but more expensive) TSP technology</li> <li>Multiple agencies within Los Angeles County operate BRT services</li> </ul>	<ul style="list-style-type: none"> <li>TSP implemented at 11 of the major intersections (adjusts the green cycle), triggered automatically (headway based)</li> <li>Coordinated programming with cities of Las Vegas and North Las Vegas so as not to interfere with emergency vehicles' manual signal preemption system</li> <li>An integrated regional traffic management system is being developed under RTC's Freeway and Arterial System of Transportation (FAST) program</li> <li>Queue jump in one area, traffic enforcement issue initially but resolved</li> </ul>	<ul style="list-style-type: none"> <li>TSP at major intersections</li> <li>Queue jump lanes implemented in some areas</li> </ul>
Cross-jurisdictional policy issues	<ul style="list-style-type: none"> <li>Exclusive lanes or mixed-flow, depending upon city</li> <li>Service standards identical along entire route</li> </ul>	<ul style="list-style-type: none"> <li>Service standards identical along entire route</li> <li>Different branding (ACE) for subsequent corridors</li> </ul>	<ul style="list-style-type: none"> <li>Service standards identical along entire route</li> <li>Interconnection coordination with affected other agencies' services (local bus and rail), noted below</li> <li>"Family of services" concept, standards for Viva plus other bus (local express, shuttle) services in York Region, with performance standards being monitored for each type of service</li> </ul>

**TABLE 1: SUMMARY OF EXPERIENCE ON RELEVANT ISSUES**

	<b>Los Angeles, CA</b>	<b>Las Vegas, NV</b>	<b>York, Ontario</b>
Capital costs & funding sources	<ul style="list-style-type: none"> <li>• Demo routes required little additional operating/capital funding; reduced travel times offset cost of BRT improvements</li> <li>• Few hundred dollars for initial TSP system in City of L.A.; \$3,000 per-bus for more compatible signal prioritization technology</li> <li>• \$300,000/mile capital for expansion (not including Orange Line)</li> <li>• \$330 million for Orange Line development (not including right of way acquisition)</li> </ul>	<ul style="list-style-type: none"> <li>• \$20.3 million (\$2.7 million per mile)</li> <li>• \$175,000 per station</li> </ul>	<ul style="list-style-type: none"> <li>• \$150 million for initial phase (in 5 stages), or \$2.5 million per mile</li> <li>• \$113 million for operating and maintenance cost during first five years</li> </ul>
Local and BRT service integration	<ul style="list-style-type: none"> <li>• Maintained local routes with slight service reduction</li> <li>• Eliminated limited-stop service where present</li> </ul>	<ul style="list-style-type: none"> <li>• Maintained local route service with somewhat reduced frequency to integrate with BRT</li> </ul>	<ul style="list-style-type: none"> <li>• Connections to five other Viva BRT routes; also Toronto Transit Commission (TTC) Yonge, Spadina, and Sheppard subway lines and several TTC bus routes</li> <li>• Full integration with local York municipal bus network with single no-transfer fare</li> <li>• No integration with the regional commuter rail network (GO), except for one GO station served</li> <li>• Integration planned with Brampton Transit's BRT service (AcceleRide) in the Queen Street/Highway 7 corridor, opening later in 2008</li> </ul>

TABLE 1: SUMMARY OF EXPERIENCE ON RELEVANT ISSUES

	Los Angeles, CA	Las Vegas, NV	York, Ontario
Differentiation between local and BRT services	<ul style="list-style-type: none"> <li>• System brand name</li> <li>• Vehicle design/colors</li> <li>• Station design &amp; spacing</li> <li>• Headway-based management of frequent service, without fixed timetable</li> <li>• Frequent, all-day service</li> <li>• TSP</li> <li>• Pre-paid fare collection (Orange Line only)</li> </ul>	<ul style="list-style-type: none"> <li>• System brand name</li> <li>• Vehicle type &amp; paint scheme</li> <li>• Station design &amp; spacing</li> <li>• Multiple-door entry</li> </ul>	<ul style="list-style-type: none"> <li>• System brand name, a product of extremely thorough branding research and implementation plan</li> <li>• Vehicle type &amp; paint scheme</li> <li>• Station design and signage</li> <li>• Multiple-door entry</li> <li>• Pre-paid fare collection</li> <li>• Flexible transfer policy</li> </ul>
Typical BRT headways	<ul style="list-style-type: none"> <li>• Peak: 3-10 minutes</li> <li>• Off-peak: 6-12 minutes</li> </ul>	<ul style="list-style-type: none"> <li>• Day: 12 minutes</li> <li>• Night: 20 minutes</li> </ul>	<ul style="list-style-type: none"> <li>• Peak: 3-10 minutes</li> <li>• Off-peak: 15 minutes</li> </ul>
Typical BRT station spacing	<ul style="list-style-type: none"> <li>• ¾ mile (Metro Rapid)</li> <li>• 1 mile (Metro Orange)</li> </ul>	<ul style="list-style-type: none"> <li>• Approximately 0.7 mile</li> </ul>	<ul style="list-style-type: none"> <li>• 1-2 km (0.6-1.5 mi)</li> </ul>
Examples of where there is LRT on a portion of a BRT route	<ul style="list-style-type: none"> <li>• Metro Rapid BRT routes overlap with Red Line heavy rail and Gold, Green and Blue Lines LRT on several portions (see map)</li> <li>• New Metro Rapid lines will overlap with Blue Line LRT near Long Beach</li> </ul>	<ul style="list-style-type: none"> <li>• Not applicable; LRT rejected as rapid transit option for foreseeable future</li> </ul>	<ul style="list-style-type: none"> <li>• Viva lines feed into/ terminate at northernmost Toronto subway station, subsequent phases evaluating LRT-convertible exclusive BRT running ways</li> </ul>
Station planning for walk-to-BRT versus drive-to-BRT	<ul style="list-style-type: none"> <li>• Many Rapid stations are sidewalk-based</li> <li>• Bikeways to Orange Line stations, bike lockers</li> <li>• Bike racks on Metro Rapid and Orange Line vehicles</li> </ul>	<ul style="list-style-type: none"> <li>• Bikes allowed on board MAX vehicles; racks provided</li> </ul>	<ul style="list-style-type: none"> <li>• Viva night service (after 9 PM) allows passengers to ask drivers to drop between stations for shorter walks</li> <li>• Transit-supportive design principles also followed for Viva station area planning</li> </ul>
Passenger information systems (cost, phasing, integration into overall travel networks)	<ul style="list-style-type: none"> <li>• Real-time arrival/departure information</li> </ul>	<ul style="list-style-type: none"> <li>• Real-time arrival/departure info; other customer information provided in stations</li> </ul>	<ul style="list-style-type: none"> <li>• Real-time arrival/departure information</li> </ul>

**TABLE 1: SUMMARY OF EXPERIENCE ON RELEVANT ISSUES**

	<b>Los Angeles, CA</b>	<b>Las Vegas, NV</b>	<b>York, Ontario</b>
Convertibility of BRT corridor to LRT over time	<ul style="list-style-type: none"> <li>• Wilshire Rapid considered interim step for eventual subway</li> <li>• Orange Line running way designed so as not to preclude LRT (e.g., widths, curvatures, overcrossing bridges etc.)</li> </ul>	<ul style="list-style-type: none"> <li>• No plans for future LRT, although alignment geometries would support LRT</li> </ul>	<ul style="list-style-type: none"> <li>• Later phases may incorporate LRT or subway extensions</li> </ul>
BRT - LRT intersections	<ul style="list-style-type: none"> <li>• See above; pedestrian walkways and wayfinding signage on Orange Line to Red Line heavy rail</li> </ul>	<ul style="list-style-type: none"> <li>• N/A</li> </ul>	<ul style="list-style-type: none"> <li>• See above</li> </ul>

## 2.2. Los Angeles County Metropolitan Transportation Authority

### *General Agency Information*

Los Angeles County Metropolitan Transportation Authority (LACMTA) is the state-chartered regional transportation planning and public transportation-operating agency for the county of Los Angeles. LACMTA operates the third-largest public transportation system in the United States by ridership, with two subway lines, three light rail lines, three transitways (one of which is BRT), and 191 bus routes. The LACMTA system services all of Los Angeles County, which includes the City of Los Angeles and 87 other communities, as well as unincorporated areas. In total, LACMTA's services encompass a 1,433-square-mile bus operating area, 73 miles of rail, 62 rail stations, and 24 transitway stations.<sup>1</sup> The agency's budget for fiscal year 2008 is set at \$3.13 billion, with \$1.22 million allocated to Metro bus and rail operations.<sup>2</sup> Weekday boardings for the LACMTA system average 1.5 million (estimates are as of February 2008).

LACMTA has implemented two different types of BRT. Metro Rapid is an arterial BRT system, which currently consists of 26 different routes. The Metro Orange Line is currently a single route operating within a dedicated transitway. Although rubber-tired vehicles are used on Metro Orange, the LACMTA markets the Metro Orange Line as part of its rail network. (LACMTA has never considered Metro Rapid a substitute for rail service, but instead uses the program as a pragmatic interim measure given budgetary constraints.) After a brief description of the origins of BRT in Los Angeles County, both systems are described in detail.

### *BRT Development*

BRT development in Los Angeles County started as an investigation into methods of increasing bus speeds, which had declined an average of one percent per year since the 1980s. In addition, a delegation of officials from LACMTA visited the BRT system in Curitiba, Brazil and were impressed by how that city significantly changed the market share for public transportation with much less investment than would have been required for a rail-based system.

These officials and Metro staff identified 12 elements of BRT's success in Curitiba:

- More frequent service
- Priority in traffic at signalized intersections
- Headway-based schedules (as opposed to fixed timetables, which characteristically result in periodic bunching of vehicles – some early, some late)
- Simplified route structure\*
- Fewer stops spaced about a mile apart\*
- Integration with other modes and types of bus service
- Level boarding

<sup>1</sup> The LACMTA system map is too large to be included in this document, but can be viewed online at [http://www.metro.net/riding\\_metro/maps/system\\_map.pdf](http://www.metro.net/riding_metro/maps/system_map.pdf).

<sup>2</sup> The latter figure is for operations only and does not include capital, construction, debt service, paratransit, or streets and highways funds.

\* These items are characteristic of rail transit service.

- Coordinated branding that interrelates buses, stations, and passenger information
- Higher-capacity buses
- Exclusive rights-of-way to take buses out of slower traffic flow
- Prepaid fare collection
- Bus feeder services\*

For the demonstration program and the BRT service in L.A. to date, Metro planners incorporated the first eight of these attributes. The last attribute was in a sense adopted as well because local service, while reduced to a small degree, was maintained on these two corridors.

### **Metro Rapid**

BRT began in L.A. with two demonstration lines, which, at \$14 million in reprogrammed capital funds, had virtually no new cost to build and operate. The plan, called Metro Rapid, was a no-frills approach. It debuted in June 2000 with two corridors totaling more than 40 miles, running on Ventura Boulevard and Wilshire Boulevard, two of the most heavily patronized bus corridors in the County. These first two demonstration lines increased bus speeds by 29% on the Wilshire/Whittier corridor and 23% on the Ventura corridor. Ridership increased by more than 42% on Wilshire/Whittier and 29% on Ventura immediately; today, the two corridors are up 49% and 45% respectively since their launch. One third of those riders are new to transit and previously commuted by automobile.

**FIGURE 1: EARLY METRO RAPID VEHICLES**



The overall increase in the Wilshire/Whittier corridor appears to result from major growth in both Metro Rapid and local ridership even though limited-stop service in the corridor was eliminated. Part of this may possibly be explained by (a) the synergies between wider stop spacing for Metro Rapid and more closely spaced local service stops, resulting in some transfers

between the two; and (b) dropping the old limited-stop service, which was only limited-stop for a portion of the route and operated redundantly with local service for long segments of the alignment. A more rational route structure resulted when Metro Rapid was implemented. Later growth occurred because the Wilshire/Whittier Metro Rapid was initially capacity-constrained in the morning peak period, and LACMTA added 23 more trips (89 buses) in September 2000 to alleviate this constraint.

Buoyed by these results, the Metro board voted to expand the system to a 28-route network comprising 450 miles (see map in Appendix I). The expansion timetable has been aggressive, launching an average of two new routes every six months through 2008. Since that announcement, the agency has reconfigured several routes to include “Rapid Express” routes, which are skip stop routes along existing Metro Rapid corridors. However, the total number of original-concept Metro Rapid lines remains the envisioned 28, of which 24 have been deployed, with the last four to be in place by the middle of this year.

Although the results have not been as impressive as with the first two lines, these other Metro Rapid lines have also performed well. For example, in the Broadway corridor, which runs north–south through downtown on the eastern edge of the central business district, ridership is up seven percent since the launch of Metro Rapid, while on the Vermont line to the west of the downtown core, patronage is up only four percent. These result, however, are during a time when the rest of the bus system has experienced ridership declines due to financially induced service cutbacks. According to LACMTA documents, overall performance of the Metro Rapid network implemented to date has achieved a 25 percent reduction in passenger travel times on most routes, and a 25 percent increase in passenger capacity in each of the first 18 corridors for virtually the same operating cost per revenue vehicle service hour.

**Metro Rapid Service Characteristics.** On the Metro Rapid system, simple route structures and high-frequency services – with buses arriving as often as every three to ten minutes during peak commuting times – are the norm.

**Metro Rapid Station Design.** Metro Rapid stations provide information, lighting, canopies, and “Next Trip” displays.

**Metro Rapid Fare Policy.** Fares are the same as other Metro bus and rail service: a one-way ticket is \$1.25, and an all day Metro pass is \$3. Effective in 2009, fares will increase: the base fare will be \$1.50, a day pass will be \$6.00, a weekly pass will be \$20.00, and a monthly pass will be \$75.00. Metro Rapid buses also accept municipal transfers.

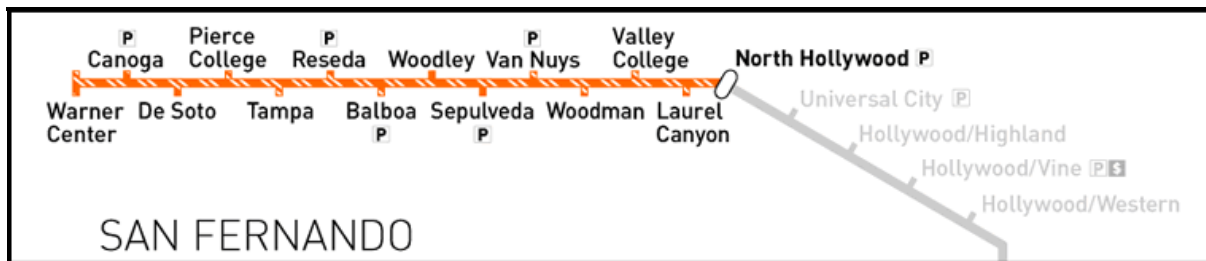
**Metro Rapid Fleet.** The Metro Rapid fleet consists exclusively of low-floor buses manufactured by either North American Bus Industries (NABI) or New Flyer. Buses include 40-foot New Flyer buses, 40-foot NABI buses, 45-foot NABI Compobuses, and 60-foot NABI articulated buses. Forty-foot buses are used on most lines, with high-capacity 45- and 60-foot vehicles on the most heavily used routes.

**Metro Rapid Technology/Infrastructure.** Metro Rapid buses run in mixed traffic lanes. Metro Rapid vehicles are equipped with special transponders that can initiate the advancement or extension of traffic-signal green time to favor the bus. Buses are granted priority depending on the scheduled headway after the most recent Metro Rapid bus detected at the intersection. Traffic signal priority is not operative outside of the City of Los Angeles because only the City has tied the transponders to the signal network. The Los Angeles County Department of Public Works is working on extending priority availability in all the other cities served by Metro Rapid buses. This entails the use of a separate traffic signal priority system; if the traffic-loop-and-bus transponder-type system cannot be used, a radio-frequency-based system mounted on each bus is required. This has driven the cost up from a few hundred dollars per bus to approximately \$3000 per bus.

### **Metro Orange Line**

Perhaps the largest-scale improvement in BRT in the county is the \$330 million, 14-mile Orange Line. This BRT system is in an exclusive busway roughly parallel to the Ventura Metro Rapid Line about half a mile to the north in the San Fernando Valley (see **Figure 2**). The BRT line, which features prepaid fare collection, high-capacity advanced-design articulated buses and light rail-like stations with attractive landscaping, bike paths, and other amenities, has exceeded ridership expectations. More than 25,000 weekday passengers use the Orange Line, which has been branded as part of the county's rail system rather than as part of the Metro Rapid network.

**FIGURE 2: ORANGE LINE ROUTE MAP**



The Metro Orange operating budget for fiscal year 2008 is set at \$21 million.

The Orange Line is designed with characteristics similar to an urban light rail system such as a dedicated right-of-way, longer station spacing, platform ticket machines for faster boarding, public art, park-and-ride lots, and other amenities. Vehicles have no fareboxes because the Metro Orange Line operates on a proof-of-payment system, like the Metro Rail network.

**Metro Orange Service Frequency.** Buses run every 12 minutes, with headways reduced to six minutes during peak travel times.

**Metro Orange Station Design and Amenities.** The Metro Orange line serves 14 inviting, passenger friendly transitway stations, with each station featuring artist-designed seating and

paving, pedestrian pathways from surround neighborhoods and bicycle parking. Some stations include park-and-ride lots and other amenities. Stations are approximately one mile apart.

**Metro Orange Fare Structure and Policies.** The Metro Orange fare structure is the same as for the Metro Rapid and LACMTA system. Ticket Vending Machines (TVM) dispense one-way tickets and day passes. There are no fare gates on the Metro Orange Line. Instead, the Los Angeles County Sheriff's Department and Metro fare inspectors conduct random checks of the system. Unticketed passengers can be fined up to \$250 and/or ordered to perform community service for 48 hours. LACMTA estimates that only about three percent of riders avoid paying the fare. As of 2006, however, LACMTA was considering the possibility of adding turnstiles to raise fare system security.

**Metro Orange Fleet.** The Metro Orange fleet consists of 30 articulated buses 60 feet in length. These "Metro Liners" have three doors for faster boarding and alighting. The Metro Liners are made by NABI and are fueled by compressed natural gas, which is now the fuel for almost all LACMTA buses.

### *LACMTA System Branding*

Metro operates three types of bus services, which are distinguished by the color of the buses. Metro Local buses, orange in color, make frequent stops along major thoroughfares (some routes make limited stops but are not part of the Rapid program). Metro Local is the only service with any diesel-powered or standard-floor buses in the agency's fleet.

Metro Express vehicles, which operate freeway-based, reduced-stop service, are painted dark blue.

Metro Rapid buses are distinguished by their bright red color. This service offers all-day service with limited stops as described above, with headways not longer than ten minutes and as close as every three minutes at peak periods. These lines feature no-schedule, headway-managed operation, avoiding bunching as well as periodic extended stops at time points, both of which are characteristic of bus operations subject to schedule adherence. The frequent service and uniform time between buses makes passengers confident that another bus will be appearing shortly—a fact also given reassurance by the "next bus" variable message signs in the branded Metro Rapid shelters that are distinct in style from other bus stops.

**FIGURE 3: METRO FLEET**



The National Bus Rapid Transit Institute (within the Center for Urban Transportation Research at the University of South Florida in Tampa) initiated a BRT image project that has begun a study of the Los Angeles branding system on rider perceptions and ridership. The study, which is still underway, completed a focus group phase in Los Angeles in November 2007. A follow-on rider survey will be conducted in June 2008. Both the bus branding and rail system branding are part of the study's scope. The study investigators have learned interesting focus group views on the Blue Line and Gold Line light rail services. Perceptions of the service were very different, even though they are essentially the same mode. According to the investigators interviewed for this report, it appears that perceptions may be based more on the area served by the rapid transit route than the mode used.

#### ***BRT Funding at LACMTA***

The LACMTA board and staff have made several requests for federal Small Starts funds in order to complete the expansion of the Metro Rapid network. Last year, LACMTA successfully obtained \$16.7 million for the \$25.7 million Metro Rapid Gap Closure Project under an FTA Small Starts Project Development Grant Agreement (PDGA). The project's goal is to reduce passenger trip times further along the eight newest Metro Rapid corridors, which in total add 120 route miles. (Four of those were rolled out last December, while the remainder were introduced in June.) These routes will expand the Metro Rapid network to more than 400 miles of service through 35 cities and other unincorporated areas of the County of Los Angeles.

This year, LACMTA received another PDGA and an additional FTA commitment of \$23.3 million for the \$31.5 million Wilshire Boulevard Bus-Only Lane Project. This project involves design and construction of a dedicated bus lane along portions of a 12.5-mile length of Wilshire Boulevard, on the western portion of the line, between downtown Los Angeles and the City of Santa Monica. The project will convert 9.6 miles of curb lanes into exclusive bus lanes during morning and afternoon peak-period operations. (This mileage is contiguous except for a section of the street running through Beverly Hills in the middle of the corridor. LACMTA officials are working with that city's street officials to address this segment.)

The lanes will be differentiated in their appearance by means of pavement markings and lane delineators, and will be enforced for moving violations by the Los Angeles Police Department. Other aspects will include an enhanced transit traffic signal priority system and other traffic engineering improvements as well as curb lane pavement repair throughout the area. Concrete bus pads at all bus stops and intersections will also be constructed to avoid the deterioration that frequent and heavy bus service can exact on traditional street pavement. Travel times are expected to improve by a further 24% due to the project, which was the highest-rated Small Start project evaluated for this fiscal year among applications submitted, according to LACMTA staff.

The Los Angeles Department of Transportation, which has jurisdiction over the city's street and traffic control networks, is also a project partner. FTA recommended \$10.95 million in Small Starts funding for the project in its FY 2009 budget request to Congress.

Two other projects have yet to be funded in the Small Starts program, but the LACMTA will likely resubmit the requests again next year, just as it did when the Wilshire exclusive bus lane plan was not funded in FY 2008. These include the Sepulveda Corridor Bus-Only Lane Project and the Van Nuys Corridor Bus Speed Improvement Project, designed to improve two other well-used San Fernando Valley Metro Rapid Routes with additional infrastructure improvements such as exclusive bus lane segments. If eventually successful in obtaining their sought-after PDGAs, they will receive nearly \$37 million in additional federal funding.

Expansions of the network have another dimension to be noted. In addition to LACMTA Metro Rapid routes, Santa Monica's Big Blue Bus also operates the Lincoln Boulevard line, which runs between that city's downtown and Los Angeles International Airport, to the south. It has a modified dark blue and gold livery and brand called "Rapid Blue," but otherwise operates with the same service standards as other Metro Rapid routes. This agency is looking to operate another such route, and Culver City Lines and Torrance Transit will also operate a Metro Rapid line each. Both Culver City and Torrance agreed to use the Metro Rapid branding and service standards.

The effectiveness and expansion of Metro Rapid may be furthered by another effort underway. As a result of increased traffic congestion on local arterials, the LACMTA has seen a 12 percent decline in average bus speeds since the mid-1980s. To reverse this trend, Metro has been working in partnership with the Los Angeles Department of Transportation (LADOT) and the Los Angeles County Department of Public Works (LACDPW) to prepare the Los Angeles Bus-Speed and Street Design Improvement Study. The study will evaluate ways to improve bus speeds including signal priority and the establishment of bus-only lanes where this is feasible.

The Los Angeles experience has several lessons being recognized by other public transit agencies. The first is the modest start-up of the initial two lines, which were implemented with virtually no net additional operating or capital funds. This is because the travel time improvements of between 24 percent and 29 percent in the arterial BRT network, allowing more miles of service (more frequent trips) to be provided without increased hours of service.

Overall, much more service was provided with only 20 percent more service hours. Per-passenger operating costs have actually declined in each of the 18 corridors to date, according to managers of the arterial BRT network.

Moreover, because the signal priority and bus fleet were taken from existing infrastructure, the only marginal capital costs of the program were software reprogramming for the automatic headway-based signal priority system; the next-stop variable message signs and modular stations, which totaled less than \$10,000 per station; and marketing expenses. Total one-time capital costs for the 20-corridor, 356-mile expansion (i.e., after the first two lines and excluding the Orange Line) are \$110.5 million, according to Metro budget documents—slightly more than \$300,000 per mile.

There is another rationale for such an incremental BRT approach. Despite record levels of federal funding during the past decade and, by all indications from Congress, for the foreseeable future, competition for federal transit funding in the Major Capital Investment Program has been acute, and low-cost and incremental BRT solutions are becoming more attractive. For example, of the 13 PDGAs approved by the FTA to date, ten are for BRT. Of those, seven are mostly arterial-based BRT projects. Metro officials often point out that none of these successes at either the federal or the local levels would be possible without the successful lower-risk, lower cost initial demonstration project.

### **2.3. Regional Transportation Commission of Southern Nevada: Las Vegas MAX**

#### *General Agency Information*

With a population of 552,539 in the 2000 census, but a metropolitan region of more than two million, Las Vegas has been among the fastest growing regions in the U.S. for decades. The Regional Transportation Commission of Southern Nevada (RTC) is an independent governmental agency responsible for transportation in Southern Nevada, primarily Clark County. The RTC serves a 266-square mile area, and operates the Citizens Area Transit (CAT) system, which currently includes the Metropolitan Area eXpress BRT system, a conventional fixed-route bus service, and the newest service—a double-decker bus known as "The Deuce" servicing the Las Vegas Strip. The RTC public transit operating expenses for fiscal year 2007 were \$156.6 million. In 2006, the RTC systems carried 61 million riders on the fixed-route system.

#### **MAX**

In 2004, the RTC launched an inaugural BRT line, which it branded Metropolitan Area eXpress (MAX), extending north of the central city on Las Vegas Boulevard toward Henderson. MAX is billed as a hybrid between bus and rail systems, and serves a seven-mile route from Las Vegas' Downtown Transportation Center to Nellis Air Force Base (see map in Appendix ).

The predecessor to the MAX on Las Vegas Boulevard North – Line 113 – had the fourth highest ridership of all CAT routes. The corridor was also selected because of the opportunity to take advantage of an extra vehicular lane that could easily be converted into a dedicated bus lane.

Service in the corridor is augmented by the predecessor Line 113 local service, though its frequencies have recently been reduced for greater corridor cost-effectiveness.

**Service Policies:** MAX vehicles run on a 12-minute headway during the day, and every 20 minutes at night.

**Station Design:** Twenty-two stations serve the route, including 11 northbound and 11 southbound. The unique architecture of the passenger stations functions to provide customers with comfort and convenience while creating a distinct identity for the system (see **Figure 4**). Stations feature elevated boarding areas at bus entrance height, ticket vending machines, soda vending machines, shaded area, benches and aesthetic treatment, and are designed to complement the surrounding urban development.

**FIGURE 4: MAX STATION**



**Fare Policy:** Fares for the MAX service are the same as those for a CAT Bus: the adult fare is \$1.25, a one-day pass is \$5, and a monthly pass is \$40.00. Tickets are purchased prior to boarding, and ticket vending machines located in every station to sell and validate MAX/CAT full-fare passes, reduced-fare passes, one-day passes and one-ride passes. No fare collection occurs on the vehicle itself, furthering the likeness to a rail system and reducing vehicle stopped times at stations; fare enforcement officers check bus passes on board the vehicle.

**Fleet:** The MAX fleet consists of ten 61-foot articulated vehicles that look like a cross between a bus and a bullet train, and have a distinctive paint scheme (see **Figure 5**). Each vehicle can carry approximately 120 passengers, who are able to load simultaneously through four doors for more efficient boarding. Vehicles feature an environmentally sound hybrid diesel-electric propulsion engine and are powered by electric motors, accomplishing smoother acceleration and less engine noise. MAX vehicles have an expected useful life of 22 years, compared to a 12-year span for regular CAT buses.

**FIGURE 5: MAX VEHICLE**



The MAX vehicles, called Civis, are the nation's most advanced BRT vehicle technology deployed in the United States to date. The vehicles were manufactured in France by European bus builder Irisbus under Buy America and Altoona testing waivers granted by the FTA. Civis vehicles incorporate numerous features designed to enhance system performance and operational efficiency, and require augmentation of field service levels and familiarization training for operations and maintenance staff of ATC, the Veolia subsidiary that contracts with RTC to operate service (both local and MAX). Parts availability for air conditioning and other systems was a challenge in the initial months of MAX service, but these issues have been resolved.

