BROAD STREET RAPID TRANSIT STUDY
DETAILED SCREENING OF ALTERNATIVES

This Detailed Screening of Alternatives summarizes the second round analysis performed on the detailed set of alternatives identified to meet the Purpose and Need of the Broad Street Rapid Transit Study. This screening proceeds with an initial screening and utilizes the measures of effectiveness identified in the January 6, 2010 *Evaluation Methodology* in combination with feedback provided by stakeholders (Technical Advisory Committee, Policy Advisory Committee, general public) to make a determination as to which alternative would be most likely to meet the goals and objectives of the study.

1.0 INITIAL ALTERNATIVES AND INITIAL SCREENING

The initial alternatives for this study are summarized in Table 1-1, and are described in greater detail in the January 21, 2010 *Initial Definition of Alternatives*. Each of the alternatives was developed to (a) meet the goals and objectives established for the study; and, (b) ensure that they would meet the minimum requirements of a project under the Federal Transit Administration (FTA) Small Starts program.

TABLE 1-1: SUMMARY OF INITIAL ALTERNATIVES

	No Build	Build Alternatives	
		Build 1	Build 2
Route Length (mi.)	Existing Route 6	7.6	
Miles of Dedicated Bus Lanes	0.75	3.4	6.7
Number of Stations	Existing local stops	16 stations	
Peak/Off Peak Frequency (min.)	n/a	15-Oct	
Hours of Operation	Weekdays: 5:30 AM-11:30 PM Weekends: 6:00 AM-11:30 PM		
Network Changes and Feeder Service	None*	Comprehensive Operations Analysis Phase I and Phase II recommendations*	
Fare Collection	On-board (cash, Go Cards)	Off-board Proof of purchase (BRT tickets)	
Vehicles	Existing GRTC vehicles	Dedicated Bus Rapid Transit (BRT) vehicles	
Intelligent Transportation Systems	Existing traffic control systems	Signal priority at intersections along bus lanes	
Branding?	No	Stations, vehicles, guideway, signage, marketing efforts	

*Since the initial alternatives were defined, new information from on-board surveys has been made available to the study team. GRTC has indicated that the survey information may warrant the implementation of some COA improvements before the opening year. Refinements in the implementation of the COA will be noted in the No Build as part of the Detailed Definition of Alternatives.

These alternatives underwent an initial screening process summarized in Table 1-2. The results of this analysis, in conjunction with feedback provided by stakeholders (Technical Advisory Committee, Policy

Advisory Committee, general public) resulted in the advancement of three alternatives (No Build, and Build 1) and the removal of one alternative from further consideration (Build 2). Details on this screening are available in the *Initial Screening of Alternatives Report*.

TABLE 1-2: SUMMARY OF INITIAL SCREENING RESULTS

Measures of Effectiveness	No Build	Build 1	Build 2
Improve local and regional mobility			
▪ Impact on transit ridership	C	B	B
▪ Impact on general traffic	C	D	F
▪ Impact on on-street parking	C	D	F
▪ Impact on vehicle and pedestrian safety	F	B	B
Support economic development along the corridor			
▪ Impact on residential access to transit	C	B	B
▪ Impact on transit access to activity centers	C	A	A
▪ Impact on transit access to redevelopment sites	C	A	A
Promote livable, transit-oriented development			
▪ Ability to support higher density land uses	C	B	B
Create a multi-modal transportation system with attractive travel choices			
▪ Average operating speed	C	B	A
▪ Number of intermodal connections	C	B	B
▪ Level of investment that can support future upgrades	C	B	B
▪ Frequency, schedule, and travel times of transit services in the corridor	C	A	A
Optimize return on public investment			
▪ Order-of-magnitude capital cost	C	D	F
▪ Order-of-magnitude operating cost	C	D	D
Enhance environmental quality			
▪ Impact on natural resources (parklands, wetland, water, habitat)	C	B	B
▪ Impact on historic and cultural resources	C	C	C

2.0 DETAILED ALTERNATIVES

Following the initial screening of alternatives, the retained alternatives were refined and defined in sufficient detail such that this second screening could evaluate (a) how well each alternative meets the goals and objectives established for the study; and, (b) how the alternatives compare to one another in terms of costs, benefits, and impacts. Refinements included discrete analyses of north/south routing options between the Broad Street and Main Street portions of the corridor, and of the most appropriate

