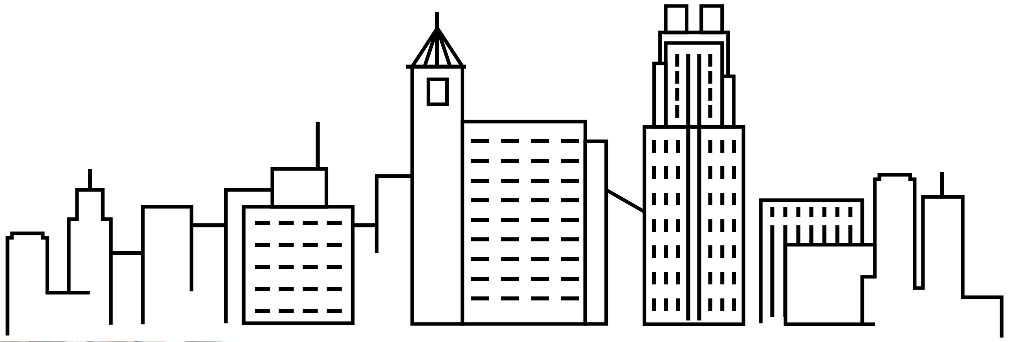
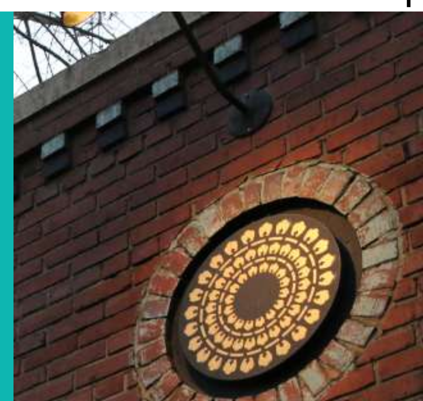
Raleigh Downtown Transportation Plan

VOLUME 2: SCENARIO EVALUATION REPORT

April 2019





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1.0 Introduction

The **Raleigh Downtown Transportation Plan** project team, in close coordination with the Technical Team and the City of Raleigh, developed four multimodal scenarios for evaluation. The scenario evaluation process shows how each combination of multimodal infrastructure performs against performance indicators and core values identified throughout the planning process. The sections that follow are outlined below.

- 2.0 Scenario Development – This section outlines the process used to create a universe of alternatives and the process of screening these initial alternatives.
- 3.0 Evaluation Framework – This section defines the framework including objectives, metrics, methodology, and data sources for evaluating each of the four final scenarios.
- 4.0 Scenario Evaluation – The final section of this report steps through the evaluation of each metric in the Evaluation Framework in greater detail, displays the evaluation results, and highlights the key takeaways.

2.0 Scenario Development

2.1 Bus Rapid Transit Route Development

The Technical Team met on May 24th, 2018 in a four-hour workshop and developed draft potential BRT routing scenarios for the four proposed BRT corridors within the Downtown Raleigh study area limits. The following key assumptions were used when developing these preliminary BRT routing scenarios:

- Potential BRT corridors into Downtown include all options currently under consideration by the *Wake Transit Major Investment Study (MIS)*, and no other alternatives. These corridors intersect Downtown on the following streets:
  - North Corridor: West Street or Capital Boulevard
  - South Corridor: South Saunders Street; Dawson and McDowell Streets; or South Wilmington Street
  - East Corridor: Edenton Street and New Bern Avenue
  - West Corridor: Western Boulevard
- Future two-way conversions may be considered such as Jones and Lane Streets, Blount and Person Streets, and Wilmington and Salisbury Streets.
- Fayetteville Street will not be considered for BRT routing.
- Consider West Street Extension under railroad tracks as a viable alternative. For any scenarios utilizing this, an interim solution will also be needed until the extension is completed. Timing of the implementation will be key.
- In general, no exclusive transit streets will be included for this exercise.
- BRT routing scenarios should be routed to GoRaleigh Station and/or Raleigh Union Station and some sort of very frequent transit connection between Raleigh Union Station and GoRaleigh Station is vital, whether BRT or not.
- All BRT in the study area operates in exclusive BRT lanes. Details and potential modifications will be studied in detail in future phases of the BRT projects.
- The overlap of the BRT routes is a key consideration—where different BRT routes can use the same exclusive lanes, this is a positive.

- Sidewalk width is important on all Downtown streets—10 feet should be considered as an absolute minimum width and 14-16 feet is desirable.

The Technical Team was broken into three working groups and developed four draft potential BRT routing scenarios during the workshop, as shown on Exhibits A.1-A.4. These scenarios were reviewed, discussed by the entire Technical Team, and slightly refined during that discussion. Temporary names were given to the scenarios based on the general shape of the routes in Downtown: Scenarios “H”, “I1”, “I2”, and “O”.

2.2 Tier 1 Screening

Following the Technical Team workshop described above, a Tier 1 initial screening of the draft scenarios was conducted. The evaluation metrics used in this Tier 1 screening were intended to facilitate comparison of the BRT routing scenarios to one another to identify which routing scenarios had the most viability and likelihood for success in further screening processes, and to refine the number of scenarios down to a maximum of three. The metrics used for this Tier 1 screening were also intended, to the extent practical, to align with the evaluation metrics found in the Wake County Transit Plan Major Investment Study (MIS) BRT Evaluation Framework (MIS BRT Evaluation Framework). The evaluation categories and metrics used in the MIS BRT Evaluation Framework were reviewed, and the topics most applicable to the routing scenarios in Downtown Raleigh were speed improvement, reliability, connections to frequent transit, connections to commuter rail, ease of access, and cost effectiveness. These metrics were then modified to be more applicable to the Downtown environment and to be useful for this high-level Tier 1 screening. The resulting evaluation categories used for the Tier 1 screening for the potential BRT routing scenarios in Downtown are:

- Speed and Reliability
- Connectivity
- Ease of Access
- Cost Effectiveness

2.2.1 Scoring

For each category described below the draft preliminary BRT routing scenarios were given a score of 1 through 3 or 4 with 1 being the lowest and 3 or 4 being the highest. There was no weighting applied to any of the evaluation categories. See Table 1 for the tier 1 evaluation matrix and the maximum scores for each metric.

TABLE 1: TIER 1 EVALUATION MATRIX AND MAXIMUM POSSIBLE SCORES

MIS Metric(s)	Evaluation Category	Prioritization Metric	Evaluation Methodology	Measure	Max Points
Speed Improvement and Reliability	Speed and Reliability	BRT travel time through Downtown	Assuming all BRT lanes are exclusive, more miles of BRT alignment correlates to longer travel time	Route Miles	4.0
Connections to frequent transit & Connections to commuter rail	Connectivity	Transit hub connections	Connections to GoRaleigh Station and Raleigh Union Station	Connect to GoRaleigh	4.0
				Connect to RUS	3.0
Ease of Access	Ease of Access	Walking distance between directions	Return trips are more difficult to access with one-way alignments than two-way alignments	Walk distance between alignments at Martin Street	4.0
Cost Effectiveness	Cost Effectiveness	Mileage of BRT infrastructure	Mileage of BRT infrastructure in study area: more miles of BRT infrastructure correlates with higher capital cost	BRT lane miles	4.0

Speed and Reliability

The essence of BRT is that bus operating speed and reliability can be improved by reducing or eliminating the various types of delay. For this study, it was assumed that all BRT lanes within the study area are exclusive, transit-only lanes. Dedicated transit lanes provide significant congestion relief for BRT service and can create competitive travel times compared to vehicular travel. At this high-level planning phase of the project there are many operating assumptions that have not been developed yet (such as station locations, BRT average speeds, intersection delay times, etc.). Therefore, to estimate which scenarios could likely have higher travel times compared to other scenarios, it can be assumed that greater BRT route miles within the study area will result in higher travel times. This also assumes that the further the BRT service has to travel within the Downtown study area, the more intersections it will encounter, the more stations it may require, and the more turns it may need to make which would all add to the travel time for the corridor. Total route miles for all BRT routes were calculated for each scenario and compared to the other scenarios to assign a score of 1 through 4, with 1 being the lowest score (highest total BRT route miles) and 4 being the highest score (lowest total BRT route miles).

Connectivity

BRT functions best if the investment will create and strengthen connections and access to other transit routes. Currently all local and regional routes that operate in the study area stop at GoRaleigh Station, and a new bus facility is planned adjacent to the existing Raleigh Union Station which will provide additional bus route transfer access as well. The connectivity category is used to determine which BRT scenarios provide connections to these transit hubs and therefore connections to other transit routes. The scoring for this category was based on GoRaleigh Station being the most important connection given that approximately 6,000 transit trips are made every weekday from the station, and Raleigh Union Station being 2nd most important. Additionally, providing connections to these stations in both directions scores higher than having a connection in one direction or via a circulator bus. Therefore, the scores for this category were assigned as 4.0 for connectivity to GoRaleigh Station in two directions and 3.0 for connectivity to Raleigh Union Station in two directions. A score of 2.0 was assigned for connectivity to GoRaleigh Station in one direction and a score of 1.5 was assigned for connectivity to Raleigh Union Station in one direction. Connectivity to either transit hub via circulator only was assigned a score of 1.0. It should be noted that for Scenario I1, the southbound and westbound corridors are one block away from GoRaleigh Station and that was assumed to be close enough to qualify for accessing that station in those directions of travel.

Ease of Access

Within the Downtown study area particularly, the transit riders will begin and/or end their trip as pedestrians, walking to and from the BRT stations. Therefore, ease of access to the BRT routes will be very important. For transit riders, return trips are more difficult to access along one-way alignments than two-way alignments because the rider does not get on and off on the same street. Also, in certain one-way alignment scenarios, the inbound stop where the rider departs the system may be a significant distance away from the outbound stop for the return trip. This makes access more difficult for pedestrians because they must walk further for one trip than the other and this can also make it more difficult for the rider to understand the system. For this evaluation metric the walk distance between alignments for each scenario was calculated along Martin Street, as that is the common street which provides access to all four BRT corridors in all four scenarios. The shorter the distance between directions of travel, the higher the score assigned to each scenario.

Order of Magnitude Capital Cost

The evaluation for this category assumes that increased mileage of BRT infrastructure proposed within the Downtown study area correlates with higher overall capital cost. The total BRT infrastructure lane mileage for each scenario was calculated and the higher the total mileage the lower the score assigned.

2.2.2 Tier 1 Screening Results and Recommendations

Of the four BRT routing scenarios, Scenario H scored the highest with a total score of 14 points. Scenario I1 scored a total of 13 points, followed by Scenario I2 with 12 points, and Scenario O scored the lowest with 7.5 points. Scenarios H, I,1 and I2 were recommended for further analysis, with a few minor modifications as shown on Exhibits A.5, A.6, and A.7. For Scenario I1, the southbound alignments were recommended to be moved from Salisbury Street to Blount Street. This adjustment would provide direct access to GoRaleigh Station on Blount Street. Scenario H as originally configured depends on the two-way conversion of Wilmington Street and Blount Street. The timing of the implementation for these two-way conversion projects is currently unknown. Therefore, it was recommended that the eastbound alignment in Scenario H be relocated from Blount Street to Wilmington Street between Martin Street and Morgan Street. Additionally, the southbound alignment is recommended to be relocated from Wilmington Street to Blount Street in this scenario. This will provide BRT alignments in the current direction of vehicular travel on all streets. With these modifications, the BRT alignments in Scenario H will not depend on the two-way conversion projects but will not preclude those projects either. The two-way conversion projects can still be implemented in this modified scenario with little impact to the BRT operations. It was also noted at that Scenario H would require further analysis to determine the traffic impacts of two-way BRT on Martin Street and if the impacts are too great that one-way BRT on Martin Street and one-way BRT on Hargett Street would be the recommended alternative.

TABLE 2: TIER 1 EVALUATION RESULTS

Evaluation Category	Measure	Max Points	O	H	I1	I2	O	H	I1	I2
Speed and Reliability	Route Miles	4.0	9.04 miles	8.95 miles	7.96 miles	7.08 miles	1.0	2.0	3.0	4.0
Connectivity	Connect to GoRaleigh	4.0	1 way	2 way	2 way	Circulator	2.0	4.0	4.0	1.0
	Connect to RUS	3.0	1 way	2 way	Circulator	Circulator	1.5	3.0	1.0	1.0
Ease of Access	Walk distance between alignments at Martin Street	4.0	0.53 miles	0.05 miles	0.10 miles	0.10 miles	1.0	4.0	2.0	2.0
Cost Effectiveness	BRT lane miles	4.0	7.61 miles	7.92 miles	7.14 miles	5.93 miles	2.0	1.0	3.0	4.0
						Total	**7.5**	**14.0**	**13.0**	**12.0**

2.3 Final Scenarios for Evaluation

Following the Tier 1 screening of the BRT scenarios, the three proposed scenarios carried forward were further developed and studied in preparation for the technical analysis described in Section 4.0 of this report. Throughout this process additional input on the scenarios was gathered from both the Technical Team and the Advisory Committee. As a result of the more detailed development of the scenarios and the feedback received, additional modifications were made to the scenarios and eventually a new scenario was also developed. Additionally, the scenarios were also renamed to Scenario A (previously H), B (previously I1), C (previously I2), and D (new scenario). The scenarios will be referred to as Scenarios A, B, C, and D for the remainder of this report. These BRT scenarios are shown in Exhibits A.5, A.6, A.7, and A.8 in Appendix A.

Scenario modifications were proposed for Scenarios A and B to minimize negative impacts to traffic flow. These modifications maintain the same overall network connectivity, but lessen auto delay. It was initially suggested to route southbound BRT exiting Downtown along Blount Street all the way to Martin Luther King Jr. Boulevard (MLK Blvd) for both scenarios. Upon further evaluation it was determined that the southbound BRT route exiting Downtown should instead be routed along Salisbury Street due to the existing traffic issues on MLK Blvd between Wilmington Street and Blount Street, which would be further compounded by adding BRT.

Additionally, Scenario D was developed as a way to address the issue of Scenario C not providing access to either of the two transit hubs in Downtown. Scenario D, like Scenario C, utilizes Dawson Street and McDowell Streets for BRT entering and exiting Downtown to the north, avoiding the constrained right-of-way on Peace Street around William Peace University and the CSX rail bridge. However, Scenario D then routes the BRT to and from GoRaleigh Station via Edenton, Morgan, Wilmington, and Blount Streets. The advantage of this scenario is that it avoids the traffic impacts created by utilizing Peace Street for east-west BRT operation and still provides access to GoRaleigh Station. These final four BRT scenarios selected to advance for further evaluation are shown on Exhibits A.5-A.8 in Appendix A.

Scenarios B, C, and D include some type of transit circulator operating between GoRaleigh Station and Raleigh Union Station on Hargett, Martin, Blount, and West Streets. The Technical Team expressed that some sort of very frequent transit connection between these two transit hubs is vital to providing the most opportunities for transit connections in Downtown. The proposed route for the circulator service is also shown on the BRT scenario maps in Exhibits A.5-A.8 in Appendix A.

2.4 Bicycle Networks

Scenarios A, B, C, and D as described above include proposed BRT routing only. The next step in creating the proposed multimodal networks was to develop the complementary bicycle networks for each BRT scenario as described below.

2.4.1 Vision for the Bicycle Network

The vision statement in the *2016 BikeRaleigh Plan* is: "Raleigh is a place where people of all ages and abilities bicycle comfortably and safely for transportation, fitness, and enjoyment. The BikeRaleigh network is integrated into the transportation system to connect people to where they live, work, play, and learn." One of the goals created in the plan to reach this vision was to build priority projects to serve cyclist of all ages and abilities. Raleigh's Downtown bicycle network is key to connecting Raleigh's greater bicycle network and supporting transit as a first-mile, last-mile option. Additionally, in 2014 the City completed a full study and implementation plan for a future bike share system that would start in the Downtown area. These planning efforts were used as the basis for developing the bicycle networks for each of the proposed BRT networks.

2.4.2 Bicycle Network Development

The network planning approach used for this effort assigns modal priorities to specific streets to accommodate all modes in Downtown Raleigh. The 4 BRT scenarios developed assigned BRT as the modal priority for specific streets. Once these were defined, the next step was to assign streets for bicycle priority and develop the proposed bicycle network for each scenario. The following key steps and best practices were used to develop the proposed bicycle networks:

- Identify the network of "low stress" streets where people already feel safe riding bikes
- Identify strategic corridors that would connect places of interest most efficiently
- Identify the correct facility type to allow people riding bikes to feel safe on strategic corridors
- Prioritize construction of facilities on these strategic corridors based on how much of the existing or planned low stress network they connect to.
- If a street has high motor vehicle volumes, only a physically separated bicycle facility will make inexperienced bike riders feel safe and comfortable.
- If the observed motor vehicle speed on a street is greater than 30 mph, only a physically separated bicycle facility will make inexperienced bike riders feel safe and comfortable.
- Standard five-foot or six-foot bike lanes in the door zone of parked cars are not considered low stress facilities.
- Standard or buffered non-separated bike lanes are only low stress facilities when they are next to the curb and average traffic speeds are approximately 30 mph or less. If there is space for a buffered bike lane, it is best to add a vertical element to the buffer to create a separated facility.
- Bike lanes where buses must frequently pull through to reach their stop are not low stress facilities.