The Civis vehicles have optical guidance systems giving station-stop precision sufficient to meet ADA requirements for level boarding. Finding problems with maintaining the integrity of painted guidance marks along the center of bus lanes, CATS officials ordered that the automated guidance system be turned off, and directed drivers to perform the precision docking in stations manually. Although no performance data regarding the difference between manual and guided docking reliability in the stations have been collected, officials report that drivers are able to perform the function satisfactorily. They attribute this capability to the centrally-positioned driver location in the Civis vehicles.

The RTC did not purchase additional Civis vehicles for the expansion of the MAX service. Instead, it procured 50 "Streetcar" articulated low-floor vehicles from the Wright Group, a Northern Ireland-based bus builder. These futuristic, highly stylized vehicles are being equipped with diesel-electric hybrid drives by ISE Research in San Diego. The vehicles were purchased with local funds, obviating the need for either Altoona testing or Buy America regulatory compliance, which would be required if federal funds were used.

### **Technology/Infrastructure**

The MAX vehicles run on a dedicated transit lane for approximately five miles of the seven-mile route, between the Downtown Transportation Center (DTC) and Nellis Air Force Base. The dedicated lane is reserved for transit vehicles and vehicles making a right turn. The remaining two miles of the route are in a mixed traffic lane, but MAX operation benefits from traffic signal priority (TSP): MAX vehicles have the ability to advance or extend the green traffic signal at over 20 signalized intersections along the route.

TSP implementation for MAX did not result in any traffic disruptions or other impacts, except for the high-traffic intersection at the Civic Center and Las Vegas Boulevard, which is also located in a closely-spaced street network. After several attempts were made to alleviate traffic disruption and optimize the TSP, RTC decided to disable TSP at this location during the PM peak period.

Meanwhile, a queue jump operation was successfully implemented at the Tonopah and Las Vegas Boulevard intersection. It comprises detection loops at the MAX stop to detect the arrival of the Civis vehicle. The controller programming was modified to provide a short queue jump phase when the traffic controller detects both a bus and a TSP call. All vehicular and pedestrian indicators are held at red while the MAX vehicle receives a short green indication, allowing it to clear the intersection before any other traffic. A special LRT-type signal display that uses a vertical white bar indication has been installed for the Civis vehicle operators, to indicate that their movements are cleared to proceed ahead of adjacent mixed traffic but without giving a visible green signal indication to other drivers in adjacent lanes.

**Ridership:** MAX ridership in July 2007 was estimated at 197,411 for the month, or approximately 6,300 passengers per day.

**Costs:** The capital cost of the first MAX line (Las Vegas Boulevard North) was reported to be \$19.4 million, or \$2.7 million per mile (2004 dollars).

**Other Performance Measures:** Since the opening of MAX, operating cost per passenger for Route 113 increased 19 percent, partly because the vehicle service hours for this line were maintained at pre-MAX levels for several months after the start of MAX operations, which of course attracted some passengers from the slower local service. This slight duplication of service had a negative effect on local service operating efficiency.

One-way travel times on MAX are approximately 50 percent faster than travel times of the local service operating along the same route, due largely to the lower number of stops. Another factor, however, is that dwell times on MAX are approximately 60 percent lower than previously in the corridor, which RTC/CATS officials attribute to multiple-door entry, level boarding at station platforms and off-vehicle fare collection.

Schedule adherence as measured by headway reliability on MAX is close to 100 percent, which officials attribute mainly to MAX's dedicated running way. This is much better schedule adherence than is achieved by the local service.

Customer surveys have rated MAX very high for appearance, comfort, convenience and reliability. Overall, 97 percent of riders surveyed rated the MAX experience as "good" or "excellent," compared with a 62 percent rating of the existing local service.

### **Future Development**

The RTC rapid transit system is currently being expanded to include a second BRT system, known as ACE. ACE and MAX will function as one system, and ACE will be similar to MAX, with the exception of using different vehicle types and station designs. The first ACE line will be named "ACE Downtown Connector" and will provide service between Downtown Las Vegas and McCarran Airport. Construction of the ACE line is scheduled to be completed in early 2009, with operations starting in summer 2009.

Two other lines are in development. The first, Sahara Avenue, and the second, Resort Corridor, are projects that have successfully cleared environmental assessments. In these and other future BRT corridors in Las Vegas, RTC indicated that it will continue to implement TSP. To minimize impacts on traffic, however, consideration will be given to integrating TSP with the CATS Automated Vehicle Location (AVL) system to maintain vehicle headways or conditionally allow TSP based on schedule adherence performance measures, as is the case with LACMTA's Metro Rapid system. On segments of future corridors where a dedicated running way is not available, RTC intends to implement "queue jumpers" to bypass traffic bottlenecks along the corridor at heavily traveled intersections.

## **2.4. York Region Transit**

### *General Agency Information*

York is a suburb located north of Toronto, Ontario. Currently, York has 935,000 residents and is projecting population growth of more than 60 percent by 2026. York lies in one of the fastest-growing regions of Canada, which is also one of the most affluent, with above-average car ownership. York Region Transit (YRT) is the public transit operator in the York Region. YRT services consist of 66 local bus and 5 BRT routes within the Urbanized York Region. The YRT operating budget for 2007 is approximately CA\$147 million (US\$146 million). In 2006, the YRT system received 12.9 million total boardings.<sup>3</sup>

### *Viva*

YRT is the parent company to the Viva BRT program, which provides service within the York Region and connections to northern Toronto and Toronto Transit Commission (TTC) subway stations. The York Region has control over all fares and service planning.

---

<sup>3</sup> The York Transit System map is too large to be included in this document, but can be viewed online at [http://www.yrt.ca/maps/navigation/YRT-Viva\\_system\\_map.pdf](http://www.yrt.ca/maps/navigation/YRT-Viva_system_map.pdf).

Viva is the brand name for the York Region Rapid Transit Plan, which was funded through a Public-Private Partnership consortium called the York Region Rapid Transit Corporation. The Viva BRT is the first phase of a three-phase rapid transit plan to reduce congestion on local roads. Although there was strong political leadership in favor of the three-phase multi-decade incrementally developed and deployed plan, there was need to overcome a skeptical public and customer base. Branding became an essential component of the roll-out strategy; there is a conscious strategy to change consumers' attitudes toward transit. Viva, York Region's new bus rapid transit service, was successfully launched in September 2005. Viva is being implemented in four phases within its place as the first phase of the overall rapid transit plan. The Viva operating budget in 2007 was CA\$43.8 million (US\$43.6million).

Viva was also developed in a way that is unique to BRT development in North America. The York Regional Council invited potential private sector consortia from around the world to submit proposals; five were received. After an evaluation process that lasted six months, the York Regional Council selected York Consortium 2002, comprised of AECOM, IBI, Delcan, Kiewit, Irisbus and Ellis Don. The consortium proposed a three-phase development program to be implemented over a 20-year period. The first phase is what has been implemented to date, which is a mainly arterial system with attractive stations, branding and vehicles that use queue jumps and traffic signal priority to speed travel times. This approach also has helped to offset some of the financial burden by giving the consortium time to build political support for additional government funding as well as to explore alternative private sources of financing, including various private development opportunities.

The Viva system consists of five interconnected routes along the Highway 7 and Yonge Street corridors; routes range from five to twenty miles in length. The five lines are named by color: Viva Blue (Finch-Richmond Hill-Newmarket line, 23 stations, running north-south), Viva Purple (York University-Richmond Hill-Cornell line, 23 stations, running east-west), Viva Orange (Martin Grove-York University-Downsview line, 12 stations, running southeast-northwest), Viva Pink (Finch-Richmond Hill-Unionville line, 18 stations, running southwest-northeast), and Viva Green (Don Mills-McCowan-Cornell line, 11 stations, running southwest-northeast). Viva's route network connects all of the service area's major urban centers of Markham, Richmond Hill, Vaughan, Aurora and Newmarket via five truck routes. Viva also interconnects with the Toronto subway system, the GO Transit commuter rail system and the suburb of Peel's bus network. It will eventually interconnect with the suburb of Durham's bus network in Phase 2.

**Service Levels:** Viva runs at least every 15 minutes, and increases in frequency to headways of three to ten minutes during peak travel times.

Viva routes run in mixed traffic lanes, and make use of existing or specially lengthened right-turn lanes to move through an intersection ahead of traffic. BRT vehicles are given priority at traffic signals.

**Branding/Service Differentiation:** Viva service is designed with the concepts and market differentiators of convenience/frequency, flexibility (passengers are able to get on and off the system because their tickets are valid for two hours) and comfort. The system also features prepaid fare collection with ticket vending machines that allow passengers to purchase tickets before boarding.

Beyond techniques that have been well-demonstrated by successful BRT systems around the world, Viva's design and branding campaign also conveys the image of a service intended to provide a great everyday experience, which is even underscored in its choice of the brand name Viva. Ridership to date is up over 35 percent compared with previous service in the corresponding corridors. Weekday boardings are approaching 31,000 and the modal split for public transportation continues to increase.

**Station Design:** The Viva system consists of 59 stops, referred to as "Vivastations". Stations are modern, bright and well-lit for a perception of greater safety. Each Vivastation incorporates a ticket vending machine, ticket validator, and real time "next bus" electronic displays. Most Vivastations are blue, but several stops on Yonge Street have a unique bronze design referred to as "vivavintage" in order to better suit the historic areas. Where only limited space is available (for example, along Yonge Street in Thornhill, Richmond Hill, and Aurora) miniature "vivamicro" stations have been designed, and Vivastations on York University's campus are red in keeping with the University's signage policy.

**Fare Policy:** Viva operates on a pre-paid, proof-of-payment system, and riders must have a ticket prior to boarding. Tickets can be purchased and previously purchased tickets can be validated at all Vivastations; when a ticket is validated, the date and expiration time are printed on the ticket.

Viva operates under the YRT's *1system* fare policy, such that a Viva fare and a YRT fare are treated the same. A two-hour ticket permits travel on any YRT or Viva vehicle in any direction for a two-hour period on one fare; riders are able to transfer from one service to another for the two-hour period without having to pay an additional fare. The *1system* operates on a zone fare system; there are three fare zones. Adult fares are CA\$3 (US\$2.95) for Zone 1 and CA\$4.00 (US\$3.93) for Zone 2. Discounted fares are available when purchasing a monthly pass or tickets in packs of ten: a monthly pass is CA\$95.00 (US\$93.42) and CA\$140.00 (US\$137.67) for Zones 1 and 2, respectively; ten tickets are CA\$24.00 (US\$23.60) and CA\$34.00 (US\$33.43) for Zones 1 and 2, respectively.

**Fleet:** The Viva fleet of 25 articulated 60-foot vehicles and 60 integral body 40-foot vehicles was built by the Belgian bus manufacturer Van Hool, which also built the BRT vehicles for Oakland and Washington, DC. The vehicles feature wide doors and permission to board at any door, making for more efficient boarding, and come equipped with low floors and a ramp, so riders in wheelchairs or with strollers can easily roll on or off. Engines meet stringent low emission standards.

**FIGURE 6: VIVA BRT VEHICLE**

**Operating and Procurement Structure:** Veolia Transportation is the operator. Both Van Hool and Veolia were selected in competitive procurements held by the private sector consortium, with the consortium assuming risk of any project delay or reliability issues due to the equipment and service suppliers.

### **Future Plans**

In June 2007, the Government of Ontario announced full funding of Viva's Phase 2, which is part of a \$17.5 billion package to expand rapid transit across the Greater Toronto region, known as the MoveOntario 2020 Plan. York Regional Council had already committed \$539 million contingent on the receipt of these matching funds from the provincial and federal Governments.

Phase Two includes construction of a more complete BRT System by 2012. Dedicated transit lanes will be built, separating rapid transit vehicles from general traffic. There will also be larger stations and terminals with a variety of additional customer services and new park-and-ride facilities. The second phase is expected to cost between \$1.5 and \$2 billion.

In Phase 3, Viva options include conversion to light rail, construction of subway extensions, or expansion of Bus Rapid Transit. A decision to proceed with the final phase will be made after a major review in 2009.

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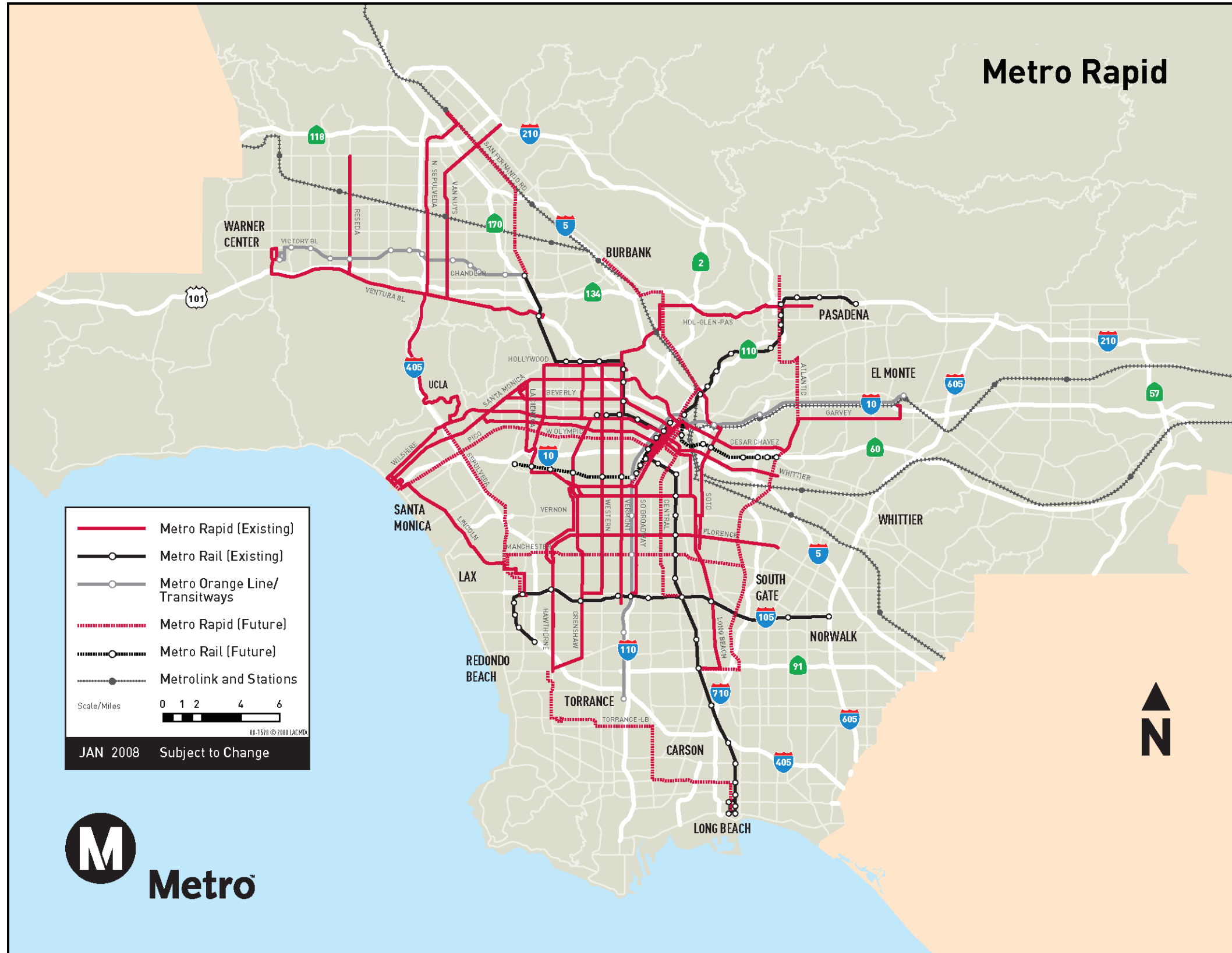
## **APPENDIX**

### **System Maps**



# LACMTA RAIL & BRT SYSTEM

## Metro Rapid

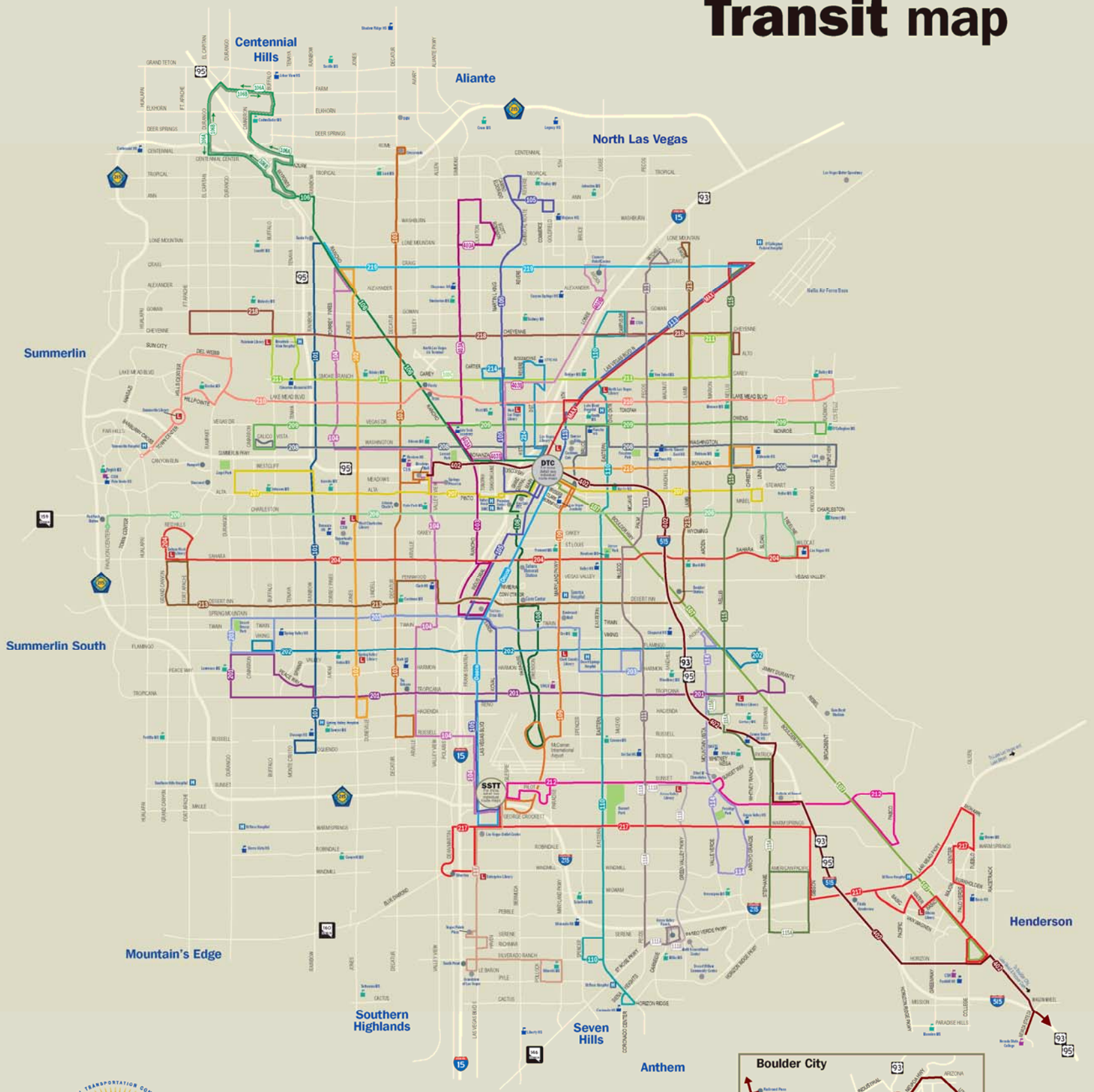


— Metro Rapid (Existing)  
— Metro Rail (Existing)  
— Metro Orange Line/  
Transitways  
- - - Metro Rapid (Future)  
- - - Metro Rail (Future)  
- - - Metrolink and Stations  
Scale/Miles 0 1 2 4 6  
01-1518 © 2008 LACMTA  
JAN 2008 Subject to Change

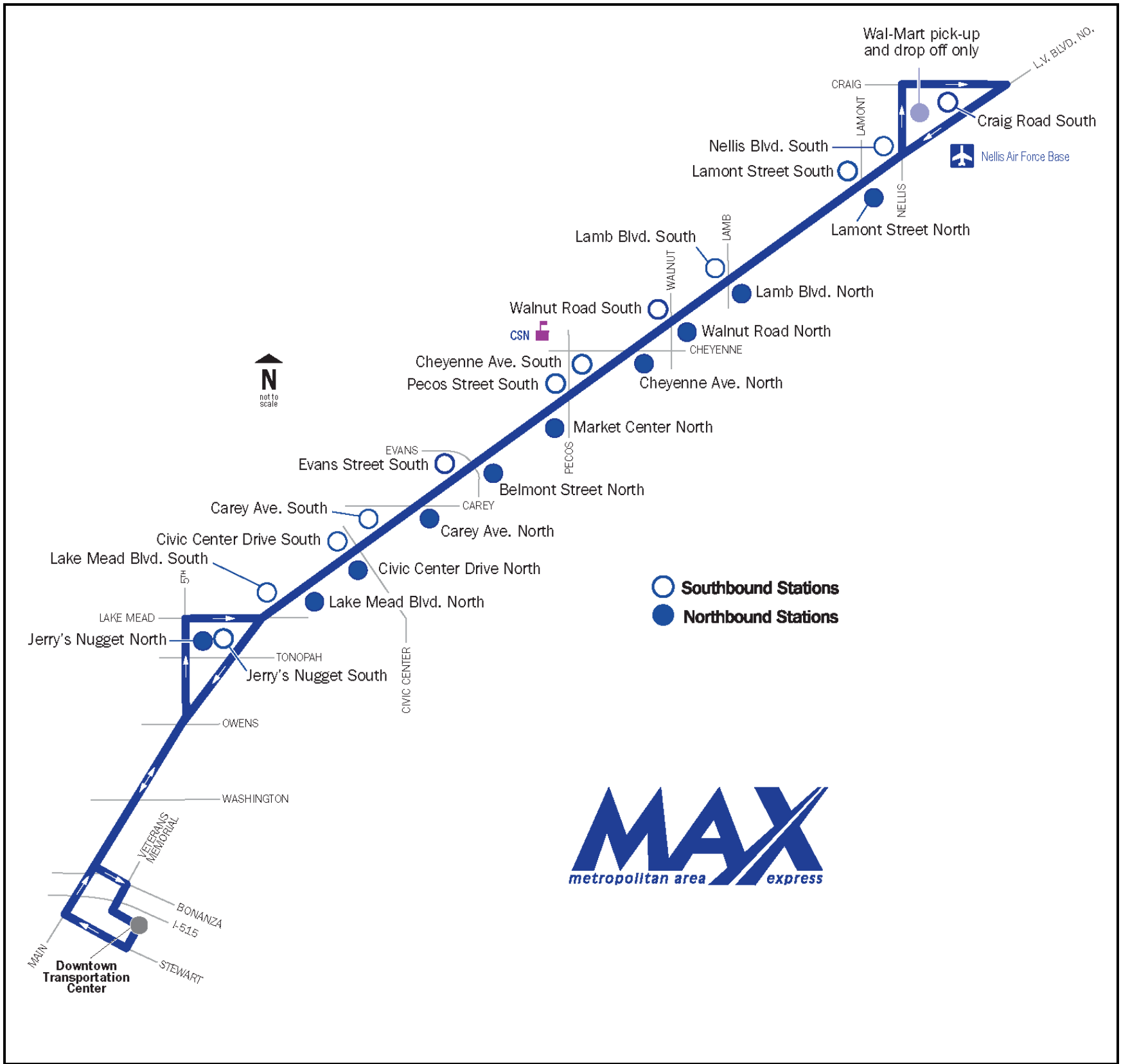


RTC SYSTEM MAP

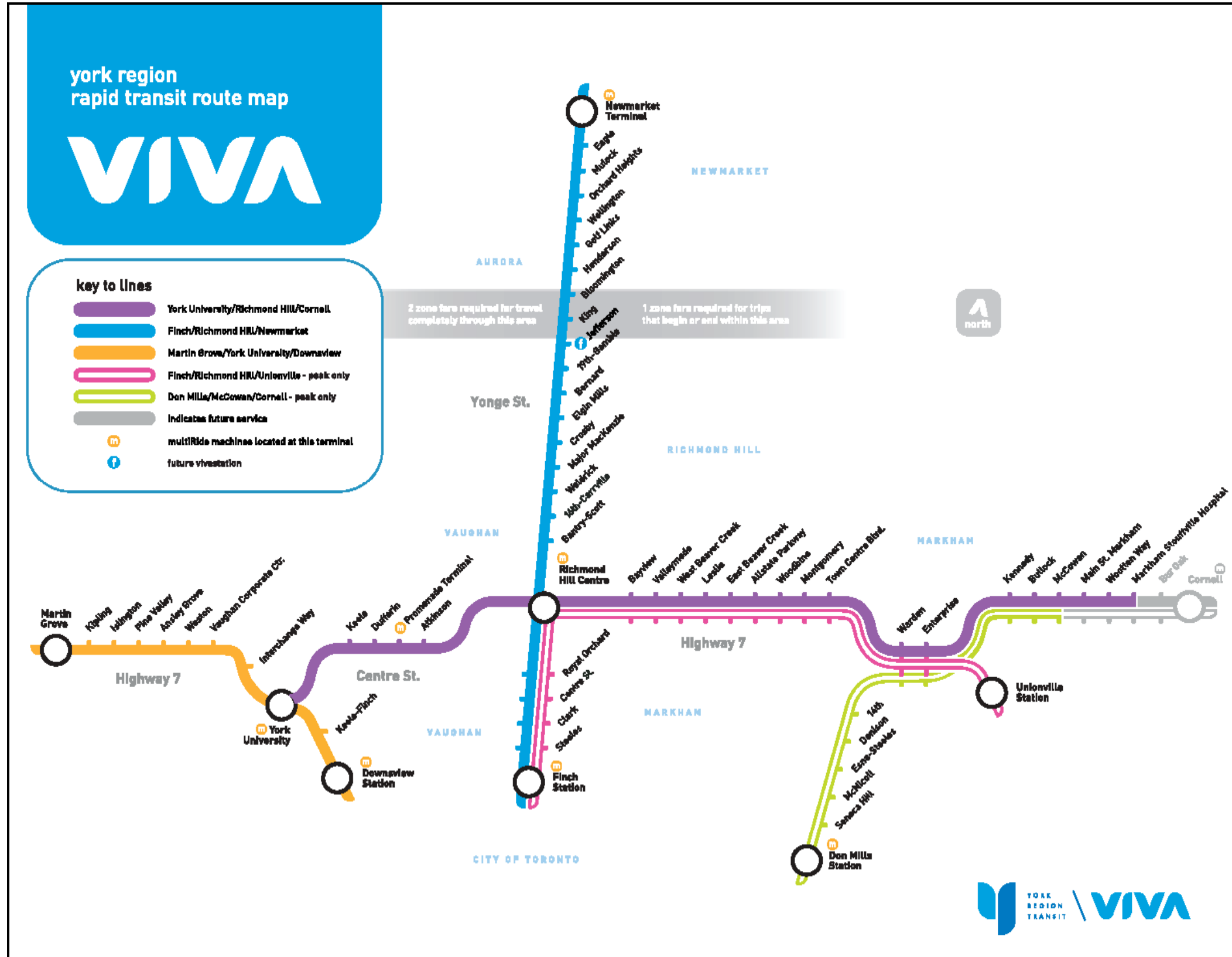
October 2007  
Transit map



# MAX LINE LAS VEGAS BOULEVARD NORTH



# YORK'S VIVA SYSTEM MAP



**RPTA Comprehensive Arterial Bus Rapid Transit Planning Study**

**Final Working Paper for  
Task 4: Analyze Transit Networks  
& Task 6: Ridership Estimates**

June 2009

**Submitted To:**  
Valley Metro/RPTA

**Submitted By:**  
Parsons Brinckerhoff



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## INTRODUCTION

This working paper documents an inventory and analysis of the metropolitan Phoenix region's relevant transit networks, socio-economic trends, transportation demand and needs; and the interaction of existing and future transit service and other transportation infrastructure on the arterial bus rapid transit (BRT) network.

Each of the corridors is profiled, including information on existing transit ridership in the corridor, routes that have the potential of linking to the planned arterial BRT ("LINK") network, current and planned transit service, existing and planned fleet type, and transit infrastructure including park-and-ride lots, transit centers, and transit signal priority (TSP) technology. Information on ridership is based on Valley Metro/RPTA monthly ridership summaries and/or on the November 2007 on-board survey information. The corridors are examined in order of implementation date as established in the Regional Transportation Plan and updated in the 2007 Regional Transportation Plan Evaluation.