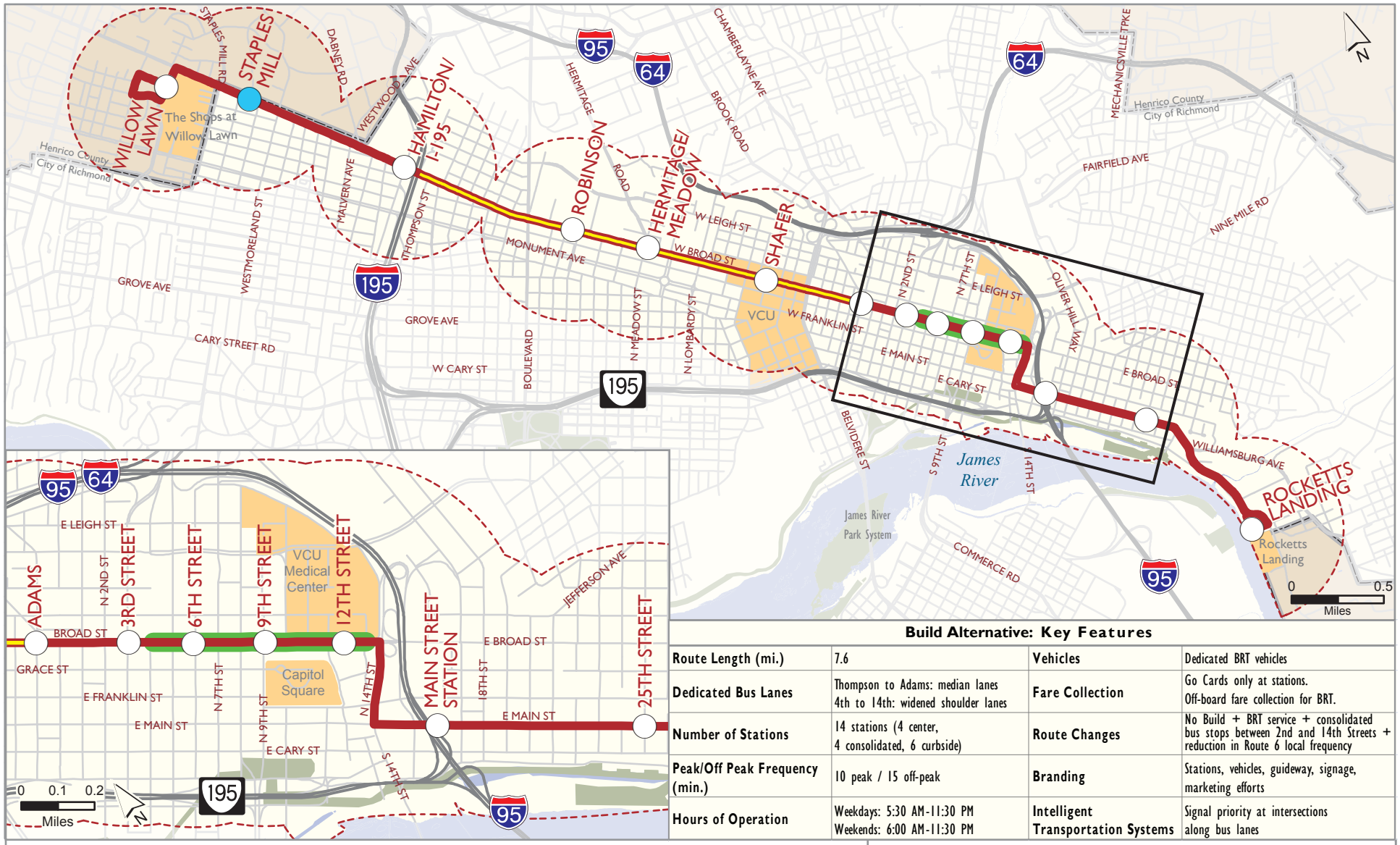
number and locations of stations. Detail was established such that assessments could take on a more quantitative nature than during the initial screening. Furthermore, during the time between the initial screening completion and the detailed screening analysis, FTA regulations changed so that a Baseline alternative is no longer required. Since the Baseline Alternative did not meet economic development goals of the project, it has therefore been eliminated from further consideration. A summary of details for the two remaining alternatives is included in Table 2-1. Figure 2-1 shows the alignments and key features of the Build Alternative. Full descriptions of all alternatives are available in the *Detailed Definition of Alternatives Report*.

TABLE 2-1: SUMMARY OF DETAILED ALTERNATIVES

	No Build*	**Build Alternative**
Route Length (mi.)	n/a*	7.6
Dedicated Bus Lanes?	Existing 2nd to 14th Street lanes	Thompson to Adams: median lanes 4th to 14th: widened shoulder lanes
Number of Stations	Existing local stops	14 stations (4 center, 4 consolidated, 6 curbside)
Station Amenities	Basic shelters, signage, and benches	Enhanced shelters with branding, real-time schedule information, bicycle racks
Peak/Off Peak Frequency (min.)	n/a**	10 peak/15 off-peak
Hours of Operation	Weekdays: 5:30 AM-11:30 PM	
Route Changes	Refined adjustments to routes using Broad Street based on Transit Development Plan (TDP)	No-Build + BRT service + consolidated bus stops between 2nd and 14th Street. Reductions in frequency for local Route 6 Service.
Fare Collection	On-board (cash, Go Cards)	Go Cards only at stations served by bus lanes, Off-board fare collection for BRT services
Vehicles	Existing GRTC vehicles	Dedicated BRT vehicles
Intelligent Transportation Systems	Existing traffic control systems	Signal priority at intersections along bus lanes
Park and Ride	n/a	One Park-and-Ride possible lot at Staples Mill Road Station
Branding?	No	Stations, vehicles, guideway, signage, marketing efforts

*No service currently operates the entire length of the proposed route.

**The three branches of the Route 6 currently offer a combined headway of 6-12 minutes during peak hours and 12 minutes during off-peak hours of operation.



Build Alternative: Key Features

Route Length (mi.)	7.6	**Vehicles**	Dedicated BRT vehicles
Dedicated Bus Lanes	Thompson to Adams: median lanes 4th to 14th: widened shoulder lanes	**Fare Collection**	Go Cards only at stations. Off-board fare collection for BRT.
Number of Stations	14 stations (4 center, 4 consolidated, 6 curbside)	**Route Changes**	No Build + BRT service + consolidated bus stops between 2nd and 14th Streets + reduction in Route 6 local frequency
Peak/Off Peak Frequency (min.)	10 peak / 15 off-peak	**Branding**	Stations, vehicles, guideway, signage, marketing efforts
Hours of Operation	Weekdays: 5:30 AM-11:30 PM Weekends: 6:00 AM-11:30 PM	**Intelligent Transportation Systems**	Signal priority at intersections along bus lanes

Legend

- Proposed BRT Stations
- With Potential Park-and-Ride Facilities
- Half-Mile Buffer

Guideway

- Median Running
- Curb Running
- Mixed Traffic Operations

Figure 2-1: Build Alternative

BROAD STREET RAPID TRANSIT STUDY

3.0 DETAILED SCREENING METHODOLOGY

The intention of the detailed screening is to generate sufficient information about the remaining alternatives to screen out those alternatives least likely to meet the established Purpose and Need. At this stage in the analysis, the emphasis is on developing quantitative estimates of the costs, benefits and impacts of each alternative, such that differences between alternatives are readily apparent. Many measures have been included to add depth to the evaluation process by differentiating each alternative according to its anticipated impacts and benefits. The measures of effectiveness are estimated for the base year, 2015.