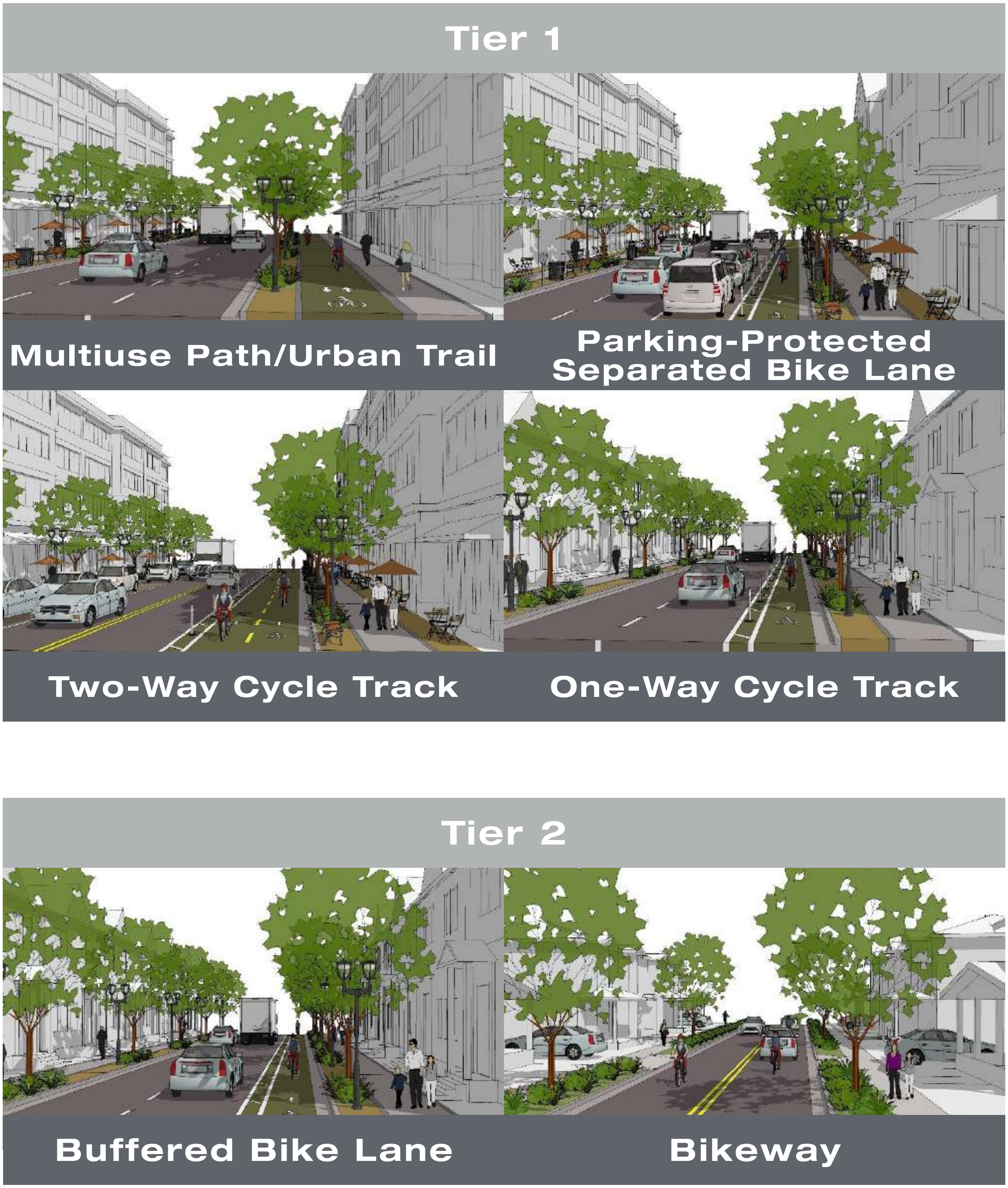
To meet the goals of the *2016 BikeRaleigh Plan*, the highest bicycle priority streets must provide bicycle facilities suitable for all ages and abilities. Due to the space constraints and the competing priorities on each street within Downtown Raleigh, the bike network development approach focuses on fewer, physically separated bike facilities rather than providing more non-separated facilities. These separated facilities are designed to provide comfortable, low-stress bicycling conditions which accommodate riders of all ages and abilities and are considered Tier 1 facilities for this bicycle network development process. These facilities are proposed on streets that will best serve bicyclists needs at the network level. The Tier 1 bicycle facilities proposed for Downtown include multiuse paths, parking-protected separated bike lanes, one-way separated bike lanes, and two-way cycle tracks. The most important element of the Tier 1 bicycle facilities is physical separation from the motor vehicle travel lane. This physical separation could be a curb, bollard, or other vertical element to separate people on bikes from traffic. In the case of multiuse paths proposed for Downtown Raleigh, this separation is provided by the roadway curb since these facilities are raised above street level at the sidewalk level. The Tier 2 bicycle facilities proposed include buffered bike lanes and bikeways. Buffered bike lanes provide a striped buffer between the bike lane and adjacent motor vehicle traffic or the bike lane and the parking lane. Bikeways are low volume, low speed streets where a shared lane environment for bicycles and automobiles is proposed. Examples of each of these Tier 1 and Tier 2 facilities are shown in Figure 1.

Due to the potential conflicts and competing space requirements between BRT and bicycle facilities on the same street, it was established that the Tier 1 and Tier 2 bicycle facilities would not be proposed on the same streets as BRT. Considerable right-of-way would be needed to accommodate BRT and bicycle facilities on the same street while still maintaining lanes for vehicular traffic as well. Mitigation measures would also be needed where the bicycle lanes interact with proposed BRT stations to avoid conflicts between bicyclists and BRT buses and/or passengers. These measures would likely be infeasible within the constrained right-of-way of Downtown streets. The existing roadway grid allows bicycle facilities to be located on streets parallel to the proposed BRT streets removing the potential conflicts while still creating a network that provides accessibility throughout Downtown for both modes. The following bicycle facility selection best practices were also followed when developing the bicycle networks:

- If the average motor vehicle speed on a street is greater than 30 miles per hour (mph), only a physically separated (Tier 1) bicycle facility will make inexperienced bike riders feel safe and comfortable.
- Standard five-foot or six-foot bike lanes in the door zone of parked cars are not considered low stress facilities.
- Standard or buffered non-separated bike lanes are only low stress facilities when they are next to the curb and average traffic speeds are 30 miles per hour (mph) or less. If there is space for a buffered bike lane, it is best to add a vertical element to the buffer to create a separated facility.
- Bike lanes where buses must frequently pull through to reach their stop are not low stress facilities.

Exhibits A.9-A.12 provide maps of each of the bicycle network scenarios developed. The facilities selected were verified through a Level of Traffic Stress (LTS) and Low Stress Island analysis described in Section 4.4.

FIGURE 1 — TIER 1 AND TIER 2 BICYCLE FACILITIES



3.0 Evaluation Framework

In order to compare the multimodal scenarios that were developed, an evaluation framework was created to help assess the anticipated relative impacts of the multimodal scenarios and their ability to meet the identified priorities and objectives, in comparison to one another. Each metric listed in the evaluation framework is accompanied by an objective, mode, indicator, evaluation methodology and data source.

Each multimodal scenario was evaluated based on the metrics and indicators shown in this evaluation framework matrix. The results were calculated in terms of length, distance, quantities, counts, etc. for each metric and summarized for each multimodal scenario. Due to the small size of the Downtown study area as well as the similarities between the multimodal scenarios, the evaluation process yielded very similar results for many of the evaluation metrics. Therefore, only the meaningful key differentiators were used when developing ratings for each scenario to be shared with stakeholders and the public.

The objectives used to guide the development of the evaluation framework are:

- Improve mobility and travel choices
- Provide high quality BRT service
- Minimize impacts to vehicular travel
- Provide cost effective multimodal investments

The differentiating raw data from the technical analysis was translated into relative ratings indicating how well each multimodal scenario addressed the objectives identified. These ratings along with key information was included on “report cards” for each scenario and served to aid in the outward communication to the public and stakeholders describing the relative performance of each multimodal scenario. Reviewing the relative performance of the scenarios helped enable the public and stakeholders in understanding the tradeoffs between the scenarios, identifying how well each scenario meets the objectives and develop consensus around key elements of the scenarios for advancement.

OBJECTIVE: IMPROVE MOBILITY AND TRAVEL CHOICES

MODE	METRIC	INDICATOR	EVALUATION METHODOLOGY	DATA SOURCE
BUS RAPID TRANSIT	Access to employment	Number of jobs	Calculate total number of jobs (from year 2013) within 1/4 mile radius of assumed BRT stations.	2013 Triangle Regional Model (TRM) Traffic Analysis Zones (TAZs)
	Proximity to population	Total Population	Calculate total population (from year 2013) within 1/4 mile radius of assumed BRT stations.	2013 TRM TAZs
	Access to employment	Number of jobs	Calculate total number of jobs (for year 2045) within 1/4 mile radius of assumed BRT stations.	2045 TRM TAZs
	Proximity to population	Total Population	Calculate total population (for year 2045) within 1/4 mile radius of assumed BRT stations.	2045 TRM TAZs
	Access to community services	Number of community service facilities	Calculate number of community service facilities (City Hall, public library, County Courthouse, etc.) within 1/4 mile of assumed BRT stations.	Community service facilities will be identified in coordination with the City of Raleigh
	Access to community affordable housing	Number of affordable housing units	Calculate number of affordable housing units within 1/4 mile of assumed BRT stations.	Affordable housing units will be identified in coordination with the City of Raleigh using the FTA definition of affordable housing
	Access to recreation and entertainment	Number of recreation and entertainment facilities	Calculate total number of recreation and entertainment facilities within 1/4 mile radius of assumed BRT stations.	List of recreation and entertainment facilities will be developed in coordination with Downtown Raleigh Alliance (DRA)
BICYCLE	Access via bicycle network	Miles of Tier 1 Bicycle Infrastructure (Tier 1 defined as cycle track, multi-use path or urban trail)	Calculate total miles of Tier 1 bicycle infrastructure within study area.	Proposed Multimodal Scenarios
	Access via bicycle network	Miles of Tier 2 Bicycle Infrastructure (Tier 2 defined as buffered bicycle lanes and bikeways)	Calculate total miles of Tier 2 bicycle infrastructure within study area.	Proposed Multimodal Scenarios

OBJECTIVE: PROVIDE HIGH QUALITY BRT SERVICE

MODE	METRIC	INDICATOR	EVALUATION METHODOLOGY	DATA SOURCE
BUS RAPID TRANSIT	Travel Time	Transit travel time improvement	Calculate anticipated travel time from common end points for each BRT corridor within the study area. Compare this to estimated travel time for existing local bus in mixed traffic.	Proposed Multimodal Scenarios and existing GoRaleigh bus operations performance data
	Travel Time	Customer travel time	Calculate amount of time it takes the customer to reach GoRaleigh Station and Raleigh Union Station from common end points for each BRT corridor.	Proposed Multimodal Scenarios
	Transit Hub Connections	Total number of transit hub connections	Calculate number of connections to existing GoRaleigh and Raleigh Union Stations as well as future Raleigh Union Station Bus hub.	Proposed Multimodal Scenarios
	Customer Experience	Walking distance between directions	Calculate distance between travel directions for each BRT corridor. Return trips are more difficult to access with one-way alignments than two-way alignments.	Proposed Multimodal Scenarios
	Customer Experience	Number of transfers	Calculate the number of transfers required to get to GoRaleigh Station and Raleigh Union Station transit hubs.	Proposed Multimodal Scenarios

OBJECTIVE: MINIMIZE IMPACTS TO VEHICULAR TRAVEL

MODE	METRIC	INDICATOR	EVALUATION METHODOLOGY	DATA SOURCE
MOTORIZED VEHICLES	Queuing	Acceptable or not acceptable queue impacts	Analyze queues to determine if any alternatives result in significant spillback or grid lock. Vehicular queues and delay will be provided for the weekday AM and PM peak hours (60 minutes)	Synchro/SimTraffic analysis
	Delay	Number of intersections functioning below acceptable LOS	Calculate the number of intersections with projected LOS of E or worse.	Synchro analysis
	Delay	Total seconds of system delay	Calculate the total seconds of system delay.	Synchro analysis
	On-Street Car Storage Spaces (On-Street Parking)	Net increase or decrease in on-street car storage spaces	Calculate the total number of free and metered on-street car storage spaces to be added or removed compared to existing.	Data from 2016 parking study
	Loading	Net increase or decrease in linear feet of on-street loading zones	Calculate the total linear feet of on-street loading zones to be added or removed compared to existing.	Data from 2016 parking study

OBJECTIVE: PROVIDE COST EFFECTIVE MULTIMODAL INVESTMENTS

MODE	METRIC	INDICATOR	EVALUATION METHODOLOGY	DATA SOURCE
ALL MODES	Cost	Miles of high, medium, and low infrastructure impacts	Calculate total miles of high, medium, and low infrastructure impacts. High impact requires curb lines on both sides of the street to be moved. Medium impacts require the curb line on one side of the street to be moved. Low impacts require no curb line adjustments.	Proposed Multimodal Scenarios

4.0 Scenario Evaluation

The next step in the process was to perform the detailed technical analysis for each of the four proposed multimodal scenarios as shown in Exhibit A.9 - A.12 using the evaluation framework. The evaluation framework described in Section 3.0 includes traditional transportation indicators combined with community access indicators to offer a diverse perspective of the scenarios. This comprehensive approach ensures consideration of the effects on a variety of community interests as well as overall mobility. The performance indicators remained constant among all four scenarios. The sections that follow describe this technical evaluation process and the methodology used for analysis. The scenario evaluation process was used as a tool to inform the public, stakeholders, Advisory Committee, Technical Team, and elected officials of the benefits, impacts, and trade offs of each scenario.

4.1 BRT Station Areas

As shown in Figure 2, each of the four BRT scenarios were assigned BRT station areas at or in the vicinity of the following locations:

- GoRaleigh Station
- Raleigh Union Station
- Northern section of study area
- Southern section of study area

These station area assumptions were developed based on the concept that the proposed BRT scenarios should be routed to GoRaleigh Station and/or Raleigh Union Station to the extent possible in each scenario. It was also established that other BRT station areas should be proposed within Downtown in addition to the ones at the transit hubs. Therefore, in order to compare the scenarios equally, one additional station area was proposed on the north side of Downtown and one additional station area on the south side in each scenario. This resulted in four proposed station areas for Scenario A because the BRT is routed to both GoRaleigh Station and Raleigh Union Station, and three proposed station areas for Scenarios B, C and D. These station areas were important to the scenario evaluation process because certain performance metrics are based on proximity to these assumed BRT station areas.

FIGURE 2 — BRT STATION AREA ASSUMPTIONS

4.2 Community Access

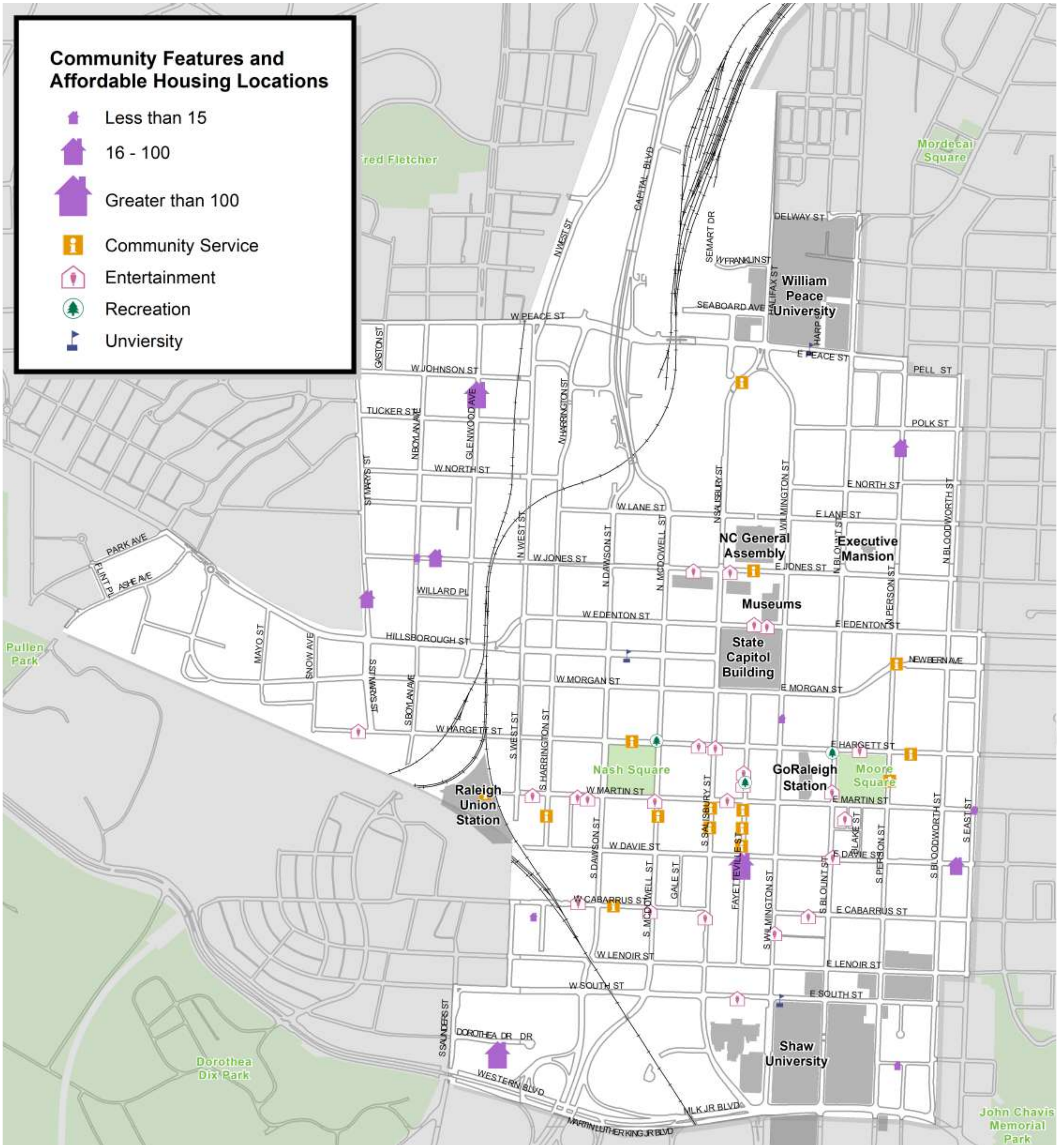
Mobility offers the community members access to education, jobs, cultural resources, recreational activities, entertainment, and more. Transit and transportation play important roles in this relationship by connecting people and providing access to these key locations. The community services, entertainment, recreation, universities and affordable housing locations shown in Figure 3 were developed in coordination with the City of Raleigh and the Downtown Raleigh Alliance (DRA) as key locations in Downtown. Affordable housing data was provided by the City of Raleigh and only identifies the approximate location and number of affordable housing units.

ArcGIS Network Analyst is a service area tool which helps evaluate accessibility and delineate 'travel sheds' for vehicles, bicycles, and pedestrians. The service area tool models which networks (bike or roads) can be reached within a given distance and under defined restrictions. This tool was used to determine the walkable routes within a quarter-mile distance from the center of the assumed BRT station area locations. The area encompassed by these walkable routes is also known as a walkshed. The number of community resources, entertainment/recreation locations and universities within each walkshed was calculated and the totals were determined for each scenario and the results are shown below in Table 3.

TABLE 3 — COMMUNITY ACCESS LOCATIONS WITHIN A 1/4-MILE OF ASSUMED BRT STATION AREAS

Indicator	Scenario			
	A	B	C	D
Community Service Facilities	12	10	9	9
Affordable Housing Units	457	156	0	156
Recreation and Entertainment facilities	26	22	20	21
Total	**495**	**188**	**29**	**186**

FIGURE 3 — COMMUNITY FEATURES AND AFFORDABLE HOUSING LOCATIONS



4.3 Population and Employment Access

The 2013 Triangle Regional Model Version 6 (TRM v6) Traffic Analysis Zones (TAZ) data was used for the population and employment analysis. The TRM v6 is the latest update to the model and includes estimated 2013 and forecasted 2045 population and employment data. For this scenario evaluation the 2013 data was established as the existing condition and the 2045 data as the future condition. Figure 6 shows the 2013 and 2045 population density data from the TRM v6 for Downtown Raleigh. For this analysis the total population and total number of jobs within 1/4-mile walksheds of the assumed BRT station areas were calculated for each scenario. The results of the population and employment analysis are shown in Figure 4 and Figure 5 below. Taking a closer look at employment hubs within the community allows for a better understanding of opportunities for multimodal connections, specifically BRT routes and stations.