This working paper also describes the results of ridership estimates developed within this study for the purpose of obtaining an approximate estimate of the ridership potential of BRT in each of the corridors. Ridership methodologies differ based on the corridor under review. For Arizona Avenue, whose implementation is more imminent, a detailed ridership estimate for 2010 and 2030 was created. The ridership analysis includes estimation of the effect of BRT introduction on overall transit ridership in the corridor (including changes in local bus service). For the other corridors, an estimate of BRT potential ridership was developed based on ridership on existing transit routes in the corridor and the results of more extensive Arizona Avenue modeling procedure.

Following the corridor profiles and ridership estimates is a brief discussion of the LINK Main Street BRT route. The purpose of examining the LINK route is to understand the structure and ridership of arterial BRT in the Valley thus far.

[NOTE: At the time of this working paper, the Valley is experiencing a sharp decline in sales tax revenues due to the global economic downturn. As a result, Valley Metro and its member agencies are considering a range of proposals to contend with the decrease in sales tax revenues. The proposals are still in discussion but could involve the postponement and/or the elimination of transit routes, including some fixed route arterial (supergrid) and arterial BRT services. At this time, the Arizona Avenue BRT is planned for implementation in July 2010 as scheduled; however, plans for all other BRT routes, as well as local arterial services, are uncertain.]

## 1.1. Detailed Corridor Profiles

This section presents information on each of the corridors in the planned arterial BRT system. Information on the transit system is based on the 2007 Regional Transportation Plan Evaluation and the associated Draft Project Assessment Report (PAR) documents. Population and employment projection information is based on April 2007 maps from the Maricopa Association of Governments (MAG), which are appended to this report. Ridership information comes from two different sources. October 2008 figures are from Valley Metro/RPTA monthly ridership summaries. Information from November 2007 comes from on-board passenger surveys. All ridership information is presented for weekdays only.

### *Arizona Avenue - FY2011 (July 2010)*

The Arizona Avenue BRT corridor would extend north/south on Arizona Avenue, east/west on Main Street and east/west on Germann Road for a total of 11.9 miles. The northern terminus of the route is planned to be at the Main/Sycamore light rail (LRT) station in Mesa and the southern terminus is planned for the Chandler park-and-ride at Germann/Hamilton. A map of the Arizona Avenue BRT corridor is shown in Figure 1.

#### *Existing transit routes & ridership*

The Arizona Avenue corridor is currently served by Route 112 (Country Club/Arizona Avenue). Route 112's northern terminus is at McKellips Road and its southern terminus is at Frye Road.

Route 112 currently has 52 trips per weekday (26 inbound and 26 outbound), with 30-minute frequencies throughout the service day (6:00 am to 7:30 pm). There is currently no weekend service on route 112. (See "Planned Transit" for details on service improvements.)

Route 112 passenger counts in October 2008 averaged 1,722 per weekday (1,199 boarding in Mesa and 523 boarding in Chandler). Information from November 2007 estimated ridership in the corridor at 1,148.

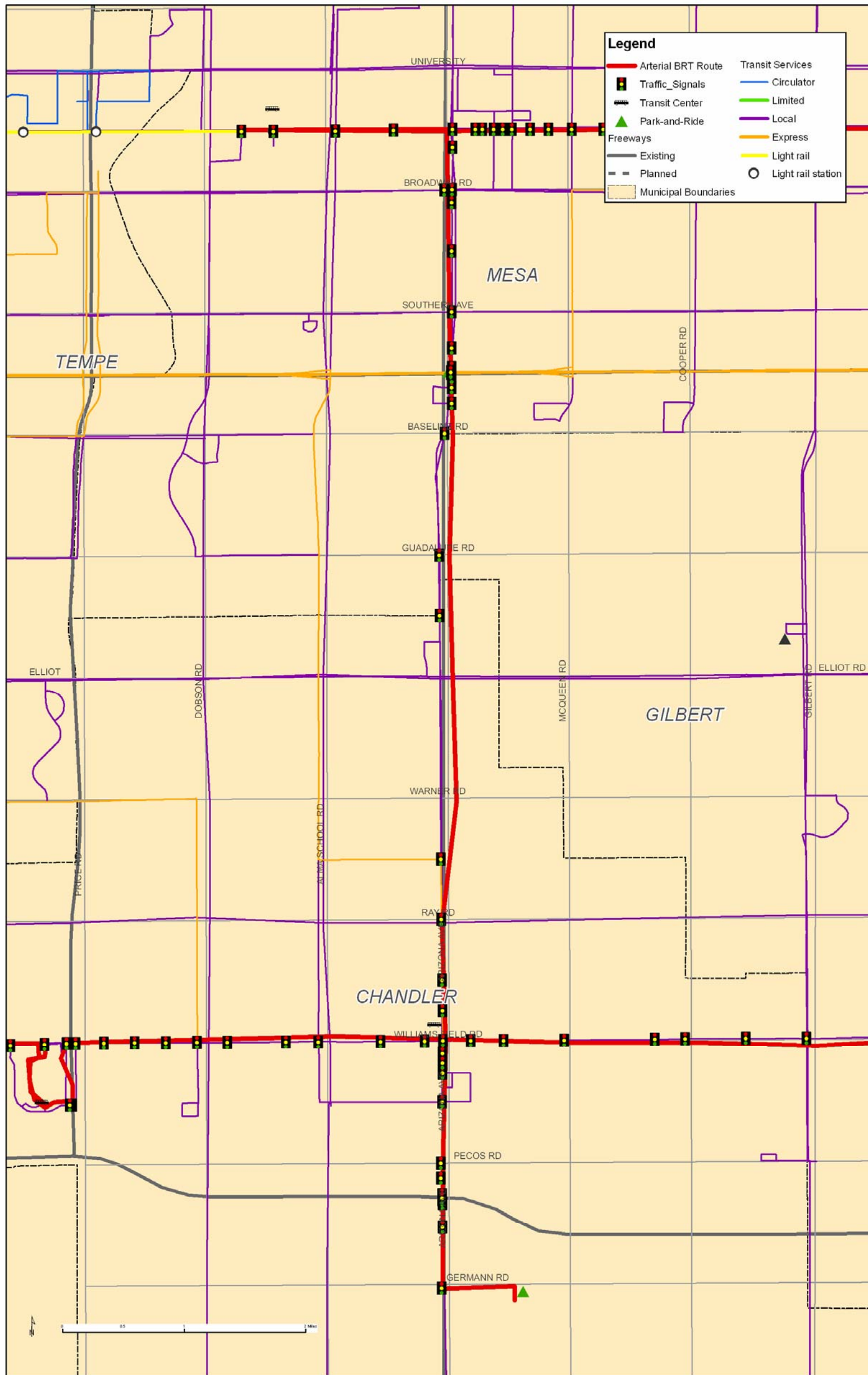
Route 104 (Alma School Road) parallels the entire corridor one mile to the west, and experienced average daily passenger trips of 1,706. Route 120 (Mesa Drive) parallels the northern portion of the corridor one mile to the east and experienced average daily passenger trips of 575.

#### *Intersecting routes:*

The Arizona Avenue BRT corridor intersects with the following transit services:

- Light rail at Main/Sycamore station
- LINK (Main St. BRT service) at Main/Sycamore station
- Route 40 (Main Street)
- Route 45 (Broadway)
- Route 61 (Southern)
- Route 108 (Elliot)
- Route 156 (Chandler Blvd)

Figure 1 Arizona Avenue BRT Corridor



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### *BRT funding plans*

According to the 2007 RTP Evaluation, the Arizona Avenue BRT route is funded based on the following assumptions:

- Two-way service
- 40 one-way trips per weekday<sup>1</sup>
- No weekend service<sup>2</sup>
- Trip length (one-way) 14.99 miles
- Service operations between the South Chandler Transit Center and the end-of-line light rail station
- Service will operate in a limited-stop mode
- Capital facility enhancements within the Arizona Ave/Country Club Dr right-of-way are funded in the amount of \$25.8 million (2007 \$).<sup>3</sup> Corridor improvements are being funded with a \$15 million American Reinvestment and Recovery Act (ARRA) stimulus grant

### *Other planned transit routes & infrastructure*

In addition to BRT, other transit improvements are planned for the Arizona Avenue corridor, mainly in the form of supergrid services.<sup>4</sup>

In July 2011, the RTP plans to fund new supergrid service on Route 112, more than doubling the number of trips during the day and lengthening service hours. Weekend services are also funded. Route 112 will also be extended to the South Chandler Transit Center.

In addition to the existing intersecting routes, new service on Ray Road is planned for July 2014 and will be implemented at the supergrid level. Supergrid services will also improve service levels on routes 45 (Broadway), 61 (Southern), and 108 (Elliot).

A park-and-ride lot in the vicinity of Arizona Avenue & Juanita Road (in Mesa) is planned for implementation in July 2010, as is the Downtown Chandler Transit Center.

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<sup>1</sup> Service hours and frequency of service were not identified in the 2007 RTP Evaluation.

<sup>2</sup> While the RTP only identifies weekday funding for the Arizona Avenue BRT, there is the potential of adding weekend service on this route after the implementation of Supergrid service in this corridor. The Supergrid service in the RTP includes funding for both Saturday and Sunday service as well as 15 minute peak service Monday Through Friday. Shifting funds between the Supergrid and BRT routes could allow for weekend BRT service while maintaining overall service levels within the corridor.

<sup>3</sup> The 2007 RTP Evaluation programmed dedicated arterial BRT capital funding proportionately along the corridors with dedicated BRT routes, but noted that actual implementation may differ. Specific capital improvements were not identified.

<sup>4</sup> Supergrid services are arterial-based local service routes identified in the 2004 Regional Transportation Plan as regionally significant. Supergrid routes are funded by a regional sales tax and meet a minimum level of service.

*Roadway profile and travel speeds*

The Arizona Avenue BRT corridor is just under 12 miles long and extends east-west along Main Street for 1.74 miles, north-south along Arizona Avenue for 9.6 miles, and east-west on Germann Road for 0.6 miles.

Main Street has two lanes and a shoulder in each direction and a center median/left turn lane. Arizona Avenue has two to three lanes in each direction and a center median/left turn lane. Germann Road has two lanes in each direction and a center median/left turn lane. A total of 38 traffic signals are present along the corridor – for a density of 3.2 signals per mile – and are identified in Figure 1.

The posted speed limit in the corridor ranges from 35 to 45 mph. Morning average arterial speeds are generally below posted speed limits in the northbound direction.<sup>5</sup> Mid-day speeds are generally 30-40 mph, with segments in the 20-30 mph range, and segments above 40 mph. Afternoon travel speeds are generally 30-40 mph in the corridor, with some small segments of speeds below 20 mph.

Transit schedules reflect a current average daily bus travel speed in the corridor of 14.5 mph.<sup>6</sup> Bus travel speeds range from 5.5 mph to 24 mph, depending on the segment. Route 112 is 94% on-time.

*Transit priority treatments in place*

A queue jump is an additional lane on the approach to an intersection designated for high-capacity transit use (and sometimes other roadway users), which gives a transit vehicle a “head start” at a traffic signal.

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<sup>5</sup> Information on posted speed limits and average travel speeds are from the 2007 MAG Regional Travel Time & Travel Speed Study.

<sup>6</sup> Calculations for travel speed estimates for each route are included in Appendix I.

**Figure 2 Queue jump in City of Chandler**



*Source: City of Chandler*

In anticipation of BRT, queue jumps have been installed at the following arterial-to-arterial intersections:

- Main Street/Sycamore
- Main Street/Arizona Avenue
- Arizona Avenue/Elliot Road
- Arizona Avenue/Warner Road
- Arizona Avenue/Ray Road

Within the City of Chandler, intersections of major/minor roads will prioritize transit with an early green light or extended green (depending on conditions). Queue jumps are paired with transit signals, which are railroad style signals to ensure motorists are not confused.

#### *Population & employment characteristics*

Population density in the Arizona Avenue corridor is high along the northern portion; north of US 60, population density is greater than 6,000 people per square mile. South of US 60, population density is moderate at 4,000 to 6,000 people per square mile, with some areas greater than 6,000 per square mile at Chandler Blvd. and Ray Road. According to MAG estimates, population density is not projected to change significantly over time.

Employment density north of US 60 is moderate (in the range of 4,000 to 6,000 employees per mile) and downtown Mesa is has employment density greater than 6,000 employees per square mile. South of US 60, employment density is consistently 2,000 to 4,000 employees per square mile along the corridor between US 60 and the southern Loop 202. Over time, the employment corridor is projected to stretch farther south to Ocotillo, but is not projected to grow denser. Land west of Arizona Avenue south of Loop 202 is zoned light industrial as far south as Hunt Highway.

### *Ridership estimates*

For Arizona Avenue, a pivot model was developed to estimate ridership demand for 2010, 2015, and 2030, based on analyzing existing total travel (based on TAZ data) and transit data (based on on-board survey data). Factors for transit improvements related to BRT are then applied and projected for future years. The model “pivots” off of existing information and projects ridership changes in response to various criteria, allowing the user to select BRT transit improvements and evaluate various operational scenarios.<sup>7</sup>

### Overall ridership

The model produces information on weekday ridership projections for BRT only and for total corridor ridership. Ridership projections at 10-minute and 30-minute frequencies are summarized in Table 1. (For the purposes of this forecast, peak and off-peak frequencies are assumed the same.)

**Table 1 Estimated Weekday Ridership in Arizona Avenue Corridor with BRT**

	2010		2015		2030	
	10-min	30-min	10-min	30-min	10-min	30-min
BRT Only	2,293	1,763	2,575	1,986	3,177	2,462
Local service	655	761	721	841	881	1,032
Total transit trips	2,948	2,524	3,296	2,827	4,058	3,494
Annualized weekday ridership	752,000	644,000	840,000	721,000	1,035,000	891,000

Table 1 also shows an estimate of the future ridership, broken down into existing ridership, trips diverted to transit, induced trips, and the total ridership in the corridor after BRT is implemented.

Both BRT and local arterial services grow over time. Greater frequency BRT service results in a lower number of passengers on local arterial service. For the identified BRT service frequencies, local bus service still carries a substantial number of passengers.

### Zone-specific estimates

The model also produces results by zone to show a relative measure of zonal activity. A map of the zones is available in Appendix V and a summary of the zonal trips is shown in Appendix VI. Findings with the greatest implications for BRT operations are discussed below.

<sup>7</sup> A more detailed explanation of the ridership methodologies employed for the Arizona Avenue corridor and other BRT corridors is provided in Appendix IV.

Generally, the trends between BRT and total corridor transit travel are similar. One slight difference is that intra-corridor destinations are more prominent on local services than on BRT, which makes sense given that local service serves a greater number of local destinations.

*Importance of light rail destinations*

Travel to or from zones located along the light rail line is estimated to account for about 40% of the transit trips taken on the Arizona Avenue corridor. LRT share of total transit corridor trips grows slightly over time, from 40% in 2010 to 43% in 2030. LRT makes up a slightly greater share of BRT trips than of total transit trips (19.9% in 2010). Downtown Phoenix is the top destination for travelers along the Arizona Avenue corridor and grows in share of trips over time, from 5.6% of trips in 2010 to 6.5% of trips in 2030.<sup>8</sup>

Implications for operations:

- The importance of light rail emphasizes the need for quick travel to the Main/Sycamore light rail station.
- Transfers between Arizona Avenue BRT and the light rail should be easy and quick, with BRT arrivals/departures at the LRT station timed to coincide with light rail arrivals/departures.
- In the future (assuming operational funding is available), Arizona Avenue BRT should be increased over time to approach the frequency of light rail in the peak commute times.

*Important in-corridor destinations*

The intra-corridor destinations in order from greatest to least number of trips in 2010 are listed below. (Each zone is identified by the arterials streets that border it or by a prominent destination. Trends for BRT trips vs. total transit trips are similar.)

- Zone 7, from Warner to north of Elliot, has the greatest number of intra-corridor trips
- Zone 6, between Ray Rd & Warner Rd
- Zone 9, between Guadalupe Rd & Baseline Rd
- Zone 5, Chandler Blvd
- Zone 4, downtown Chandler
- Zone 12, between Southern & Broadway
- Zone 1, southern Chandler
- Zone 11, between US 60 & Southern
- Zone 8, Guadalupe Blvd
- Zone 2, Chandler park-and-ride
- Zone 3, between loop 202 & Pecos
- Zone 10, between US 60 & Baseline

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<sup>8</sup> Note: Ridership estimates are based on information collected before light rail was implemented. Anecdotal evidence suggests students have shifted to light rail for trips to ASU Tempe campus.

All of the zones grow in overall number of trips through 2030. Over time, Zones 7, 6, 9, and 5 remain the top within-corridor zones. Zone 1 (in southern Chandler) grows in share of trips by 2020, as does Zone 2 (the Chandler park-and-ride).

*Other destinations*

- Zone 33, downtown Mesa (east of the LRT station) is another prominent zone.
- Zone 21, along Elliot Road, generates passengers for the Arizona Avenue corridor.
- Zone 14, along Chandler Blvd, also generates passengers.

Implications for operations:

- The high number of trips in Zone 7 implies transfer activity to Route 108; station placement and size should anticipate this activity.
- Growth in Zones 1 and 2 demand may be met in several ways:
  - Expansion of Chandler park-and-ride
  - Local arterial service connections to Arizona Avenue BRT
  - Eventual extension of BRT service to South Chandler Transit Center
- Neither Ray Rd nor Warner Rd currently has transit service, but arterial supergrid service is planned for Ray Road. Future station placement should be anticipated to account for eventual transfer activity to Ray Road service.

**Grand Avenue - FY2013 (July 2012)<sup>9</sup>**

The planned Grand Avenue corridor extends from Bell Road/Reems Road in Surprise to downtown Phoenix, for a total of 25.8 miles.

*Existing transit routes & ridership*

The planned Grand Avenue Limited corridor is currently served by two commuter-oriented bus routes:

- The existing Grand Avenue Limited operates peak-directional peak-hour services on weekdays, with four inbound trips in the morning and four outbound trips in the evening. The route starts at Bullard Avenue/Greenway Road in Surprise and terminates at Central Station in downtown Phoenix. October 2008 weekday ridership averaged 127 passengers.
- The 571 (Surprise Express) travels a similar route as the Grand Avenue Limited (but does not stop in Peoria or Glendale) and has three inbound and three outbound trips. October 2008 weekday daily ridership averaged 100 passengers.
- The November 2007 on-board survey data results in an estimated 100 passengers per day in the Grand Avenue corridor. (Note: the on-board survey did not include the existing Grand Avenue Limited route.)

The Grand Avenue corridor is diagonal and intersects the regional street grid at many points along the route. Transit service is present on the following streets that intersect with the Grand Avenue corridor:

Route 106 (Peoria Road/Shea Boulevard)	Route 60 (Bethany Home Road)	Route 29 (Thomas Road)
Route 67 (67th Avenue)	Route 50 (Camelback Road)	Route 27 (27th Avenue)
Route 59 (59th Avenue)	Route 43 (43rd Avenue)	Route 19 (19th Avenue)
Route 70 (Glendale Avenue/24th Street)	Route 41 (Indian School Road)	Route 17 (McDowell Road)
Route 51 (51st Avenue)	Route 35 (35th Avenue)	Route 3 (Van Buren Street)
		Route 1 (Washington Street /Jefferson Street)

Currently there is little interaction between the existing Grand Avenue Limited and the 571 and the intersecting routes due to the limited number of stops along the Grand Avenue corridor.

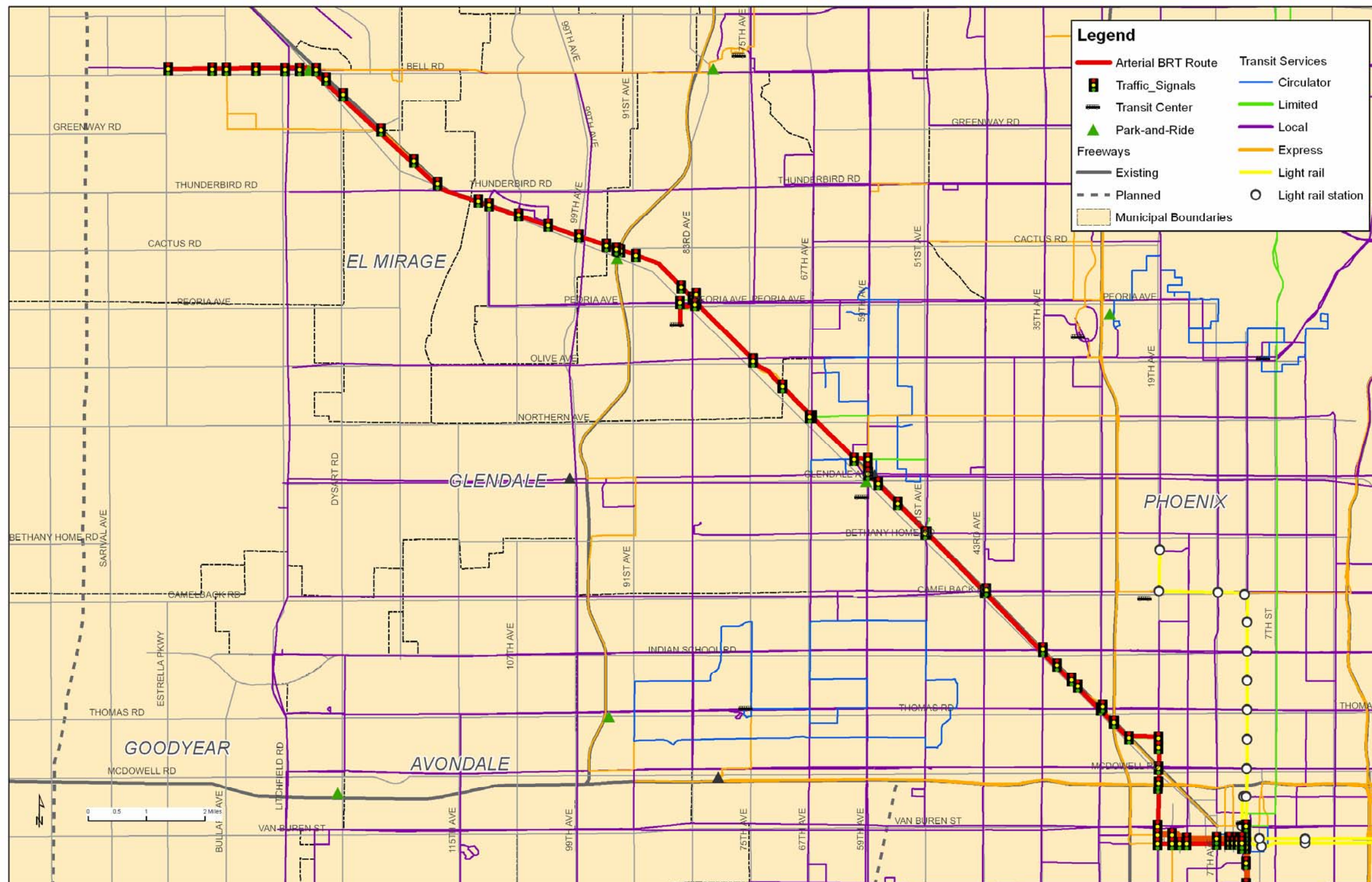
*BRT Funding Plans*

The Grand Avenue BRT route is funded based on the following assumptions:

- Two-way service

<sup>9</sup> The route is referred to as the “Grand Avenue Limited” in the 2007 RTP Annual Report draft PAR documents; thus that terminology is used in this working paper.

Figure 3 Grand Avenue Limited Corridor



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- 24 one-way trips per weekday
- Trip length (one-way) - 25.89 miles
- Service between Surprise and Downtown Phoenix; stops in El Mirage, Peoria, and Glendale
- Capital funding for the Grand Avenue corridor is included under Proposition 400's freeway program and includes additional grade separations at key intersections and the widening of the Agua Fria Bridge to six lanes. Vehicles are also funded.

*Other planned transit routes & infrastructure*

The Grand Avenue Limited route will replace the current Grand Avenue Limited and existing express route 570 (Glendale Express)<sup>10</sup>. Route 571 (Surprise Express) is currently funded on an annual basis with available funds by the City of Surprise, so its long-term plans are not clear.

New transit services are planned for Litchfield (July 2023), Bell Road (July 2018), Thunderbird Road (July 2019), 99<sup>th</sup> Avenue (July 2020), 83<sup>rd</sup> Avenue/75<sup>th</sup> Avenue (July 2022), and Olive Rd/Dunlap Rd (July 2020). Services will be enhanced on many existing intersecting routes, as well.

Park-and-rides are planned for Grand Avenue/Litchfield Road in Surprise and Loop 101 & Bell Road, along with a transit center in downtown Glendale.

The BNSF rail line, which parallels the Grand Avenue corridor, is being examined for potential commuter rail operations. The Maricopa Association of Governments is currently studying commuter rail service options in this corridor. At this point, any commuter rail service would not be implemented before 2030.

*Roadway characteristics & travel speeds*

The posted speed limit in the corridor is 45 mph. Morning peak period average arterial speeds are below the posted speed limit in both directions in some sections. Mid-day travel speeds range from 30-45 mph along the corridor, with speeds greater than 50 mph from Bethany Home to Thomas Road. Afternoon peak travel speeds are in the range of 20 to 40 mph in the corridor, with travel speeds under 20 mph in downtown Phoenix and from Camelback Road to Glendale Road.

Transit schedules indicate average daily bus travel speeds in the corridor ranging from 17.1 mph to 19 mph. The existing Grand Avenue Limited's on-time performance is above 91%.

Grand Avenue is three lanes in each direction from 19<sup>th</sup> Avenue to 83<sup>rd</sup> Avenue; east of 19<sup>th</sup> Avenue and west of 83<sup>rd</sup> Avenue, Grand Avenue is two lanes in each direction. There are 56 traffic signals along the span of the planned Grand Avenue Limited corridor (2.2 signals per mile).

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<sup>10</sup> Route 570 travels on Northern Avenue and Central Avenue between downtown Glendale and downtown Phoenix.

*Population & employment characteristics*

The Grand Avenue corridor travels through areas that are relatively densely populated from downtown Phoenix to the border of Sun City. From Sun City to Surprise, the corridor population density is low; in some places below 250 people per square mile. The corridor is projected to grow denser over time. The portion between Sun City and Surprise is projected to achieve densities between 250 and 2,000 people per square mile (and greater in some areas).

Employment density follows a similar pattern, with existing dense employment on the southeast portion of the corridor and light employment density from Sun City to Surprise. Employment is projected to grow denser along the Sun City to Surprise portion of the corridor.

While the corridor passes through areas of density, Grand Avenue itself is difficult to access. The BNSF rail tracks parallel Grand Avenue on the south, and the roadway is grade-separated at many intersections.

*Ridership estimations*

Because the planned Grand Avenue Limited improvements are simply increased express bus trips, rather than BRT-oriented capital improvements, ridership estimates for this corridor were not developed. However, important origin and destination zones were identified. Key zones for the Grand Avenue Limited include Surprise, downtown Phoenix, the Grand Avenue corridor in Phoenix, and Grand Avenue in El Mirage/Sun City. Connections to the Central Corridor and to downtown Tempe were also identified as important.

**Scottsdale Road/Rural Road - FY2014 (July 2013)**

The planned Scottsdale/Rural BRT corridor extends from Chandler Fashion Center in the south to Shea Boulevard in the north, a total length of 24 miles. Note: While this study examines the entire Scottsdale/Rural corridor, the portion of this corridor south of 202 is also the subject of an ongoing Alternatives Analysis process. Findings between the two studies will be reconciled in the working paper for Task 7.

*Existing transit routes & ridership*

The planned Scottsdale Road/Rural Road BRT corridor is currently served by Route 72 (Scottsdale Rd/Rural Rd), which extends from Mayo Boulevard in north Scottsdale to Chandler Fashion Center. Route 72 currently has over 120 trips per weekday<sup>11</sup>, with 15-minute frequencies from 4:00am until 5:00pm, when service is reduced to 30-minute frequencies until 1:00am. On weekends, service is provided with roughly 30-minute frequencies from 5 am until 1:00am. October 2008 passenger counts show an average of 6,535 passengers on weekdays; the November 2007 on-board survey produced an estimate of 8,610 passengers per weekday.