TABLE 3-1: GOALS, OBJECTIVES AND MEASURES OF EFFECTIVENESS

Goal	Objectives	Measures of Effectiveness
Improve local and regional mobility	• Increase transit ridership • Improve access to the regional transit network • Improve transit service in high ridership areas • Decrease travel times in the study area • Increase transit reliability and on time performance • Minimize negative impact on transit and auto operations in the corridor • Increase transportation system productivity (passengers/hour) within the corridor	• Number of new transit riders • Number of low-income households, zero-car households and minority populations with ½ -mile of stations • On-time performance of transit vehicles • Traffic impact at key intersections and on key road segments • Number of on-street parking spaces lost • Person-capacity of corridor's road and transit networks • Impact on vehicle and pedestrian safety within the corridor
Support economic development along the corridor	• Improve transit access to existing and future developments • Create connections between transit and centers of employment, education, residence, shopping, culture and entertainment • Provide opportunities for joint development of transit stations and facilities	• Number of housing units within ½ -mile of transit stations • Number of retail/office jobs within ½-mile of transit stations • Acres of potentially developable (vacant) land within ¼-mile of transit stations • Acres of potential redevelopment within ¼ -mile of transit stations
Promote livable, transit-oriented development	• Provide high-capacity transit facilities at locations where existing and future land uses make them mutually supportive • Promote improved pedestrian connectivity between transit services and adjoining land uses • Encourage transit usage for different trip types and purposes	• Total population and employment within ½ -mile of transit stations, current and proposed • Additions to pedestrian infrastructure • Frequency, schedule, and travel times of transit services in the corridor
Create a multi-modal transportation system with attractive travel choices	• Create a premium transit route with service characteristics that make it competitive with the private automobile • Integrate premium transit service with local bus, bicycle, pedestrian, private automobile and intercity travel modes • Provide safe, convenient and attractive	• Average operating speed • Number of intermodal connections • Level of investment that can support future upgrades

Goal	Objectives	Measures of Effectiveness
	transfer facilities • Create opportunities for future upgrades or additional premium transit services	
Optimize return on public investment	• Develop cost-effective transit solutions • Capitalize on existing local and regional transit facilities and operations • Support state, regional and local plans • Maximize funding opportunities from state, local, and federal sources	• Capital cost • Annual operating cost • Cost-effectiveness index • Increases in tax revenue
Enhance environmental quality	• Minimize and mitigate negative impacts to the human and natural environment	• Impact on natural resources (parklands, wetland, water, habitat) • Impact on historic and cultural resources

4.0 DETAILED SCREENING RESULTS

Table 4-1 summarizes the findings of the detailed screening. Performance for each measure is categorized as generally positive (+), generally negative or adverse (-) or having negligible effects on the study area (O). A double positive sign (++) indicates a situation where two alternatives have positive effects, but one alternative has a greater positive effect.

In general, the major differences between alternatives are related to the number of stops made along Broad Street and the degree to which buses use dedicated lanes. While new bus lanes are anticipated to improve transit travel times and reliability of service, these benefits come at the expense of additional capital costs, parking impacts, and traffic impacts. While the conditions for livability and economic revitalization are the same throughout the corridor for 2015, the text that follows describes how the interaction of these characteristics with the alternatives may produce more positive results and achieve local land use objectives. In this regard, the Build Alternative is anticipated to provide the most positive effects.

The following paragraphs provide a more detailed description as to how the alternatives fare under each of the detailed screening measures of effectiveness.

TABLE 4-1: SUMMARY OF DETAILED SCREENING RESULTS

Measures of Effectiveness	No-Build Alternative	Build Alternative
Improve local and regional mobility		
Number of new transit riders	+	+
Number of low-income households, zero-car households and minority populations within ½-mile of stations (rating represents number/benefits)	+/O	+/+
On-time performance of transit vehicles	O	+
Traffic impact at key intersections and on key road segments	O	–

Measures of Effectiveness	No-Build Alternative	Build Alternative
Number of on-street parking spaces lost	O	–
Person-capacity of corridor's road and transit networks (Peak Hour)	O	–
Impact on vehicle and pedestrian safety within the corridor	O	+
Support economic development along the corridor		
Number of housing units within ½-mile of transit stations	O	+
Jobs within ½-mile of transit stations	O	+
Acres of potentially developable land within ¼-mile of transit stations	O	+
Acres of redevelopment within ¼ -mile of transit stations	O	+
Promote livable, transit-oriented development		
Total population and employment within ½-mile of transit stations, current and proposed	O	+
Additions to pedestrian infrastructure	O	+
Frequency, schedule, and travel times of transit services in the corridor	O	+
Create a multi-modal transportation system with attractive travel choices		
Average operating speed	O	+
Number of intermodal connections	O	+
Level of investment that can support future upgrades	O	+
Optimize return on public investment		
Capital cost	O	–
Annual operating cost	O	–
Increases in tax revenue	O	+

4.1 Local and Regional Mobility

A key reason to invest in transit infrastructure is to improve mobility for the population served. The measures described below assess how well each alternative improves mobility in the corridor through expanding ridership, expanding population served or improving transit or traffic operations.

4.1.1 Number of New Transit Riders

Ridership is expected to increase under all alternatives, based on the ridership modeling completed for the project. Based on the 2009 rider survey, existing ridership on all routes is 27,650. In the No Build Alternative, this would increase to 29,670 by 2015. Under the Build Alternative, ridership is forecast to reach 29,700. Therefore, the No Build would lead to 2,020 new riders and the Build 2,050. These represent a 7.3% and 7.4% increase over existing ridership, respectively.

4.1.2 Number of Low-Income Households, Zero-Car Households and Minority Populations within ½-mile of Stations

Low income households are defined as those households earning less than 30% of the median income for each jurisdiction. As such, in Henrico County, households earning less than $14,755 annually are

considered to be low-income. For the City of Richmond, households earning less than $9,336 are considered to be low-income. Low income households are predominately located in the City of Richmond between the Hermitage/Meadow and 12th Street stations.

Minority populations also must be considered and minority populations are concentrated in many of the same areas as low-income households.

Lastly, zero-car households were calculated as those without access to personal automobiles are dependent on public transportation to meet their transportation needs. Similar to patterns of minority populations and low-income households, zero-car households are also concentrated in Richmond between the Adams and 12th Street stations.

While the number of low income households, zero-car households and minority persons is not expected to be any different under any alternative, the service improvements under the Build Alternative would benefit theses populations within the study area. These populations will experience increased frequency of service, travel time savings and increased regional accessibility as a result of the Build Alternative. Table 4.1-1 shows the breakdown of low income and minority populations by station area. Table 4.4-2 shows the breakdown of zero car households by station area.