FIGURE 4 — 2013 AND 2045 EMPLOYMENT ACCESS BY SCENARIO

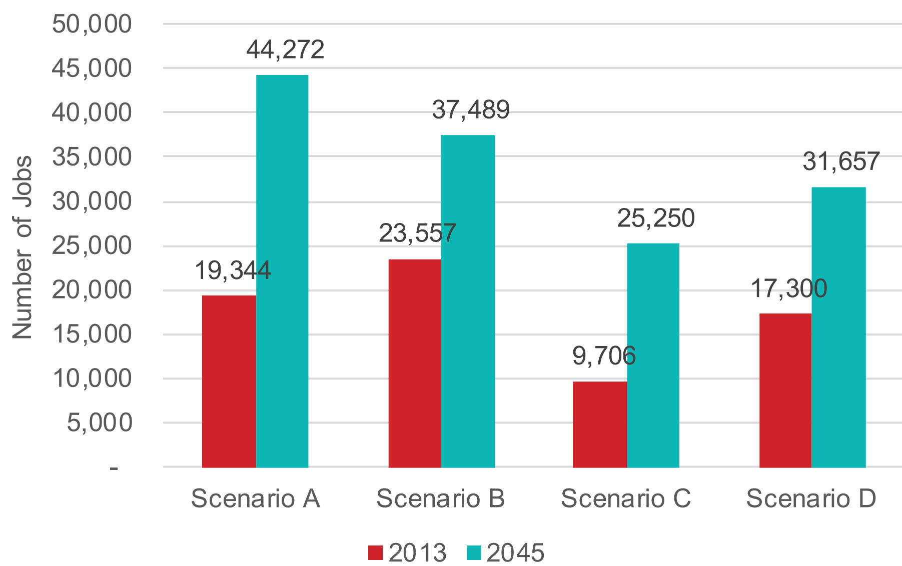


FIGURE 5 — 2013 AND 2045 POPULATION ACCESS BY SCENARIO

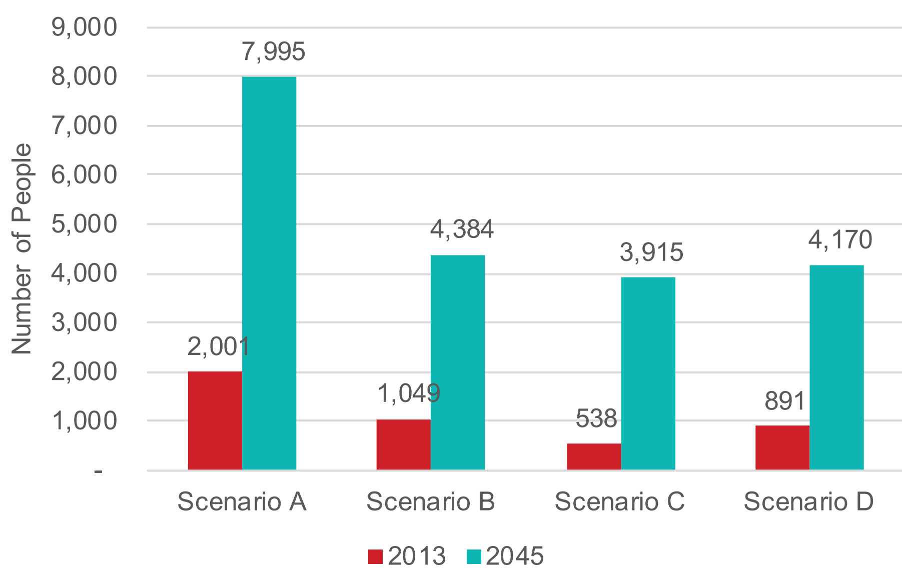
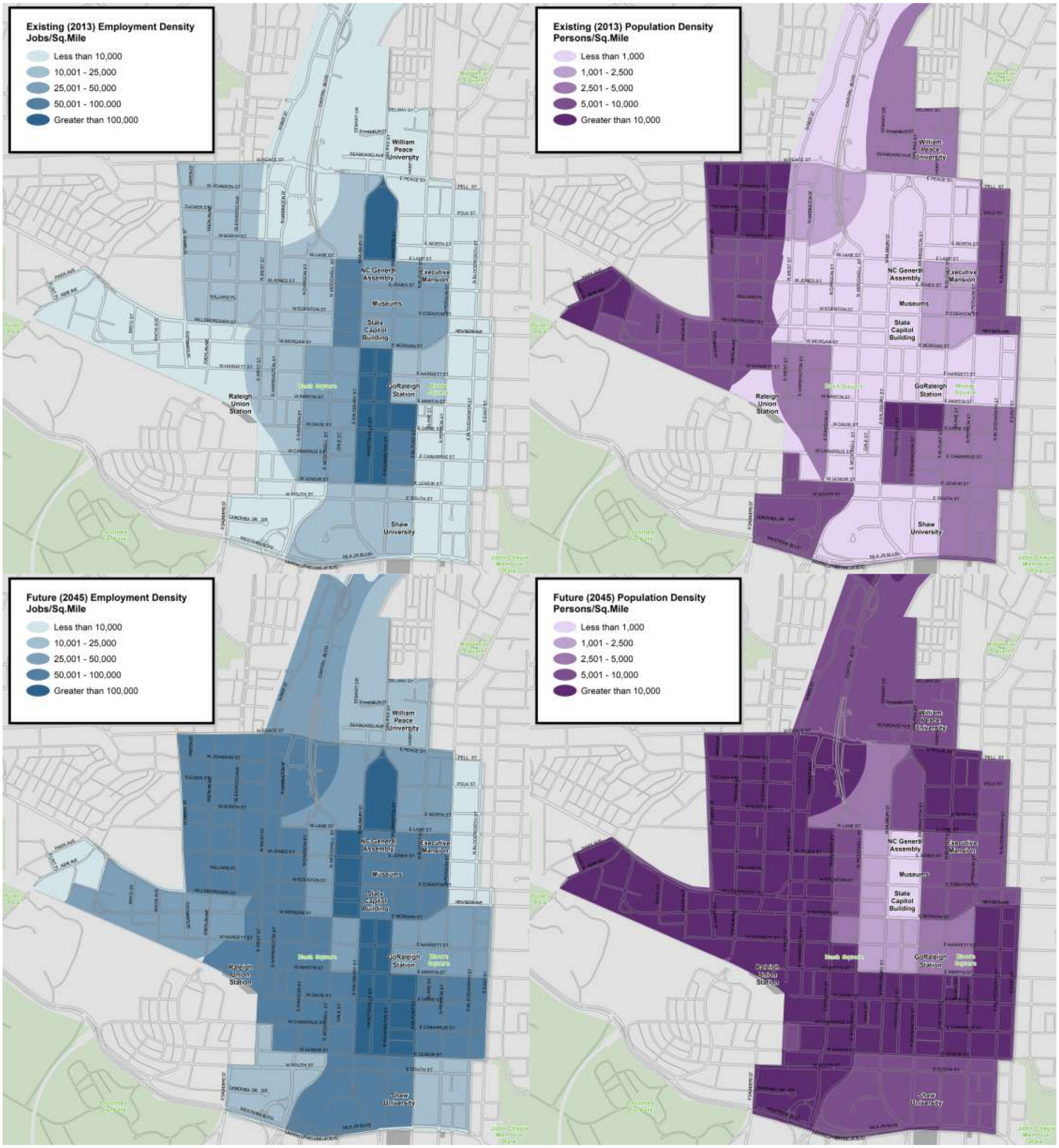


FIGURE 6 — EXISTING (2013) AND FUTURE (2045) EMPLOYMENT AND POPULATION



4.4 Bicycle Access

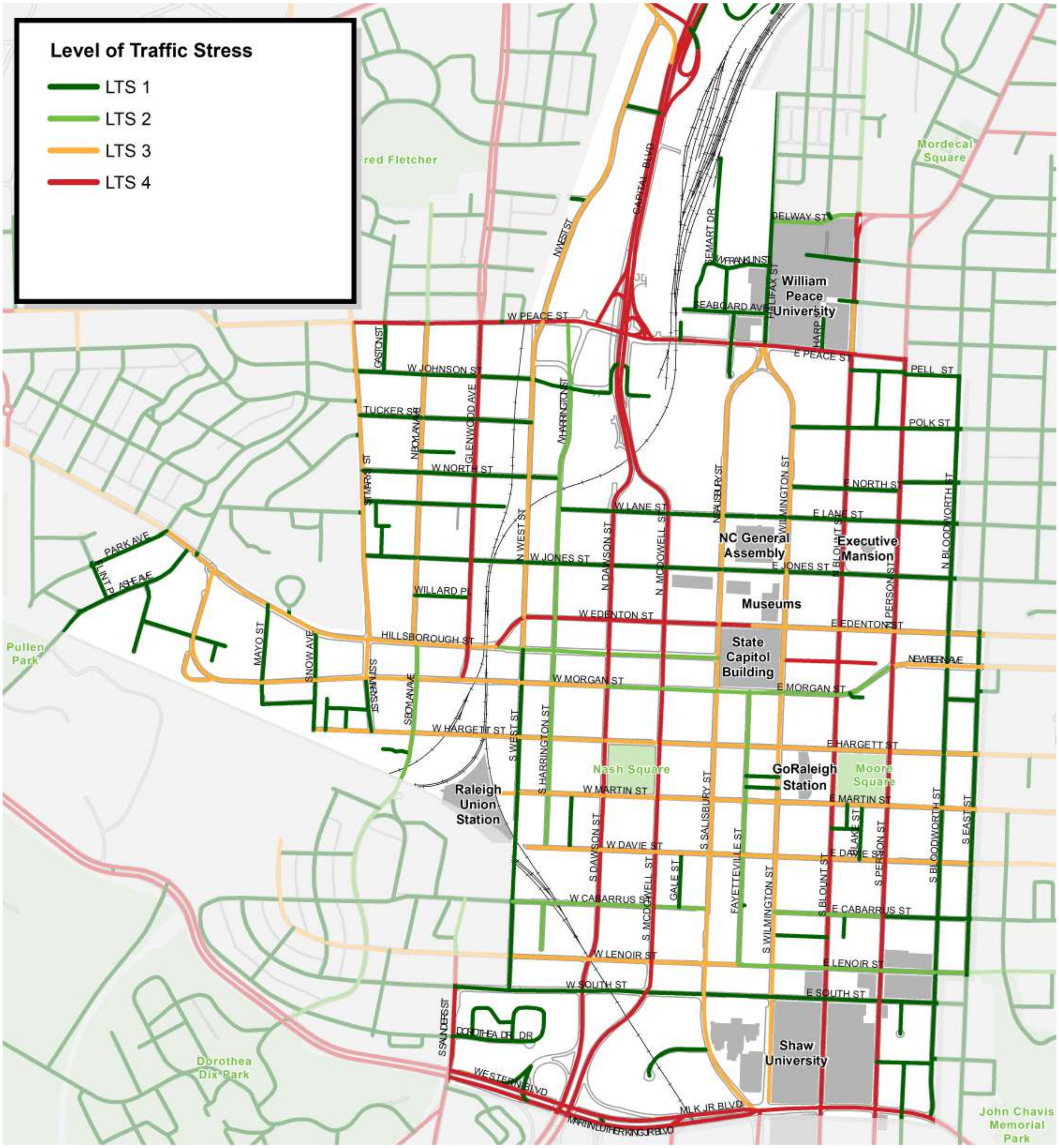
4.4.1 Level of Traffic Stress

Level of Traffic Stress (LTS), Low Stress Island (LSI) and bike shed analyses were used to evaluate the bicycle networks for each scenario. These evaluation tools help understand the mobility and access provided for bicycles within Downtown for each of the scenarios. An LTS analysis is intended to measure the level of stress or discomfort a bicyclist will feel on a facility or street based on the traffic intensity and characteristics of the facility. Historically, LTS has been substantially based on speed limit and traffic volumes. The previous LTS scores included in the 2016 BikeRaleigh Plan indicated that many streets within Downtown were LTS 1 due to posted speed limits of 25 mph and traffic volumes below 8,000 - 10,000 average vehicles per day. However, these same facilities, in practice, are not ones that people of all ages and abilities are comfortable bicycling. Therefore, a refined LTS methodology was applied to update the scores for Downtown Raleigh to include the unique challenges that Downtown presents. The updated bicycle LTS methodology used for this analysis assigns classifications to roadway segments based on the effects that traffic-based stress has on bicycle riders. This measure of traffic stress quantifies the perceived safety issue of being in close proximity to vehicles. The methodology does not include explicit consideration of traffic volumes as the proximity stress is present regardless of how much traffic happens to be occurring at that time. This methodology defines the four LTS classifications as:

- LTS 1 – Represents little traffic stress and requires less attention, so is suitable for all cyclists. This includes children that are trained to safely cross intersections alone and supervising riding parents of younger children. Generally, the age of 10 is the earliest age that children can adequately understand traffic and make safe decisions which is also the reason that many youth bike safety programs target this age level. Traffic speeds are low and there is no more than one lane in each direction. Intersections are easy to cross by children and adults. Typical locations include residential local streets and separated bike paths/cycle tracks.
- LTS 2 – Represents little traffic stress but requires more attention than young children can handle, so is suitable for teen and adult cyclists with adequate bike handling skills. Traffic speeds are slightly higher than LTS 1, but speed differentials are still low, and roadways can be up to three lanes wide (both directions combined). Intersections are not difficult to cross for most teenagers and adults. Typical locations include collector-level streets with bike lanes or a central business district.
- LTS 3 – Represents moderate stress and suitable for most observant adult cyclists. Traffic speeds are moderate but can be on roadways up to five lanes wide (both directions combined). Intersections are still perceived to be safe by most adults. Typical locations include low-speed arterials with bike lanes or moderate speed two and three-lane roadways (number of lanes is combined in both directions).
- LTS 4 – Represents high stress and suitable only for very experienced and skilled cyclists. Traffic speeds are moderate to high and can be on roadways over five lanes wide (both directions combined). Intersections can be complex, difficult to cross, wide, high volume/speed, and can be perceived as unsafe by adults. Typical locations include high-speed, multilane roadways with narrow or no bike lanes.

This methodology resulted in the updated existing LTS scores shown in Figure 7 for Downtown Raleigh.

FIGURE 7 — EXISTING LEVEL OF TRAFFIC STRESS



4.4.2 Low Stress Island Analysis

Based on the results from the LTS analysis, low stress “islands” were identified for each scenario. A low stress island encompasses streets with an LTS score of either 1 or 2, which are areas the general population is comfortable riding a bike for a continuous trip. Low stress islands are defined assuming that interested but concerned riders will ride on streets that produce low stress to the rider. These may be low speed residential streets or streets where low stress bike facilities have been implemented. The presence of a bicycle facility does not assume a low stress experience. Only bike facilities that are appropriate for the traffic volumes and speed of the road are considered low stress. Once these riders encounter a high stress street they will likely feel unsafe. Therefore, these bicyclists are typically only willing to ride within the island. Figure 8 provides a map of the existing low stress islands in Downtown Raleigh. The goal of network planning is to “unlock” these islands by connecting them via high quality, low stress bicycle facilities. These islands were used to determine the areas of influence for each scenario.

Scenario A

The speed limits and traffic volumes on Hillsborough, Morgan, Edenton, Salisbury and Person Streets exceed thresholds that would allow a buffered bike lane to be considered “low stress” or suitable for the general population. Due to these conditions, it is recommended to choose one of these streets to provide a separated bicycle connection east-west and one to provide a two-way separated bicycle connection north-south. Separated bicycle facilities as such will be protected by a buffer and vertical element, such as parking or bollards. Hillsborough Street already has a buffered bike lane on portions of it that could be upgraded to a separated bike lane. Upgrading the existing bike lane to a Tier 1 facility would involve moving the existing bike lane next to the curb, narrowing the travel lanes to add a 1-foot to 2-foot buffer and then creating a parking protected or barrier protected bike lane. Salisbury Street already has a bike lane and low enough traffic volumes that a one-way separated bike lane may be feasible with a lane diet (reducing the width of the travel lanes). Therefore, the proposed separated bike lane on Hillsborough has been extended to Salisbury Street to connect the two facilities. These two facilities would create a higher area of influence than providing multiple buffered bike lanes. Also, Lane Street has an opportunity to connect multiple islands within the northeast corner of Downtown. Additionally, Lenoir Street is a key part of the Art to Heart Corridor and connects the Chavis Way greenway on the east side of Downtown with the Dix Park and Rocky Branch Trail on the west side of Downtown. A facility on Lenoir Street could also serve as part of the East Coast Greenway (ECG) that traverses Downtown Raleigh. The wide sidewalks along Lenoir Street west of Fayetteville Street present an opportunity to incorporate an iconic urban trail through the southern side of Downtown.

Scenario B

Similar to Scenario A, prioritizing Hillsborough and Person Streets to serve as separated facilities adds connectivity value. In scenario B bicyclists can travel across Downtown Raleigh on the separated bike lanes via Hillsborough Street, Salisbury Street, Martin Street, and Person Street as these are identified for Tier 1 facilities. Similar to Scenario A, the wide sidewalks along Lenoir Street west of Fayetteville Street present an opportunity to incorporate an iconic urban trail through the southern side of Downtown.

Scenario C

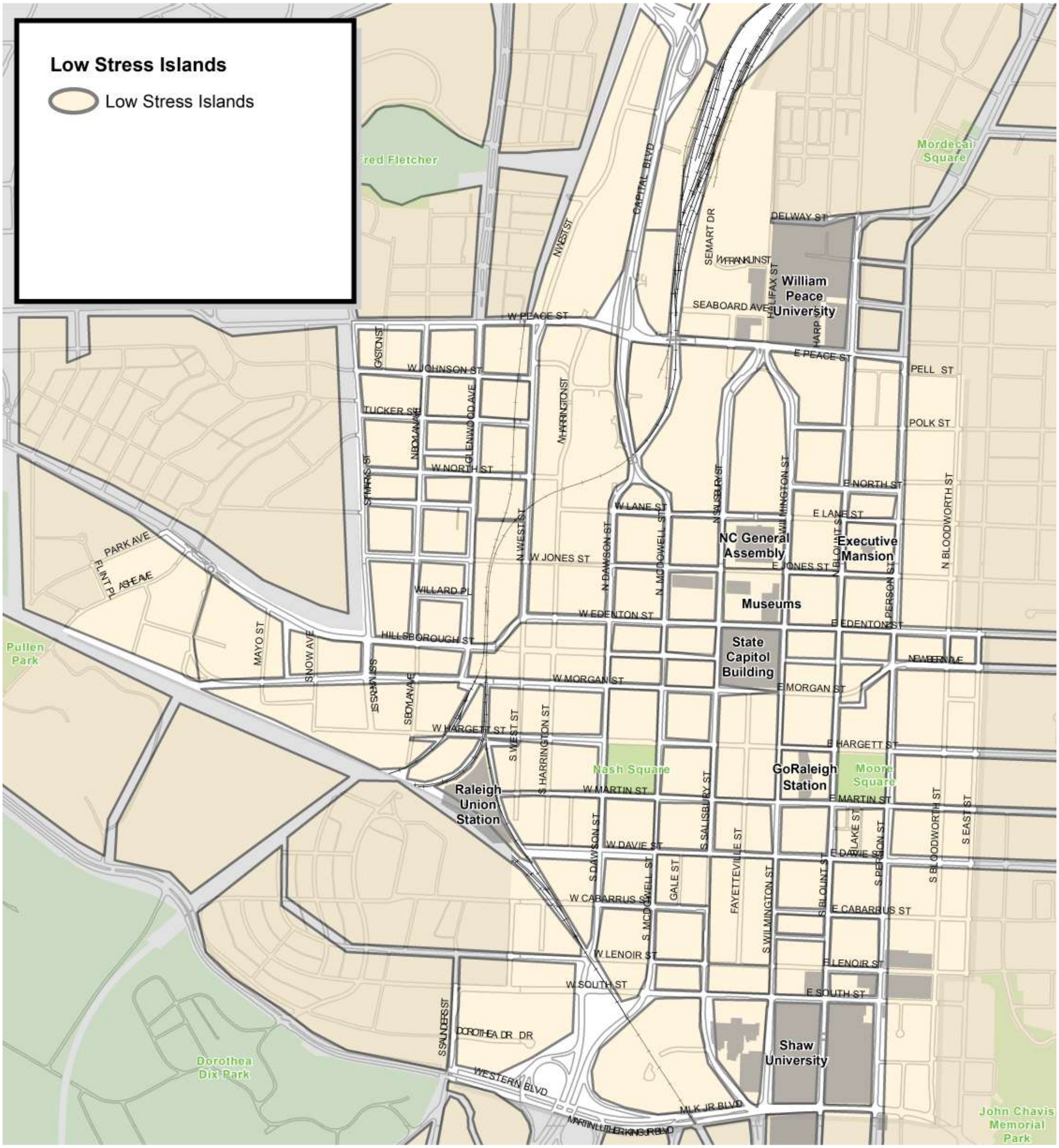
Like Scenario A, prioritizing Hillsborough, Wilmington and Salisbury Streets to serve as separated, Tier 1 facilities adds connectivity value. In Scenario C, Salisbury and Wilmington Streets are prioritized out of the four north-south corridors to be upgraded to Tier 1 facilities. In this scenario, the maximum value of a Tier 1 facility on Salisbury Street comes with adding a buffered bike lane (Tier 2) on Morgan Street and a separated bike lane (Tier 1) on Martin Street. This allows cyclists to have continuous low stress connections through Downtown. Lenoir Street is also identified as a Tier 1 facility and is a candidate for an urban trail connection for the reasons identified in Scenario A.