Route 81 (Hayden Road/McClintock Road) parallels the corridor along its entire length and is one mile to the east. (North of Indian Bend Road, Route 81 veers farther to the east.) Route 66 (Mill Avenue/68<sup>th</sup> Street) parallels the corridor from Camelback Road in the north to Guadalupe Road in the south. 68<sup>th</sup> Street is one-half mile to the west of the Scottsdale Road/Rural Road corridor, while Mill Avenue is one-mile to the west.

Route 72 intersects with the METRO light rail line at the Tempe Transportation Center.

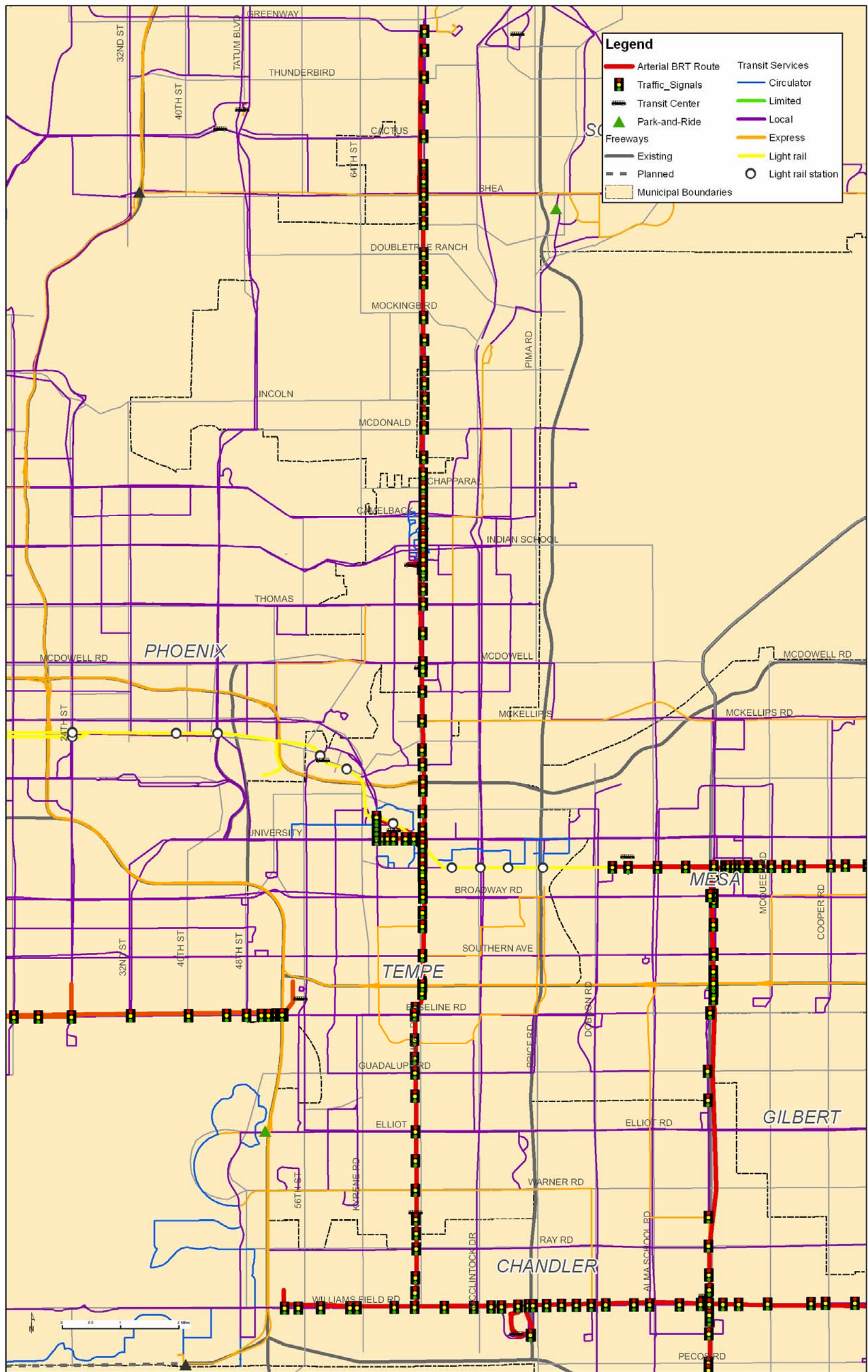
Route 72 intersects with the following local transit services:

Route 154 (Greenway Rd?)	Route 84 (Granite Reef Rd)	Route 92 (48 <sup>th</sup> St/Guadalupe Rd)
Route 106 (Peoria Rd?/Shea Rd?)	Route 76 (Miller Rd)	Route 77 (Baseline Rd)
Route 50 (Camelback Rd)	Route 30 (University Dr)	Route 108 (Elliot Rd)
Route 41 (Indian School Rd)	Route 40 (Apache Rd/Main St)	Route 156 (Chandler Blvd)
Route 29 (Thomas Rd)	Route 45 (Broadway Rd)	
Route 17 (McDowell Rd)	Route 61 (Southern Rd)	

Route 72 also intersects with express routes 512 (to downtown Phoenix) at Shea Boulevard and Route 510 (to downtown Phoenix) at Loloma Station. Express Routes 511 (express service between Scottsdale, Tempe, and Chandler) and Route 572 (to Surprise) originate at Scottsdale Airpark, on the northern tip of the BRT corridor.

<sup>11</sup> Portions of the route have additional trips.

Figure 4 Scottsdale Road/Rural Road BRT Corridor



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### *BRT funding plans*

The Scottsdale Road/Rural Road BRT route is funded based on the following assumptions:

- Two-way service
- 48 one-way trips per weekday
- Trip length (one-way) - 23.10 miles
- Service operations between Shea Boulevard and Chandler Fashion Center. Stops at Downtown Scottsdale/Loloma Station Transit Center, Scottsdale Fashion Square Mall, Downtown Tempe Transit Center, and Arizona State University
- Capital facility enhancements within the Scottsdale Road/Rural Road right-of-way are funded in the amount of \$39.99 million (2007 \$\$).
- METRO rail's South Tempe Alternatives Analysis will identify additional infrastructure improvements in the Rural Road portion of this corridor. The RTP identifies light rail level funding for the segment from the current light rail corridor south to Baseline Road.

### *Other planned transit routes & infrastructure*

Skysong Transit Center (at Scottsdale Road & McDowell Road) and the South Tempe Transit Center (at Rural Road & Warner Road) are both planned for opening in 2011.

### *Travel speeds*

The Scottsdale/Rural BRT corridor is three lanes in each direction for almost the entire length. In downtown Scottsdale (between Thomas Road and Camelback Road), Scottsdale Road is only two lanes in each direction. It is also two lanes in each direction north of Frank Lloyd Wright Boulevard, between Baseline Road and Elliot Road, and south of Warner Road. There are 74 traffic signals in the corridor, or 2.8 per mile.

The Scottsdale/Rural BRT corridor has a posted speed limit of 40 or 45 mph. Weekday morning travel speeds in the corridor are at posted speed in the northern portion but generally below posted speeds, in the 20-40 mph range, on the remainder of the route. Midday speeds are below 20 mph in downtown Scottsdale and in the range of 30-40 mph along the rest of the corridor. Weekday afternoon peak speeds are below 20 mph in downtown Scottsdale and downtown Tempe, and between 20 and 40 mph along the remainder of the corridor.

Travel time on Route 72 averages 12.2 mph throughout the day.

### *Population & employment characteristics*

Population density in the Scottsdale/Rural BRT corridor is moderate, with very low density in the portion within Paradise Valley. Higher segments of residential density (between 6,000 to 8,000 people per square mile) are present in downtown Scottsdale and downtown Tempe.

Employment density is also moderate (between 250 and 4,000 employees per square mile), with segments of very high employment density (over 8,000 employees per square mile) at the Scottsdale Airpark, downtown Scottsdale, and downtown Tempe.

Population and employment density are both projected to remain at about the same density in through 2030.

#### *Ridership estimates*

BRT improvements in the Scottsdale/Rural corridor could raise daily transit ridership in the corridor to over 11,000 daily riders. (Note: for the Scottsdale/Rural BRT, the Scottsdale Airpark area was included in the analysis.) Table 2 shows the current ridership on the Scottsdale/Rural corridor and the effect that BRT improvements could have if implemented immediately.

**Table 2 Scottsdale/Rural BRT Weekday Ridership Estimates**

Oct. 2008 Passenger Counts	Transit O-D Survey	Increase with BRT	Induced Trips	Total with BRT	Annualized Ridership with BRT
6,535	8,610	2,645	343	11,597	2,957,000

The top zones ranked by the total number of passengers expected in the zone (counting both boardings and alightings) are the following:

- Zone 31: LRT/downtown Tempe
- Zone 44: Scottsdale Fashion Center
- Zone 43: Downtown Scottsdale
- Zone 46: Scottsdale Airpark
- Zone 36: Rural Road/Baseline Road
- Zone 35: Rural Road/Elliot Road
- Zone 27: LRT/Central Corridor
- Zone 18: Chandler Boulevard/West Chandler
- Zone 26: LRT/Camelback Corridor
- Zone 28: LRT/downtown Phoenix
- Zone 45: Scottsdale Resorts/Paradise Valley

There are many important destinations within the Scottsdale/Rural corridor. The top zones are downtown Tempe, Scottsdale Fashion Center, and Downtown Scottsdale. Collectively, these zones comprise almost 3,000 boardings & alightings. (See Appendix VI for a detailed table of zonal attractors.) The portion of the corridor north of and including downtown Tempe comprises about 49% of the boardings and alightings.

#### *Implications for operational planning*

Important zones along the Scottsdale/Rural corridor span the entire corridor. In addition to being an important zone in and of itself, the Downtown Tempe zone provides a connection to light rail. Since six of the top 20 zones are along the light rail line, the coordination between this BRT route and the light rail line is crucial. (Note: Trips to the Central Avenue Corridor and the Camelback area may be accommodated by transfers to local bus service rather than light rail.)

Zone 45, which includes resorts and Paradise Valley, has a surprisingly high number of trips. A stop in this zone should be considered. Zone 17, in Ahwatukee, generates a large number of

trips in the Scottsdale/Rural corridor. Transfers between Chandler Boulevard bus services should be facilitated. Coordinating Scottsdale/Rural transfers with the Main Street LINK service is also important, given that almost 300 trips are generated from the eastern Main Street zones 23 and 24.

**South Central/Baseline BRT Corridor (July 2015 & July 2016)**

The planned South Central A, B, and Express BRT corridors would include the areas covered by the South Central Express (FY2015 (July 2014)), the South Central BRT A (FY2016 (July 2015)) and the South Central BRT B (FY2016 (July 2015)). This area would extend along Baseline Road between 59<sup>th</sup> Avenue and 56<sup>th</sup> Street, on Central Avenue between Baseline Road and Washington Street, and along Washington and Jefferson streets to 19<sup>th</sup> Avenue.<sup>12</sup> The South Central BRT corridors are shown in Figure 5.

*Existing transit routes & ridership*

South Central Avenue is currently served by Route 0 (Central Avenue) which operates from Dobbins Road to Dunlap Avenue. Route 0 provides almost 80 trips in each direction, and service between Dobbins Road and Central Station (which corresponds to the South Central Avenue portion of the planned BRT corridor) is very frequent, with a trip every ten minutes in the peak commute periods and every twenty minutes in the off-peak during weekdays.

Route 77 (Baseline Road) serves Baseline Road from 39<sup>th</sup> Avenue to Dobson Road. The route has 34 trips in each direction with 30-minute service from 5:00am until 11:00pm on weekdays and 7:00am until 10:00pm on weekends.<sup>13</sup> Route 7 (7<sup>th</sup> Street) parallels Central Avenue one-half mile to the east and runs from Dobbins Road to Union Hills Drive. Route 8 (7<sup>th</sup> Avenue) parallels Central Avenue one-half mile to the west and runs from Baseline Road to Dunlap Avenue. Route 61 (Southern Ave) parallels Route 77 one mile to the north.

As indicated, the South Central Avenue/Baseline Road corridor is served by several transit routes. However, most of these routes extend beyond the planned BRT corridor and passenger counts are not available for the portions of these routes that serve the planned BRT corridor. For that reason, the November 2007 on-board survey is a better source of ridership information. Based on this information, weekday ridership in the corridor is estimated at 11,231.

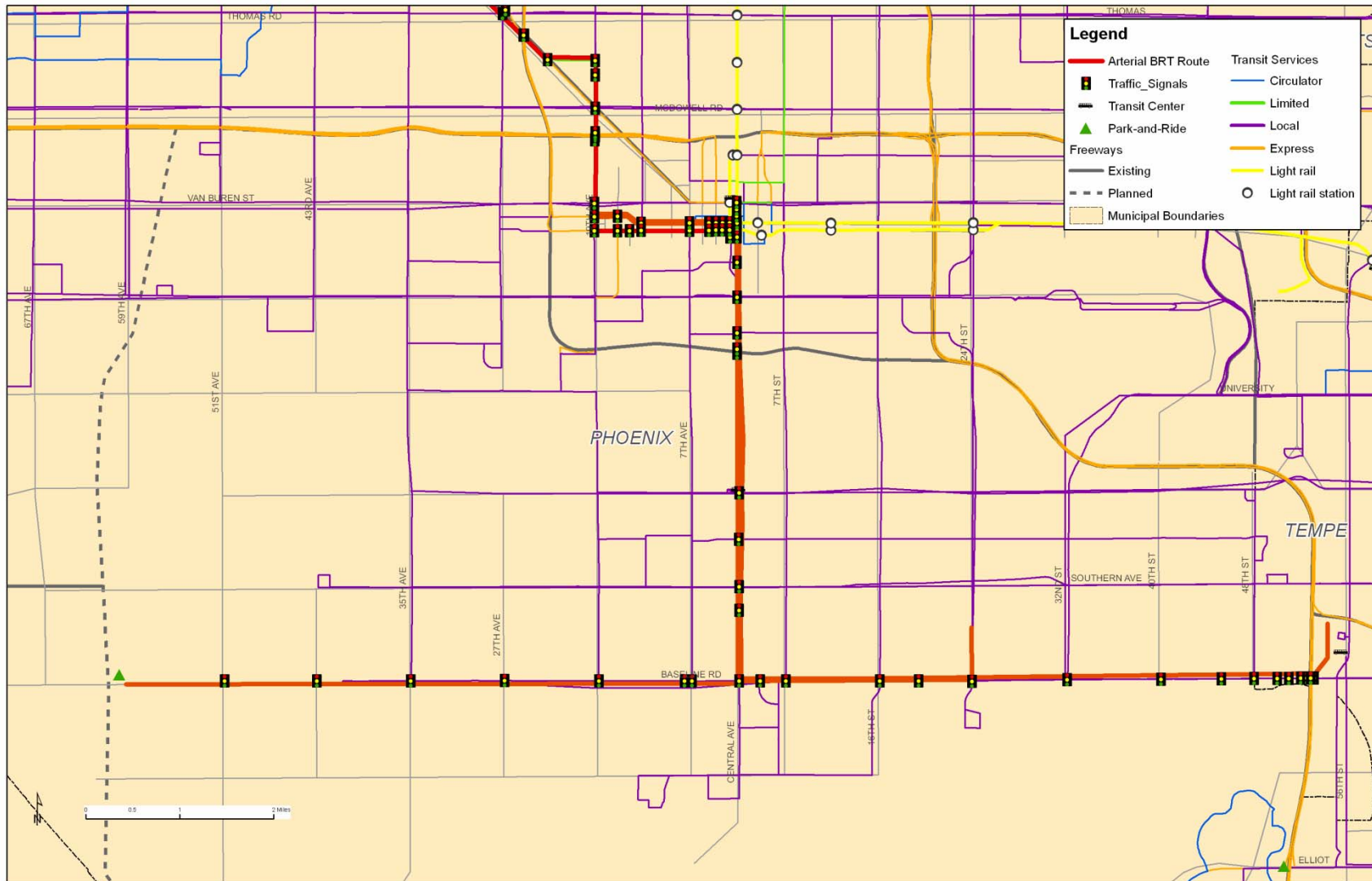
The South Central corridor meets the light rail line at Central Station and intersects the following local routes:

<b>North-South Routes</b>	<b>East-West Routes</b>
Route 35 (35th Ave)	Route 61 (Southern Ave)
Route 19 (19th Ave)	Route 52 (Roeser St)
Route 16 (16th St)	Route 45 (Broadway Rd)
Route 70 (Glendale Ave/24th St)	Route 13 (Buckeye Rd)
Route 30 (University Dr)	Route 15 (15 <sup>th</sup> Ave)
Route 92 (48th St)	Route 1 (Washington St/ Jefferson St)
Route 108 (Elliot Rd)	

<sup>12</sup> The TRP also identifies an extension of the Salt River Parkway west to 59<sup>th</sup> Avenue that could ultimately become the routing for the South Central BRT A.

<sup>13</sup> There are additional weekday and weekend trips on the portion of route 77 that operates within the City of Tempe.

Figure 5 South Central/Baseline BRT Corridor



The South Central corridor also intersects a variety of express bus routes at that terminate in downtown Phoenix at Central Station.

*BRT funding plans*

The three BRT routes that comprise this corridor are funded based on the following assumptions:

South Central Express (July 1, 2014)	South Central BRT A (July 1, 2015)	South Central BRT B (July 1, 2015)
<ul style="list-style-type: none"> <li>• Two-way service</li> <li>• 48 one-way trips per weekday</li> <li>• Trip length (one-way) - 9.38 miles</li> <li>• Service operations between South Mountain Community College, downtown Phoenix, and the Arizona State Capitol</li> </ul>	<ul style="list-style-type: none"> <li>• Two-way service</li> <li>• 20 one-way trips per weekday</li> <li>• Trip length (one-way) – 11.57 miles</li> <li>• Service operates between 59<sup>th</sup> Avenue/Baseline Road and Central Station</li> </ul>	<ul style="list-style-type: none"> <li>• Two-way service</li> <li>• 20 one-way trips per weekday</li> <li>• Trip length (one-way) 12.13 miles</li> <li>• Service operates between Arizona Mills Transit Center and Central Station</li> </ul>
<p>Capital facility enhancements within the South Central Avenue and Baseline Road rights-of-way are funded in the amount of \$20.47 million (2007 \$\$)</p>		

*Other planned transit Routes & infrastructure*

Route 77 (Baseline Road) becomes a supergrid route in July 2010, which will increase the number of weekday trips to 88, with 15-minute service in the peak and 30-minute service off-peak.

A park-and-ride lot is planned at Baseline Road & 59<sup>th</sup> Avenue.

*Roadway profile & travel speeds*

Central Avenue is two lanes in each direction. Baseline Road is one lane west of 51<sup>st</sup> Avenue, two lanes between 51<sup>st</sup> Avenue and 16<sup>th</sup> Street, and three lanes east of 16<sup>th</sup> Street. There are 15 traffic signals on Central Avenue, and 20 on Baseline Road; traffic signal density is 1.75 signals per mile.

Baseline Road has a posted speed limit at speeds of 40 or 45 mph. Central Avenue has a posted speed limit of 35 or 40 mph. Travel speeds throughout the day are generally in the 30-40 mph range, with speeds less than 20 mph in downtown Phoenix, and speeds above 40 mph on some areas of Baseline Road.

Weekday bus travel speeds are 14 mph in the peak on South Central Avenue and 15.1 mph in the off-peak. On Baseline Road, weekday travel speeds are 16.9 mph in the peak and 18 mph in the off-peak.

*Population & employment characteristics*

Population density in the South Central corridor ranges from moderate (2,000 to 6,000 people per square mile) to high (greater than 6,000 people per square mile). Density is generally lower along Baseline Road, but it is projected to become denser over time.

Employment density is very low (less than 250 employees per square mile) in the western portion of Baseline Road, but is projected to increase in the future. Employment density is higher along Central Avenue. The northernmost portion of the corridor is extremely dense with high employee density in downtown Phoenix. The Central Avenue and eastern Baseline Road portions of the corridor are not projected to change a great deal over time.

*Ridership estimates*

BRT improvements in the South Central Avenue/Baseline Road corridor could raise daily transit ridership in the corridor to over 15,000 daily riders. Table 3 shows the current ridership in the corridor (including parallel routes) and the effect that BRT improvements could have if implemented immediately. (Note: ridership within only the Central Avenue corridor was estimated at 5,200.)

**Table 3 South Central BRT Corridor Weekday Ridership Estimates with BRT**

Corridor	Transit O-D Survey	Increase with BRT	Induced Trips	Total with BRT	Annualized Ridership with BRT
South-Central	11,231	3,450	447	15,128	3,858,000

The top zones ranked by the total number of passengers expected in the zone (counting both boardings and alightings) are the following:

- Zone 39: Baseline Road/Central Avenue to 35<sup>th</sup> Ave
- Zone 37: Baseline Road/Arizona Mills Mall
- Zone 38: Baseline Road/SMCC
- Zone 27: LRT/Central Avenue Corridor
- Zone 28: LRT/Downtown Phoenix
- Zone 47: South Central Avenue (btw. Buckeye & Southern)
- Zone 29: LRT/Sky Harbor North
- Zone 48: Grand Ave/Downtown Phoenix
- Zone 26: LRT/Camelback Road
- Zone 40: Baseline Road/35<sup>th</sup> Avenue to 67<sup>th</sup> Avenue

The top three zones are within the corridor itself, while three of the top ten zones require a transfer. Facilities at these transfer opportunities will need to be adequate in order to support large transfer activity.



### *Chandler Boulevard – FY2024 (July 2023)*

The planned Chandler Boulevard BRT corridor would extend 17.7 miles from 54<sup>th</sup> Street/Galveston Street in Chandler to the Arizona State Polytechnic Campus in Mesa.

#### *Existing transit routes & ridership*

Route 156 currently operates on the Chandler Boulevard corridor between Desert Foothills Parkway and the ASU Polytechnic campus at Power Road. There are 35 trips in each direction, with 30-minute service throughout the day from 5:00am until 11:00pm on weekdays and weekends. Average weekday ridership on route 156 is 1,146.

There is currently no service on parallel roads within one mile.

The Chandler Boulevard BRT corridor intersects with the following routes:

- Route 56 (56th Street)
- Route 65 (Mill Avenue/Kyrene Road)
- Route 72 (Scottsdale Road/Rural Road)
- Route 81 (Hayden Road/McClintock Road)
- Route 96 (Dobson Road)
- Route 104 (Alma School Road)
- Route 112 (Country Club Drive?/Arizona Avenue)
- Route 136 (Gilbert Road)

#### *BRT funding plans*

The Chandler Boulevard BRT route is funded based on the following assumptions:

- Two-way service
- 48 one-way trips per weekday
- Trip length (one-way) - 18.52 miles
- Service operations between 54th Street & Galveston Street in Chandler to Arizona State University East Campus\Gateway Airport in Mesa. Regional destinations include Chandler Fashion Center, Arizona State Polytechnic Campus/Gateway Airport, and downtown Chandler
- Capital facility enhancements within the Chandler Boulevard right-of-way are funded in the amount of \$32.08 million (2007 \$\$)

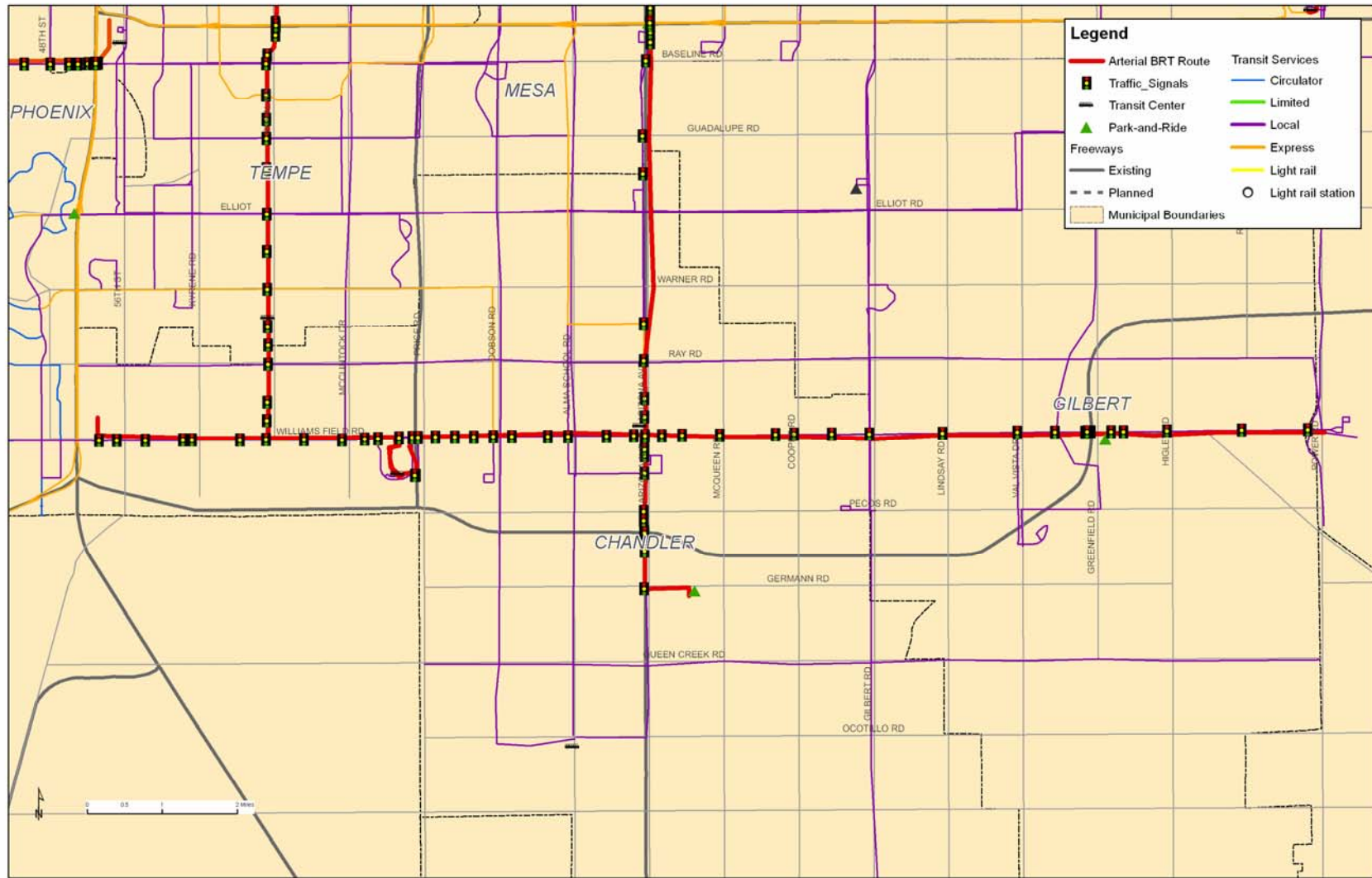
#### *Other planned transit routes & infrastructure*

By the time the Chandler Boulevard BRT is implemented in FY2024, the following additional transit services will be in place:

- Scottsdale/Rural BRT
- Arizona Avenue BRT
- Supergrid service on Power Road, Ray Road, and Greenfield Road

In addition, a park-and-ride facility will be constructed at Loop 202 and Val Vista Drive.

Figure 6 Chandler Boulevard BRT Corridor



*Roadway profile and travel speeds*

The Chandler Boulevard corridor is three lanes in each direction, from 32<sup>nd</sup> Street to Arizona Avenue and two lanes east of Arizona Avenue. There is a median/left-turn lane along the entire corridor. There are 35 traffic signals along the corridor, or 1.98 signals per mile.

The posted speed limit on the majority of the length of Chandler Boulevard is 45 mph, but short portions have posted speeds of 40, 50, or 55 mph. Travel speeds throughout the day are in the 30-40 mph range along the corridor. At mid-day, some segments experience travel speeds of 40-50 mph, especially the western end of the corridor; and in the afternoon peak period, there are some delays around 56<sup>th</sup> Street and McClintock Road.

Travel speed on bus route 156 along the corridor currently averages 13 mph.

*Population & employment characteristics*

Population density in the corridor is currently moderate (between 2,000 and 6,000 people per square mile) with a pocket of high density in the Chandler Boulevard/Arizona Avenue area. Population density is generally higher in Chandler than in Gilbert and Mesa. Population density is expected to increase a great deal in the easternmost portion of the corridor.