TABLE 4.1-1: MINORITY AND LOW INCOME POPULATIONS IN STUDY CORRIDOR

Census Tract	Jurisdiction	Total Population (2010)	Total Minorities (% Minority)	Total Low-Income (% Low-Income)	Primary Station Area(s)	Secondary Station Area(s)
Total for City of Richmond		204,214	120,926 (59.2%)	40,434 (19.8%)	n/a	n/a
Total for Henrico County		306,935	125,216 (40.8%)	22,099 (7.2%)	n/a	n/a
2003.01	Henrico County	1,250	143 (11.4%)	0 (0.0%)	Willow Lawn	
504	City of Richmond	2,907	263 (9.0%)	1,134 (3.9%)	Willow Lawn	
2005.01	Henrico County	2,154	956 (44.4%)	69 (3.2%)	Willow Lawn	Staples Mill
502	City of Richmond	3,006	182 (6.1%)	93 (3.1%)	Staples Mill	Willow Lawn
2005.02	Henrico County	2,061	391 (19.0%)	115 (5.6%)	Staples Mill	Hamilton/I-195
501	City of Richmond	2,577	292 (11.3%)	126 (4.9%)	Hamilton/I-195	Staples Mill
407	City of Richmond	2,373	315 (13.3%)	0 (0.0%)	Hamilton/I-195	
402	City of Richmond	3,900	2,273 (58.3%)	234 (6.0%)	Hamilton/I-195	Robinson, Hermitage/ Meadow, Shafer
406	City of Richmond	1,810	231 (12.8%)	0 (0.0%)	Robinson	Hamilton/I-195
409	City of Richmond	2,544	402 (15.8%)	201 (7.9%)	Robinson	
405	City of Richmond	3,152	403 (12.8%)	120 (3.8%)	Robinson	Hermitage/ Meadow

TABLE 4.1-1: MINORITY AND LOW INCOME POPULATIONS IN STUDY CORRIDOR

Census Tract	Jurisdiction	Total Population (2010)	Total Minorities (% Minority)	Total Low-Income (% Low-Income)	Primary Station Area(s)	Secondary Station Area(s)
410	City of Richmond	2,625	202 (7.7%)	0 (0.0%)	Robinson	Hermitage/ Meadow
404	City of Richmond	4,032	879 (21.8%)	637 (15.8%)	Hermitage/ Meadow	Shafer
111	City of Richmond	2,932	2,661 (90.8%)	337 (11.5%)	Hermitage/ Meadow	Shafer
411	City of Richmond	3,724	907 (24.4%)	454 (12.2%)	Shafer	
403	City of Richmond	4,101	1,745 (42.6%)	1,107 (27.0%)	Shafer	Adams Street
412	City of Richmond	1,179	152 (12.9%)	98 (8.3%)	Adams	
301	City of Richmond	2,895	2,843 (98.2%)	1,980 (68.4%)	Adams	3rd Street
302	City of Richmond	2,055	1,084 (52.7%)	388 (18.9%)	Adams, 3rd, 6th, 9th, 12th	
305	City of Richmond	4,029	2,136 (53.0%)	1,056 (26.2%)	Adams, 3rd, 6th, 9th, 12th, Main Street Station	
204	City of Richmond	5,115	5,052 (98.8%)	2,517 (49.2%)	12th Street	
205	City of Richmond	3,851	1,550 (40.2%)	597 (15.5%)	Main Street Station	12th Street, 25th Street
206	City of Richmond	1,544	639 (41.4%)	174 (11.3%)	25th Street	
208	City of Richmond	1,410	530 (37.6%)	124 (8.8%)	25th Street	Rocketts Landing
211	City of Richmond	1,432	1,212 (84.6%)	115 (8.0%)	Rocketts Landing	25th Street
212	City of Richmond	1,575	1,352 (85.8%)	468 (29.7%)	Rocketts Landing	
2015.01	Henrico County	9,872	8,105 (82.1%)	1,204 (12.2%)	Rocketts Landing	
2016.02	Henrico County	4,916	2,155 (43.8%)	0 (0.0%)	Rocketts Landing	

Source: US Census Data, 2010
Shaded cells indicate census tracts where the percentage of the population of concern is greater than 50% OR greater than the percentage in the corresponding locality.

TABLE 4.1-2: ZERO CAR HOUSEHOLDS IN STUDY CORRIDOR

Census Tract	Jurisdiction	Zero Car Households	% Zero Car Households	Primary Station Area(s)	Secondary Station Area(s)
Total for City of Richmond		14,973	17.9%	n/a	n/a
Total for Henrico County		7,594	6.1%	n/a	n/a
2003.01	Henrico County	38	6.9%	Willow Lawn	
504	City of Richmond	54	7.3%	Willow Lawn	
2005.01	Henrico County	21	2.5%	Willow Lawn	Staples Mill
502	City of Richmond	251	6.6%	Staples Mill	Willow Lawn
2005.02	Henrico County	52	2.6%	Staples Mill	Hamilton/I-195
501	City of Richmond	188	18.8%	Hamilton/ I-195	Staples Mill
407	City of Richmond	848	61.2%	Hamilton/ I-195	
402	City of Richmond	299	13.6%	Hamilton/ I-195	Robinson, Hermitage/ Meadow, Shafer
406	City of Richmond	64	7.7%	Robinson	Hamilton/I-195
409	City of Richmond	45	8.0%	Robinson	
405	City of Richmond	63	12.6%	Robinson	Hermitage/ Meadow
410	City of Richmond	89	17.0%	Robinson	Hermitage/ Meadow
404	City of Richmond	771	69.9%	Hermitage/ Meadow	Shafer
111	City of Richmond	156	20.6%	Hermitage/ Meadow	Shafer
411	City of Richmond	494	27.6%	Shafer	
403	City of Richmond	198	17.0%	Shafer	Adams Street
412	City of Richmond	115	35.1%	Adams	
301	City of Richmond	488	27.7%	Adams	3rd Street
302	City of Richmond	217	12.2%	Adams, 3rd, 6th, 9th, 12th	
305	City of Richmond	96	9.6%	Adams, 3rd, 6th, 9th, 12th, Main Street Station	
204	City of Richmond	110	8.6%	12th Street	
205	City of Richmond	122	9.1%	Main Street Station	12th Street, 25th Street
206	City of Richmond	95	6.9%	25th Street	
208	City of Richmond	180	10.5%	25th Street	Rocketts Landing
211	City of Richmond	59	11.3%	Rocketts Landing	25th Street
212	City of Richmond	110	7.7%	Rocketts Landing	
2015.01	Henrico County	33	2.3%	Rocketts Landing	
2016.02	Henrico County	10	0.9%	Rocketts Landing	

Source: US Census Data, 2010
Shaded cells indicate census tracts where the percentage of the population of concern is greater than 50% OR greater than the percentage in the corresponding locality.