Scenario D

Similar to Scenario B, prioritizing Hillsborough, Salisbury and Person Streets to serve as separated, Tier 1 facilities adds connectivity value. In Scenario D, Salisbury Street and Person Street are prioritized out of the four proposed north-south buffered bike lanes to be upgraded to a separated bike lane (Tier 1). In this scenario, the maximum value of a two-way separated bike lane on Person Street comes with adding separated, Tier 1 bike lanes to Jones Street and Martin Street. This allows anyone traveling to or from southeast Raleigh to have a continuous low stress connection through Downtown. Salisbury Street being one-way makes it difficult to travel north from the center of Downtown without out-of-direction travel to Person Street or West Street. The distance between Salisbury Street and Person Street also leaves a few islands isolated from the network. Lenoir Street is also identified as a Tier 1 facility and is a candidate for an urban trail connection for the reasons identified in Scenario A. Lenoir Street is a candidate for an urban trail connection for the reasons identified in Scenario A.

The existing low stress islands are shown in Figure 8 and the low stress island analysis for each of the four scenarios are shown in Exhibits A.41-A.44.

FIGURE 8 — LOW STRESS ISLANDS



4.4.3 Bike Shed Analysis

The next step in the bicycle network analysis was the bike shed analysis. One objective of this analysis was to understand how the proposed bicycle network would support and connect to the proposed BRT system. This analysis shows whether the BRT stations are accessible by bike based on the bike shed analysis and connecting bike network. Using the ArcGIS Network Analyst tool, a bike shed analysis was conducted for each of the four scenarios using the following parameters:

- The travel paths were developed by identifying the low stress islands that were accessible within a half-mile when traveling away from the proposed BRT stations.
- Only low stress streets were considered in the bike sheds. If the travel path included traveling along a high stress street, the path ended. A street was only considered low stress when:
    - The street had an existing score of LTS 1 or 2,
    - If the street had a separated bike lane, greenway or trail (Tier 1 facility) proposed,
    - If the street was previously an LTS 1 or 2 and had a bike lane or bikeway proposed on the segment.

The total miles of Tier 1 and Tier 2 bicycle facilities proposed are shown in Table 4.

Scenario A

Most of the proposed BRT station areas for Scenario A are adjacent to low stress facilities which maximizes the amount of accessible area. The proposed Tier 1 facilities on Harrington Street, Hillsborough Street and Lenoir Street create a good spine to the network from the stations on West Street. The high stress nature of Dawson Street, McDowell Street and Glenwood Avenue present barriers to the Tier 2 facility proposed on Jones Street. Jones Street will provide minimal east-west connection on the north side of Downtown without specific intersection mitigations where Jones crosses these high stress streets.

Scenario B

Scenario B results in the most limited bike shed of the four scenarios. This is largely due to the BRT station areas on the north side of Downtown located on Peace Street, which is not accessible comfortably by bikes. The BRT station areas that are accessible by bike are concentrated in the southeast corner of the Downtown area. Also, to travel north, many of the trips would travel along Martin Street or Hargett Street to Person Street. This detour hinders the ability for a bicyclist to travel north from these stations areas along the most direct route, which would be along Wilmington Street and Salisbury Street. Finally, the immediate access to the Tier 1 facility on Martin Street creates strong east-west coverage through the middle of the Downtown area and to Raleigh Union Station.

Scenario C

In scenario C, the Tier 1 facility proposed on West Street provides connectivity from the BRT station area on Capital Boulevard to the parcels between West Street and Glenwood Avenue. Also, the Tier 1 facility proposed on Jones Street allows high stress streets such as McDowell Street and Dawson Street to be traversed in the north part of Downtown. However, bicycle access to the northeast section of Downtown from the BRT station areas are limited by the Tier 2 facilities proposed on the one block of Jones Street between Salisbury Street and Wilmington Street and the one block of Salisbury Street between Jones Street and Lane Street.

Scenario D

In scenario D, the BRT station area on Capital Boulevard is connected to the Harrington Street Tier 1 facility via Johnston Street. While this provides connectivity to the northwest portion of Downtown, the indirect connection limits what is accessible to the south within a half-mile of the station area. The BRT station areas in the southeast of Downtown have direct access to an east-west bicycle facility and/or a low stress street on Martin Street and Hargett Street. This allows much of the core of Downtown to be accessible by bike from the station areas. However, the bicycle connections on the north-south streets are much more limited, as Person Street is the closest Tier 1 north-south route to the BRT station areas on Martin Street and Hargett Street. This network creates a detour of up to 8 blocks for bicyclists trying to access destinations directly north of the BRT stations along Martin Street, Hargett Street and South Street. Also, the one-way facility on Salisbury Street limits a bicyclists ability to travel towards the northwest without out-of-direction travel.

TABLE 4 — TOTAL MILES OF TIER 1 AND TIER 2 BICYCLE FACILITIES BY SCENARIO

Indicator	Scenario			
	A	B	C	D
Miles of Tier 1 Bicycle Facilities	9.63 Mi	9.12 Mi	10.38 Mi	9.27 Mi
Miles of Tier 2 Bicycle Facilities	6.49 Mi	4.59 Mi	5.84 Mi	5.04 Mi

4.5 BRT and Customer Travel Time

BRT travel times are an important metric that can be used to understand how quickly riders will be able to travel to and through Downtown Raleigh. For this evaluation BRT travel times were calculated for the evening (PM) peak period, which is considered the worst-case scenario for operations.

4.5.1 Travel Time Methodology

The travel times were estimated using a spreadsheet model that accounts for three main components of BRT travel time:

- Time in motion
- Intersection delay
- Station dwell

Time in Motion

Time in motion covers the time the bus is traveling with the doors closed, including acceleration, cruising speed, and deceleration. For this project we used a constant acceleration rate of 1.5 miles per hour per second (mphps) from 0 to 25 mph was used and a rate of 1.0 mphps was used from 25 to 55 mph. The bus deceleration rate is a constant 2.0 mphps for all speeds.

BRT vehicles were assumed to stay within the posted speed limit on each corridor and have no congestion in places with bus lanes. Bus lanes were assumed for the entirety of each BRT corridor.

Intersection Delay

Intersection delay measures the amount of time a BRT vehicle will be stopped at a signalized intersection. Typically, this is calculated as an average delay per intersection. However, a different methodology was used for this study due to the number of corridors in Downtown Raleigh that employ traffic signal progression. Progression means that all the delay accrues at a single location, with the vehicle receiving green times at downstream intersections. To that end, three distinct signal types were created in the travel time model:

- Always red: 50 seconds of delay[1]
- Always green: 0 seconds of delay
- Random arrival: Average intersection delay based on cycle time [2]

When a BRT vehicle enters Downtown via a corridor with progression it will get stopped at an always red signal and then proceed to get green signals at the downstream intersections. Because the BRT will also stop at stations, the random arrival delay was used for any intersection downstream of a station. The random arrival was also used for any corridor that is not part of the Downtown progression. For example, West Street was assumed to have new traffic signals at certain locations. These were assumed to have a random delay assigned because it is unlikely that progression will occur on this corridor. Table 5 details the progression characteristics of the main BRT corridors in Downtown Raleigh.

TABLE 5 — CORRIDOR PROGRESSION CHARACTERISTICS IN DOWNTOWN RALEIGH

Corridor	Cycle (seconds)	Green Time to Cycle Time (g/C)	Progression
Wilmington	100s	0.55	y
Blount	100s	0.55	y
Edenton	100s	0.50	n
Morgan/New Bern	100s	0.50	n
Dawson	100s	0.70	y
McDowell	100s	0.70	y
Martin	100s	0.30	n
West	100s	0.50	n

In general, it was assumed that BRT progression would be dependent on the existing signal timings and progression within the Downtown grid. No Transit Signal Priority (TSP) was assumed along these routes for the sake of comparing alternatives. It should be noted that in a Downtown grid setting the potential impact of a transit vehicle actuation via TSP on progression for other high-volume corridors intersecting those BRT routes will need to be taken into account when determining if TSP should be used within Downtown.

Station Dwell

Dwell time refers to the amount of time a transit vehicle stops at any given transit station or stop to allow passengers to board and alight. It is assumed that for each scenario the BRT vehicles will stop at the center of the assumed station areas. It is assumed that dwell times will be the highest at

1 Based on green time to cycle time (g/C) ratio of 0.5 and a 100 second cycle time

2 In this case average delay ssumes a 50% chance of a red light and a normal distribution of delay within the red time cycle. This results in an average delay that is 1/4 of the cycle time.

GoRaleigh Station because that is where the majority of the transfers occur and where most of the bus routes currently travel to in Downtown. Based on the existing level of activity at GoRaleigh Station it is assumed that the BRT vehicles will need to dwell here longer to allow more passengers to board and alight than at other stations. The future Raleigh Union Station Bus Facility is also anticipated to have more passenger activity and transfers than the other BRT stations in Downtown. Therefore, the dwell time was increased at Raleigh Union Station Bus Station, although not as much as at GoRaleigh Station. The dwell time for all other BRT stations in Downtown is based on other similar BRT systems in similar settings nationally. The dwell times assumed for this analysis are:

- GoRaleigh Station: 50 seconds of dwell
- Raleigh Union Station Bus Facility: 35 seconds of dwell
- All other Downtown BRT stations: 20 seconds of dwell

4.5.2 BRT End to End Travel Time

End to end travel time is important to understand the overall impact that each scenario alignment has on proposed BRT operations. These numbers are useful to understand BRT mobility, that is, how fast can riders travel through Downtown on each scenario without disembarking the vehicle.

Table 6 shows the end to end travel times for each direction and each scenario under consideration. These travel times represent the time it would take a rider traveling on a BRT vehicle from one side of the study area to another without disembarking. The following trip pairs are presented in the table:

- Northbound: From MLK Blvd/McDowell Street to Peace Street/Capital Blvd
- Southbound: From Peace Street/Capital Blvd to MLK Blvd/McDowell Street
- Eastbound: From Western Blvd/S. Saunders Street to New Bern Avenue/East Street
- Westbound: From Edenton Street/East Street to Western Blvd/S. Saunders Street

TABLE 6 — ESTIMATED BRT VEHICLE TRAVEL TIMES (END TO END)*

Direction	Scenario			
	A	B	C	D
Northbound	13.0 min	10.5 min	6.5 min	11.5 min
Southbound	17.5 min	13.5 min	7.0 min	13.5 min
Eastbound	12.5 min	8.0 min	9.0 min	8.0 min
Westbound	12.0 min	10.0 min	8.5 min	10.0 min
Totals	**55.0 min**	**42.0 min**	**31.0 min**	**43.0 min**

*Note that travel times rounded to the nearest half minute.

At this phase of BRT planning, there are many variables in the planned BRT operations which have yet to be determined. These factors include dwell times, layovers, headways, travel speeds, station locations, number of stations and many other factors. These variables increase the uncertainty of the estimated travel times provided; however, operational assumptions were made based on characteristics of similar BRT systems in order to provide a comparison between the scenarios. Exclusive BRT lanes were assumed in the entirety of each BRT corridor and traffic signals did not include transit signal priority (TSP) for this analysis. BRT station locations were assumed as described in Section 4.1. These travel times can be more accurately estimated once details are determined regarding the proposed BRT corridors and operations for each in later phases of design.

Table 6 shows that Scenario C has the shortest total end to end travel time. In Scenario C the BRT travels on Dawson and McDowell Streets which are high speed corridors with good traffic signal progression. Scenarios B and D have virtually the same travel times, which is logical since both use Wilmington and Blount Streets for long stretches and have similar BRT travel distances.

Scenario A has the longest travel time because it operates on West and Martin streets, each of which are slower than north-south counterparts in other scenarios. In addition, neither street currently benefits from traffic signal progression and, in the case of travel on Martin Street, there is actually a disadvantage with signal progression wherein Martin Street loses green time to the north-south pairs it crosses in Downtown.

4.5.3 Customer Travel Time

Customer travel time includes the transit rider's time on the BRT vehicle as well as the rider's transfer time, time on the proposed circulator and walking time as needed to specific destinations. The customer travel times are useful to understand BRT accessibility, that is, how quickly can riders access these two desired destinations in Downtown in each scenario. The destinations chosen in Downtown for these calculations are GoRaleigh Station and Raleigh Union Station. The calculations were done from the following common starting points where the proposed BRT routes enter the Downtown study area:

- From the west the start point is Western Boulevard at South Saunders Street
- From the east the start point is Edenton Street at East Street
- From the north the start point is Capital Boulevard at Peace Street
- From the south the start point is Martin Luther King Jr. Boulevard at McDowell Street

Because not every scenario directly serves each station, walk times or transit transfer times were also added into the customer time calculation. The walk time was calculated as the distance from the nearest BRT station to either destination. A walk speed of 5 minutes per ¼ mile was used. The transit transfer time to the circulator assumes a wait time of 5 minutes (approximately half the proposed 10-minute frequency for the circulator), along with a circulator travel speed of 12 mph to reach either of the Downtown stations.

Table 7 shows the estimated customer travel times from each direction to GoRaleigh Station. As the table shows, scenarios B and D are the fastest overall. Each of these benefits from operating on Wilmington and Blount Streets, which have progression that minimizes delay. Scenario A is slower by using Martin Street, which has a slow operating speed through Downtown. Scenario C has the fastest in-vehicle travel times but is slower overall due to the walk time or transfer and circulator time required to actually access GoRaleigh Station.

Table 8 shows the estimated customer travel times from each direction to Raleigh Union Station. In this analysis Scenario A is the fastest, while Scenario C is second fastest. Scenarios B and D have the longest customer travel times because riders must ride to GoRaleigh Station and then walk or transfer to the circulator to travel across Downtown to Raleigh Union Station.

TABLE 7 — ESTIMATED CUSTOMER TRAVEL TIME TO GORALEIGH STATION

	Scenario			
	A	B	C	D
Western Boulevard at South Saunders Street to GoRaleigh Station				
BRT travel time	8.2 min	4.4 min	4.0 min	4.4 min
Walk travel time	-	-	5.0 min	-
Circulator wait time	-	-	5.0 min	-
Circulator travel time	-	-	1.3 min	-
Total with walk	N/A	N/A	9.0 min	N/A
Total with circulator	N/A	N/A	10.3 min	N/A
Capital Boulevard at Peace Street to GoRaleigh Station				
BRT travel time	8.5 min	6.4 min	2.8 min	7.6 min
Walk travel time	-	-	5.0 min	-
Circulator wait time	-	-	5.0 min	-
Circulator travel time	-	-	1.8 min	-
Total with walk	N/A	N/A	7.8 min	N/A
Total with circulator	N/A	N/A	9.6 min	N/A
Martin Luther King Jr. Boulevard at McDowell Street to GoRaleigh Station				
BRT travel time	3.4 min	3.4 min	3.5 min	3.4 min
Walk travel time	-	-	5.0 min	-
Circulator wait time	-	-	5.0 min	-
Circulator travel time	-	-	1.3 min	-
Total with walk	N/A	N/A	8.5 min	N/A
Total with circulator	N/A	N/A	9.8 min	N/A
Edenton Street at East Street to GoRaleigh Station				
BRT travel time	2.9 min	2.5 min	5.7 min	2.5 min
Walk travel time	-	-	5.0 min	-
Circulator wait time	-	-	5.0 min	-
Circulator travel time	-	-	1.8 min	-
Total with walk	N/A	N/A	10.7 min	N/A
Total with circulator	N/A	N/A	12.5 min	N/A
Combined Total Shortest Travel Times:	**23.0 min**	**16.7 min**	**36.0 min**	**17.9 min**

TABLE 8 — ESTIMATED CUSTOMER TRAVEL TIME TO RALEIGH UNION STATION BUS FACILITY

	Scenario			
	A	B	C	D
Western Boulevard at South Saunders Street to Raleigh Union Station				
BRT travel time	4.5 min	4.4 min	4.0 min	4.4 min
Walk travel time	-	10.0 min	5.0 min	10.0 min
Circulator wait time	-	5.0 min	5.0 min	5.0 min
Circulator travel time	-	2.6 min	1.3 min	2.6 min
Total with walk	N/A	14.4 min	9.0 min	14.4 min
Total with circulator	N/A	12.0 min	10.3 min	12.0 min
Capital Boulevard at East Street to Raleigh Union Station				
BRT travel time	4.8 min	6.4 min	2.8 min	7.6 min
Walk travel time	-	10.0 min	5.0 min	10 min
Circulator wait time	-	5.0 min	5.0 min	5 min
Circulator travel time	-	2.6 min	0.9 min	2.6 min
Total with walk	N/A	16.4 min	7.8 min	17.6 min
Total with circulator	N/A	14.0 min	8.7 min	15.2 min
Martin Luther King Jr. Boulevard at McDowell Street to Raleigh Union Station				
BRT travel time	6.9 min	3.4 min	3.5 min	3.4 min
Walk travel time	-	10.0 min	5.0 min	10.0 min
Circulator wait time	-	5.0 min	5.0 min	5.0 min
Circulator travel time	-	2.6 min	1.3 min	2.6 min
Total with walk	N/A	13.4 min	8.5 min	13.4 min
Total with circulator	N/A	11.0 min	9.8 min	11.0 min
Edenton Street at East Street to Raleigh Union Station				
BRT travel time	7.3 min	2.5 min	5.7 min	2.5 min
Walk travel time	-	10.0 min	5.0 min	10.0 min
Circulator wait time	-	5.0 min	5.0 min	5.0 min
Circulator travel time	-	2.6 min	0.9 min	2.6 min
Total with walk	N/A	12.5 min	10.7 min	12.5 min
Total with circulator	N/A	10.1 min	11.6 min	10.1 min
Combined Total Shortest Travel Times:	**23.5 min**	**47.1 min**	**36.0 min**	**48.3 min**