Employment density is moderate (2,000 to 4,000 employees per square mile) in the Chandler portion of the corridor and low (fewer than 2,000 employees per square mile) in the Gilbert/Mesa portion. Employment density is projected to increase in the vicinity of Val Vista Drive. The corridor ties together several significant employment centers, including the Intel campus at Rural Road, Chandler Fashion Center, the Chandler Municipal complex, Mercy Gilbert Hospital, ASU Polytechnic campus, and Phoenix-Mesa Gateway Airport.

*Ridership estimates*

Ridership estimates for the Chandler Boulevard corridor are based on current ridership figures, but they do not reflect the growth that is anticipated in the corridor, especially in the eastern portion around the Williams Gateway/ASU Polytechnic Campus area.<sup>14</sup> Ridership figures reflecting ridership impacts if BRT were implemented immediately are presented here. However, given that BRT implementation is planned for July 2023, the figures are primarily useful in terms of the zones that are attractors.

Ridership

**Table 4 - Chandler Boulevard Weekday Ridership Estimates with BRT**

Corridor	Recent Passenger Counts	Transit O-D Survey	Increase with BRT	Induced Trips	Total with BRT	Annualized Ridership with BRT
Chandler Boulevard	1,146	1,184	364	47	1,595	406,725

<sup>14</sup> Appendix VII shows growth rates in terms of trip origins for all of the zone groups. The table shows that high growth rates occur in eastern Chandler, southern Arizona Avenue, western South Central, and the light rail corridor.

The top zones ranked by the total number of passengers expected in the zone (counting both boardings and alightings) are the following:

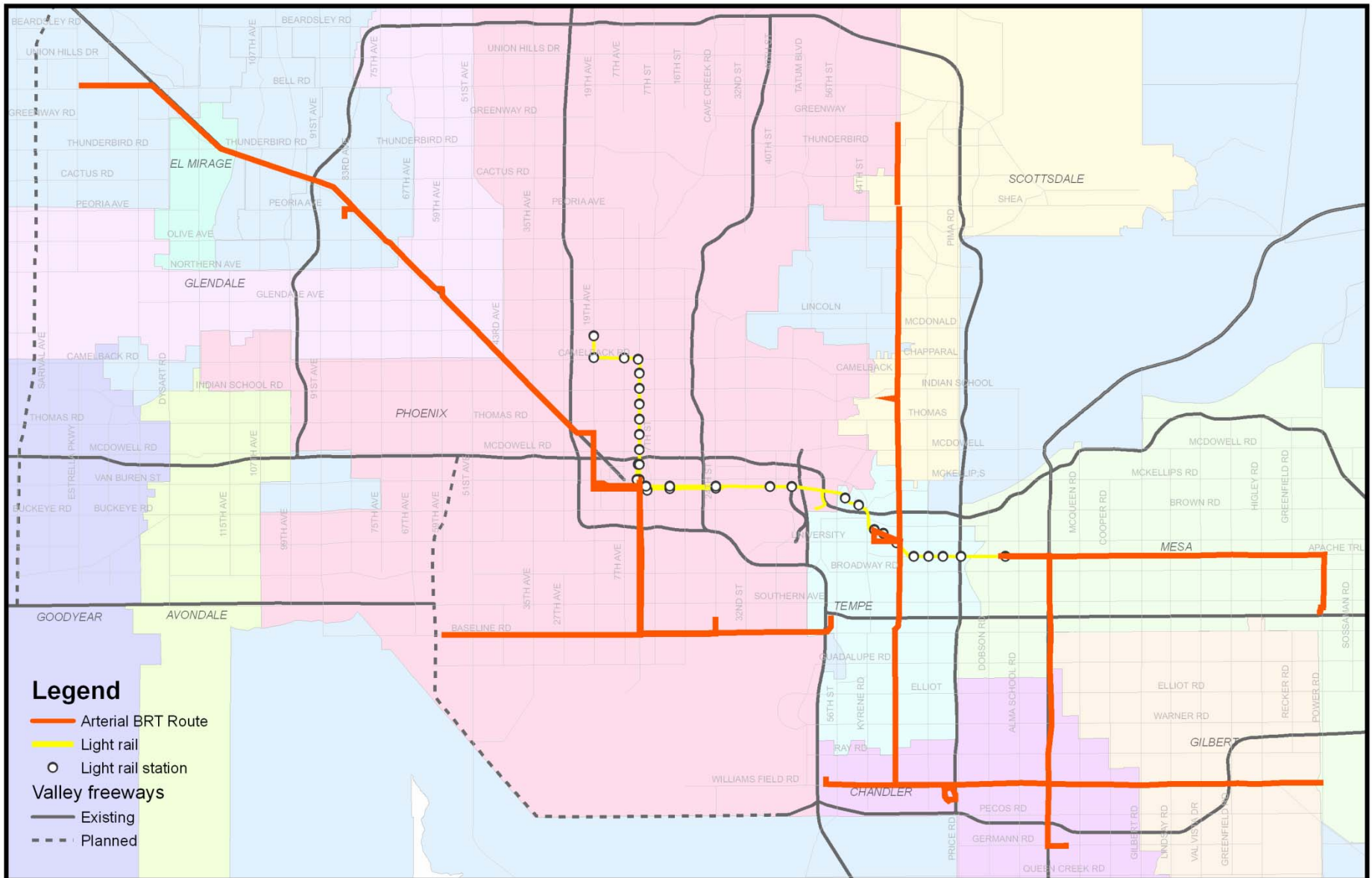
- Zone 17: Chandler Boulevard/Ahwatukee
- Zone 19: Price Road Corridor/Chandler Fashion Center
- Zone 18: Chandler Boulevard/West Chandler
- Zone 16: ASU/Williams Gateway
- Zone 31: LRT/downtown Tempe
- Zone 37: Baseline Road/Arizona Mills Mall
- Zone 5: Chandler Boulevard & Arizona Avenue
- Zone 14: Chandler Boulevard east
- Zone 4: Downtown Chandler
- Zone 15: Chandler Boulevard/Val Vista Drive to Power Road (east of 202)

## 1.2. Summary of BRT Corridor Characteristics

BRT Corridor	Length	Existing Weekday Transit Service	Existing Transit Ridership (Weekdays)	Existing Average Transit Travel Speeds	Potential Transit Ridership with BRT (Future)
Arizona Avenue	11.9 miles	56 one-way trips (30-min frequencies)	Approx. 1,200 – 1,800 avg. daily boardings	14.5 mph	2,100 – 2,500
Grand Avenue	25.8 miles	14 one-way trips (peak commute period, peak direction only)	Approx. 100 - 280 avg. daily boardings	17.1 – 19 mph	N/A
Scottsdale/Rural	24 miles (plus 2.7 mile extension)	120 one-way trips (15-min frequencies)	Approx. 6,500 to 8,600 avg. daily boardings	12.2 mph	11,600
South Central Avenue	6.7 miles	156 one-way trips (10-min peak/20-min off-peak)	Approx. 11,200 avg. daily boardings	14 mph peak 15.1 mph off-peak	15,100
Baseline Road	13.3 miles	68 one-way trips (30-min frequencies)		16.9 mph peak 18 mph off-peak	
Chandler Boulevard	17.7 miles		Approx. 1,200 avg. daily boardings	13 mph	1,600

A map of the entire arterial BRT network is shown in Figure 7.

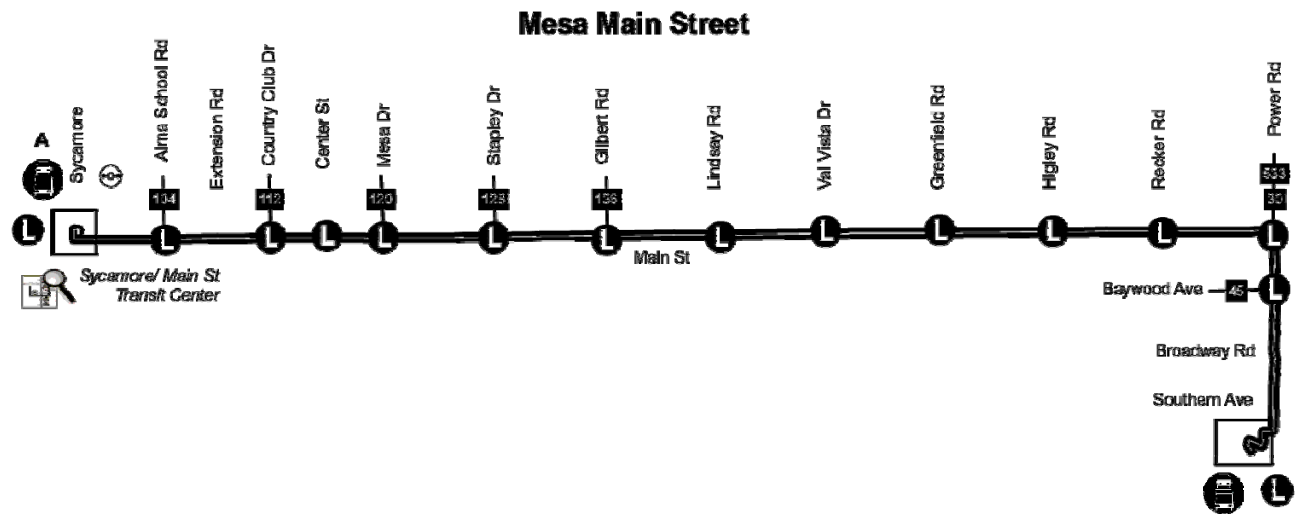
Figure 7 Arterial BRT Network



### 1.3. LINK-Mesa Main Street BRT Implementation & Ridership

The LINK service on Main Street in Mesa is the first example of arterial BRT service to be implemented in the Valley. A map of the Mesa Main Street BRT route is shown in Figure 8.

Figure 8 Mesa Main Street LINK (BRT) Route



Source: Valley Metro/RPTA, January 2009

As the map shows, there are 14 stations on the 12-mile LINK corridor. Stations are generally spaced a mile apart, at the intersection of major streets. Exceptions to this rule are at Center Street in downtown Mesa and at Baywood Avenue at Baywood Medical center. Both are major route destinations.

Rather than operating with a timetable, the LINK service operates on a frequency-based schedule. Trips are scheduled for every 15 minutes in the weekday morning and afternoon peak hours, and every 30 minutes throughout the rest of the day. Service is hourly on weekends. Service extends from 6:00am until 10:00pm on both weekdays and weekends.

Underlying the LINK service is local Route 40, which extends from Superstition Springs Transit Center to Sky Harbor Airport. Route 40 operates at 30-minute frequencies on weekdays and weekends. Route 40 service hours start at about 5:00am and terminate at about 9:30pm in Mesa, but start earlier and continue later on the portion of the route in Tempe and Phoenix.

The runtime on the LINK service from Superstition Springs Park-and-Ride to Main & Sycamore is 45 minutes. Route 40 travels the same distance in 67 minutes. Traffic signal prioritization is not yet in place on the LINK service, but will be implemented later in 2009 and should decrease travel times slightly.

Though the LINK theoretically operates without a timetable, planners attempt to time the LINK and Route 40 so that the services are somewhat coordinated, allowing for more frequent service on the corridor at common stations. However, given the longer runtime on Route 40, the service is not coordinated at downstream stations.

*Ridership*

Prior to the implementation of LINK and Route 40, no transit was present on this portion of Main Street. Preliminary ridership results on the corridor are impressive, but somewhat counter-intuitive. Table 5 shows average daily boardings by month on each route since inception in January 2009. (Note: boarding numbers on the Route 40 are for Mesa only.)

**Table 5 Average Weekday Boardings on LINK and Route 40**

Month	LINK	Route 40	TOTAL
January 2009	782	1,420	2,202
February 2009	834	1,494	2,328

As the table shows, the combined ridership in the corridor is over 2,000 passengers per day, which is an impressive number for a corridor that previously had no transit service at all. What is counter-intuitive is the split in ridership. Ridership on Route 40 is almost twice that of the LINK service. While the service quantity is similar on both routes, the quality of service on the LINK service is higher given the faster travel speeds and unique buses.

While the ridership results are preliminary and may not illustrate a trend, planners at the City of Mesa have identified several possible reasons for this unexpected split. Route 40 travels directly to Sky Harbor Airport, a major employment site in the Valley. (LINK travelers can also access Sky Harbor, but must transfer first to the light rail and then to a shuttle bus.) Passengers may simply not be familiar with the LINK and understand its travel patterns. The eastern portion of the Main Street corridor is residential, and Route 40's frequent, mid-block stops may allow easier access for people who live in the area. Planners have found that people are traveling to the nearest stop, and not necessarily selecting the LINK service. To address this last point, City of Mesa planners are planning on setting up shared-use park-and-ride lots near LINK stations to ensure parking is available near each LINK station.



## SUMMARY OF KEY FINDINGS

The corridors comprising the arterial BRT network vary greatly in development patterns, level of traffic, and existing transit services and transit ridership. Therefore, the appropriate BRT solution for the corridors will differ. However, planning for all corridors can begin immediately at various levels. In addition, common elements in terms of branding and customer experience can ensure a cohesive system is achieved.

Preliminary results from the LINK service on Main Street indicate that, in areas underserved (or not served at all) by transit, BRT may act simply as an augmentation of other transit services rather than a specialized transit service. The Main Street LINK experience also indicates the need to clearly differentiate types of transit services to potential transit customers to avoid confusion. The Main Street LINK service is an example of a “BRT Lite” service that may be appropriate for certain corridors in the Valley Metro arterial BRT network.

Recommendations for BRT service and facility improvements will be presented in the Draft Working Paper for Task 7.

## **APPENDICES**

### **Task 4 & Task 6 Working Paper**



## APPENDIX I: Transit Travel Speed Estimate Calculations

For all routes, weekday peak period travel speed is calculated for routes departing from 6am - 9am or 4pm - 7pm, using the average of inbound & outbound travel time. If no off-peak travel time is shown, there is no difference in travel speed between the peak and off-peak period.

### Arizona Avenue

Travel time estimate based on Route 112.

Start	End	Distance (mi)	Travel time (min)		Average Speed (mph)	
			Peak	Off-peak	Peak	Off-peak
Germann	Frye	1.5	unknown	unknown	unknown	unknown
Frye	Chandler	0.5	5.5	5	5.5	6.0
Chandler	Ray	1	5	5	12.0	12.0
Ray	Elliot	2	5	5	24.0	24.0
Elliot	Guadalupe	1	5	5	12.0	12.0
Guadalupe	Southern	2	7.5	7.5	16.0	16.0
Southern	Main	1.5	5	5	18.0	18.0
<i>TOTAL (GERMANN-MAIN)</i>		8	33	32.5	14.5	14.8

## Grand Avenue

Travel time based on Route 571 and Grand Avenue Limited

Route 571						
Start	End	Distance (mi)	Travel time (min)		Average Speed (mph)	
			Peak	Off-peak	Peak	Off-peak
Surprise Park and Ride	Greenway Rd at Dysart Rd	2.5	5	n/a	30.0	
Greenway Rd at Dysart Rd	1st Ave at Van Buren	20	67.5		17.8	
1st Ave at Van Buren	18th Ave at Adams	1.7	9		11.3	
<i>TOTAL</i>		<i>24.2</i>	<i>76.5</i>		<i>19.0</i>	

Grand Avenue Limited						
Start	End	Distance (mi)	Peak	Off-peak	Peak	Off-peak
Surprise Park and Ride	Greenway Rd at Dysart Rd	2.5	5	5	30.0	30
Greenway Rd at Dysart Rd	Peoria Park-and-ride	7	20	20	21.0	21
Peoria Park-and-ride	59th & Myrtle	4.5	15	15	18.0	18
59th & Myrtle	18th Ave & Jeff/Adams	8.8	37	30	14.3	17.6
18th Ave & Jeff/Adams	1st Ave & Van Buren	1.7	9	9	11.3	11.3
<i>TOTAL</i>		<i>24.5</i>	<i>86</i>	<i>79</i>	<i>17.1</i>	<i>18.6</i>

## Scottsdale/Rural

Travel time estimate based on route 72.

Start	End	Distance (mi)	Travel Time	Average Speed
Chandler TC	Rural/Chandler	1.5	9	10.0
Chandler	Ray	1	4	15.0
Ray	Elliot	2	7	17.1
Elliot	Southern	3	11	16.4
Southern	Apache	1.5	7	12.9
Apache	McDowell	3.5	29	7.2
McDowell	Thomas	1	5	12.0
Thomas	Shea	7	33	12.7
Shea	Greenway	2.8	10	16.8
<b>TOTAL (CHANDLER TC TO GREENWAY)</b>		<b>23.3</b>	<b>115</b>	<b>12.2</b>

## South Central Avenue

Travel time estimate based on Route 77 (Baseline), Route 0 (Central Ave), and Route 1 (Jefferson)

Start	End	Distance (mi)	Travel time (min)		Average Speed (mph)	
			Peak	Off-peak	Peak	Off-peak
Baseline/24th (SMCC)	Central/Baseline	3	13	11	13.8	16.4
Central/Baseline	Central/Broadway	2	8	8	15.0	15.0
Central/Broadway	Central Station (1st Ave/Van Buren)	3	12	12	15.0	15.0
Central Station (1st Ave & VanB)	19th Ave/Jefferson (State Capitol)	1.8	9	8	12.0	13.5
<b>TOTAL</b>		<b>9.8</b>	<b>42</b>	<b>39</b>	<b>14.0</b>	<b>15.1</b>

Start	End	Distance (mi)	Travel time (min)		Average Speed (mph)	
			Peak	Off-peak	Peak	Off-peak
59th Ave/Baseline	39th Ave/Baseline	2.5	unknown	unknown	unknown	unknown
39th Ave/Baseline	Central/Baseline	4	12	10	20.0	24.0
Central at Baseline	Central at Broadway	2	8	8	15.0	15.0
Central at Broadway	Central Station (1st Ave & Van Buren)	3	12	12	15.0	15.0
<b>TOTAL</b>		<b>9</b>	<b>32</b>	<b>30</b>	<b>16.9</b>	<b>18.0</b>

## Chandler Boulevard

Travel time estimate based on route 156.

			Travel time (min)	Average Speed (mph)
Start	End	Distance (mi)	Peak	Peak
56th St	Rural	2	7.5	16.0
Rural	Chandler FC	2	9	13.3
Chandler FC	Dobson at Frye	2	11	10.9
Dobson at Frye	Arizona Ave	3.5	9	23.3
Arizona Ave	Higley Rd	7	44	9.5
Higley Rd	Power Rd	2	5	24.0
<i>TOTAL</i>		<i>18.5</i>	<i>85.5</i>	<i>13.0</i>

**APPENDIX II: Capital Funding per Corridor**

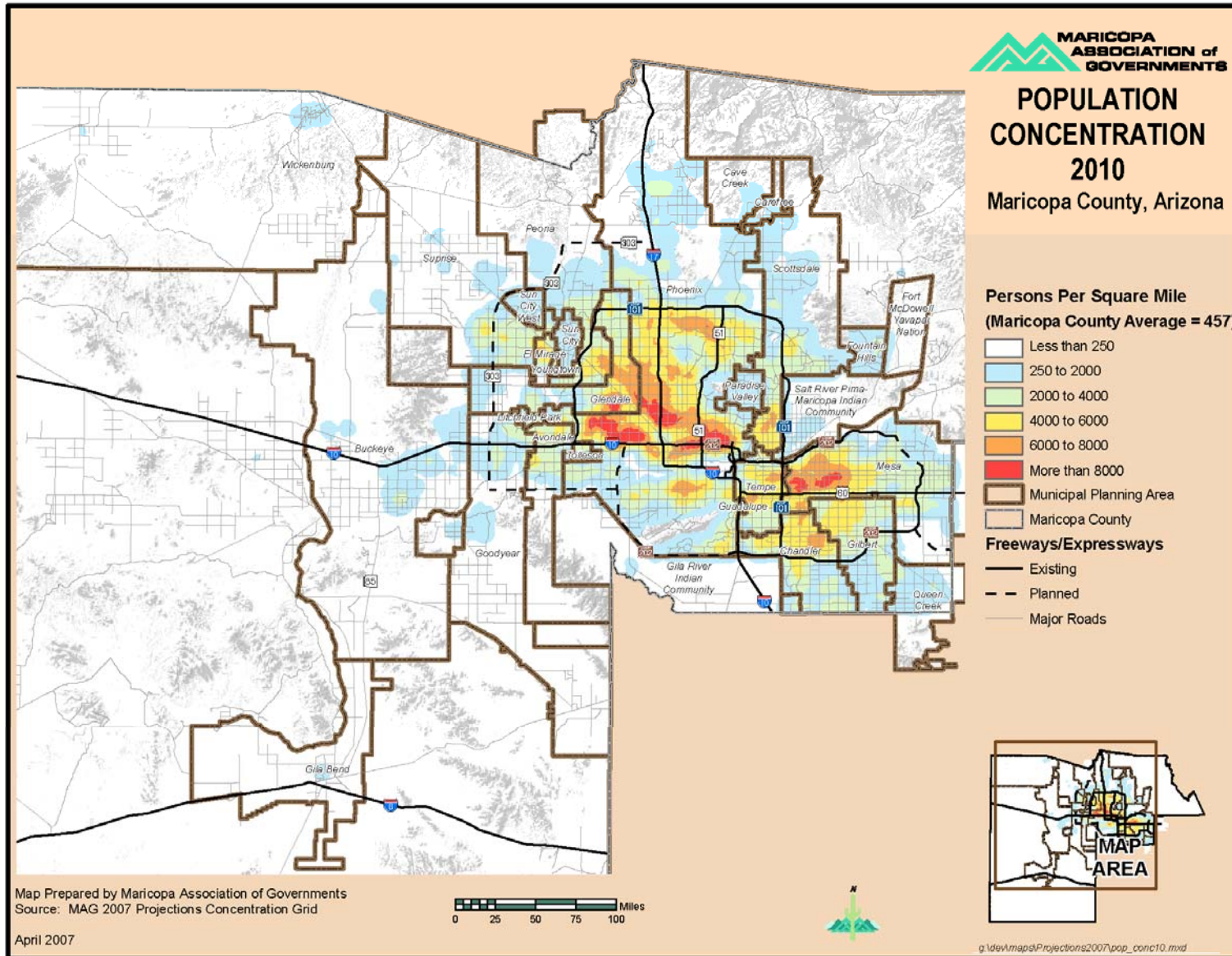
TOTAL CAPITAL FUNDING AVAILABLE			
\$ 136,493,815	based on 2007 Annual Review		
Route	Cities	%	\$\$
Main St	Mesa	13.5%	\$ 18,426,665
Arizona Avenue	Chandler	11.8%	\$ 16,106,270
	Gilbert	0.8%	\$ 1,091,951
	Mesa	6.3%	\$ 8,599,110
			\$ 25,797,331
Grand Avenue	Surprise	0.0%	\$ -
	Peoria	0.0%	\$ -
	Glendale	0.0%	\$ -
			\$ -
Scottsdale/Rural	Chandler	4.3%	\$ 5,869,234
	Paradise Valley	0.0%	\$ -
	Scottsdale	11.7%	\$ 15,969,776
	Tempe	13.3%	\$ 18,153,677
			\$ 39,992,688
South Central Dedicated BRT	Phoenix	15.0%	\$ 20,474,072
			\$ 20,474,072
Chandler Blvd	Chandler	15.0%	\$ 20,474,072
	Gilbert	7.4%	\$ 10,100,542
	Mesa	1.1%	\$ 1,501,432
			\$ 32,076,047
<b>TOTAL</b>		<b>100.2%</b>	<b>\$ 136,766,803</b>
			\$ (272,988)
		(differences due to rounding)	