4.1.3 On-Time Performance of Transit Vehicles

While the bus operations modeling did not specifically address on-time performance, improvements in on-time performance can be inferred from the modeling of bus speeds and travel times. This is particularly plausible in light of the fact that current bus operations have been shown to experience issues with on-time performance in this corridor (discussed in detail in the Problem Statement). Faster bus speeds and shorter travel times would suggest fewer congestion-related delays in bus operations and therefore a higher likelihood of on-time performance. Based on the VISSIM modeling completed for the project, Build Alternative is projected to positively affect travel times and speeds along the corridor. Table 4.1-3 shows the VISSIM model travel times and speeds for the two alternatives in both the peak and reverse peak directions. The comparison of travel time and speed to the local bus service is limited to the Willow Lawn to 12th Street section since the proposed Route 6 service in the future would not serve the east end. In the peak direction of the No Build Alternative, the local bus travel time is 36.04 minutes with an average travel speed of 7.99 miles per hour. The reverse peak direction is forecasted to have a travel time of 36.78 minutes and an average bus travel speed of 7.83 mph.

Compared to the No Build Alternative, the Build alternative substantially reduces travel times and increases the travel speed of buses. The VISSIM simulation of the Build Alternative shows a reduction in the travel time of 14 minutes compared to No Build Alternative in both the peak and reverse peak directions. Additionally, of the two alternatives, the Build Alternative is expected to have the highest bus travel speeds, with an average travel speed of 13.24 mph in the peak direction and 12.62 mph in the reverse peak direction. Furthermore, the Build Alternative is the only alternative where the proposed improvements would improve operations on other routes as well. The Build Alternative would include consolidated platforms for stations between 2nd and 14th Street in downtown. These consolidated platforms would speed the boarding and alighting process at downtown stations for all routes that stop at those stations, thereby reducing dwell times and improving on-time performance for all routes that operate over that segment of Broad Street.

TABLE 4.1-3: BUS RUNNING TIMES AND SPEEDS

Direction	Alternative	Local Bus Travel Time(mins)	Local Bus Speed (mph)	Limited Stop or BRT Travel Time (mins)	Limited Stop or BRT Speed (mph)
Peak	No Build	36.04	7.99	-	-
	Build Alternative	32.69	8.87	21.88	13.24
Reverse Peak	No Build	36.78	7.83	-	-
	Build Alternative	35.77	8.10	22.96	12.62

Source: VHB, 2010.

4.1.4 Traffic Impact at Key Intersections and on Key Road Segments

Based on the Synchro analysis of the 2015 conditions, the majority of intersections in the corridor are forecast to operate with an overall LOS C or better under all alternatives. Under the No Build Alternative, three intersections are forecast to operate at LOS D in either the AM peak, PM peak or both:

AM Peak:

- Broad Street at Malvern Avenue/Westwood Avenue (LOS D)

PM Peak:

- Broad Street at Staples Mill Road (LOS D)
- Broad Street at Malvern Avenue/Westwood Avenue (LOS D)
- Broad Street at Belvidere Street (LOS D).

Under the Build Alternative, two additional intersections would operate at LOS D in the PM Peak:

- Broad Street at Boulevard (LOS D)
- Broad Street at Bowe Street (LOS D)

Given that LOS D is considered to be acceptable in an urban environment such as the Project Corridor, and given that the reduction of only two intersections from LOS C to LOS D is not likely to cause diversion of traffic from the corridor, the Build Alternative's negative impact is minimal.

4.1.5 Number of On-Street Parking Spaces Lost

With the limited changes expected under the No Build Alternative, few, if any, on-street parking spaces are expected to be removed within the corridor. The space necessary to accommodate stations and exclusive bus lanes under the Build Alternative would require the removal of on-street parking in some sections of the corridor. Specifically, where median running guideway is recommended, between Thompson Street and Adams Street, the existing right-of-way is only wide enough to preserve on-street parking on one side of the street. This will result in approximately a 50% reduction in the remaining on-street parking. On-street parking space losses in this section of the corridor are expected to total 453 spaces. Where curb running guideway is recommended, between 4th and 14th Streets, on-street parking will be restricted 24 hours per day. Currently, parking is allowed in many sections of the existing curb lane in off-peak periods. The on-street parking restrictions, therefore, will be expanded in this area, resulting in a loss of parking availability in the off-peak periods. On-street parking space losses during the off-peak periods in this section of the corridor are expected to total 161 spaces. Currently, however, the existing restricted bus lane exists between 2nd and 14th Streets. Therefore, under the Build Alternative, about 20 on-street parking spaces within the two blocks between 2nd and 4th Streets will be reclaimed during the peak periods. Table 4.1-4 details the on-street parking impacts

TABLE 4.1-4: ON-STREET PARKING IMPACTS

Corridor Section	Curb Length (ft)		Estimated Existing On-Street Spaces	Estimated Build On-Street Spaces	Difference
	Existing Available for Parking	Build Available for Parking			
I-195 to Hermitage/Meadow	6,974	2,764	387	154	234
Hermitage/Meadow to Adams	7,068	3,127	393	174	219
2nd Street to 14th Street[1]	2,905	312	161	17	144
Total	16,947	6,203	942	345	597

Source: City of Richmond GIS, 2009.

Table Notes: 1. Existing bus lanes from 2nd to 14th are only enforced in the peak periods. The Build Alternative would reduce the dedicated lanes to the section from 4th to 14th but would expand the hours of enforcement to 24 hours. The result is a loss of 144 spaces in the off-peak periods, but an increase of 17 spaces in the peak periods.

4.1.6 Person-Capacity of Corridor's Road and Transit Networks

Four sections of the corridor were analyzed under all alternatives to estimate effects of the different guideway types. Person-capacity of the corridor was calculated in two steps, one for roadway capacity and one for transit capacity. Roadway capacity was calculated by reducing the saturation free flow volume of the roadway by the average green time for signals and then multiplying the resulting vehicle capacity by the average typical occupancy of 1.2 persons per vehicle. Transit capacity was calculated by counting the number of buses traveling along each segment and multiplying each by the maximum capacity of the typical GRTC bus, about 47 persons.