4.6 Traffic Capacity Analysis

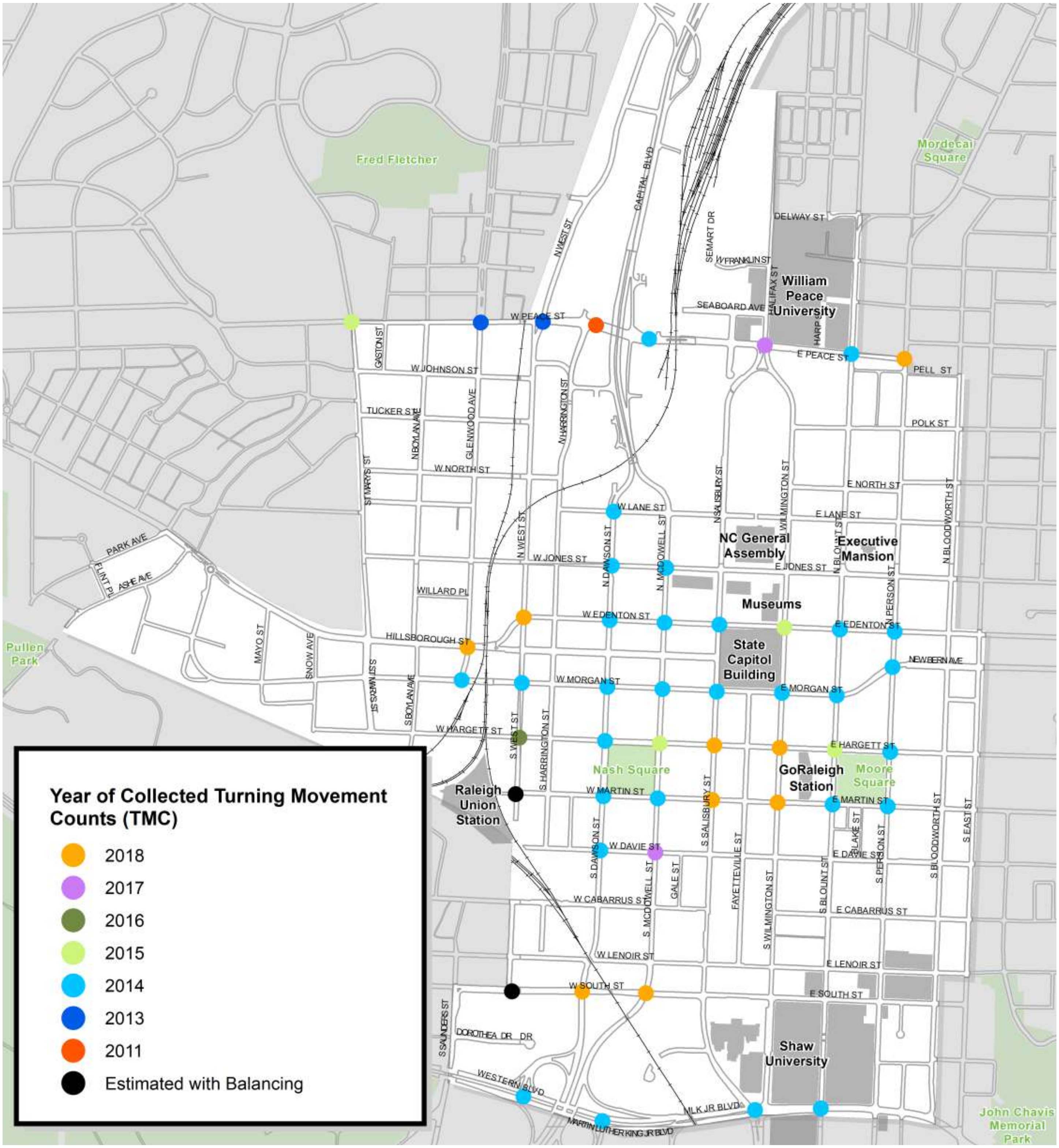
4.6.1 Traffic Capacity Analysis and Study Area

As part of the multimodal scenario evaluation, AM and PM peak hour traffic capacity analyses were performed for the existing year and future year conditions. The study area consisted of the following 50 intersections:

1. Peace Street at St. Mary's Street
2. Peace Street at Glenwood Avenue
3. Peace Street at West Street
4. Peace Street at Capital Boulevard Southbound Ramp
5. Peace Street at Capital Boulevard Northbound Ramp
6. Peace Street at Halifax Street/Salisbury Street/Wilmington Street
7. Peace Street at Blount Street
8. Peace Street at Person Street
9. Lane Street at Dawson Street
10. Jones Street at Dawson Street
11. Jones Street at McDowell Street
12. Edenton Street/Hillsborough Street at Glenwood Avenue
13. Edenton Street at West Street
14. Edenton Street at Dawson Street
15. Edenton Street at McDowell Street
16. Edenton Street at Salisbury Street
17. Edenton Street at Wilmington Street
18. Edenton Street at Blount Street
19. Edenton Street at Person Street
20. Morgan Street/New Bern Avenue at Person Street
21. Morgan Street at Blount Street
22. Morgan Street at Wilmington Street
23. Morgan Street at Salisbury Street
24. Morgan Street at McDowell Street
25. Morgan Street at Dawson Street
26. Morgan Street at West Street
27. Morgan Street at Glenwood Avenue
28. Hargett Street at West Street
29. Hargett Street at Dawson Street
30. Hargett Street at McDowell Street
31. Hargett Street at Salisbury Street
32. Hargett Street at Wilmington Street
33. Hargett Street at Blount Street
34. Hargett Street at Person Street
35. Martin Street at Person Street
36. Martin Street at Blount Street
37. Martin Street at Wilmington Street
38. Martin Street at Salisbury Street
39. Martin Street at McDowell Street
40. Martin Street at Dawson Street
41. Martin Street at West Street
42. Davie Street at Dawson Street
43. Davie Street at McDowell Street
44. South Street at McDowell Street
45. South Street at Dawson Street
46. South Street at West Street
47. Western Boulevard/Martin Luther King Jr. Boulevard at Dawson Ramps
48. Western Boulevard/Martin Luther King Jr. Boulevard at McDowell Ramps
49. Martin Luther King Jr. Boulevard at Salisbury Street/Wilmington Street
50. Martin Luther King Jr. Boulevard at Blount Street

Figure 9 shows the 50 study intersections and the dates at which turning movement counts were collected for each. The turning movement counts and data collection efforts associated with the traffic analysis are discussed further in Section 4.6.3.

FIGURE 9 — TRAFFIC ANALYSIS STUDY INTERSECTIONS AND TURNING MOVEMENT COUNT YEARS



4.6.2 Description of Analysis

Capacity analyses were performed for the base year and future year traffic conditions to determine the projected operations of the intersections within the study area. Each scenario was evaluated using the expected roadway laneage associated with the proposed multimodal improvements (including proposed bicycle and BRT infrastructure). The scenarios were evaluated based on intersection delay, intersection level-of-service (LOS), queueing and system delay. For each scenario, intersection capacity analyses for signalized and unsignalized intersections were performed for peak hour conditions using Synchro and SimTraffic software version 9.2. The analyzed scenarios are listed below:

- Future Year No Build
- Future Year Build – Multimodal Scenario A
- Future Year Build – Multimodal Scenario B
- Future Year Build – Multimodal Scenario C
- Future Year Build – Multimodal Scenario D

Level-of-service is a measure used to describe operational conditions on a roadway segment, ramp junction or at an intersection. The grades for LOS range from A as the highest through F as the lowest and are based on average vehicle delay with respect to intersections. LOS D is the typical target threshold for urban settings during the peak hours of operation. LOS E and F represent near failing and failing conditions, respectively and may occur frequently in urban conditions during peak hours. Per the *City of Raleigh Street Design Manual*, mitigation is generally required when LOS degrades from E to F. LOS values are most important at signalized intersections, since adjustments to timing and lane geometry have the potential to alleviate problems and distribute delay more evenly over all approaches. Poor LOS values at unsignalized intersections that do not warrant a signal may be more difficult to improve. The weekday AM peak hour typically falls between 7 AM and 9 AM, and the weekday PM peak hour typically falls between 4 PM and 6 PM. Table 9 lists the LOS control delay thresholds published in the *Highway Capacity Manual (HCM 2010)* for signalized and unsignalized intersections. An analysis of both the AM and PM periods was performed to capture the expected worst-case condition.

TABLE 9 — LEVEL-OF-SERVICE CONTROL DELAY THRESHOLDS

Level-of-Service	Signalized Intersections — Control Delay Per Vehicle (sec/veh)	Unsignalized Intersections — Average Control Delay (sec/veh) & Qualitative Operational Design	
A	≤ 10	≤ 10	Short Delays
B	> 10 – 20	> 10 – 15	
C	> 20 – 35	> 15 – 25	
D	> 35 – 55	> 25 – 35	Moderate Delays
E	> 55 – 80	> 35 – 50	
F	> 80	> 50	Long Delays

4.6.3 Peak Hour Volume Development

Existing vehicle and pedestrian peak hour turning movement count data for the study intersections was provided by the City of Raleigh. Some new counts were collected by the City at intersections that were identified as critical and counts from previous years were used as well at some study intersections. Based on a review of NCDOT count stations near Downtown within the last 10 to 15 years, traffic volumes have shown minimal growth in the Downtown area despite significant development in the central business district. As a result, based on a review of this data with City staff, it was determined that the use of counts from previous years would provide sufficient results for the purposes of this planning-level comparative analysis.

Figure 9 shows the 50 study intersections and the year during which turning movement counts were collected for each. Traffic volumes were adjusted to provide balanced traffic between study intersections in situations where the volumes, which often came from separate years, differed substantially and where the land uses between those intersections supported the assumption that there would be minimal mid-block traffic demand.

Future Year Volume Development

As mentioned above, historic traffic volumes have shown minimal growth in the Downtown area. Based on these trends, it was determined (in coordination with City staff) that in general, the use of existing counts would provide sufficient data for the purposes of comparing multimodal alternatives. However, to account for some known future changes in traffic patterns due to major development of the warehouse district, additional volumes were accounted for at intersections in that area.

Traffic volumes were added to several intersections in the Warehouse District to account for the addition of Raleigh Union Station and the Dillon mixed-use development as well as the proposed Raleigh Union Station Bus Facility (RUS BUS). Estimates of the expected traffic impact of these developments were based on *ITE Trip Generation (10th Edition, 2018)* methodology as well as information obtained from the RUS BUS Facility Traffic Impact Analysis (TIA) completed in December 2016. This TIA developed trip generation assumptions for all three of these development prior to the opening of Raleigh Union Station and the Dillon, using ITE Trip Generation (9th Edition, 2012). The RUS BUS TIA did not assume any reductions in trips due to use of alternative travel modes such as biking, walking or transit however these modes are expected to be a prominent mode of travel in this area. Therefore, for the purposes of the traffic analysis for the **Raleigh Downtown Transportation Plan**, the trip generation calculations were updated to reflect the latest ITE data and to assume a 10% bicycle, pedestrian, and transit reduction on trips to the site. Additional reductions were made for the retail land uses with the assumption that during the AM peak hour, many of the street-level retail uses in this area would be closed (or otherwise focused on pedestrian patronage), and therefore, the projected trip generation of these uses would be less than what would be projected for typical retail uses from ITE. For the street-level retail uses in the Dillon development, trip generation for the AM peak hour was assumed to be 50% of the trip generation projected from ITE.

4.7.4 Peace Street/Capital Boulevard Interchange Improvements

Statewide Transportation Improvement Program (STIP) project B-5121/B-5317 consists of replacing two interchanges along Capital Boulevard, one of which is in the project study area. The existing intersection of Peace Street at Capital Boulevard southbound ramp operates as an unsignalized intersection, and the adjacent intersection of Peace Street at Capital Boulevard northbound ramp operates as a signalized intersection. Project B-5121/B5317 modifies both intersections to be signalized with a new ramp configuration and phasing improvements. These proposed interchange modifications were included in the future year analysis as the multimodal alternatives were compared, and traffic volumes through the interchange were reassigned to the appropriate ramps based on the existing volumes. The proposed interchange improvements associated with TIP B-5121/B-5317 can be found in Appendix C.

4.6.5 Multimodal Scenario Modeling

To estimate the impact of the potential multimodal build scenarios, a Synchro model was created to reflect each scenario according to the preferred multimodal scenario maps (provided in the appendix) developed by the project team. In general, in developing the assumed roadway laneage for each multimodal scenario, existing general travel lanes or turn lanes were removed on a roadway segment only if parking was expected to be a priority in accommodating a proposed BRT lane or bicycle infrastructure. It was also assumed that widening of a corridor beyond the existing cross section to accommodate BRT was not a feasible option in most locations.

To model the effect of additional BRT vehicles moving through intersections, it was assumed that 25 buses/hour would travel the BRT routes in both the AM and PM peak hours. Synchro volumes and heavy vehicle percentages were adjusted accordingly for any lanes that are expected to be utilized as shared BRT/general purpose travel lanes. The majority of the BRT lanes were assumed to be outside-curb running with some exceptions. Detailed figures showing the assumed laneage used to model each multimodal scenario are provided in the appendix. At intersections where right-turn movements are expected to be allowed within a portion of BRT lanes, it was assumed that the BRT lane would accommodate approximately 100 feet of storage to allow for general purpose right-turning vehicles to use the BRT lane as a turn lane.

In some instances, exclusive BRT phases were added to signals to model the reality that BRT buses would need to make movements that would conflict with existing signal phases. It was assumed that the buses would need a 20 second split to safely travel and clear through the intersection before any opposing movements receive a green indication. In other instances, a BRT queue jump was modeled. It was assumed that the buses would need 8 seconds to safely travel through and clear the intersection before any other vehicles making the same movement would begin.

Multimodal Scenario A features a two-way BRT cross-section on Martin Street from West Street to Blount Street with only one-way (eastbound) general purpose traffic. Due to the proposed conversion of Martin Street from two-way to one-way general-purpose traffic, existing westbound traffic volumes along Martin Street were diverted to either Hargett Street or Davie Street for that scenario. For westbound through volumes, it was assumed that half of the volumes would use Hargett Street and half would use Davie Street. Northbound and southbound turns onto westbound Martin Street were diverted to the adjacent north or south intersections proportionally based on the existing turning volumes. These volume diversion assumptions as well as the assumed future traffic volumes for all multimodal scenarios can be found in the intersection spreadsheets included in the Appendix C.

4.6.6 Peak Hour Intersection Level-of-Service Analysis

Intersection analyses were performed in Synchro (Version 9.2) using methodologies prescribed in the *Highway Capacity Manual (HCM 2010)* to compute LOS and delay for each of the study intersections under the following scenarios:

- Future Year No Build
- Future Year Build – Multimodal Scenario A
- Future Year Build – Multimodal Scenario B
- Future Year Build – Multimodal Scenario C
- Future Year Build – Multimodal Scenario D

NCDOT Congestion Management Capacity Analysis Guidelines were followed (unless otherwise noted) to develop a network for the study area. Existing signal settings and timings were used (unless otherwise noted) for all scenarios. Given the compact grid of Downtown Raleigh streets, all existing signals were assumed to remain pre-timed rather than preempted through transit signal priority (TSP). Right Turn on Red (RTOR) was enabled in the signal settings at locations where RTOR is allowed today. A peak hour factor (PHF) of 0.9 was used for all movements.

Synchro queue analysis was used to evaluate the average and 95th percentile queue lengths at the study intersections. In addition, the data was transferred to SimTraffic to create a representative simulation of traffic conditions. The simulation helped to identify areas where queuing and congestion would present potential problems at the network level, as opposed to intersection performance alone, including the impact of potential laneage changes.

The following performance measures were primarily considered in determining the overall impacts for each scenario:

- Number of intersections expected to perform at LOS E or LOS F
- System-wide delay (total hours of delay)
- Queuing and delay at major street intersections with high volumes of vehicles
- Impacts on signal coordination and progression throughout key corridors

All of these measures were considered in developing the traffic impacts report card relative performance for each scenario. Table 10 provides a summary of the number of intersections expected to operate at a particular LOS by scenario. Synchro system-wide delay metrics for each multimodal scenario are presented below in Table 11. Detailed Synchro LOS reports for all 50 study intersections are provided Appendix C.

TABLE 10 — SYNCHRO INTERSECTION LEVEL-OF-SERVICE SUMMARY (PROJECTED NUMBER OF INTERSECTIONS BY LOS)

Scenario	LOS A		LOS B		LOS C		LOS D		LOS E		LOS F	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Future Year No Build	13	6	24	27	8	11	2	4	2	1	1	1
Future Year - Scenario A	13	7	19	20	9	10	3	7	2	3	4	3
Future Year - Scenario B	13	6	16	23	12	9	4	6	3	2	2	4
Future Year - Scenario C	9	3	23	21	6	10	6	7	2	5	4	4
Future Year - Scenario D	12	5	19	22	9	8	4	6	2	5	4	4

TABLE 11 — TOTAL SYSTEM-WIDE DELAY (HOURS)

Scenario	AM	PM	Total
Future Year No Build	596	757	1353
Future Year - Scenario A	950	1084	2034
Future Year - Scenario B	790	1165	1955
Future Year - Scenario C	1006	1281	2287
Future Year - Scenario D	943	1224	2167

4.6.7 Scenario Characteristics and Performance

The following sections detail the analysis results and provide general conclusions regarding the performance of each scenario.

Characteristics of Scenario A

Multimodal Scenario A proposes BRT along streets with lower traffic volumes, which in general results in reduced operational impacts in some areas. However, the proposed conversion of Martin Street from two-way to one-way for general purpose traffic requires the diversion of existing westbound traffic to adjacent streets such as Hargett Street and Davie Street, which could increase traffic on those streets up to 24%. Based on the traffic analysis, this expected diversion of traffic to adjacent streets is projected to cause very poor operations along those streets at times during the peak hours. For example, the eastbound and westbound approaches at the intersection of Davie Street at McDowell Street are projected to go from LOS D to LOS F in the PM peak as a result of the diversions.

Scenario A proposes two-way traffic for BRT vehicles along Martin Street. Based on a review of the existing signal timings that are running within the Downtown grid, it would be difficult to achieve good two-way progression for BRT vehicles along Martin Street without affecting progression on the north-south streets that Martin Street intersects.

Additionally, Scenario A proposes to use West Street and the extension of West Street as a primary BRT route. Since the study intersections did not include many intersections along West Street and since the extension is not yet constructed, the analysis was limited in analyzing movements along this corridor.

Characteristics of Scenario B

Multimodal Scenario B proposes to route BRT along streets with lower traffic volumes, which in general results in reduced operational impacts relative to the other scenarios. Based on the metrics shown in Tables 10 and 11, Scenario B is projected to result in the fewest number of intersections expected to operate at LOS E or LOS F, and it is projected to operate with the least amount of system delay relative to the other scenarios.

Scenario B proposes BRT routes along Blount Street and Wilmington Street, which based on the existing signal timings, could allow for good progression of BRT vehicles. However, the existing progression along Blount Street and Wilmington Street is not as good as the progression along Dawson Street and McDowell Street, which are proposed to be used as a part of Scenarios C and D.

Scenario B proposes to reduce the laneage for general purpose vehicles along MLK Boulevard at Salisbury/Wilmington Street, which is expected to worsen operations for an intersection that already operates poorly during the peak hours. Additionally, at the intersection of Peace Street and Salisbury/Wilmington Street, Scenario B proposes to add BRT lanes along Peace Street and a queue jump for the northbound bus movement. Note that this intersection operates with long delays at times today during the peak hours, so the addition of a queue jump and a reduction in general purpose laneage would be expected to worsen operations at that intersection.

Characteristics of Scenario C

Based on the analyses, Multimodal Scenario C is expected to result in the largest traffic impacts in terms of system delay out of all scenarios. This is due to the proposed BRT routes being located along the high-volume corridors of Dawson Street and McDowell Street thus impacting the most existing traffic. The elimination of through lanes and/or auxiliary lanes along these corridors is expected to worsen operations and result in long delays for through vehicles at times during the peak hours. Scenario C is also projected to result in the highest number of intersections (along with Scenario D) expected to operate at LOS E or LOS F. Note that because Scenario C proposes BRT routes along Dawson Street and McDowell Street, it is expected that the existing signal timings will allow for good progression of BRT vehicles in the north-south direction.