Source: 2007 Annual Report, HDR/SRBA

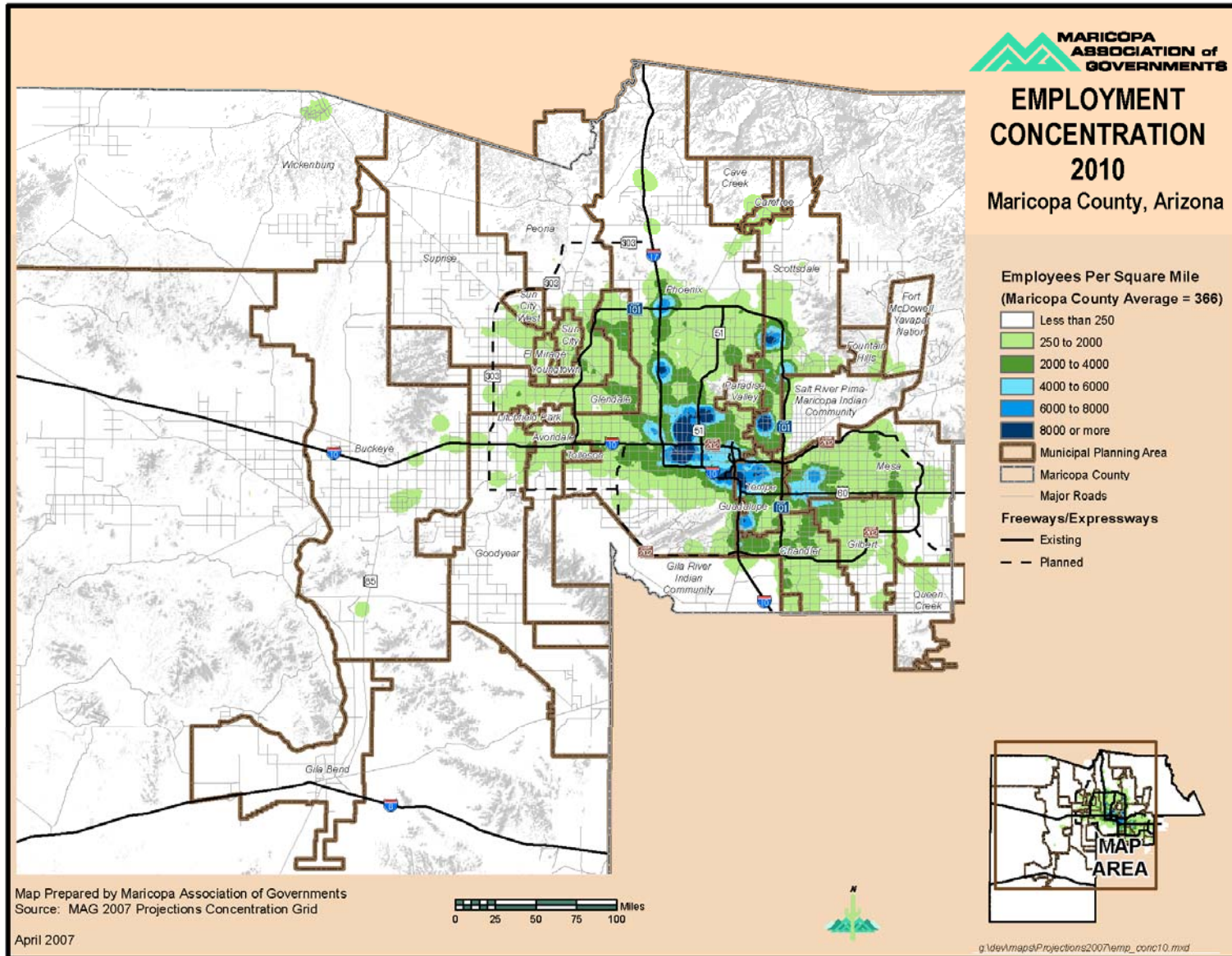


## **APPENDIX III: Population and Employment Projections**

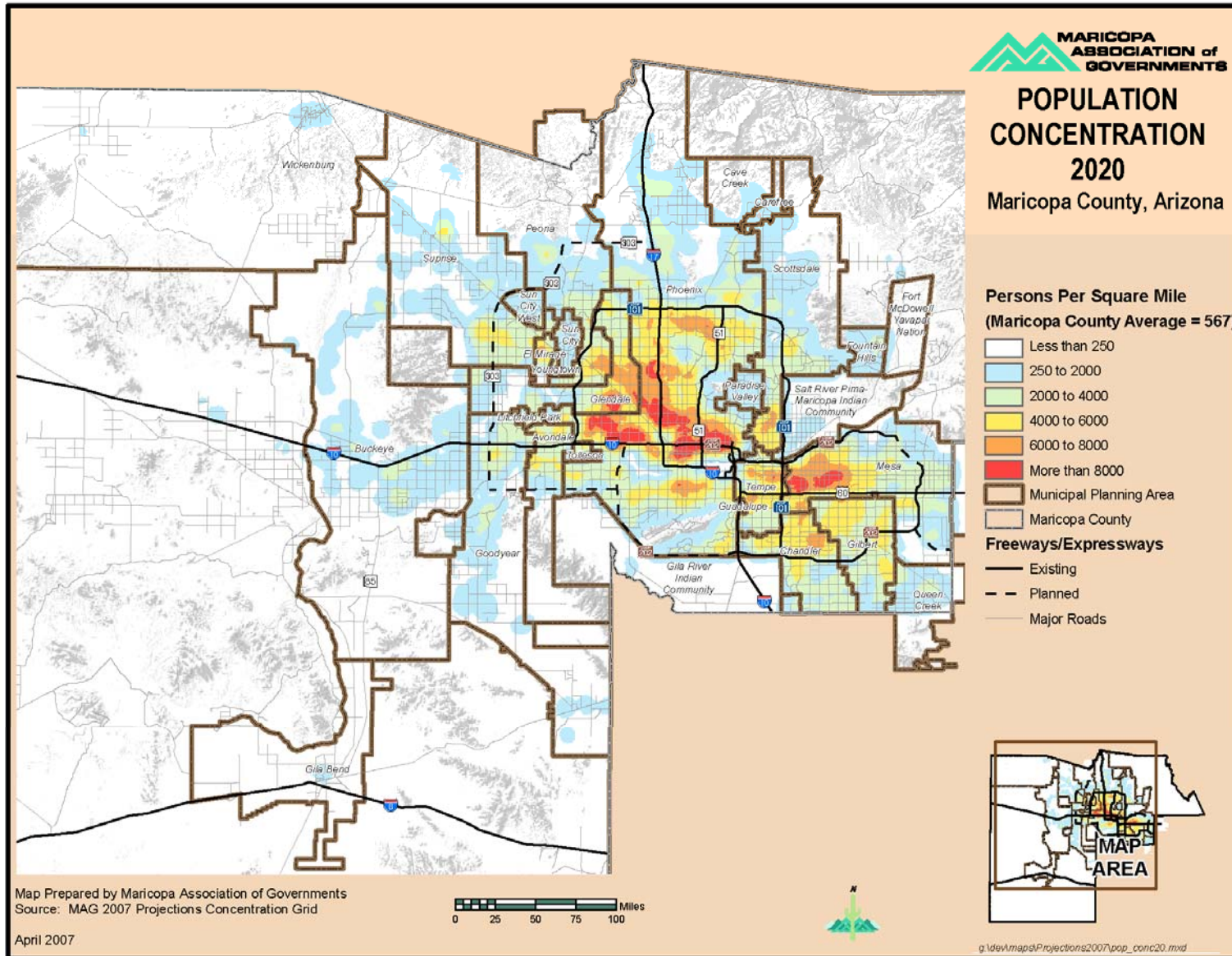
Appendix Figure 1



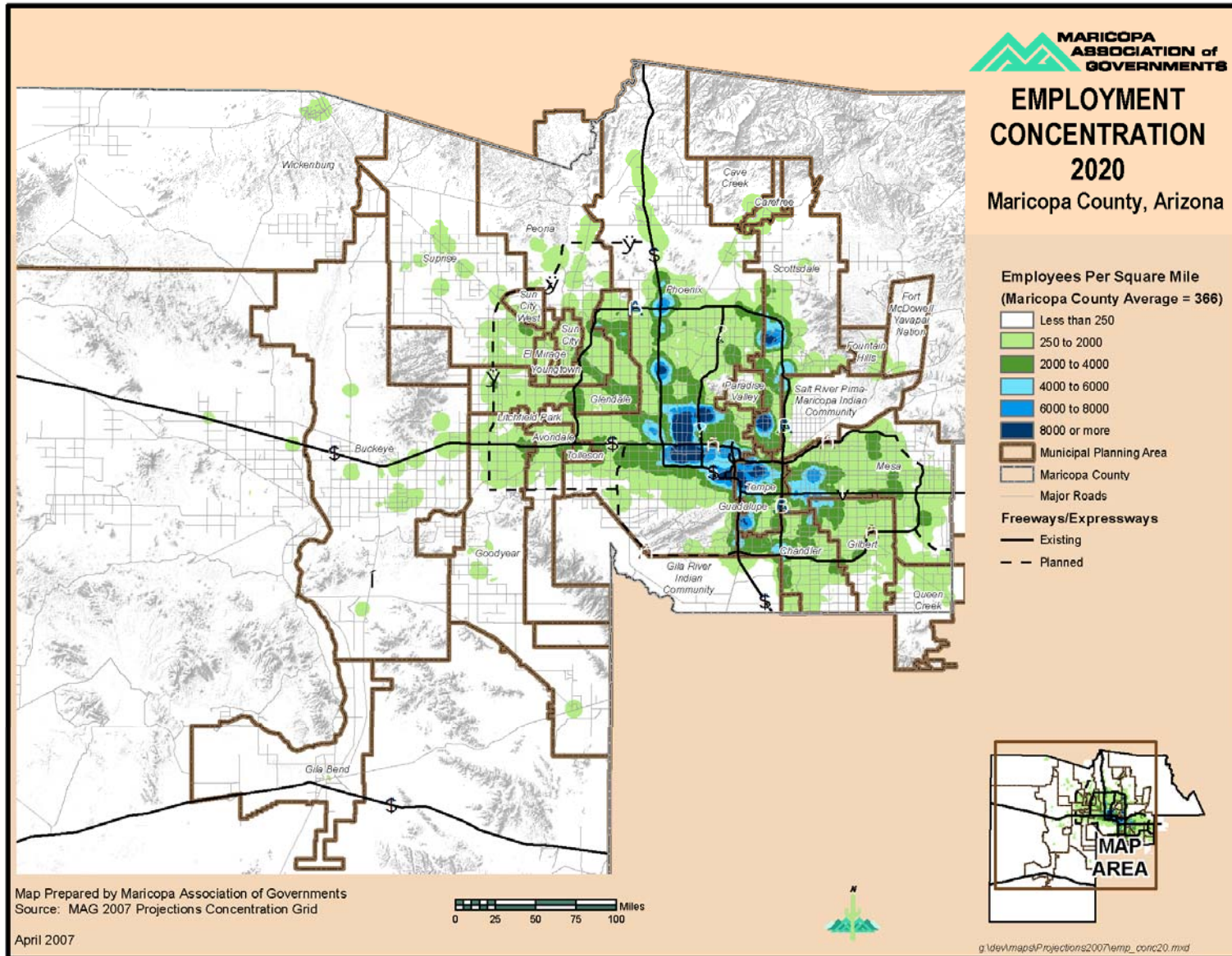
Appendix Figure 2



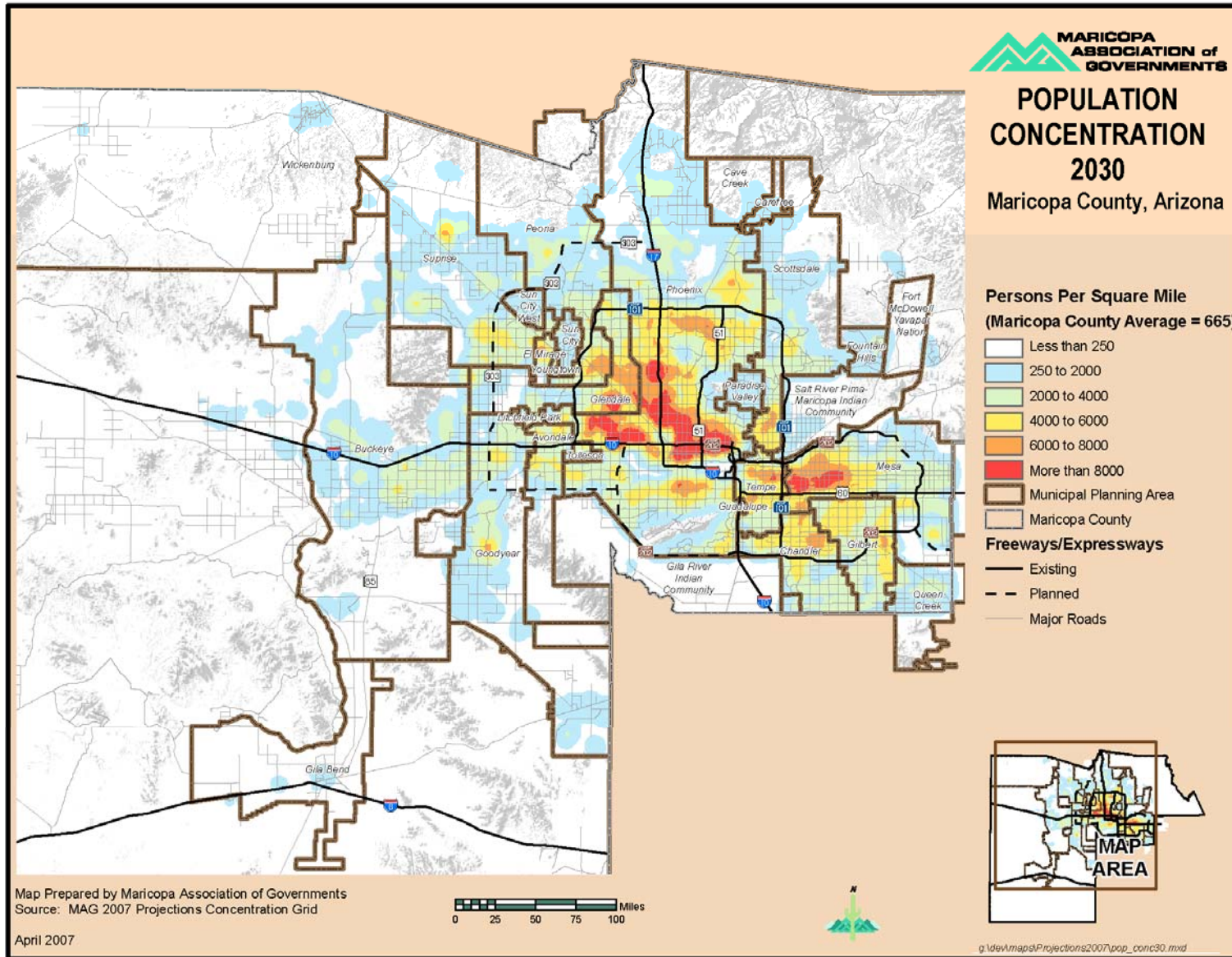
Appendix Figure 3



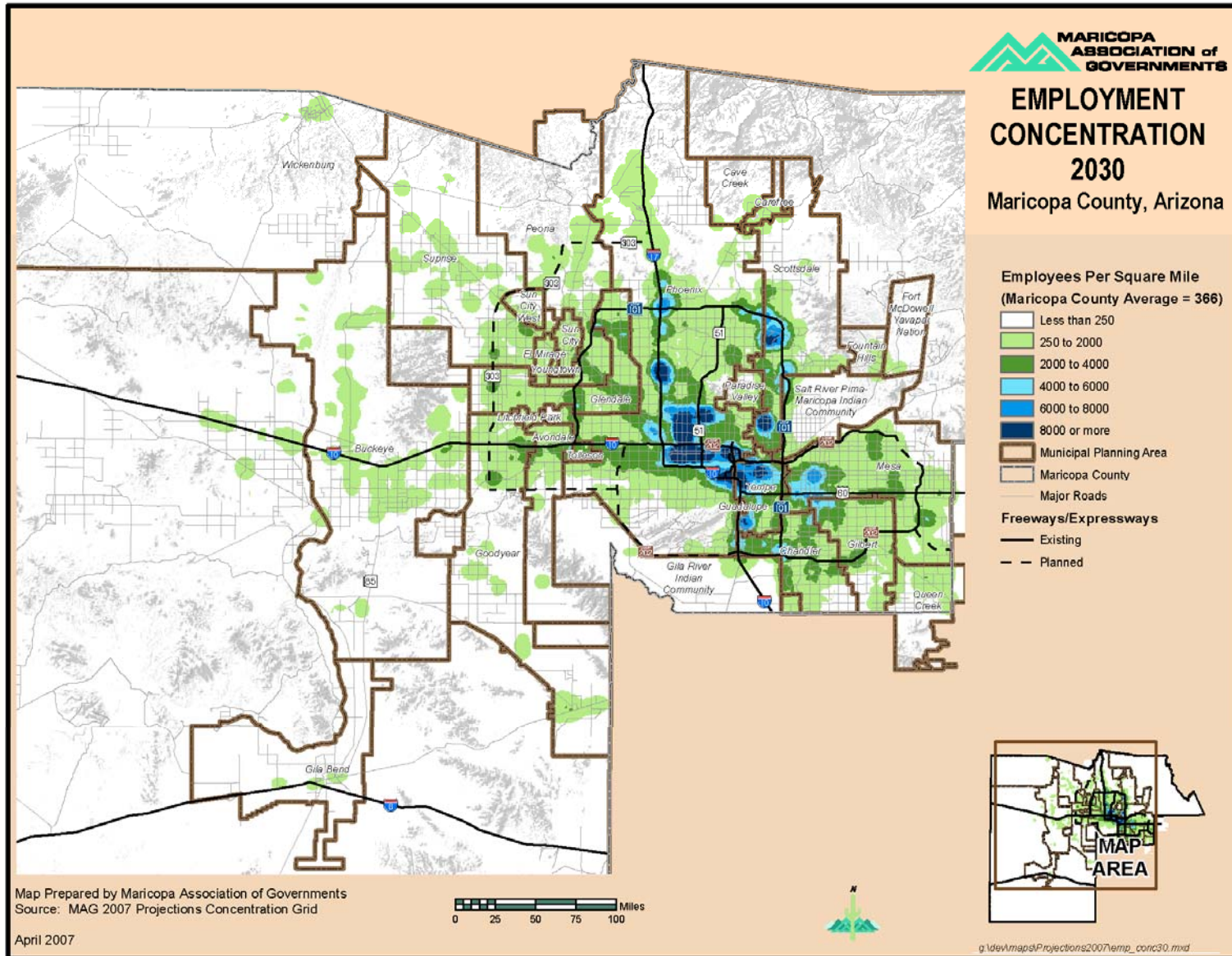
Appendix Figure 4



Appendix Figure 5



Appendix Figure 6





## APPENDIX IV: RIDERSHIP ESTIMATION METHODOLOGIES



## **Arizona Avenue BRT Modeling Methodology**

### Introduction

This section describes the methodology for Arizona Avenue ridership analysis as well as that employed for other corridors in the arterial BRT network.

The model is a pivot model based on analyzing existing total travel (based on TAZ data from the MAG regional travel demand model) and transit data (based on on-board survey data). Factors for transit improvements related to BRT are then applied and projected for future years. The model allows the user to select BRT transit improvements and evaluate various operational scenarios.

Although the model is applied to year 2015 and 2030 conditions, development of the model is at the 2009 level, and this year level is discussed and presented with this working paper.

A primary advantage of the modeling approach described here is its instantaneous “what if” capability. The user can make changes in inputs such as service headway, fare level, or the cost of automobile fuel, for example, and immediately see the anticipated effect on ridership, bus fleet requirements, and annual costs of providing the indicated service. Another advantage is that, being calibrated to replicate current transit service in the specific corridor under study, it may well provide better answers than can be obtained from use of the regional travel demand model, unless significant post-processing of the regional model output is undertaken.

### **Ridership Modeling**

Data availability and the range of demographic and transit service characteristics found among the identified future BRT corridors have guided the design of the ridership modeling methodology and process. The principal factors affecting the methodology and process include:

- Typical difficulties in the use of regional travel demand models to estimate ridership at the individual corridor level
- Availability of data on overall regional total person-trip travel patterns
- Availability of current route-level transit ridership and passenger origin-destination data, acquired by means of recent passenger surveys.
- Recent Parsons Brinckerhoff experience in BRT corridor planning, for a city having a regional travel demand forecasting model but no mode choice model
- Recognition of nationally-recognized guidance on BRT ridership estimation, especially as found in the publication Bus Rapid Transit Practitioner’s Guide (TCRP 118, Transportation Research Board, 2007)

In view of these factors, the model form selected for analysis of the Arterial Bus Rapid Transit Network has the following characteristics:

- Division of each corridor into analysis zones based on existing transit services and the regional travel demand model TAZs, grouped according to anticipated BRT stop locations.
- Definition of additional zones (Zone Groups) based on the regional travel demand TAZs and selected on the basis of the principal bus routes connecting with each BRT corridor, and the main trip origin and destination areas generating or attracting trips beyond the BRT corridor. The initially-defined Zone Groups for the Arizona Avenue BRT analysis are shown in Figure 1, attached. As explained later in this working paper, only a subset of these Zone Groups was finally used.
- Determination of current transit service distances, running times, fares, and headways inter-connecting the selected Zone Groups. Development of corresponding information for the Central Phoenix/East Valley light rail route.
- Compilation from the transit O-D results to describe current transit ridership volumes, for the selected Zone Groups.
- Estimation of BRT service distances, running times, fares, and headways in each corridor.
- Incorporation of the recognized usual effect of enhancements that may be present in BRT services and facilities, as indicated in TCRP 118.
- Construction of the model to provide for acceptance of user-selected parameters including service headways, fares, and BRT enhancements.
- Addition of model output information including local service and BRT fleet requirements, corridor transit operating statistics, estimated O&M costs, estimated passenger trips, passenger miles, and user benefits (time and cost savings), and fare revenues.

Given these characteristics, the modeling process includes the following steps:

- Definition and calibration of a logit formulation that gives reasonable replication of the current ridership in each planned BRT corridor.
- Confirmation that the logit-based model gives understandable resulting BRT and local bus ridership forecasts in each corridor under a range of varying input parameters.
- Application of the model, including equilibration if desired to achieve acceptable productivity of the planned local and BRT services.

- Sensitivity testing to demonstrate risks associated with parameters that may affect attainment of the projected ridership results.
- Summarization of the modeling results.

The model is sensitive to the following BRT characteristics:

Behavior-weighted travel times, using weights for in-vehicle and out-of-vehicle (walking and waiting) times consistent with those in the regional travel demand forecasting model's mode choice component, possibly supplemented by factors supplied in TCRP 118.

- a. Predictability (anticipated extent of on-time performance) of BRT and of other related transit services relevant to travel within each corridor).
- b. Fares.
- c. Vehicle amenities.
- d. Station amenities including ITS features.
- e. Vehicle-station interface quality.
- f. Quality of running way including incorporation of ITS features compared with that of other bus services.
- g. Distinctiveness of branding of the BRT service.

Following guidelines provided in TCRP 118, the levels of amenities and features described in items d through h above will be interpreted to assign an in-vehicle travel time advantage, which may differ for each corridor, of up to ten minutes.

The model was designed to accept estimated door-to-door travel times via available travel modes including BRT, for selected zone-to-zone movements of selected trip purposes. The travel times include behavioral weighting and incorporation of the assigned travel-time-advantage constant for each corridor, as described above. Fares were accounted for as equivalent time, using an average value of time consistent with the treatment of fares in the regional travel demand model's mode choice component.

The model was structured to make use of a logit formulation for estimation of transit use. This was an independent logit mode choice model using person trip input, with the formula calibrated to replicate, with acceptable accuracy, current mode split for the zone-to-zone trips selected for analysis. The model includes the ability to predict diversion from private modes to public transportation as well as to predict which transit trips would make use of the BRT route in each corridor.

BRT trips in each corridor were processed by the model to separate trips according to those made during peak periods and those made at all other times of day.

The model also provides for assignment of peak-period BRT passenger trips to the BRT route in each corridor, thus giving an indication of peak-period passenger loadings, for confirmation of service frequency assumptions. Application of the model may include iterations to balance service frequency with passenger loadings.

The expectation is that the model provide approximate (sketch-planning) estimates, sufficiently indicative of passenger demand to support the advancement of the BRT projects to the next stage in project development

The logit formulations considered areas follows:

For the independent logit model:

Probability of using PT =  $\exp(\text{TP}/\text{DP} \times \text{PTT}) / [\exp(\text{TP}/\text{DP} \times \text{PTT}) + \exp(\text{TP}/\text{DP} \times \text{NTT})]$

Where:

PTT = weighted travel time using best-available public transportation

NTT = weighted travel time using non-transit mode

In addition, the independent logit model splits trips between BRT and other transit modes

### **Model Format**

The model was built as an Excel Workbook (.xls) file comprising seven worksheets. A unique Excel Workbook may be saved in multiple versions in which the input parameters are varied as desired and output results documented. Alternatively, only the first worksheet, which contains inputs and outputs, can be copied to a separate file and saved as a record of the assumptions and results.

The first worksheet in each file, as noted above, accepts user-selected input parameters and displays the main output values. Subsequent worksheets provide sequential model components including definition of the base year model and its calibration results, the primary forecast results for local and BRT services, the effects of BRT service and facility enhancements, and the estimation of service and use descriptors including passenger boardings, peak and all-day passenger flows, vehicle passenger loads at maximum load points, and other operating statistics.

The seven worksheets are further discussed below and a screen capture of each worksheet is attached after the discussion:

1. **User Inputs and Summary Results:** This worksheet is divided into three sections, delineated by borders. In the **first section**, the primary input variables are listed. These include BRT and current local corridor bus service headways. The latter are listed both for current conditions and as anticipated for local service when BRT is introduced. Other

inputs include current and BRT fares, Phoenix CBD all-day parking cost, and the cost of automobile fuel. The user accepts default values for these inputs or makes changes as desired; the model responds with adjustment of the ridership estimate. The **second section** on this worksheet lists BRT enhancements that are recognized in TCRP 118 as having a measurable effect on BRT ridership. The word “Yes” is already entered for those enhancement features expected to be included; the user can change any of those entries and the model will respond with corresponding adjustment of the ridership estimate. This second section also lists other model inputs. In its present form the model is sensitive to changes on the User Inputs sheet in automobile miles per gallon, the value of user time, behavioral weights for each mode and applied to time spent walking or waiting, and an automobile preference constant. The anticipated average speed of the BRT service in the corridor is also listed but changing the value on this sheet does not affect the model output. In fact all of these “semi-fixed inputs” are associated with model calibration for the corridor, and should not be changed. The **third section** of the User Inputs and Summary Results worksheet provides selected output of the corridor model.

2. **Fixed Inputs:** This worksheet contains matrices of Zone Group to Zone Group data developed for and use in the ridership estimation process. The matrices include:
  - a. Current transit weekday passenger origin-destination (O-D) trips, drawn from the recent passenger O-D survey results
  - b. Year 2009 weekday person trips, drawn from the regional forecasting model output for that year; only the home-based work trips are used, because the trip patterns for that trip purpose more closely resemble transit passenger trip patterns. The production-attraction format of the forecasting model data was transformed to origin-destination format for use in this BRT model. These home-based work trips are compiled in two matrices. One matrix includes only those Zone Groups whose trips are unlikely to use other adjacent, overlapping, or crossing routes in the corridor; the other matrix contains additional Zone Groups that can be expected to have trips attracted to BRT service because of its greater frequency and shorter in-vehicle times. These Zone Groups are referred to as “expansion Zone Groups.
  - c. Zone Group to Zone Group distances, in miles.
  - d. Matrices of in-vehicle travel times for automobile, current local bus, BRT, and local bus when BRT is in operation in the corridor. The latter two matrices also assume that LRT is in operation.
  - e. Matrices of automobile and transit access times (walking, waiting, and transferring between routes) for current local bus, BRT, and local bus when BRT is in operation in the corridor.

- f. A matrix containing calculated passenger miles for the current transit passenger trips. This matrix is used in calibrating the ridership model.
3. **Trip Diversion:** This worksheet, also constituted primarily as a series of Zone Group to Zone Group matrices, contains the model calibration data and application of the calibrated model to conditions with BRT. A module at the top of the worksheet re-lists, by reference to the User Inputs worksheet, the model inputs affecting ridership. A logit model is used, based on comparing the generalized costs (combined time and money costs, expressed as minutes) of the travel modes (automobile, local bus or LRT, and BRT). The procedure includes calibration of the model to estimate trips that correlate well with the reported transit passenger O-D results, estimation of transit use once LRT is in operation, estimation of the transit share with BRT in place, splitting that total transit ridership between BRT and local bus service in the corridor, and estimation of “expansion Zone Group” BRT ridership.
4. **Induced Trips:** A recognized effect of BRT service is to cause certain trips to be made that were not previously made at all. In this analysis, a ten percent addition to BRT passenger trips is assumed. These trips are estimated on the Induced Trip worksheet. The worksheet also contains a calculation of user time savings, calculated by application of “consumer surplus” methodology applied to the “before” (existing plus LRT) and “after” transit passenger trips and their corresponding generalized cost values.
5. **Total Ridership:** On this worksheet, the primary corridor, “expansion Zone Group”, and induced passenger trips are added together to provide final matrices of BRT, local service, and total transit passenger trips for the corridor.
6. **Capacity and Loading:** Here, the total weekday transit passenger trips are factored to represent peak-hour ridership, and the results processed to tabulate passengers boarding, alighting, and on board buses during the peak hour, in the peak direction only. This tabulation allows the maximum passenger flow thus determined to be compared with the passenger capacity being provided (buses per hour times seats per bus), to determine the balance between supply and demand. Matrices include BRT, concurrent local bus, and existing local bus passenger trips, so that all three services can be evaluated.
7. **Fleet and Service:** This final worksheet provides a calculation of the number of buses required and resulting operating statistics leading to estimation of annualized capital cost and annual operating and maintenance cost. The operating statistics also support service productivity indicators shown on the first worksheet.

**Worksheet 1: User Inputs and Summary Results**

User-Selected Inputs		User Entry
BRT headways	Peak	10
	Off-Peak assumed same	
Route 112, current	Same peak and off-peak	30 C
Local same-corridor headways	Peak	30
	Off-Peak assumed same	
Fare, existing transit		\$1.25
Fare, BRT		\$1.25
CBD parking cost per weekday		\$10.00
Auto fuel cost per gallon		\$3.50

Default Values
15
30
30
\$1.00
\$1.00
\$10.00
\$3.50

Factors Increasing BRT Ridership		
<b>Running Ways (choose one)</b>		
Grade separated		
At grade busway		
Arterial median		
All-day bus lane		
Shared lane	Yes	
<b>Stations (choose applicable features)</b>		
Unique shelter	Yes	
Lighting	Yes	
Phone or security phone	Yes	
Climate control	Yes	
Passenger amenities	Yes	
Passenger services	Yes	
<b>Vehicles (choose applicable features)</b>		
Unique vehicle	Yes	
Wide, multiple doors	Yes	
Level boarding	Yes	
<b>Service Patterns (choose applicable features)</b>		
All-day service	Yes	
Headways 10 min. or less	No	
Simple, clear routing	Yes	
Off-vehicle fare collection	Yes	
<b>ITS Applications (choose applicable features)</b>		
Passenger information at stops	Yes	
Passenger information in vehicles	Yes	
<b>Branding</b>		
Vehicles and stations	Yes	
Brochures and schedules	Yes	
<b>Variable semi-fixed inputs</b>		
Average BRT stop spacing (miles)	1.00	
Average BRT speed (mi/hr)	Peak see note	
Automobile average miles per gallon	20	
Value of time (\$/hr)	Peak \$7.00	
Behavioral weights	Waiting time, BRT	2.00
	Wait or wait time, local bus	2.00
	Walking time, auto	2.00
Automobile preference constant (minutes)	-150	

Summary Output (use as guide for input refinement and sensitivity testing)		
<b>Existing Transit</b>		<b>Year 2009</b>
Total weekday boardings, existing transit, Route 112 only		1,596
Total weekday boardings, Route 112 with LRT in operation		1,709
Total weekday boardings, other affected routes with LRT in operation		1,679
Total weekday boardings, all affected existing transit, with LRT		3,387
<b>Transit with BRT (includes effect of LRT)</b>		
Total weekday BRT boardings		2,293
Total weekday boardings, Route 112		655
Total weekday boardings, other affected routes		1,376
Total weekday transit boardings in corridor		4,324
Vehicle load factor (percentage of seated capacity)	BRT	48%
	Local same-corridor	54%
Weekday boardings per vehicle hour	BRT	19.2
	Local same-corridor	12.0
Weekday passenger miles per vehicle mile	BRT	12.9
	Local same-corridor	10.5
Weekday person trips diverted from auto		2,642
Total weekday user benefits (hours)		2,620
Maximum number of vehicles in operation	BRT	8
	Local same-corridor	4
Annual O&M cost (thousands, 2009 dollars)	BRT	\$3,969
	Change in local same-corridor	\$0
	Sum	\$3,969

Notes:  
This model uses peak-period conditions to estimate total weekday ridership..