TABLE 4.1-5: PERSON CAPACITY OF CORRIDOR BY SECTION

Segment	Section	Total Capacity		Difference to No Build
		No Build	Build	
Broad Street	Willow Lawn to I-195	7,659	8,033	375
Broad Street	I-195 to Adams Street	8,130	6,091	-2,039
Broad Street	Adams Street to 14th Street	9,746	10,082	336
Main Street	14th Street to Williamsburg Rd	5,343	5,905	562

For the I-195 to Adams Street segment, person-capacity would be lower under the Build compared to the No Build as the increased bus service provided by the BRT does not fully replace the person-capacity of one general travel lane in each direction removed to accommodate the median bus lanes. That being said, as noted in previous sections, this loss of lane capacity would be result in only a marginal impact on LOS at key intersections in the corridor suggesting that congestion would be minimally affected.

4.1.8 Impact on Vehicle and Pedestrian Safety within the Corridor

In the No Build Alternative there will be no physical changes to the Broad Street corridor that would alter vehicle or pedestrian safety compared to existing conditions. The Build Alternative, however, includes improvements to the cross-section of Broad Street throughout the fixed guideway portion of the project from Thompson Street to Adams Street and from 4th Street to 14th Street. Some of these improvements will modestly narrow the travel lanes for general traffic, but in no case will the resulting lane-widths compromise safety.

The existing curb running bus lanes will be rebuilt and widened from their existing width of 9 to 10 feet. This will help transit vehicles avoid infringement on the general traffic in the adjacent travel lane, which will improve the safety of both transit and general traffic operations.

In the median-running portion of the Build Alternative, very few dedicated left-turn lanes exist today, with the effect that left-turning traffic stops through-traffic in the left lane while waiting to turn, although left turns are prohibited at many intersections either all day or during peak periods. Where left turns are allowed along Broad Street, the Build Alternative will allow these vehicles to turn from the bus lane, which reduces the likelihood of rear-end collisions from stopping in the through-lane. With the Build Alternative, potential improvements for pedestrian safety include increased shelter and lighting at BRT bus stops and updated pedestrian crossing signalization at intersections where traffic signals will be

reconstructed or updated. Furthermore, where median BRT stations are provided, the mid-street islands would also serve as pedestrian refuge medians where pedestrians could stop should the signals turn red while they cross.

4.2 Support for Economic Development

Support of economic development goals of the region is another key goal of many transportation projects. The measures below assess how well each alternative encourages increases in housing, employment, development or redevelopment within the corridor. In general, the economic development characteristics described in the following sections will be the same at base year for the No-Build and Build Alternatives. However, the Build Alternative would foster economic growth more so than the No Build Alternative by offering higher levels of transit service and peak period headways that would strongly support transit access throughout the corridor. Furthermore, given that the Build Alternative provides travel times that are even more competitive with the automobile and provides the enhanced service features of branded, low-floor BRT buses and the median-running and improved curb-running fixed-guideway portions of the corridor, the Build Alternative would be expected to be more supportive of economic development in the corridor. This is supported by the research and case studies noted in the *Economic Impacts Analysis*.

4.2.1 Number of Housing Units within ½-Mile of Transit Stations

The corridor is surrounded by some of the more densely populated neighborhoods within the City of Richmond. Based on the Richmond Area MPO's (RAMPO) most recent socioeconomic data estimates at the traffic analysis zone (TAZ) level, in 2008 there were a total of 16,381 housing units within a ½-mile of the transit stations. This is expected to increase to 17,859 by 2015, an increase of 9 percent under all alternatives.

4.2.2 Number of Jobs within ½-Mile of Transit Stations

The RAMPO TAZ employment forecasts only provide data for retail employment and non-retail employment. Therefore the total employment is being used as the best estimate of employment activity in the corridor, even though it may include some industrial employment that may not be conducive to transit use. According to RAMPO data, there were a total of 77,124 jobs in the corridor in 2008. This is expected to increase to 87,398 jobs by 2035, an increase of about 13%.

TABLE 4.2-1: POPULATION AND EMPLOYMENT STATISTICS

Station Area	Population 2008	Population 2035	Employment 2008	Employment 2035
Willow Lawn	1,927	4,690	3,766	5,646
Staples Mill	1,097	1,605	3,409	4,730
Hamilton/I-195	2,861	3,352	5,133	5,867
Robinson	4,403	4,649	3,819	4,191
Hermitage/Meadow	4,686	4,952	1,993	2,187
Shafer	7,373	7,667	10,370	11,375
Adams	4,703	4,927	4,892	5,365
3rd Street	515	629	3,379	3,709
6th Street	77	674	6,828	7,501
9th Street	433	475	8,746	9,594
12th Street	429	894	15,835	17,372
Main Street Station	1,006	1,710	7,394	8,109
25th Street	3,237	3,753	1,368	1,501
Rocketts Landing	651	884	192	251
Total	33,398	40,861	77,124	87,398

Source: RRPDC, 2012.

TABLE 4.2-2: POPULATION AND HOUSEHOLD TOTALS AND DENSITIES BY STATION AREA

Station Area	Population 2010	Population Density (per sq mile)	Households 2010	Household Density (per sq mile
Willow Lawn	1,486	2,368	693	1,104
Staples Mill	1,191	1,929	621	1,005
Hamilton/I-195	2,885	3,729	1,640	2,120
Robinson	4,468	7,490	2,609	4,373
Hermitage/Meadow	4,327	8,446	2,277	4,444
Shafer	8,480	15,131	2,624	4,682
Adams	4,581	12,077	2,014	5,308
3rd Street	763	3,585	367	1,725
6th Street	360	1,947	120	647
9th Street	347	1,961	108	610
12th Street	973	3,090	404	1,283
Main Street Station	1,482	4,447	946	2,838
25th Street	3,385	6,496	2,029	3,894
Rocketts Landing	939	2,057	351	770
Total / Average	35,667	5,690	16,803	2,681

Source: US Census 2010

4.2.3 Acres of Potentially Developable Land within ¼-Mile of Transit Stations

There is little vacant land within the corridor with most vacant land in the vicinity of Rocketts Landing. In total there is 94.9 acres of vacant land available in the corridor and this is expected to decline somewhat by 2015 as new development occurs. Table 4.2-3 shows the breakdown of vacant and redevelopable land by station. The acres of potentially developable land within ¼-mile of transit stations is expected to be the same in 2015, though the Build Alternative is expected to encourage redevelopment more so than the No Build Alternative beyond 2015.