Characteristics of Scenario D

Similar to Scenario C, Multimodal Scenario D is expected to result in notable traffic impacts in terms of delay, primarily because of some BRT routes being located along the high-volume roads of Dawson Street and McDowell Street thus impacting the most existing traffic. Scenario D is expected to provide slightly improved operations over Scenario C because the BRT routes are only proposed to use a portion of Dawson and McDowell Street in Scenario D. Scenario D is projected to result in the highest number of intersections (along with Scenario C) expected to operate at LOS E or LOS F.

Note that Scenario D is projected to provide good progression for BRT vehicles along its routes, but the progression is not expected to be as good as Scenario C because Scenario D proposes more turns in the routes. Similar to Scenario B, Multimodal Scenario D proposes to reduce the laneage for general purpose vehicles along MLK Boulevard at Salisbury/Wilmington Street, which is expected to worsen operations for an intersection that already operates poorly during the peak hours.

4.6.8 Summary of Findings

In general, the analysis indicates that Multimodal Scenario B is projected to operate with the least traffic impacts based on the metrics of system delay, number of failing intersections, and based on a review of the projected delays and queuing within the Downtown grid. Scenario A is projected to result in moderate traffic impacts with most of the impacts resulting from the conversion of Martin Street to one-way eastbound for general purpose traffic. Contraflow BRT along Martin Street requires the diversion of existing westbound traffic to adjacent streets such as Hargett and Davie Street.

The traffic impacts associated with Scenario D are moderate since this scenario is proposed to affect both lower volume intersections and some major street intersections. Scenario C is expected to have the highest traffic impacts due to the reduction in general purpose lanes to accommodate BRT along major corridors. However, it is expected to provide the fastest BRT service into and out of Downtown as a result of the chosen routes. It is worth noting that a substantial amount of the traffic that uses the Dawson Street and McDowell Street corridors today is cut-through traffic that does not stop in Downtown Raleigh. Should those trips divert to alternate routes at some point in the future, it is possible that a reduction in laneage along those corridors as proposed in Scenarios C and D could have less traffic impact than is projected in this analysis.

4.7 Curbside Storage Impacts

The on-street parking and loading zone inventory was created using data from the City of Raleigh Downtown Development and Future Parking Needs Study conducted in 2016 as a baseline. The on-street parking and loading zone locations (also known as curbside storage) were confirmed in the field and using Google Maps in September 2018. Figure 12 denotes the existing on-street parking spaces and indicates which spaces are free or metered. Figure 12 also highlights the existing curbside loading zones within the study area.

To determine the impacts to existing on-street parking and loading zones of each BRT scenario, a standard cross section was assumed for the proposed BRT streets. The following assumptions were used and applied to the proposed street cross sections (shown in Figures 14, 15, 16, and 17):

- 12-foot minimum Bus Rapid Transit (BRT) lanes
- 10-foot minimum general-purpose lanes
- 8-foot minimum on-street parking/loading areas

The proposed cross sections were applied to the existing roadway widths in order to determine where on-street parking and loading zones would need to be removed to accommodate BRT. The edge of pavement linework was obtained from City of Raleigh GIS files.

Scenario A

The proposed BRT alignments are outlined in gray. In Scenario A West Street has the most curbside storage impacts due to two-way BRT being proposed on this street. The BRT cross section proposed on Martin Street requires significant modifications to the existing traffic patterns as described in Section XX of this report as well as impacts to curbside storage spaces on the south side of Martin street. The one-way pair streets, Wilmington Street, Blount Street, Morgan Street, and Edenton Street all require curbside storage impacts on the right-hand side of each street. Based on the assumed BRT cross sections, approximately 301 on-street parking spaces and 1,103 linear feet of loading zones are impacted by the proposed BRT lanes. Scenario A has the most curbside storage impacts of all the BRT scenarios.

Scenario B

The proposed BRT alignments are outlined in gray. Based on the BRT cross section proposed the curbside storage spaces are impacted on the east side Wilmington Street, the west side of Blount Street, the south side of Edenton Street and the south side of Morgan Street. Approximately 192 on-street parking spaces and 709 linear feet of loading zones impacted by the proposed BRT cross sections.

Scenario C

The proposed BRT alignments are outlined in gray. Dawson Street, McDowell Street, Morgan Street, and Edenton Street require curbside storage impacts on the right-hand side of each street. Based on the assumed BRT cross sections, approximately 126 on-street parking spaces and 443 linear feet of loading zones are impacted by the proposed BRT lanes. Scenario C has the least curbside storage impacts of all the BRT scenarios.

Scenario D

Dawson Street, McDowell Street, Wilmington Street, Blount Street, Edenton Street, and Morgan Street require curbside storage impacts on the right-hand side of each street. Based on the assumed BRT cross sections, approximately 154 on-street parking spaces and 577 feet of loading zones are impacted by the proposed BRT lanes.

FIGURE 10 — NUMBER OF EXISTING ON-STREET PARKING SPACES IMPACTED BY PROPOSED BRT

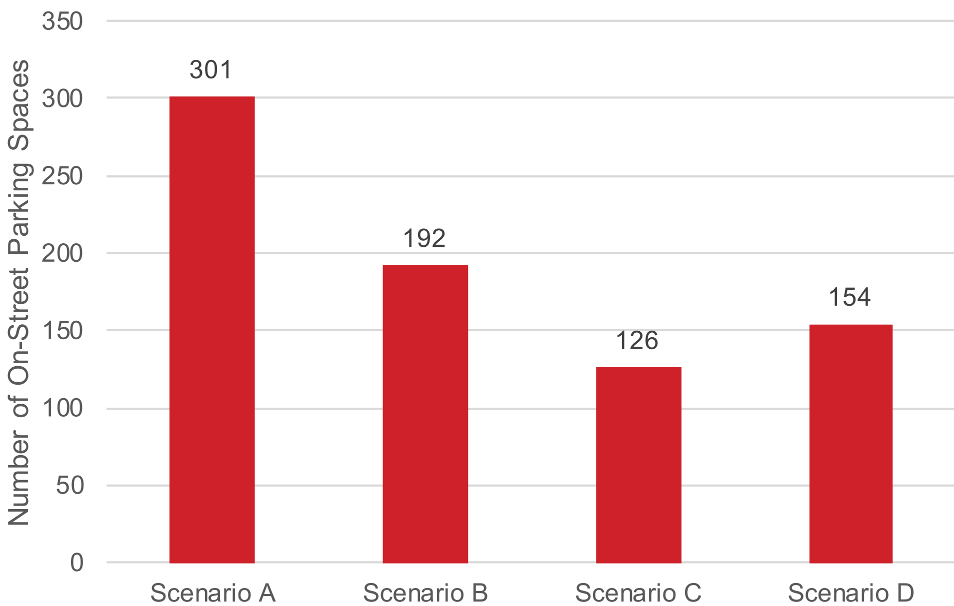


FIGURE 11 — LINEAR FEET OF EXISTING LOADING ZONES IMPACTED BY PROPOSED BRT

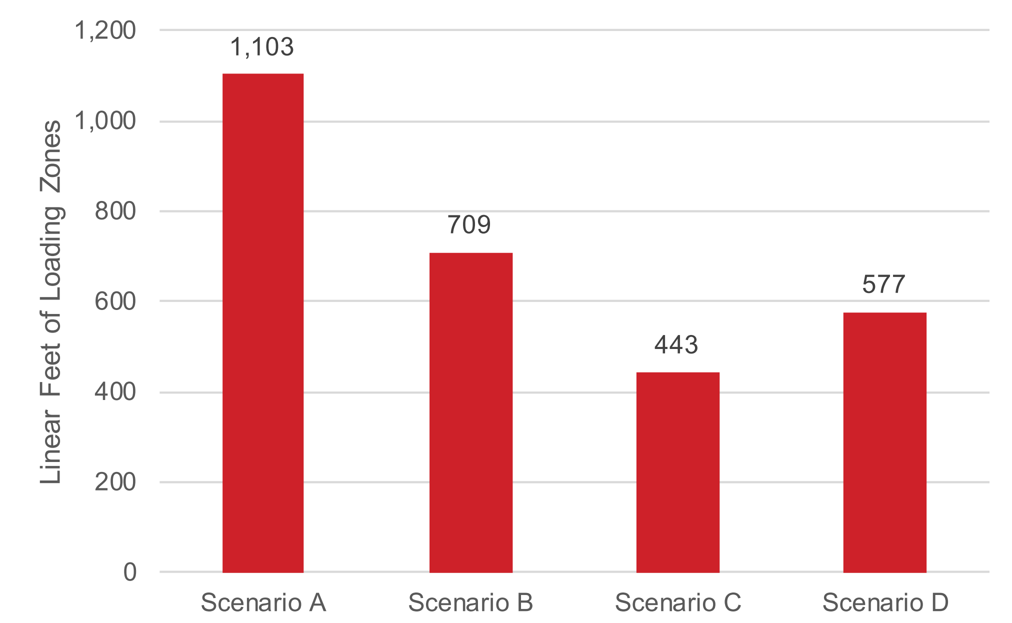
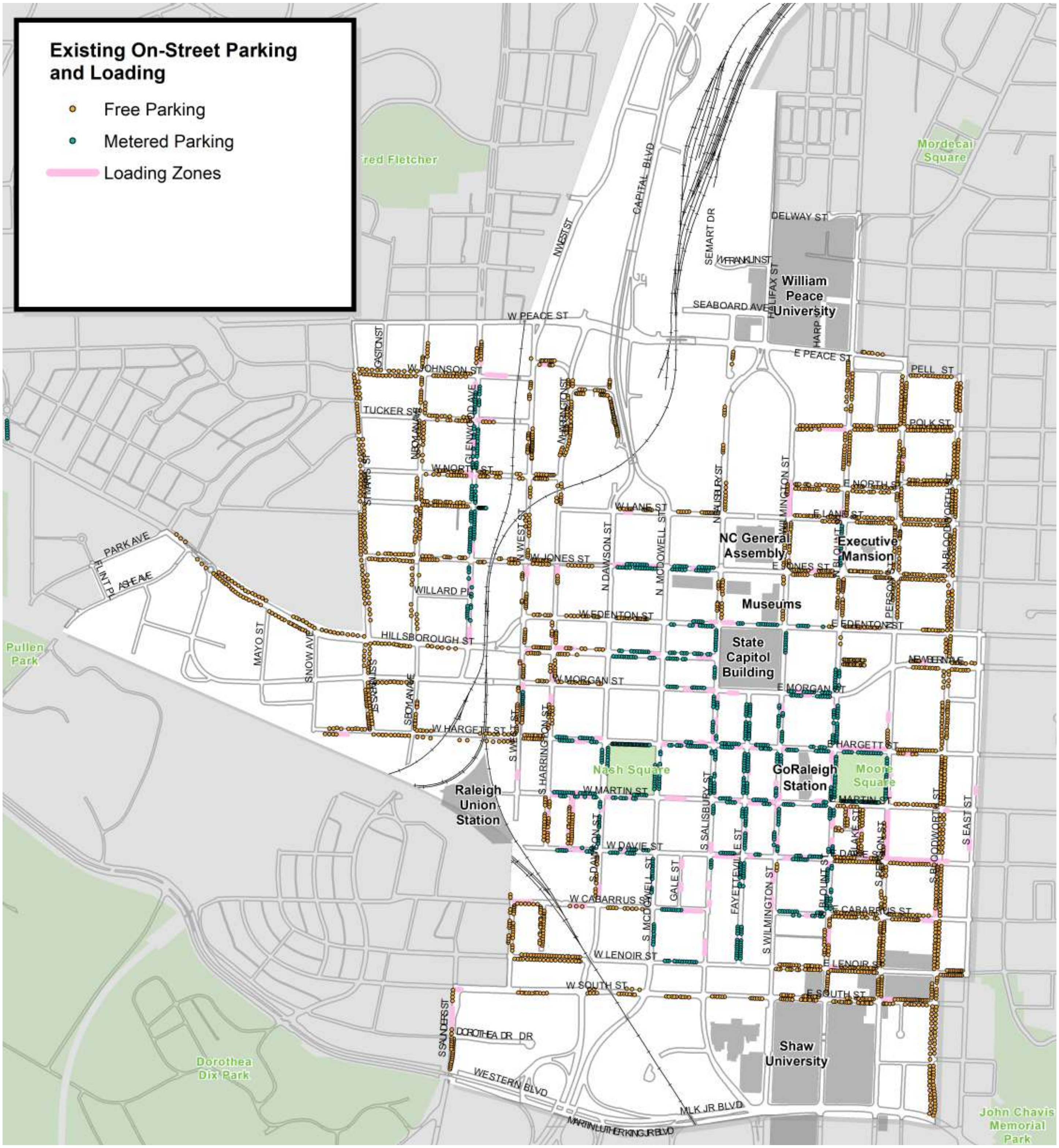


FIGURE 12 — EXISTING ON-STREET PARKING AND LOADING ZONES (2018)



4.8 Construction Impacts

To determine the construction impacts for each BRT scenario, the proposed BRT cross sections were applied to the existing street cross sections to see where existing curb lines would likely need to be adjusted in order to accommodate the proposed layout. The edge of pavement linework was obtained from City of Raleigh GIS files. Based on this analysis, if the proposed BRT cross section required curb lines on both sides of the street to be adjusted in order to accommodate the section, that was considered a high construction impact. If the curb line on only one side of the street was impacted, that was considered a medium impact, and if no curb line adjustments were needed that was considered a low impact. The total linear feet of high, medium, and low impacts were calculated for each scenario. It was assumed that in locations the existing curb would need to be moved to accommodate BRT, the roadway would need to be widened, which would result in more construction impacts. The following assumptions were used and applied to the proposed street cross sections (shown in Figures 14, 15, 16, and 17):

- 12-foot minimum Bus Rapid Transit (BRT) lanes
- 10-foot minimum general-purpose lanes
- 8-foot minimum on-street parking/loading areas

FIGURE 13 — EXISTING CURB IMPACTED BY BRT INFRASTRUCTURE

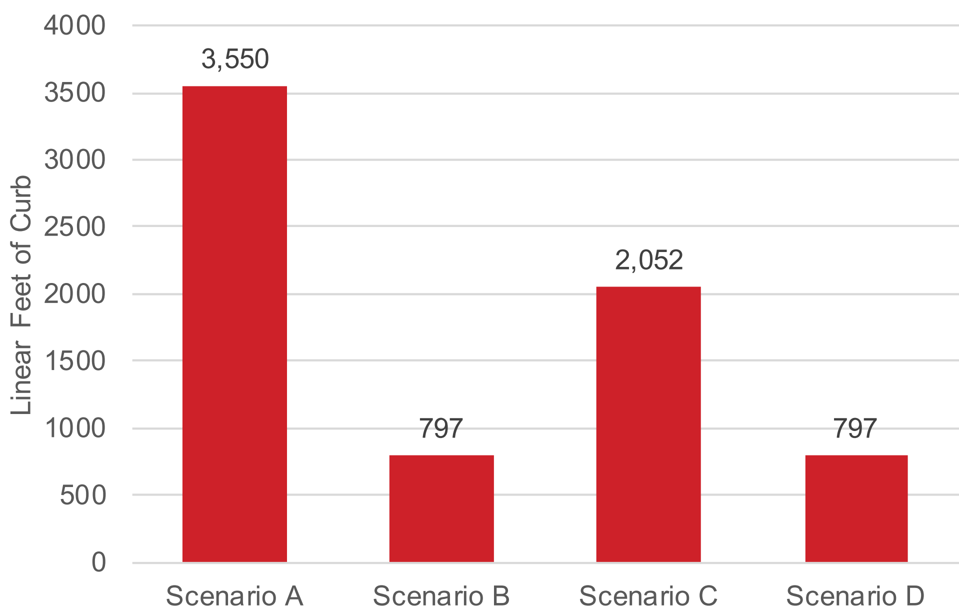
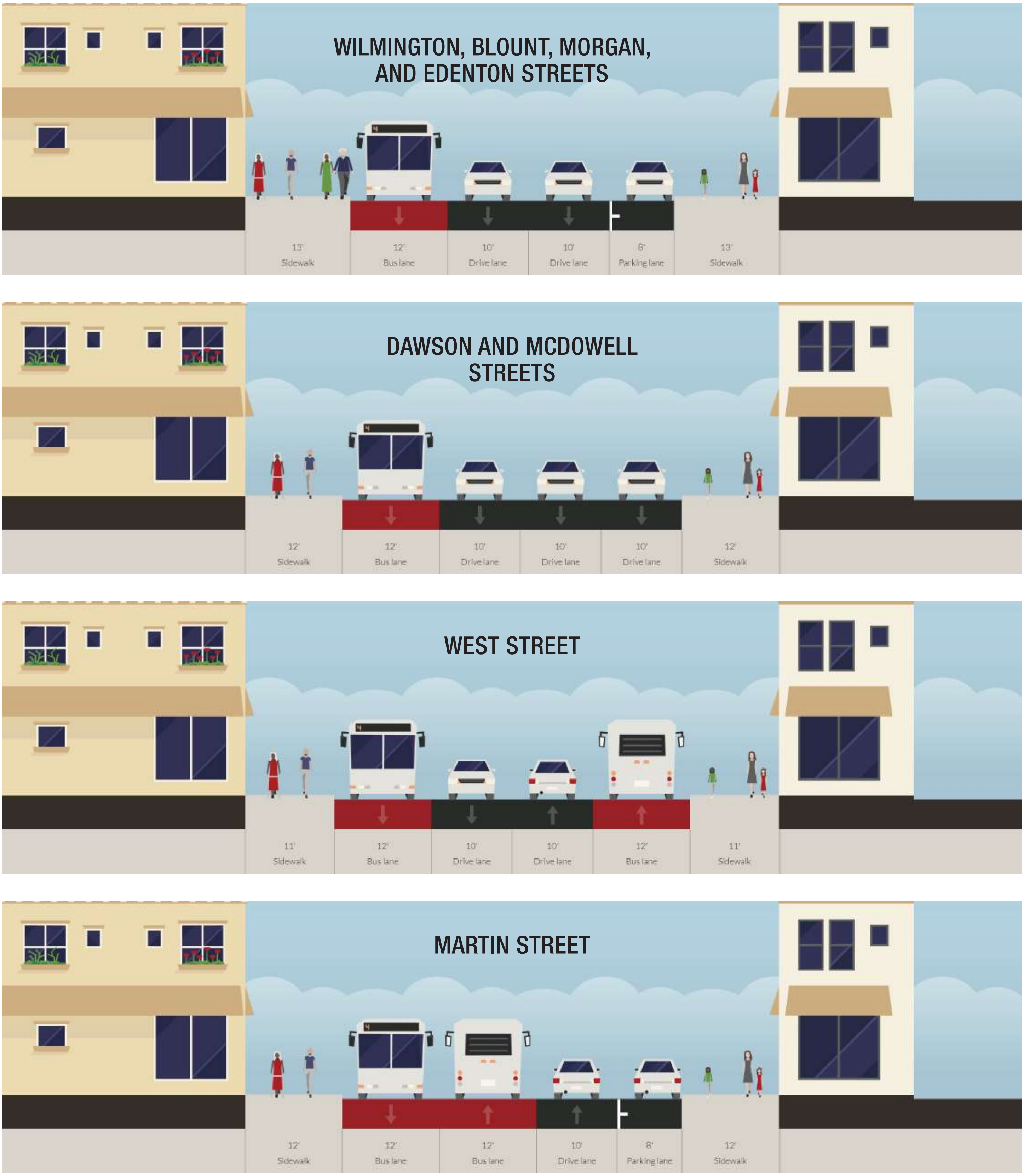