Average BRT speed (mi/hr)	Peak	18
This is a fixed value		

**Worksheet 2: Fixed Inputs (only a portion is shown)**

trip blocks			
intra AzAv	323	3.049%	of total person trips
Az-Mesa	0		of total person trips
Az-Chandler	0		of total person trips
Az-Central	1266	21.847%	of total person trips

**Existing Transit Ridership - Origin-Destination Trips of Interest**

9.17% transit share	1621 to	trips of interest																																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33				
	1																																					
	2																																					
	3				8.0																																	
	4																																					
	5				8.3																																	
	6																																					
	7																																					
	8																																					
	9																																					
	10																																					
	11			18.4	27.6																																	
	12																																					
	13																																					
	14																																					
	15																																					
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	22																																					
	23																																					
	24																																					
	25																																					
	26																																					
	27			37.0	1.2		3.2	7.6	36.0	15.9																												
	28			5.3		10.4	3.8	4.4	13.1	18.9																												
	29			0.5																																		
	30						117.2	11.8	23.1																													
	31		9.7					43.2																														
	32						48.2	14.2	45.0	186.0																												
	33							26.4																														

trip blocks	
intra AzAv	10600
Az-Central	5793

**Worksheet 3: Trip diversion (only a portion is shown)**

This sheet contains zone-to-zone matrices  
 total travel time and cost via local transit and BRT  
 total travel time via automobile  
 probability of using local transit and BRT  
 trips remaining on non-BRT transit  
 trips using BRT, diverted from transit and auto

MAKE CHANGES ONLY ON USER INPUTS PAGE		BRT FEATURES THAT AUGMENT RIDERSHIP	
30	Headway, same-corridor existing transit (minutes)	-	Running Ways (choose one)
10	Headway, BRT (minutes)	-	Grade separated
\$ 1.25	Existing transit fare	-	At grade busway
\$ 1.25	BRT fare	-	Arterial median
\$ 10.00	CBD weekday parking cost	-	All-day bus lane
\$ 3.50	Automobile fuel cost	-	Shared lane
			Stations (choose applicable features)
		0.020	Unique shelter
		0.020	Lighting
		0.030	Phone or security phone
		0.030	Climate control
		0.030	Passenger amenities
		0.020	Passenger services
			Vehicles (choose applicable features)
		0.050	Unique vehicle
		0.050	Wide, multiple doors
		0.050	Level boarding
			Service Patterns (choose applicable features)
		0.040	All-day service
		-	Headways 10 min. or less
		0.040	Simple, clear routing
		0.030	Off-vehicle fare collection
			ITS Applications (choose applicable features)
		0.070	Passenger information at stops
		0.030	Passenger information in vehicles
			Branding
		0.070	Vehicles and stations
		0.030	Brochures and schedules
		0.150	Synergism
		0.760	TOTAL
			(7.60) Mode Preference Constant applicable to all trips that use BRT

**CURRENT TRANSIT GENERALIZED COST, IN MINUTES**

from	to	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1	319.7	302.7	310.7	315.2	321.2	325.4	328.2	333.2	336.1	339.1	341.1	346.1	353.1	402.2	430.2	479.2	469.2	417.2	399.2	410.2	412.7	389.1	399.1	413.1	451.1	134.1	120.9	110.9	85.9	89.1	378.1	367.1	354.6	
2	302.7	255.7	258.7	263.2	269.2	273.4	276.2	281.2	284.1	287.1	289.1	294.1	301.1	350.2	378.2	427.2	417.2	365.2	347.2	358.2	360.7	342.1	352.1	366.1	404.1	87.1	73.9	63.9	38.9	42.1	331.1	320.1	302.6	
3	310.7	258.7	255.7	260.2	266.2	270.4	273.2	278.2	281.1	284.1	286.1	291.1	298.1	347.2	375.2	424.2	414.2	362.2	344.2	355.2	357.7	339.1	349.1	363.1	401.1	84.1	70.9	60.9	35.9	39.1	328.1	317.1	299.6	
4	315.2	263.2	260.2	255.7	261.7	265.9	268.7	273.7	276.6	279.6	281.6	286.6	293.6	342.7	370.7	419.7	409.7	357.7	339.7	350.7	353.2	334.6	344.6	358.6	396.6	79.6	66.4	56.4	31.4	34.6	323.6	312.6	295.1	
5	321.2	269.2	266.2	261.7	255.7	259.9	262.7	267.7	270.6	273.6	275.6	280.6	287.6	342.7	370.7	419.7	409.7	357.7	339.7	344.7	347.2	328.6	338.6	352.6	390.6	73.6	60.4	50.4	25.4	28.6	317.6	306.6	289.1	
6	325.4	273.4	270.4	265.9	259.9	255.7	258.5	263.5	266.4	269.4	271.4	276.4	283.4	346.9	374.9	423.9	413.9	361.9	343.9	340.5	343.0	324.4	334.4	348.4	386.4	69.4	56.2	46.2	21.2	24.4	313.4	302.4	284.9	
7	328.2	276.2	273.2	268.7	262.7	258.5	255.7	260.7	263.6	266.6	268.6	273.6	280.6	349.7	377.7	426.7	416.7	364.7	346.7	337.7	340.2	321.6	331.6	345.6	383.6	66.6	53.4	43.4	18.4	21.6	310.6	299.6	282.1	
8	333.2	281.2	278.2	273.7	267.7	263.5	260.7	255.7	258.6	261.6	263.6	268.6	275.6	354.7	382.7	431.7	421.7	369.7	351.7	342.7	345.2	316.6	326.6	340.6	378.6	61.6	48.4	38.4	13.4	16.6	305.6	294.6	277.1	
9	336.1	284.1	281.1	276.6	270.6	266.4	263.6	258.6	255.7	258.7	260.7	265.7	272.7	357.6	385.6	434.6	424.6	372.6	354.6	345.6	348.1	313.7	323.7	337.7	375.7	58.7	45.5	35.5	10.5	13.7	302.7	291.7	274.2	
10	339.1	287.1	284.1	279.6	273.6	269.4	266.6	261.6	258.7	255.7	257.7	262.7	269.7	360.6	388.6	437.6	427.6	375.6	357.6	348.6	351.1	310.7	320.7	334.7	372.7	55.7	42.5	32.5	7.5	10.7	299.7	288.7	271.2	
11	341.1	289.1	286.1	281.6	275.6	271.4	268.6	263.6	260.7	257.7	255.7	260.7	267.7	362.6	390.6	439.6	429.6	377.6	359.6	350.6	353.1	308.7	318.7	332.7	370.7	53.7	40.5	30.5	5.5	8.7	297.7	286.7	269.2	
12	346.1	294.1	291.1	286.6	280.6	276.4	273.6	268.6	265.7	262.7	260.7	255.7	262.7	367.6	395.6	444.6	434.6	382.6	364.6	355.6	358.1	303.7	313.7	327.7	365.7	48.7	35.5	25.5	0.5	3.7	292.7	281.7	264.2	
13	353.1	301.1	298.1	293.6	287.6	283.4	280.6	275.6	272.7	269.7	267.7	262.7	269.7	374.6	402.6	451.6	441.6	389.6	371.6	362.6	365.1	310.7	320.7	334.7	372.7	41.7	28.5	18.5	-6.5	-3.3	285.7	274.7	262.7	
14	366.2	314.2	311.2	306.7	306.7	310.9	313.7	318.7	321.6	324.6	326.6	331.6	338.6	363.7	371.7	395.7	395.7	363.7	363.7	420.6	423.1	386.6	396.6	410.6	448.6	111.6	98.4	88.4	78.4	79.6	368.6	357.6	331.6	
15	394.2	342.2	339.2	334.7	334.7	338.9	341.7	346.7	349.6	352.6	354.6	359.6	366.6	391.7	379.7	403.7	403.7	371.7	371.7	448.6	451.1	414.6	424.6	438.6	476.6	139.6	126.4	116.4	106.4	107.6	396.6	385.6	359.6	
16	443.2	391.2	388.2	383.7	383.7	387.9	390.7	395.7	398.6	401.6	403.6	408.6	415.6	440.7	428.7	427.7	427.7	395.7	395.7	497.6	500.1	463.6	473.6	487.6	525.6	188.6	175.4	165.4	155.4	156.6	445.6	434.6	408.6	
17	433.2	381.2	378.2	373.7	373.7	377.9	380.7	385.7	388.6	391.6	393.6	398.6	405.6	395.7	403.7	427.7	427.7	395.7	395.7	487.6	490.1	453.6	463.6	477.6	515.6	26.7	25.5	25.5	25.5	36.7	333.7	337.7	398.6	
18	381.2	329.2	326.2	321.7	321.7	325.9	328.7	333.7	336.6	339.6	341.6	346.6	353.6	363.7	371.7	395.7	415.7	363.7	363.7	435.6	438.1	401.6	411.6	425.6	463.6	-5.3	-6.5	-6.5	-6.5	4.7	301.7	305.7	346.6	
19	363.2	311.2	308.2	303.7	303.7	307.9	310.7	315.7	318.6	321.6	323.6	328.6	335.6	389.7	371.7	395.7	433.7	381.7	363.7	417.6	420.1	383.6	393.6	407.6	445.6	108.6	95.4	85.4	75.4	76.6	365.6	354.6	328.6	
20	374.2	322.2	319.2	314.7	308.7	304.5	301.7	306.7	309.6	312.6	314.6	319.6	326.6	420.6	448.6	497.6	487.6	435.6	417.6	363.7	363.7	374.6	384.6	398.6	436.6	99.6	86.4	76.4	66.4	67.6	356.6	345.6	319.6	
21	376.7	324.7	321.7	317.2	311.2	307.0	304.2	309.2	312.1	315.1	317.1	322.1	329.1	423.1	451.1	500.1	490.1	438.1	420.1	363.7	363.7	377.1	387.1	401.1	439.1	102.1	88.9	78.9	68.9	70.1	359.1	348.1	322.1	
22	353.1	306.1	303.1	298.6	292.6	288.4	285.6	280.6	277.7	274.7	272.7	267.7	274.7	386.6	414.6	463.6	453.6	401.6	383.6	374.6	377.1	291.7	291.7	295.7	323.7	-41.3	-42.5	-42.5	-42.5	-31.3	265.7	269.7	267.7	
23	363.1	316.1	313.1	308.6	302.6	298.4	295.6	290.6	287.7	284.7	282.7	277.7	284.7	396.6	424.6	473.6	463.6	411.6	393.6	384.6	387.1	291.7	291.7	295.7	323.7	-41.3	-42.5	-42.5	-42.5	-31.3	265.7	269.7	277.7	
24	377.1	330.1	327.1	322.6	316.6	312.4	309.6	304.6	301.7	298.7	296.7	291.7	298.7	410.6	438.6	487.6	477.6	425.6	407.6	398.6	401.1	295.7	295.7	299.7	327.7	-37.3	-38.5	-38.5	-38.5	-27.3	269.7	273.7	291.7	
25	415.1	368.1	365.1	360.6	354.6	350.4	347.6	342.6	339.7	336.7	334.7	329.7	336.7	448.6	476.6	525.6	515.6	463.6	445.6	436.6	439.1	323.7	323.7	327.7	355.7	-9.3	-10.5	-10.5	-10.5	0.7	297.7	301.7	329.7	
26	85.1	38.1	35.1	30.6	24.6	20.4	17.6	12.6	9.7	6.7	4.7	-0.3	-7.3	111.6	139.6	188.6	26.7	-5.3	108.6	99.6	102.1	-41.3	-41.3	-37.3	-9.3	-81.3	-70.5	-60.5	-50.5	-29.3	-17.3	1.7	12.7	
27	71.9	24.9	21.9	17.4	11.4	7.2	4.4	-0.6	-3.5	-6.5	-8.5	-13.5	-20.5	98.4	126.4	175.4	25.5	-6.5	95.4	86.4	88.9	-42.5	-42.5	-38.5	-10.5	-83.7	-73.7	-63.7	-42.5	-30.5	-11.5	-0.5		
28	61.9	14.9	11.9	7.4	1.4	-2.8	-5.6	-10.6	-13.5	-16.5	-18.5	-23.5	-30.5	88.4	116.4	165.4	25.5	-6.5	85.4	76.4	78.9	-42.5	-42.5	-38.5	-10.5	-83.7	-73.7	-63.7	-42.5	-30.5	-11.5	-0.5		
29	51.9	4.9	1.9	-2.6	-8.6	-12.8	-15.6	-20.6	-23.5	-26.5	-28.5	-33.5	-40.5	78.4	106.4	155.4	25.5	-6.5	75.4	66.4	68.9	-42.5	-42.5	-38.5	-10.5	-83.7	-73.7	-63.7	-42.5	-30.5	-11.5	-0.5		
30	53.1	6.1	3.1	-1.4	-7.4	-11.6	-14.4	-19.4	-22.3	-25.3	-27.3	-32.3	-39.3	79.6	107.6	156.6	36.7	4.7	76.6	67.6	70.1	-31.3	-31.3	-27.3	0.7	-29.3	-42.5	-52.5	-62.5	-61.3	-49.3	-30.3	-32.3	
31	342.1	295.1	292.1	287.6	281.6	277.4	274.6	269.6	266.7	263.7	261.7	256.7	249.7	368.6	396.6	445.6	433.7	301.7	365.6	356.6	359.1	265.7	265.7	269.7	297.7	-17.3	-30.5	-40.5	-50.5	-49.3	239.7	258.7	256.7	
32	331.1	284.1	281.1	276.6	270.6	266.4	263.6	258.6	255.7	252.7	250.7	245.7	238.7	357.6	385.6	434.6	424.6	305.7	369.6	360.6	363.1	269.7	269.7	273.7	301.7	1.7	-11.5	-21.5	-31.5	-30.3	258.7			

**Worksheet 4: Induced Trips (only a portion is shown)**

This sheet contains zone-to-zone matrices

person trips not previously made (induced trips)  
 transit user benefits  
     non-BRT transit to BRT  
     auto to BRT  
     induced trips  
     total

assume induced trips equal a selected percentage of the increase in total transit trips, for each district-to-district volume  
 10.0% selected percentage

estimate, induced trips (person trips not previously made)

from	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
85.1	1	-	-	0.1	0.3	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	0.1	0.7	1.2	0.7	0.9	0.2	0.1	0.1
	2	-	-	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	0.0	-	-	-	-	0.0	0.2	0.3	0.2	0.2	0.1	0.0	0.0
	3	0.1	0.1	-	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	0.0	-	-	-	-	0.0	0.1	0.2	0.1	0.2	0.1	0.0	0.0
	4	0.3	0.1	0.2	-	0.4	0.2	0.2	0.0	0.1	0.0	0.1	0.1	0.1	-	-	-	-	-	-	0.1	-	-	-	-	0.1	0.3	0.5	0.3	0.4	0.1	0.1	0.1
	5	0.1	0.1	0.1	0.4	-	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	0.0	-	-	-	-	0.1	0.3	0.5	0.3	0.4	0.1	0.1	0.1
	6	0.1	0.0	0.1	0.2	0.5	-	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	0.1	-	-	-	-	0.1	0.4	0.7	0.4	0.5	0.2	0.1	0.1
	7	0.2	0.0	0.1	0.2	0.2	0.4	-	0.2	0.2	0.1	0.1	0.2	0.2	0.1	-	-	-	-	-	-	-	-	-	-	0.1	0.4	0.7	0.4	0.6	0.2	0.2	0.2
	8	0.0	0.0	0.0	0.0	0.1	0.1	0.2	-	0.2	0.0	0.1	0.1	0.1	0.0	-	-	-	-	-	0.1	-	-	-	-	0.0	0.2	0.3	0.2	0.2	0.1	0.1	0.1
	9	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.2	-	0.1	0.2	0.2	0.2	0.1	-	-	-	-	-	0.1	-	-	-	-	0.1	0.4	0.6	0.4	0.5	0.2	0.2	0.2
	10	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.1	-	0.1	0.2	0.2	0.0	-	-	-	-	-	0.0	-	-	-	-	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1
	11	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	-	0.2	0.2	0.0	-	-	-	-	-	0.0	-	-	-	-	0.1	0.3	0.5	0.3	0.4	0.2	0.2	0.3
	12	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.4	0.0	-	-	-	-	-	0.1	-	-	-	-	0.1	0.4	0.6	0.4	0.7	0.3	0.3	-
	13	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2	0.4	-	0.0	-	-	-	-	-	0.0	-	-	-	-	-	-	-	-	-	-	-	-
	14	-	0.0	0.0	-	-	0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	-	-	-	-	-	-	-	-	-	-	-	0.1	0.4	0.6	0.4	0.5	0.1	0.1	0.1
	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	21	-	0.0	0.0	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	0.1	0.4	0.7	0.4	0.5	0.1	0.1	0.1
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	26	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.1	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1
	27	0.8	0.2	0.1	0.3	0.3	0.4	0.4	0.2	0.4	0.1	0.3	0.4	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3
	28	1.3	0.3	0.2	0.5	0.5	0.7	0.7	0.3	0.6	0.2	0.5	0.6	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4
	29	0.7	0.2	0.1	0.3	0.3	0.4	0.4	0.2	0.4	0.1	0.3	0.4	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.3
	30	1.0	0.2	0.2	0.4	0.5	0.6	0.6	0.3	0.5	0.2	0.4	0.7	-	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.6
	31	0.3	0.1	0.1	0.2	0.2	0.3	0.3	0.1	0.3	0.1	0.2	0.4	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4
	32	0.2	0.1	0.0	0.1	0.1	0.2	0.2	0.1	0.2	0.2	0.3	0.4	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5
	33	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.3	-	0.1	-	-	-	-	-	-	-	-	-	-	-	0.1	0.3	0.4	0.3	0.5	0.3	0.4	-

**Worksheet 5: Total Ridership (only a portion is shown)**

This sheet contains zone-to-zone matrices

total BRT boardings  
 total same-corridor transit passenger boardings (Route 112)  
 total of all corridor boardings

		Estimated Total Weekday BRT Passenger Trips																																	TOTAL											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33												
	2,293	1	-	-	1.4	3.4	1.6	1.5	2.2	0.6	1.2	0.8	0.8	0.8	0.9	-	-	-	-	-	-	-	-	-	-	-	-	2.5	13.2	21.9	12.2	13.8	2.9	1.5	1.5	84.5	91.84153	176.3								
LRT zones	2,004.8	2	-	-	2.6	3.3	1.6	1.3	1.3	0.3	0.8	0.5	0.5	0.5	0.3	0.4	-	-	-	-	-	-	-	-	-	-	1.3	6.7	11.2	6.3	7.6	1.8	1.0	0.9	50.7	53.87791	104.5									
87%		3	1.4	2.6	-	5.2	1.9	1.6	1.7	0.3	0.7	0.5	0.5	0.5	0.3	0.4	-	-	-	-	-	-	-	-	-	1.1	5.5	9.2	5.3	6.4	1.6	0.9	0.9	48.5	50.78015	99.3										
Downtown zones	458.3	4	3.4	3.3	5.2	-	10.5	6.0	5.9	1.3	2.0	1.4	1.6	1.9	1.0	-	-	-	-	-	-	-	-	-	-	2.3	11.3	18.9	10.9	13.0	3.5	2.1	2.5	108.8	112.8308	221.6										
20%		5	1.6	1.6	1.9	10.5	-	14.4	7.0	1.6	2.6	1.6	1.4	1.7	1.0	-	-	-	-	-	-	-	-	-	-	2.4	12.5	21.0	12.1	14.9	3.7	2.2	2.8	119.1	123.4797	242.6										
Growth zones	384.2	6	1.5	1.3	1.6	6.0	14.4	-	11.2	2.1	3.7	2.1	2.1	2.3	1.3	1.1	-	-	-	-	-	-	-	-	-	3.3	16.6	27.9	16.0	19.3	4.8	3.0	3.4	146.1	153.0377	299.1										
17%		7	2.2	1.3	1.7	5.9	7.0	11.2	-	6.0	6.6	3.1	4.1	5.2	2.6	1.4	-	-	-	-	-	-	-	-	-	3.9	16.7	29.1	17.3	19.7	6.0	4.7	4.8	160.5	167.779	328.3										
		8	0.6	0.3	0.3	1.3	1.6	2.1	6.0	-	4.9	1.4	1.6	2.0	0.9	0.4	-	-	-	-	-	-	-	-	-	1.6	7.7	13.1	7.6	9.0	2.5	1.7	2.1	69.8	73.28002	143.1										
		9	1.2	0.8	0.7	2.0	2.6	3.7	6.6	4.9	-	4.4	5.8	5.5	2.5	0.7	-	-	-	-	-	-	-	-	-	3.6	15.3	26.1	15.1	17.8	5.2	4.3	5.3	135.1	142.3886	277.5										
		10	0.8	0.5	0.5	1.4	1.6	2.1	3.1	1.4	4.4	-	3.5	5.0	2.3	0.5	-	-	-	-	-	-	-	-	-	0.9	2.3	4.2	2.6	2.8	1.3	1.7	1.6	45.2	45.33661	90.5										
		11	0.8	0.5	0.5	1.6	1.4	2.1	4.1	1.6	5.8	3.5	-	7.1	3.3	0.5	-	-	-	-	-	-	-	-	-	1.5	6.1	10.6	6.4	7.9	2.7	2.8	3.6	74.9	76.86887	151.7										
		12	0.8	0.5	0.5	1.9	1.7	2.3	5.2	2.0	5.5	5.0	7.1	-	5.6	0.5	-	-	-	-	-	-	-	-	-	2.0	9.1	14.1	9.2	13.3	4.5	3.9	-	95.6	99.61356	195.2										
		13	0.9	0.3	0.3	1.0	1.0	1.3	2.6	0.9	2.5	2.3	3.3	5.6	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.0	21.66531	44.7										
		14	-	0.5	0.6	-	-	1.5	1.9	0.5	1.0	0.7	0.6	0.7	0.6	-	-	-	-	-	-	-	-	-	-	-	1.4	7.3	11.9	6.7	8.0	1.6	0.8	1.2	47.4	42.40939	89.8									
		15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-								
		16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		21	-	0.3	0.3	1.1	0.9	1.5	-	1.6	1.7	0.9	0.9	1.1	0.9	-	-	-	-	-	-	-	-	-	-	-	1.6	7.9	13.1	7.5	8.8	1.9	1.1	1.5	54.4	48.28047	102.6									
		22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-							
		26	2.9	1.5	1.2	2.7	2.8	3.8	4.5	1.9	4.1	1.0	1.7	2.3	-	1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.5	35.9	29.61579	65.5							
		27	15.5	7.8	6.3	13.0	14.5	19.1	19.4	8.9	17.7	2.7	7.0	10.5	-	7.3	-	-	-	-	-	-	-	-	-	-	8.0	-	-	-	-	-	-	-	-	7.2	164.9	136.6186	301.5							
		28	25.7	12.9	10.6	21.8	24.2	32.1	33.7	15.2	30.1	4.8	12.1	16.2	-	12.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.7	275.3	228.6229	504.0							
		29	14.4	7.3	6.1	12.6	14.0	18.5	20.0	8.8	17.4	3.0	7.4	10.6	-	6.8	-	-	-	-	-	-	-	-	-	-	7.5	-	-	-	-	-	-	-	-	8.2	162.6	134.6901	297.3							
		30	16.7	9.0	7.6	15.5	17.6	22.9	23.4	10.7	21.2	3.3	9.3	15.7	-	8.0	-	-	-	-	-	-	-	-	-	-	8.8	-	-	-	-	-	-	-	-	11.8	201.4	162.0564	363.5							
		31	3.9	2.4	2.1	4.6	4.9	6.4	7.9	3.2	6.8	1.8	3.5	5.9	-	1.6	-	-	-	-	-	-	-	-	-	-	1.9	-	-	-	-	-	-	-	-	6.3	63.2	45.24629	108.4							
		32	1.9	1.3	1.1	2.8	2.9	4.0	6.2	2.3	5.7	2.3	3.7	5.2	-	0.8	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	7.7	49.0	34.84281	83.8							
		33	1.5	0.9	0.9	2.5	2.8	3.4	4.8	2.1	5.3	1.6	3.6	-	0.9	-	-	-	-	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	76.9	81.0512	158.0							
			97	57	54	120	131	163	179	78	151	49	82	106	23	45	-	-	-	-	-	-	-	-	-	-	52	-	-	-	-	-	-	-	-	31	144	242	142	172	49	38	87			

**Worksheet 6: Capacity and Loading (only a portion is shown)**

this sheet contains

peak hour passenger volume estimated as a percentage of total peak period ridership

BRT  
same corridor local bus

peak hour on-off-on board passenger flows (beginning in Column AL)

BRT  
same corridor local bus

percent of seated capacity used at maximum load point

BRT  
same corridor local bus

Peak Hour Factor

8.00% (provisional - check for data)

Capacity (seated)	max load	scheduled buses per hour	as percent of seated capacity	number of buses per hour required
50 BRT	145	6	48%	3
40 Local Bus	43	2	54%	1
Reported current ridership				
40 Local Bus	127	2	159%	3

**Peak Hour Peak Direction**

183 trips in matrix, peak-hour, both directions

Estimated Weekday Peak Hour BRT Passenger Trips

0.21 Maximum Load

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
1			0.1	0.3	0.1	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	1.1	1.7	1.0	1.1	0.2	0.1	0.1
2			0.2	0.3	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	0.0	-	-	-	-	-	0.1	0.5	0.9	0.5	0.6	0.1	0.1	0.1
3	0.1	0.2	-	0.4	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-	-	-	-	-	-	0.0	-	-	-	-	-	0.1	0.4	0.7	0.4	0.5	0.1	0.1	0.1
4	0.3	0.3	0.4	-	0.8	0.5	0.5	0.1	0.2	0.1	0.1	0.2	0.1	-	-	-	-	-	-	-	0.1	-	-	-	-	-	0.2	0.9	1.5	0.9	1.0	0.3	0.2	0.2
5	0.1	0.1	0.2	0.8	-	1.2	0.6	0.1	0.2	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	0.1	-	-	-	-	-	0.2	1.0	1.7	1.0	1.2	0.3	0.2	0.2
6	0.1	0.1	0.1	0.5	1.2	-	0.9	0.2	0.3	0.2	0.2	0.2	0.1	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	0.3	1.3	2.2	1.3	1.5	0.4	0.2	0.3
7	0.2	0.1	0.1	0.5	0.6	0.9	-	0.5	0.5	0.2	0.3	0.4	0.2	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.3	1.3	2.3	1.4	1.6	0.5	0.4	0.4
8	0.0	0.0	0.0	0.1	0.1	0.2	0.5	-	0.4	0.1	0.1	0.2	0.1	0.0	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1	0.6	1.1	0.6	0.7	0.2	0.1	0.2
9	0.1	0.1	0.1	0.2	0.2	0.3	0.5	0.4	-	0.4	0.5	0.4	0.2	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	0.3	1.2	2.1	1.2	1.4	0.4	0.3	0.4
10	0.1	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.4	-	0.3	0.4	0.2	0.0	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1	0.2	0.3	0.2	0.2	0.1	0.1	0.1
11	0.1	0.0	0.0	0.1	0.1	0.2	0.3	0.1	0.5	0.3	-	0.6	0.3	0.0	-	-	-	-	-	-	0.1	-	-	-	-	-	0.1	0.5	0.8	0.5	0.6	0.2	0.2	0.3
12	0.1	0.0	0.0	0.2	0.1	0.2	0.4	0.2	0.4	0.4	0.6	-	0.4	0.0	-	-	-	-	-	-	0.1	-	-	-	-	-	0.2	0.7	1.1	0.7	1.1	0.4	0.3	
13	0.1	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.3	0.4	-	0.0	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	
14	-	0.0	0.0	-	-	0.1	0.2	0.0	0.1	0.1	0.1	0.1	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.6	1.0	0.5	0.6	0.1	0.1	0.1
15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21	-	0.0	0.0	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	0.6	1.1	0.6	0.7	0.1	0.1	0.1
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	0.2	0.1	0.1	0.2	0.2	0.3	0.4	0.2	0.3	0.1	0.1	0.2	-	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.2
27	1.2	0.6	0.5	1.0	1.2	1.5	1.6	0.7	1.4	0.2	0.6	0.8	-	0.6	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	0.6
28	2.1	1.0	0.8	1.7	1.9	2.6	2.7	1.2	2.4	0.4	1.0	1.3	-	1.0	-	-	-	-	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	0.9
29	1.1	0.6	0.5	1.0	1.1	1.5	1.6	0.7	1.4	0.2	0.6	0.9	-	0.5	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	0.7
30	1.3	0.7	0.6	1.2	1.4	1.8	1.9	0.9	1.7	0.3	0.7	1.3	-	0.6	-	-	-	-	-	-	0.7	-	-	-	-	-	-	-	-	-	-	-	-	0.9
31	0.3	0.2	0.2	0.4	0.4	0.5	0.6	0.3	0.5	0.1	0.3	0.5	-	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.5
32	0.2	0.1	0.1	0.2	0.2	0.3	0.5	0.2	0.5	0.2	0.3	0.4	-	0.1	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	0.6
33	0.1	0.1	0.1	0.2	0.2	0.3	0.4	0.2	0.4	0.1	0.3	-	0.1	-	-	-	-	-	-	-	0.1	-	-	-	-	0.2	0.5	0.7	0.6	0.8	0.4	0.5	-	-