The Build Alternative foster economic growth more so than the No Build Alternative by offering higher levels of transit service and peak period headways that would strongly support transit access throughout the corridor. The Build Alternative is the only one that provides transit service the Rocketts Landing area, where much of the existing vacant land is found.

TABLE 4.2-3: VACANT AND REDEVELOPABLE LAND BY STATION

Station	Acres of Vacant Land	Acres of Redevelopable Land	Total Acres with Development Potential
Willow Lawn	3.0	26.6	29.6
Staples Mill	3.6	39.8	43.4
Hamilton/I-195	4.7	47.1	51.9
Robinson	3.5	29.6	33.1
Hermitage/Meadow	8.5	50.0	58.5
Shafer	3.9	27.7	31.6
Adams	8.5	20.4	28.9
3rd	8.3	18.9	27.3
6th	2.9	9.0	12.0
9th	1.2	9.2	10.4
12th	4.3	9.3	13.6
Main Street Station	11.8	22.8	34.7
25th	7.7	19.1	26.8
Rocketts Landing	22.7	12.1	34.9
Total	94.9	341.7	436.5

4.2.4 Acres of Redevelopable Land within ¼ -Mile of Transit Stations

The corridor has significant amounts of redevelopable land capable of accommodating the expected increase in infill development triggered by the BRT system. Every proposed station of the BRT system has more than 10% of land available for redevelopment potential. In total there is 341.7 acres of redevelopable land within ¼-mile of the corridor. Table 4.2-1 shows the acres of redevelopable land by station area.

The acres of redevelopable land within ¼-mile of transit stations is expected to be the same in 2015, though the Build Alternative is expected to encourage redevelopment more so than the No Build Alternative beyond 2015. This alternative provides significant transit service enhancement to the Shockoe Bottom area along Main Street where substantial redevelopment has already occurred and

further redevelopment is expected. In particular, the enhanced sense of place and identity of the transit stations and fixed guideway portions with the Build Alternative would likely encourage further redevelopment of the industrial areas north of Broad Street in the Shafer, Hermitage/Meadow and Robinson station areas as these station areas would have faster transit access to downtown via the median guideway.

4.3 Livable, Transit-Oriented Development

Encouraging the development of a more transit oriented built environment is a key goal of major transit investment. Based on the analysis *Land Use and Multimodal Connectivity Report*, the downtown and VCU sections of the corridor are already highly transit supportive in their land use mix and density. While other sections of the corridor are currently less supportive, such as Rocketts Landing, land use plans and zoning for the corridor is highly supportive of transit oriented development. The report provides recommendations to improve the livability and multimodal accessibility throughout the corridor in concert with the development of rapid transit. The measures below quantify the existing and future measures of livability and transit-oriented development.

4.3.1 Total Population and Employment within ½-Mile of Transit Stations, Current and Proposed

The proposed corridor traverses the City of Richmond's densely populated neighborhoods and central business district, which includes major government centers, a state university and medical college, as well as multiple retail and commercial businesses. RAMPO TAZ data indicates a total of 35,032 persons within a ½-mile of proposed stations in 2008. The same data source indicates 78,040 jobs within the same area; more than double the number of persons in the study area. By 2015 the population and employment are expected to increase to 37,033 and 81,987, respectively.

While the population and employment in 2015 are expected to be the same under all alternative as no induced land use changes are anticipated prior to 2015, the Build Alternative is expected to encourage higher population and employment growth within the corridor beyond 2015. The Build Alternative would foster economic growth more so than the No Build Alternative by offering higher levels of transit service and peak period headways that would strongly support transit access throughout the corridor. In particular, the mode specific effects of the Build Alternative would likely encourage further redevelopment of the industrial areas north of Broad Street in the Shafer, Hermitage/Meadow and Robinson station areas, as these station areas would have faster transit access to downtown via the median guideway.

4.3.2 Additions to Pedestrian Infrastructure

With the limited infrastructure changes anticipated under the No Build Alternative, no change is expected in any pedestrian infrastructure. Under the Build Alternative, some improvements are expected in the pedestrian infrastructure along the corridor. Specifically, pedestrian infrastructure improvements are expected to be incorporated into station design and in particular station areas along the median and curb guideways. Such improvements may include new pedestrian signals, new curb ramps, wider medians for pedestrian refuge at median stations and other streetscape improvements.

4.3.3 Frequency, Schedule, and Travel Times of Transit Services in the Corridor

Under the No Build Alternative, the Route 6 would offer service frequencies of 10 to 12 minutes in the peak periods and 15 minutes in the off-peak periods. Under the Build Alternative, the BRT service would offer service frequencies of every 10 minutes in the peak period and every 15 minutes in the off-peak periods. Under the Build Alternative the local Route 6 service offered would be reduced to 20 minutes during the peak periods and 30 minutes in the off-peak periods. In all alternatives, these services are expected to be offered weekdays from 5:30 a.m. to 11:30 p.m. and weekends from 6:00 a.m. to 11:30 p.m.

As previously described in section 4.1, Build Alternative reduces travel times for transit service in the corridor. The Build Alternative provides a reduction in the travel time of 14 minutes compared to No Build alternative in both the peak and reverse peak directions. The combination of auto-competitive travel times, high frequencies and span of service provided under the Build would be particularly supportive of more transit-oriented development by providing a transit service that allows residents and workers in the corridor to access transit without regard to a specific timetable thereby encouraging a much less auto-centric development pattern.

4.3.4 Affordable Housing

Affordable housing options are available throughout the study area and the region. The major providers of affordable housing in the Richmond region include the Richmond Redevelopment and Housing Authority (RRHA), the Better Housing Coalition and a variety of other community development corporations. Based on an assessment of total affordable housing units available in the area, there are 15,865 total affordable housing units[1] within Henrico County and the City of Richmond compared to a total of 229,826 housing units. Thus, the portion of all housing units that are affordable within both jurisdictions is 7%. Within the study corridor, there are 1,562 affordable units compared to a total of 17,831 units. Thus, within the study area, 9% of all units are affordable.