FIGURE 14 — PROPOSED BRT TYPICAL CROSS SECTIONS



Appendix A

EXHIBIT A.1 — BUS RAPID TRANSIT SCENARIO "H"

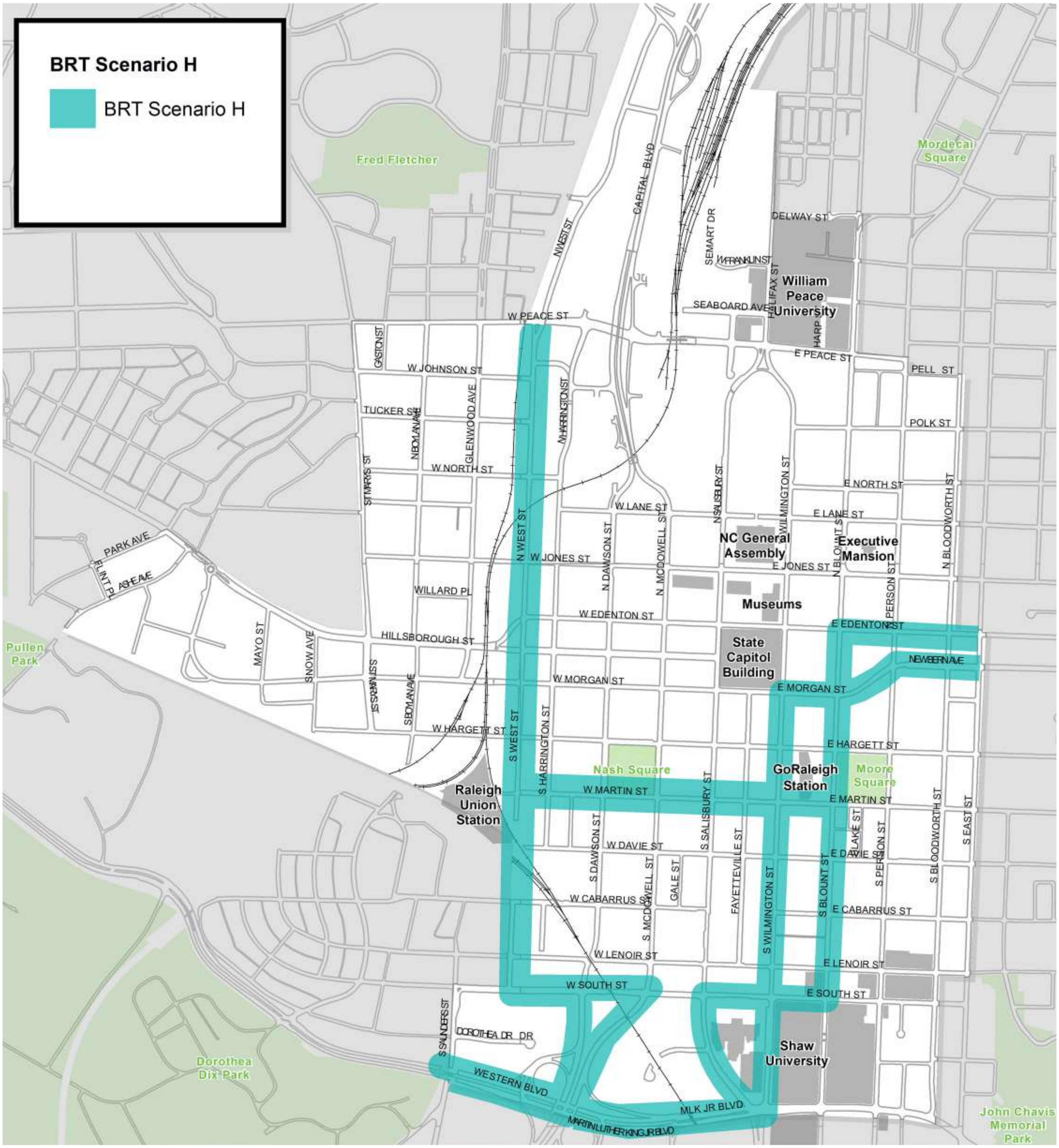


EXHIBIT A.2 — BUS RAPID TRANSIT SCENARIO “I1”

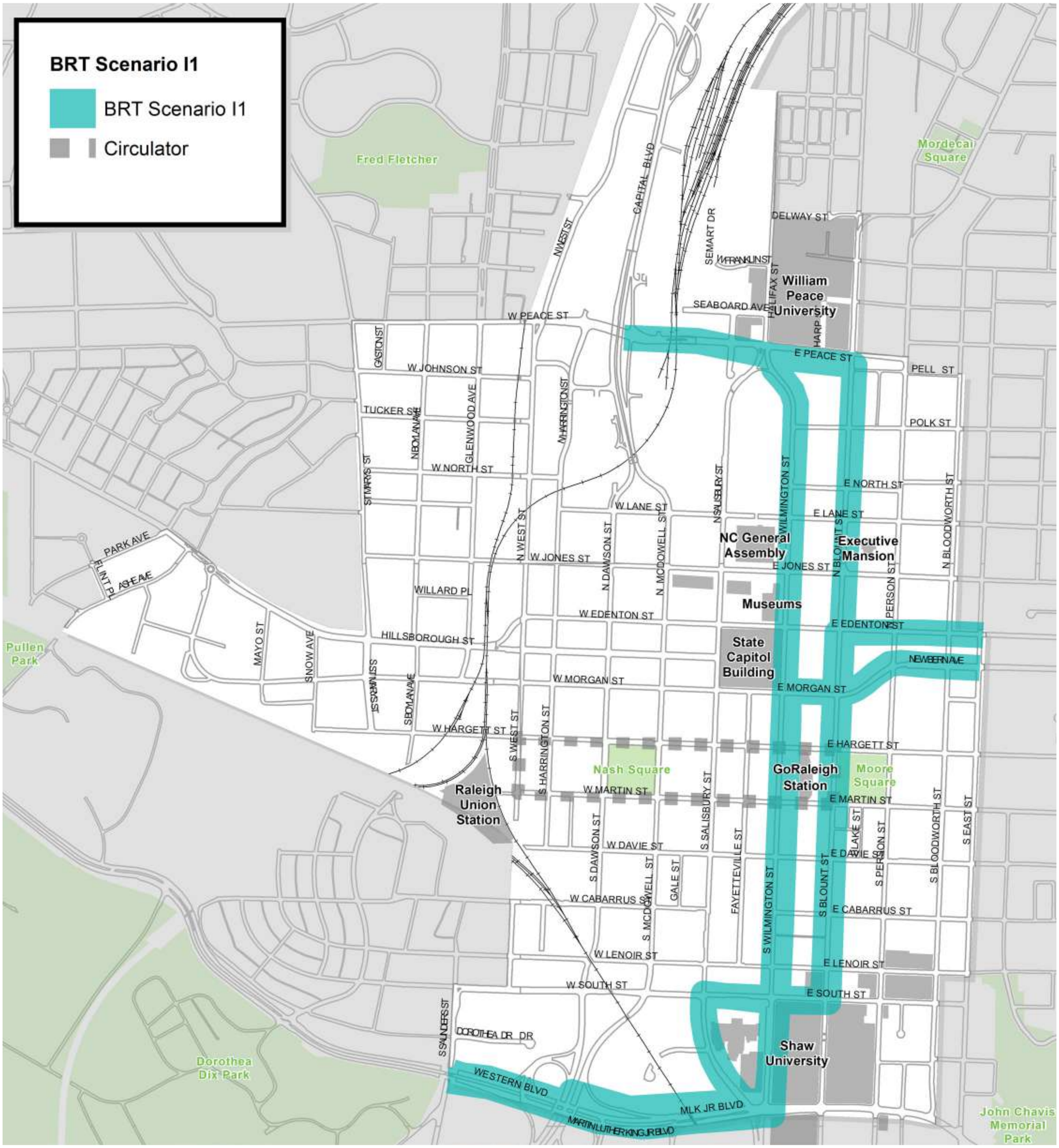


EXHIBIT A.3 — BUS RAPID TRANSIT SCENARIO "I2"

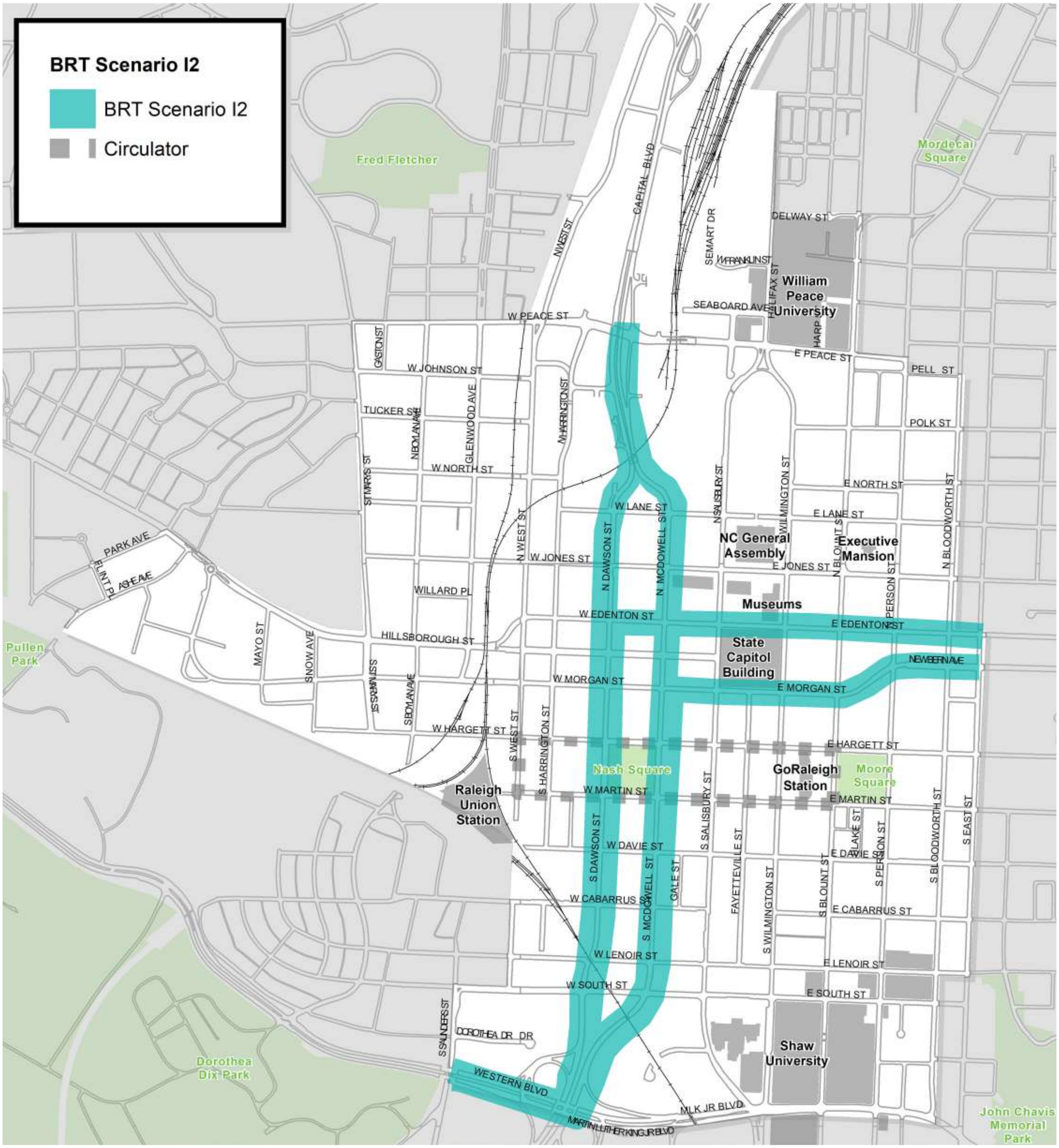


EXHIBIT A.4 — BUS RAPID TRANSIT SCENARIO "O"