ZG	on	off	on board
2	23		23
3	8	1	30
4	16	2	44
5	25	3	67
6	21	4	83
7	30	6	108
8	10	2	115
9	19	4	130
10	5	3	132
11	9	4	137
12	19	11	145
13		145	

**Worksheet 7: Fleet and Service**

This sheet provides vehicle operations information

One-way Bus Trip Length (miles)	One-way Trip Time (minutes)	Round Trip Time Including Minimum Layover (minutes)	Headway (minutes)	Vehicles Required	maximum vehicles in service
11.20	33.10	72.8	10	8	8 BRT
11.20	45.40	99.9	30	4	4 current corridor bus service
11.20	45.40	99.9	30	4	4 same-corridor local buses (change from no-build condition)
allowance for spares					
				2	BRT
				1	current corridor bus service
				1	same-corridor local buses (change from no-build condition)
total fleet					
				10	BRT
				5	current corridor bus service
				5	same-corridor local buses (change from no-build condition)
cost factor annualized capital cost of fleet (assume 12-year life)					
				0.126	\$1,134,000 BRT
				0.126	\$315,000 current corridor bus service
				0.126	\$315,000 same-corridor local buses (change from no-build condition)
					\$1,134,000 net cost
weekday rev	veh mi	equiv wkdy	annual revenue	vehicle miles of service	
2,419		317.12	767,188	BRT	
806		317.12	255,729	current corridor bus service	
806		317.12	255,729	same-corridor local buses (change from no-build condition)	
annual revenue vehicle hours of service					
119		314.30	37,452	BRT	
54		314.30	17,123	current corridor bus service	
54		314.30	17,123	same-corridor local buses (change from no-build condition)	
annual O&M cost					
					\$3,969,167 BRT
					\$1,536,064 current bus service (Route 112)
					\$1,536,064 same-corridor local buses (change from no-build condition)
					\$3,969,167 net cost

10% minimum layover and recovery time  
 15% allowance for spares  
 \$900,000 BRT vehicle capital cost  
 \$500,000 Local bus capital cost

O&M cost model, based on 2006 NTD for Valley Metro, with escalation to 2009  
 = vehicle miles x cost/mi + vehicle hours x cost/hr + max vehicles in service x cost/vehicle

BRT  
 \$1.880 O&M unit cost per vehicle mile (vehicle maintenance and fuel)  
 \$43.94 O&M unit cost per vehicle hour (operations, except fuel)  
 \$7,819 O&M unit cost per vehicle in service (non-vehicle maintenance)  
 25.98% of all other O&M (this is general administration)

Local Bus  
 \$1.709 O&M unit cost per vehicle mile (vehicle maintenance and fuel)  
 \$43.94 O&M unit cost per vehicle hour (operations, except fuel)  
 \$7,447 O&M unit cost per vehicle in service (non-vehicle maintenance)  
 25.98% of all other O&M (this is general administration)

**SERVICE ASSUMPTIONS**

	Weekday	Saturday	Sunday/Holiday	
Hours per day	18	17	16	
Days per year	257	52	56	365
Off-peak headways same as during peaks				

Because there are no explicit assumptions about weekend headways, systemwide average equivalent weekdays are used in the annualization of service and O&M cost

## OTHER BRT CORRIDORS

For the BRT corridors other than Arizona Avenue, a simpler ridership estimation approach was used. This approach is based on existing transit ridership in the corridor, and predicts growth based strictly on improved transit service. The simplified model is useful for identifying the important origins and destinations in the corridor and in other locations (implying needs for transfer opportunities). This estimation approach predicts numbers for immediate implementation only; no long-term modeling was done.

As with the Arizona Avenue model, the PB team first identified analysis zone groups for each corridor based on existing transit services and the regional travel demand model TAZs, grouped according to anticipated BRT stop locations.

- Definition of additional zones (Zone Groups) based on the regional travel demand TAZs and selected on the basis of the principal bus routes connecting with each corridor, and the main trip origin and destination areas generating or attracting trips beyond the BRT corridor. The initially-defined Zone Groups for the Arizona Avenue BRT analysis are shown in Figure 1, attached. As explained later in this working paper, only a subset of these Zone Groups was finally used.

Using data collected in the November 2008 transit origin-destination (O-D) survey, the PB team identified trips from the O-D survey that have an origin or destination within the selected Zone Groups. The sample was limited to those trips with an origin or destination within the selected Zone-Groups for all BRT corridors only, but in many cases they were trips to or from Zone-Groups remote from the specific corridor for which demand was being assembled -- the criterion for their inclusion in an individual BRT corridor was that they currently use a route that operates on the designated future BRT alignment for that corridor. In some cases, in the South Central corridor for example, some trips meeting that criterion were ineligible for inclusion because it was clear that their use of such a current bus route would be on a portion of the existing bus route not to be covered by the planned BRT route.

The result is a summary by Zone Group of boardings and alightings within that group. The totals are a valid measure of zonal activity, but are exactly twice the number of trips because both ends of each trip are counted.

In some cases, O-D patterns offer the option of alternate paths through the BRT-LRT portions of the transit network, and in those cases, trips tabulated as BRT potential for one corridor, based on current routing, might end up using a different BRT corridor, especially if the timing of the various projects does not favor use of the corridor corresponding with the current route-to-route choices people are making.

The end product should be a reasonable measure of the current transit use likely to use BRT if it is offered. Total BRT use would be subject to effects such as remaining competing local transit service and the attractive effects of BRT including its speed, frequency, convenience of stops,

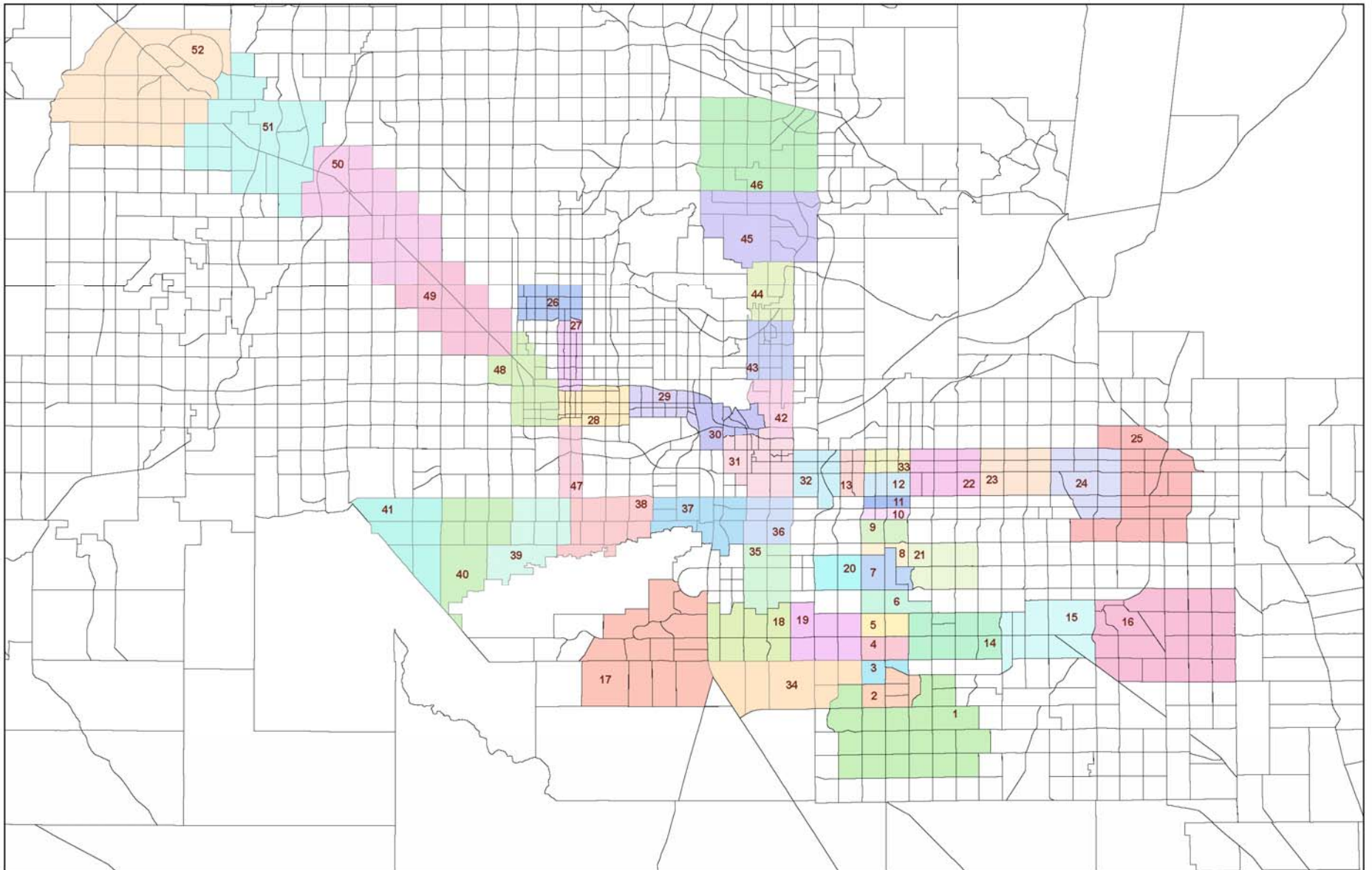
and amenities/image offered.<sup>1</sup> The increase with BRT is based on the Arizona Avenue analysis; induced trips are arbitrarily set at ten percent, as in the Arizona Avenue analysis.

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<sup>1</sup> For reference, the simplified model produces an estimate of total transit trips for Arizona Avenue in the range of 1500 daily transit trips today; the more sophisticated model estimated closer to 2000 total daily transit trips in the year 2010 (at 30-minute frequencies).

## APPENDIX V: ZONE MAP

Appendix Figure 7 Zone used in BRT Ridership Estimates



## APPENDIX VI: SUMMARY OF ZONAL ESTIMATES FOR BRT CORRIDORS

ARIZONA AVENUE CORRIDOR ZONES

Estimated Total Weekday Transit Passenger Trips		2010		2015		2030					
		15-min	30-min			15-min	30-min	15-min	30-min		
Total Trips		2,839	2,524	Total Trips		3,175	2,827	3,914	3,494		
Zone				Zone							
<b>28</b>	LRT - Downtown Phoenix	639	580	<b>28</b>	LRT - Downtown Phoenix	789	716	<b>28</b>	LRT - Downtown Phoenix	1025	931
<b>7</b>	AZ Ave btw. Warner to north of Elliot	468	425	<b>7</b>	AZ Ave btw. Warner to north of Elliot	504	458	<b>29</b>	LRT - Sky Harbor North	622	564
<b>30</b>	LRT - 52nd & Priest	455	406	<b>30</b>	LRT - 52nd & Priest	487	434	<b>30</b>	LRT - 52nd & Priest	609	543
<b>6</b>	AZ Ave btw. Ray & Warner	425	386	<b>6</b>	AZ Ave btw. Ray & Warner	457	417	<b>7</b>	AZ Ave btw. Warner to north of Elliot	595	543
<b>9</b>	AZ Ave btw. Guadalupe & Baseline	397	361	<b>27</b>	LRT - Central Corridor	448	406	<b>27</b>	LRT - Central Corridor	583	529
<b>27</b>	LRT - Central Corridor	381	345	<b>29</b>	LRT - Sky Harbor North	445	403	<b>6</b>	AZ Ave btw. Ray & Warner	555	509
<b>29</b>	LRT - Sky Harbor North	375	340	<b>9</b>	AZ Ave btw. Guadalupe & Baseline	420	383	<b>9</b>	AZ Ave btw. Guadalupe & Baseline	486	445
<b>5</b>	Chandler Blvd	345	313	<b>5</b>	Chandler Blvd	368	335	<b>5</b>	Chandler Blvd	436	399
<b>4</b>	Dtn Chandler	312	282	<b>4</b>	Dtn Chandler	337	306	<b>4</b>	Dtn Chandler	386	353
<b>12</b>	AZ Ave - btw. Southern & Broadway	220	185	<b>12</b>	AZ Ave - btw. Southern & Broadway	227	190	<b>1</b>	South Chandler	284	234
<b>8</b>	AZ Ave - at Guadalupe	204	185	<b>8</b>	AZ Ave - at Guadalupe	223	203	<b>8</b>	AZ Ave - at Guadalupe	263	241
<b>11</b>	AZ Ave - btw. US 60 & Southern	174	147	<b>1</b>	South Chandler	217	178	<b>2</b>	Chandler P&R	253	232
<b>1</b>	South Chandler	171	140	<b>33</b>	Downtown Mesa (east of LRT)	190	158	<b>12</b>	AZ Ave - btw. Southern & Broadway	246	206
<b>33</b>	Downtown Mesa (east of LRT)	171	143	<b>11</b>	AZ Ave - btw. US 60 & Southern	186	157	<b>33</b>	Downtown Mesa (east of LRT)	218	182
<b>2</b>	Chandler P&R	146	134	<b>2</b>	Chandler P&R	181	166	<b>11</b>	AZ Ave - btw. US 60 & Southern	210	176
<b>3</b>	202 - Pecos	139	126	<b>3</b>	202 - Pecos	164	149	<b>3</b>	202 - Pecos	199	182
<b>31</b>	LRT - downtown Tempe	133	113	<b>31</b>	LRT - downtown Tempe	143	121	<b>31</b>	LRT - downtown Tempe	199	169
<b>10</b>	AZ Ave - btw. US 60 & Baseline	110	94	<b>10</b>	AZ Ave - btw. US 60 & Baseline	115	98	<b>21</b>	East Elliot Rd zone	137	111
<b>32</b>	LRT - East Tempe	100	84	<b>21</b>	East Elliot Rd zone	111	89	<b>26</b>	LRT - Camelback	133	121
<b>21</b>	East Elliot Rd zone	99	80	<b>32</b>	LRT - East Tempe	101	86	<b>14</b>	Chandler Blvd - east	122	99
<b>14</b>	Chandler Blvd - east	87	70	<b>14</b>	Chandler Blvd - east	98	79	<b>10</b>	AZ Ave - btw. US 60 & Baseline	120	102
<b>26</b>	LRT - Camelback	82	74	<b>26</b>	LRT - Camelback	96	87	<b>32</b>	LRT - East Tempe	103	87
<b>13</b>	LRT - Mesa	43	34	<b>13</b>	LRT - Mesa	43	34	<b>13</b>	LRT - Mesa	42	33
LRT zones		2208	1976			2552	2286			3316	2975
		38.9%	39.1%			40.2%	40.4%			42.4%	42.6%

Estimated Total Weekday BRT Passenger Trips

	2010		2015		2030			
	15-min	30-min	15-min	30-min	15-min	30-min		
<b>Total Trips</b>	2,156	1,763	2,423	1,986	2,994	2,462		
<b>Zone</b>								
<b>28</b> LRT - Downtown Phoenix	490	410	<b>28</b> LRT - Downtown Phoenix	608	508	<b>28</b> LRT - Downtown Phoenix	787	659
<b>30</b> LRT - 52nd & Priest	352	290	<b>30</b> LRT - 52nd & Priest	378	311	<b>29</b> LRT - Sky Harbor North	481	402
<b>7</b> Elliot	318	259	<b>27</b> LRT - Central Corridor	346	289	<b>30</b> LRT - 52nd & Priest	473	390
<b>27</b> LRT - Central Corridor	293	245	<b>29</b> LRT - Sky Harbor North	344	288	<b>27</b> LRT - Central Corridor	450	376
<b>6</b> AZ Ave btw. Ray & Warner	290	236	<b>7</b> Elliot	343	279	<b>7</b> Elliot	405	331
<b>29</b> LRT - Sky Harbor North	289	242	<b>6</b> AZ Ave btw. Ray & Warner	312	256	<b>6</b> AZ Ave btw. Ray & Warner	379	312
<b>9</b> Baseline	269	219	<b>9</b> Baseline	285	232	<b>9</b> Baseline	329	269
<b>5</b> Chandler Blvd	235	191	<b>5</b> Chandler Blvd	251	205	<b>5</b> Chandler Blvd	299	245
<b>4</b> Dtn Chandler	215	175	<b>4</b> Dtn Chandler	232	189	<b>1</b> South Chandler	284	234
<b>12</b> Broadway	189	152	<b>1</b> South Chandler	217	178	<b>4</b> Dtn Chandler	266	219
<b>1</b> South Chandler	171	140	<b>12</b> Broadway	197	159	<b>12</b> Broadway	219	177
<b>33</b> Downtown Mesa (east of LRT)	153	123	<b>33</b> Downtown Mesa (east of LRT)	170	138	<b>33</b> Downtown Mesa (east of LRT)	198	160
<b>11</b> AZ Ave - btw. US 60 & Southern	147	118	<b>11</b> AZ Ave - btw. US 60 & Southern	160	129	<b>11</b> AZ Ave - btw. US 60 & Southern	185	150
<b>8</b> AZ Ave - at Guadalupe	139	113	<b>8</b> AZ Ave - at Guadalupe	151	123	<b>8</b> AZ Ave - at Guadalupe	179	146
<b>31</b> LRT - downtown Tempe	104	82	<b>2</b> Chandler P&R	126	104	<b>2</b> Chandler P&R	176	145
<b>2</b> Chandler P&R	102	84	<b>3</b> 202 - Pecos	114	93	<b>31</b> LRT - downtown Tempe	156	123
<b>21</b> East Elliot Rd zone	99	80	<b>31</b> LRT - downtown Tempe	112	88	<b>3</b> 202 - Pecos	138	114
<b>3</b> 202 - Pecos	96	79	<b>21</b> East Elliot Rd zone	111	89	<b>21</b> East Elliot Rd zone	137	111
<b>10</b> AZ Ave - btw. US 60 & Baseline	87	70	<b>14</b> Chandler Blvd - east	98	79	<b>14</b> Chandler Blvd - east	122	99
<b>14</b> Chandler Blvd - east	87	70	<b>10</b> AZ Ave - btw. US 60 & Baseline	92	73	<b>26</b> LRT - Camelback	103	86
<b>32</b> LRT - East Tempe	80	63	<b>32</b> LRT - East Tempe	81	64	<b>10</b> AZ Ave - btw. US 60 & Baseline	99	79
<b>26</b> LRT - Camelback	64	53	<b>26</b> LRT - Camelback	74	62	<b>32</b> LRT - East Tempe	82	65
<b>13</b> LRT - Mesa	43	34	<b>13</b> LRT - Mesa	43	34	<b>13</b> LRT - Mesa	42	33
<b>LRT zones</b>	1715	1418		1986	1644		2574	2133
LRT trips as percent of total trips	39.8%	40.2%		41.0%	41.4%		43.0%	43.3%

Share of total BRT trips, by Zone

	2010	2015	2030
<b>1</b> South Chandler	4.0%	4.5%	4.7%
<b>2</b> Chandler P&R	2.4%	2.6%	2.9%
<b>3</b> 202 - Pecos	2.2%	2.3%	2.3%
<b>4</b> Dtn Chandler	5.0%	4.8%	4.4%
<b>5</b> Chandler Blvd	5.5%	5.2%	5.0%
<b>6</b> AZ Ave btw. Ray & Warner	6.7%	6.4%	6.3%
<b>7</b> Elliot	7.4%	7.1%	6.8%
<b>8</b> AZ Ave - at Guadalupe	3.2%	3.1%	3.0%




<b>9</b>	AZ Ave btw. Guadalupe & Baseline	6.2%	5.9%	5.5%
<b>10</b>	AZ Ave - btw. US 60 & Baseline	2.0%	1.9%	1.6%
<b>11</b>	AZ Ave - btw. US 60 & Southern AZ Ave - btw. Southern &	3.4%	3.3%	3.1%
<b>12</b>	Broadway	4.4%	4.1%	3.7%
<b>13</b>	LRT - Mesa	1.0%	0.9%	0.7%
<b>14</b>	Chandler Blvd - east	2.0%	2.0%	2.0%
<b>21</b>	East Elliot Rd zone	2.3%	2.3%	2.3%
<b>26</b>	LRT - Camelback	1.5%	1.5%	1.7%
<b>27</b>	LRT - Central Corridor	6.8%	7.1%	7.5%
<b>28</b>	LRT - Downtown Phoenix	11.4%	12.5%	13.2%
<b>29</b>	LRT - Sky Harbor North	6.7%	7.1%	8.0%
<b>30</b>	LRT - 52nd & Priest	8.2%	7.8%	7.9%
<b>31</b>	LRT - downtown Tempe	2.4%	2.3%	2.6%
<b>32</b>	LRT - East Tempe	1.9%	1.7%	1.4%
<b>33</b>	Downtown Mesa (east of LRT)	3.5%	3.5%	3.3%

## OTHER CORRIDORS (SIMPLIFIED MODELING METHODOLOGY)

### Scottsdale/Rural Corridor

Zone	Total	Description
31	1098	LRT - downtown Tempe
44	982	Scottsdale Fashion Center
43	774	Downtown Scottsdale
42	524	So. Scottsdale
46	470	Scottsdale Airpark
36	416	Rural/Baseline
35	371	Rural/Elliot
27	323	LRT - Central Corridor
18	322	Chandler Blvd - West Chandler
26	293	LRT - Camelback
28	269	LRT - Downtown Phoenix
45	216	Scottsdale - Resorts, Paradise Valley
17	190	Chandler Blvd - Ahwatukee
32	167	LRT - East Tempe
12	153	AZ Ave - btw. Southern & Broadway
24	151	Main St/Power area
23	134	Main St/Val Vista
30	102	LRT - 52nd & Priest
20	92	West Elliot Rd zone
29	91	LRT - Sky Harbor North
19	84	Chandler Blvd - Price Corridor/Fashion Center
1	69	South Chandler
48	64	Grand Ave - downtown Phoenix
5	45	Chandler Blvd
13	43	LRT - Mesa
21	33	East Elliot Rd zone
37	33	Baseline/AZ Mills Mall
33	31	Downtown Mesa (east of LRT)
4	23	Dtn Chandler
34	20	South Rural/Pecos & Queen Creek
47	18	South Central - btw. Buckeye & Southern
7	17	AZ Ave btw. Warner to north of Elliot
2	12	Chandler P&R
15	12	Chandler Blvd - Val Vista to Power (east of 202)
10	12	AZ Ave - btw. US 60 & Baseline
14	4	Chandler Blvd - east

#### Key

	In-corridor
	Single transfer
	Multiple transfers

## South Central Corridors

Zone	Total	Desc
39	3136	Baseline/Central to 35th Ave
37	2413	Baseline/AZ Mills Mall
38	2176	Baseline/SMCC
27	1902	LRT - Central Corridor
28	1890	LRT - Downtown Phoenix
47	1256	South Central - btw. Buckeye & Southern
29	1005	LRT - Sky Harbor North
48	989	Grand Ave - downtown Phoenix
26	916	LRT - Camelback
40	888	Baseline/35th to 67th Ave
31	692	LRT - downtown Tempe
36	411	Rural/Baseline
13	353	LRT - Mesa
30	244	LRT - 52nd & Priest
49	241	Grand Ave - Phoenix
17	224	Chandler Blvd - Ahwatukee
10	206	AZ Ave - btw. US 60 & Baseline
35	179	Rural/Elliot
32	161	LRT - East Tempe
22	135	Main St/Gilbert Rd
6	117	AZ Ave btw. Ray & Warner
21	99	East Elliot Rd zone
19	39	Chandler Blvd - Price Corridor
3	37	202 - Pecos
1	25	South Chandler
18	22	Chandler Blvd - West Chandler
7	21	AZ Ave btw. Warner to north of Elliot
34	20	South Rural/Pecos & Queen Creek
23	18	Main St/Val Vista
9	12	AZ Ave btw. Guadalupe & Baseline
25	10	East Mesa/Suppe Springs TC
41	9	Laveen
50	6	Grand Ave - Peoria
44	5	Scottsdale Fashion Center
14	4	Chandler Blvd - east
43	4	Downtown Scottsdale

### Key

	on route
	single transfer
	Multiple transfers

## Chandler Boulevard

Zone	On bus	Off bus	Total	Area
17	499	222	721	Chandler Blvd - Ahwatukee
19	159	77	236	Chandler Blvd - Price Corridor/Fashion Center
18	121	79	199	Chandler Blvd - West Chandler
16	78	49	127	ASU/Williams Gateway
31	38	89	127	LRT - downtown Tempe
37	13	110	123	Baseline/AZ Mills Mall
5	57	48	105	Chandler Blvd/AZ Ave
14	61	37	99	Chandler Blvd - east
4	23	47	69	Dtn Chandler
15	1	56	57	Chandler Blvd - Val Vista to Power (east of 202)
13	25	29	54	LRT - Mesa
22	32	12	43	Main St/Gilbert Rd
28	14	24	38	LRT - Downtown Phoenix
39	0	36	36	Baseline/Central to 35th Ave
42	0	32	32	So. Scottsdale
36	12	17	29	Rural/Baseline
34	22	0	22	South Rural/Pecos & Queen Creek
27	0	21	21	LRT - Central Corridor
35	0	21	21	Rural/Elliot
20	8	9	17	West Elliot Rd zone
46	0	16	16	Scottsdale Airpark
2	12	0	12	Chandler P&R
12	0	12	12	AZ Ave - btw. Southern & Broadway
6	0	11	11	AZ Ave btw. Ray & Warner
26	0	8	8	LRT - Camelback
32	0	8	8	LRT - East Tempe
1	7	0	7	South Chandler
8	0	4	4	AZ Ave - at Guadalupe
43	3	0	3	Downtown Scottsdale
29	0	1	1	LRT - Sky Harbor North

### Key

	on route
	single transfer
	multiple transfers

xfer to Rural

xfer to Rural

xfer to 104 or 96

xfer to 136

xfer to Rural

xfer to Rural

xfer to Rural

xfer to 96

xfer to Rural

xfer to AZ Ave

xfer to AZ Ave

xfer to AZ Ave

xfer to AZ Ave

xfer to Rural

## APPENDIX VII: Growth in Zone Groups

The table below shows total trip origins in the 52 Zone-Groups that we mapped for the BRT corridors, based on home-based work trips. The table below shows growth factors calculated for 2015/2009 and 2030/2015. Zone groups that have a growth rate higher than the overall average are highlighted.

Zone group	2009 origins	2015 origins	2030 origins	Growth from 2009 to 2015	Growth from 2015 to 2030
16	1154.36	3611.92	8396.238	3.129	2.325
41	4147.21	7014.039	14401.06	1.691	2.053
15	10406.01	15128.51	21151.11	1.454	1.398
27	7972.959	11142.58	23565.53	1.398	2.115
40	7310.56	10013.24	11753.54	1.370	1.174
28	10521.6	14359.08	22712.2	1.365	1.582
39	7547.41	9318.258	10966.11	1.235	1.177
29	5041.499	6150.92	9128.388	1.220	1.484
1	20181.63	24092.16	26680.53	1.194	1.107
31	17808.69	20929.26	24892.5	1.175	1.189
30	1715.56	2014.85	2373.62	1.174	1.178
2	2403.07	2755.94	3025.289	1.147	1.098
26	9257.179	10502.36	14062.79	1.135	1.339
3	2531.04	2863.529	2968.209	1.131	1.037
38	9193.979	10235.8	11479.26	1.113	1.121
34	4513.459	4907.278	4985.02	1.087	1.016
32	12114.37	12889.94	13162.38	1.064	1.021
42	7870.928	8332.519	9115.419	1.059	1.094
33	4091.029	4313.989	4844.969	1.054	1.123

The high growth rates occur in eastern Chandler, southern Arizona, western South-Central, and in the LRT corridor.