4.4 Multi-modal Transportation and Travel Choices

A major goal of any transportation investment is to increase travel options and encourage more multi-modal travel connections. The measures below enumerate how the alternatives perform in expanding and improving the multi-modal transportation system.

4.4.1 Average Operating Speed

The Build Alternative is also projected to positively affect travel times and speeds along the corridor. Table 4.1-2 shows the VISSIM model travel times and speeds for the alternatives in both the peak and reverse peak directions. The improvements in bus running times and speeds are discussed in Section 4.1.3.

Compared to the No Build Alternative, the Build Alternative would significantly reduce travel times and increase the travel speed of buses. The Build Alternative is anticipated to improve conditions for passengers on existing local routes: travel speeds are forecast to increase up to 11% for local buses

[1] For purposes of this analysis, the FTA guidelines for "legally binding affordability restricted" housing units is used. Units must be restricted to renters with income of less than 60% of the area median income or only available for sale to owners who earn less that the area median income.

operating between Willow Lawn and 25th Street under the Build, while travel times for these routes are expected to decrease up to 9%. This may be directly attributed to the positive effects of introducing wider shoulder bus lanes and consolidated stations in downtown Richmond.

4.4.2 Number of Intermodal Connections

While all alternatives provide serve at Main Street Station, the Build Alternative would greatly enhance the number of buses serving Main Street Station. Furthermore, as the Build Alternative would provide for wider, rebuilt shoulder bus lanes with multiple platforms at each stop, it should provide for more efficient intermodal connections between the BRT and local bus services. The Build Alternative includes a park and ride facility at Broad Street and Staples Mill Road, providing an intermodal connection for auto trips.

4.4.3 Level of Investment That Can Support Future Upgrades

The Build Alternative would provide a higher level of transit service in the region than has been provided anytime in the last few decades. As such this alternative would test the market for premium transit service in Richmond and determine the appropriate level of future upgrades within the study corridor and other corridors. As the Build Alternative represents a higher level of investment and a stronger branding of the higher quality transit service, it would create a stronger case for extending or upgrading dedicated guideways in the corridor and in other corridors.

4.5 Return on Public Investment

As with any public investment, the return on investment is a critical factor in determining the value provided by a proposed project. The factors below enumerate the costs, capital, operating and maintenance, any tax benefits and the cost-effectiveness of the alternatives.

4.5.1 Capital Cost

The *Capital Costs Estimate Report* describes the methodology for estimating capital costs for all alternatives. As the No Build will not require any changes other than those already programmed, there are no capital costs associated with it. The Build Alternative incurs additional capital cost for the dedicated guideway construction, larger station structures a potential right-of-way costs for small property impacts. Total estimated capital cost in 2015 dollars is $53,751,800.

4.5.2 Annual Operating Cost

The *Operations and Maintenance Costs Estimate Report* describes the methodology for estimating operations and maintenance (O&M) costs for all alternatives. The No Build costs include the costs associated with the existing system and total cost in 2015 dollars is $46,535,000, or 1.6% more than existing costs. The Build Alternative costs total $46,899,000, or 2.4% more than existing costs.

4.5.3 Increases in Tax Revenue

Based on comparisons to other similar corridors, as documented in the *Economic Impacts Analysis* report, the Build Alternative could increase property tax revenues in the corridor due to inducement of development and redevelopment. The average annual increase in property tax revenue over 20 years is estimated to be approximately $4,250,000 and $330,000 for the City of Richmond and Henrico County, respectively.

4.6 Environmental Quality

The potential environmental effects are vital factors to consider in screening alternatives. The measures below enumerate the major categories of environmental effects, both positive and negative, associated with the alternatives.

4.6.1 Impact on Natural Resources (Parklands, Wetland, Water, Habitat)

None of the alternatives will have any adverse impact on parklands, wetlands or water habitats within the corridor.

4.6.2 Impact on Historic and Cultural Resources

As the No Build would have few changes and none outside existing right-of-way, it would have no impact on historic and cultural resources. The Build Alternative, while it would include new or expanded station platforms and other infrastructure changes in the vicinity of historic and cultural resources, it would have no adverse impact on any historic or cultural resource in the corridor.

5.0 INPUT RECEIVED AT PUBLIC MEETINGS

Input from the public was received via the study website, mail and in person at public meetings. Overall, much of the public input was supportive of the proposed Build Alternative with some concerns regarding the specific details of implementation. There was some desire to study light rail as an alternative and some concern about too many stations downtown and possible shifting of other stations. Many comments indicated a desire to see the BRT system expanded to serve other activity centers. There was strong support for the median guideway from the comments, including a desire to see the median guideway extended to 14th Street. Furthermore, some comments noted the importance of transit investment as a means to encourage transit oriented development.

6.0 CONCLUSIONS

The Build Alternative best meets the purpose and need of the study as it rates as the best on the most measures of effectiveness. It rates the best in the quantitative measures on

- Number of new transit riders,
- Frequency, schedule and travel times of transit services in the corridor and
- Average operating speed.

While the quantitative measures for all alternatives are the same for seven of the measures of effectiveness, the qualitative measures indicate that the Build Alternative rates best on:

- On-time performance of transit vehicles,
- Impact of vehicle and pedestrian safety,
- Additions to pedestrian infrastructure,
- Number of intermodal connections and
- Level of investment that can support future upgrades.

The Build Alternative rates lowest on:

- Traffic impact at key intersections and on key road segments,
- Number of on-street parking spaces lost, and

- Capital cost.

The traffic and parking impacts, however, are fairly small relative to the overall level of traffic congestion and the overall availability of parking in the corridor. While the capital cost is substantial, the overall benefits to ridership, improved transit service frequency and reliability indicates that the return on investment would be worthwhile.

While the No Build rates best on traffic impacts, on-street parking spaces lost, capital cost and operations and maintenance cost, it rates worst on most other measures meaning that overall, it does not best meet the purpose and need of this study.

7.0 NEXT STEPS

The results of this analysis will need to be presented to the public. Based on the results of this analysis and feedback from the general public, the Technical Advisory Committee and the Policy Advisory Committee will select a Locally Preferred Alternative (LPA) to be carried forward into design and implementation.