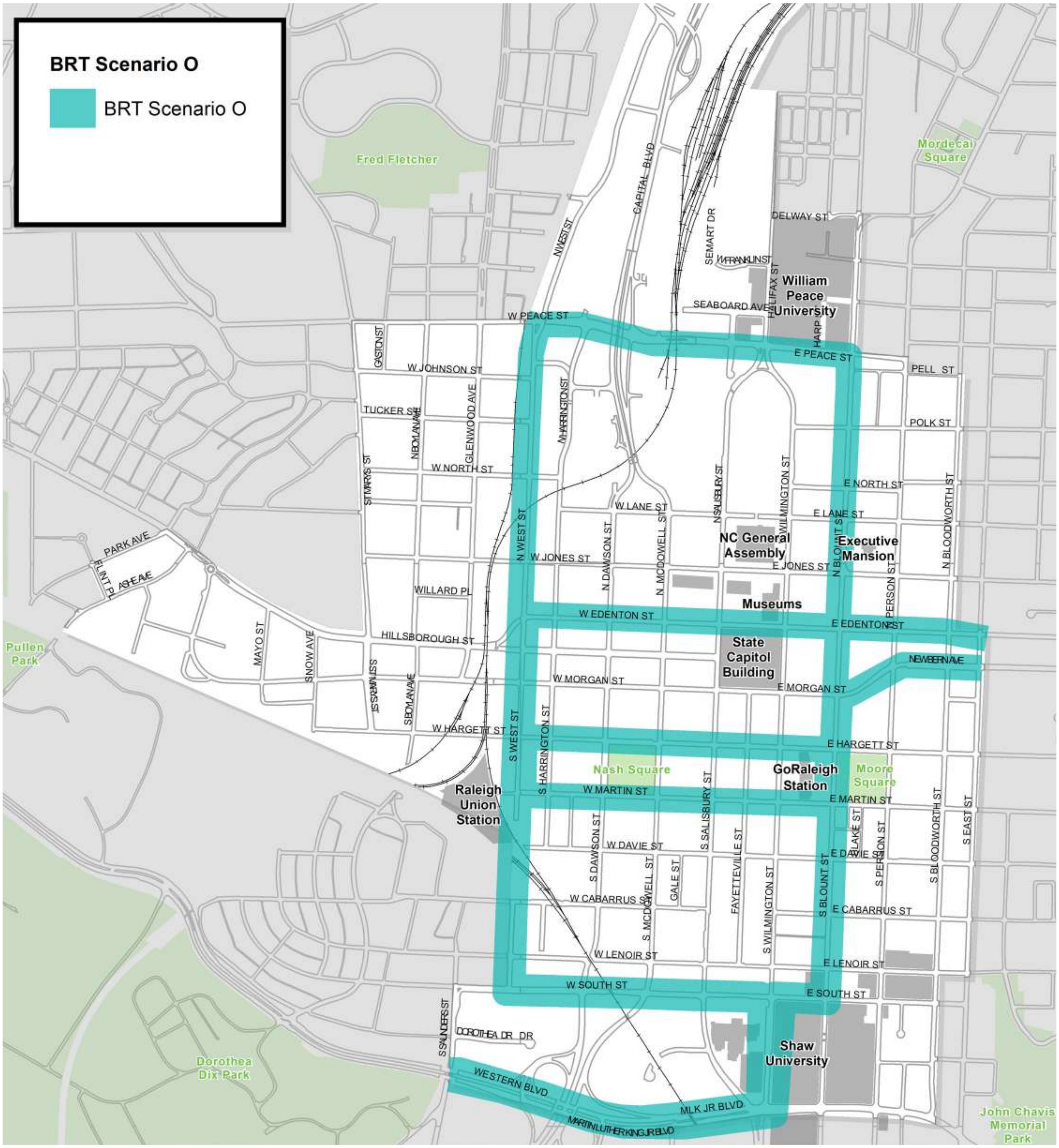


EXHIBIT A.5 — BUS RAPID TRANSIT SCENARIO A

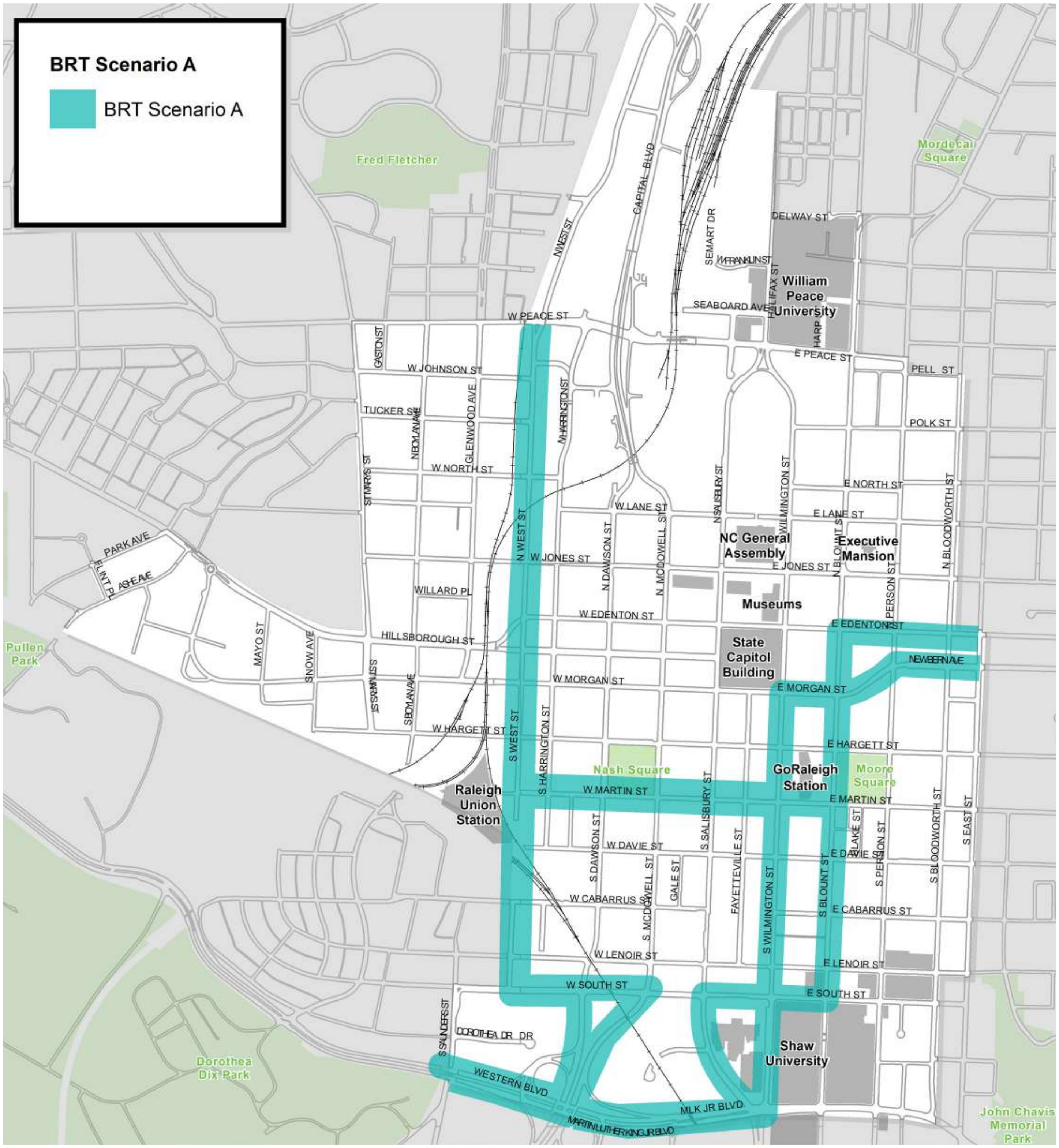


EXHIBIT A.6 — BUS RAPID TRANSIT SCENARIO B

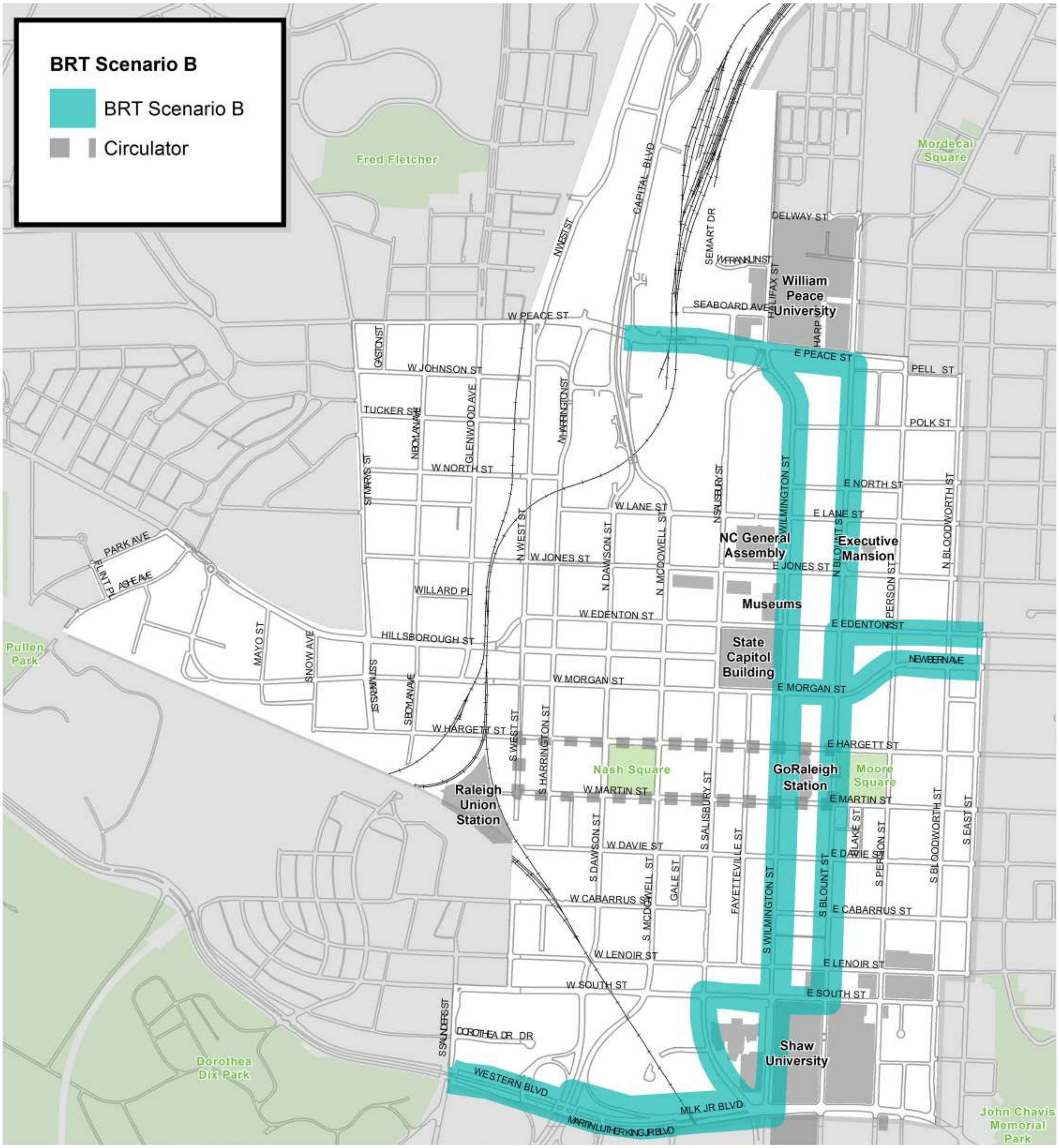


EXHIBIT A.7 — BUS RAPID TRANSIT SCENARIO C

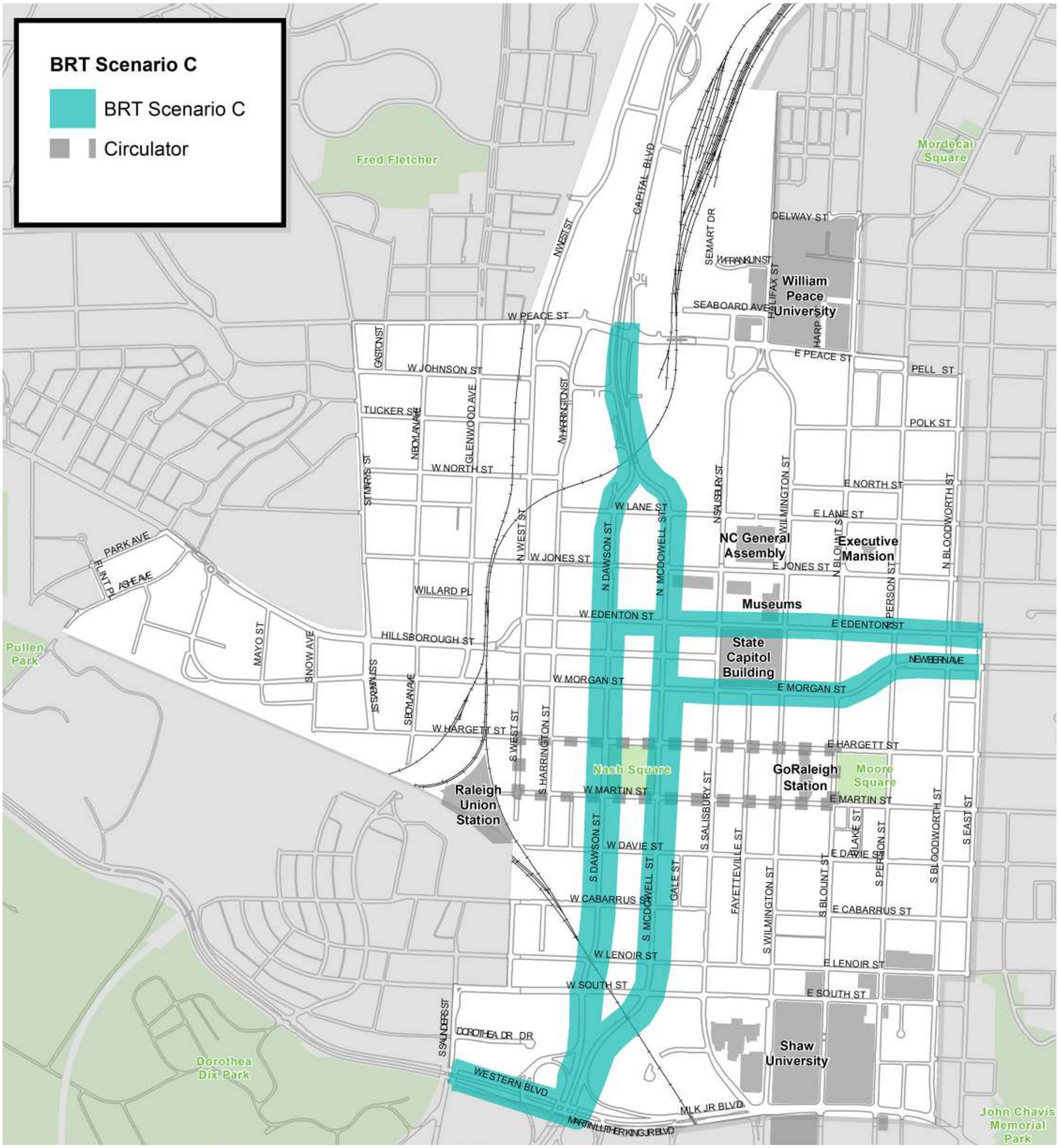


EXHIBIT A.8 — BUS RAPID TRANSIT SCENARIO D

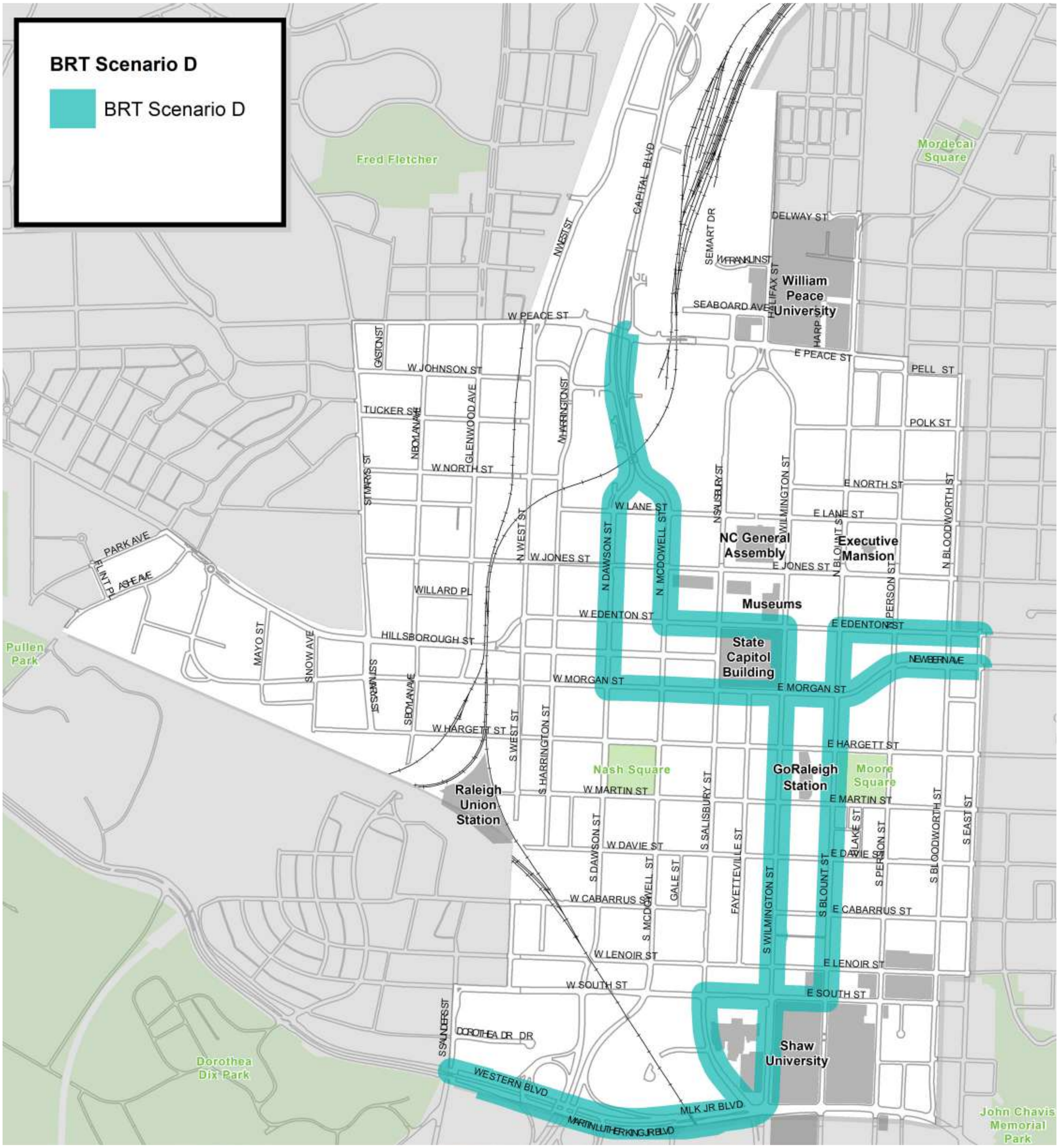


EXHIBIT A.9 — MULTIMODAL SCENARIO A

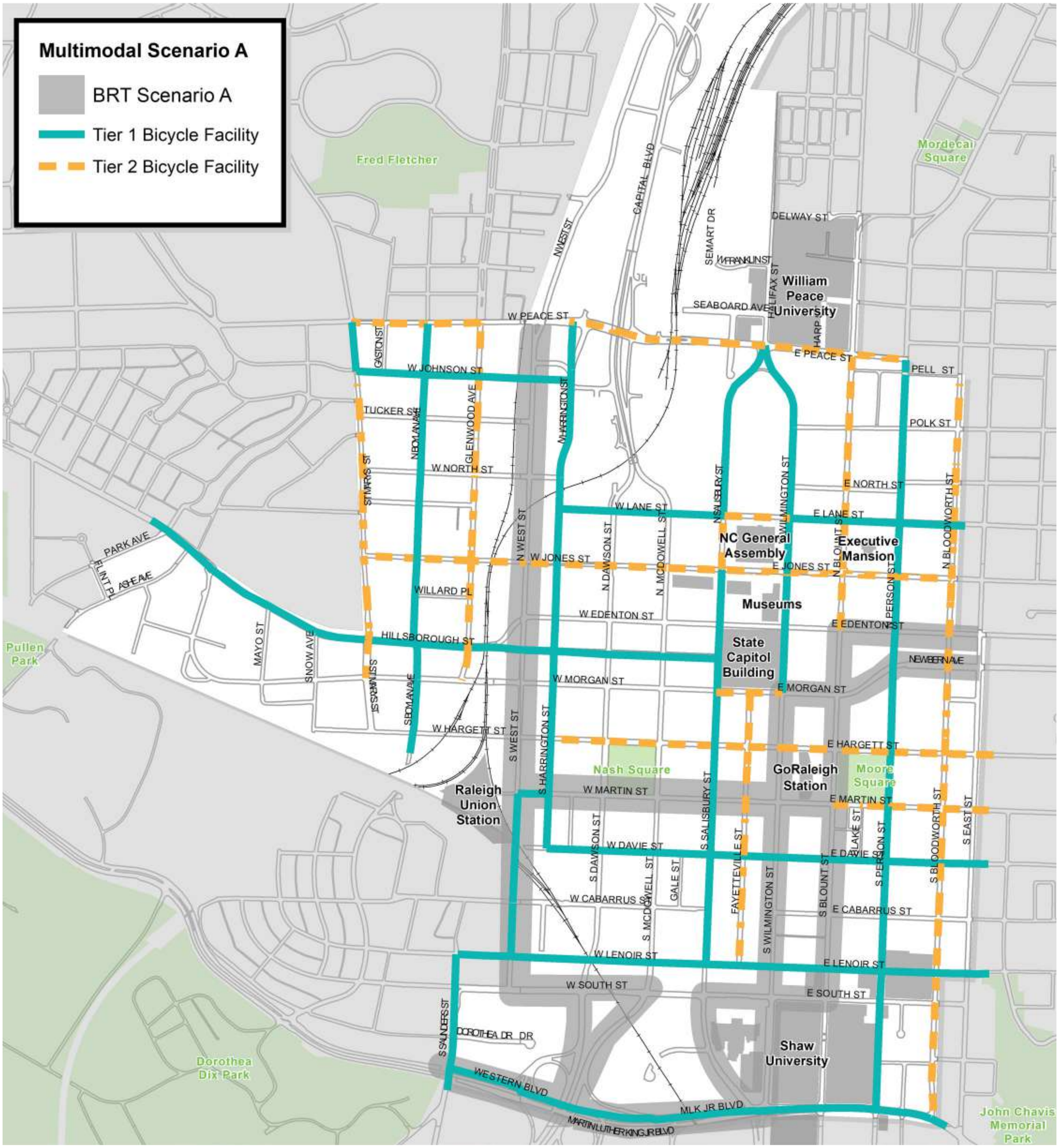


EXHIBIT A.10 — MULTIMODAL SCENARIO B

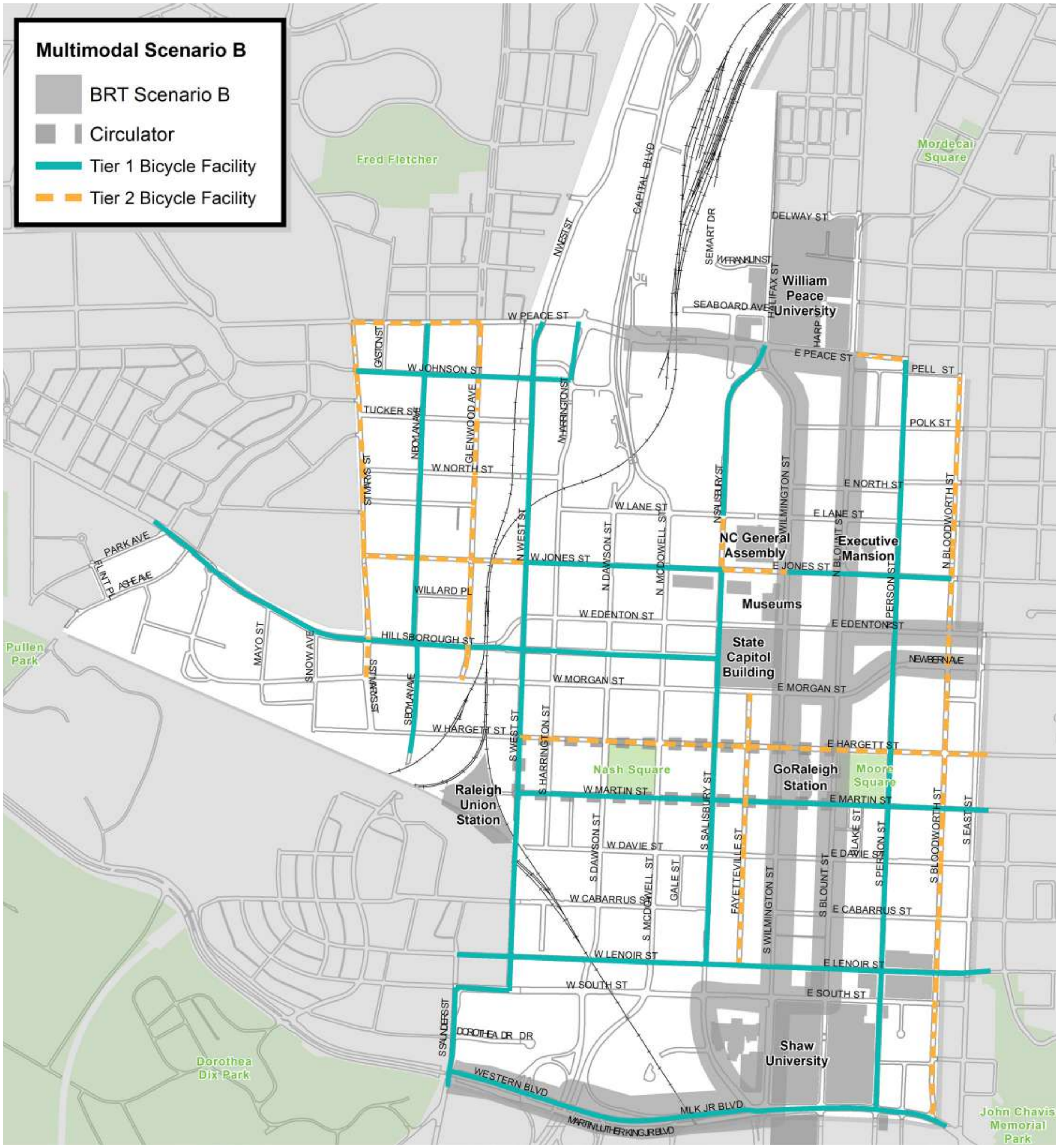


EXHIBIT A.11 — MULTIMODAL SCENARIO C

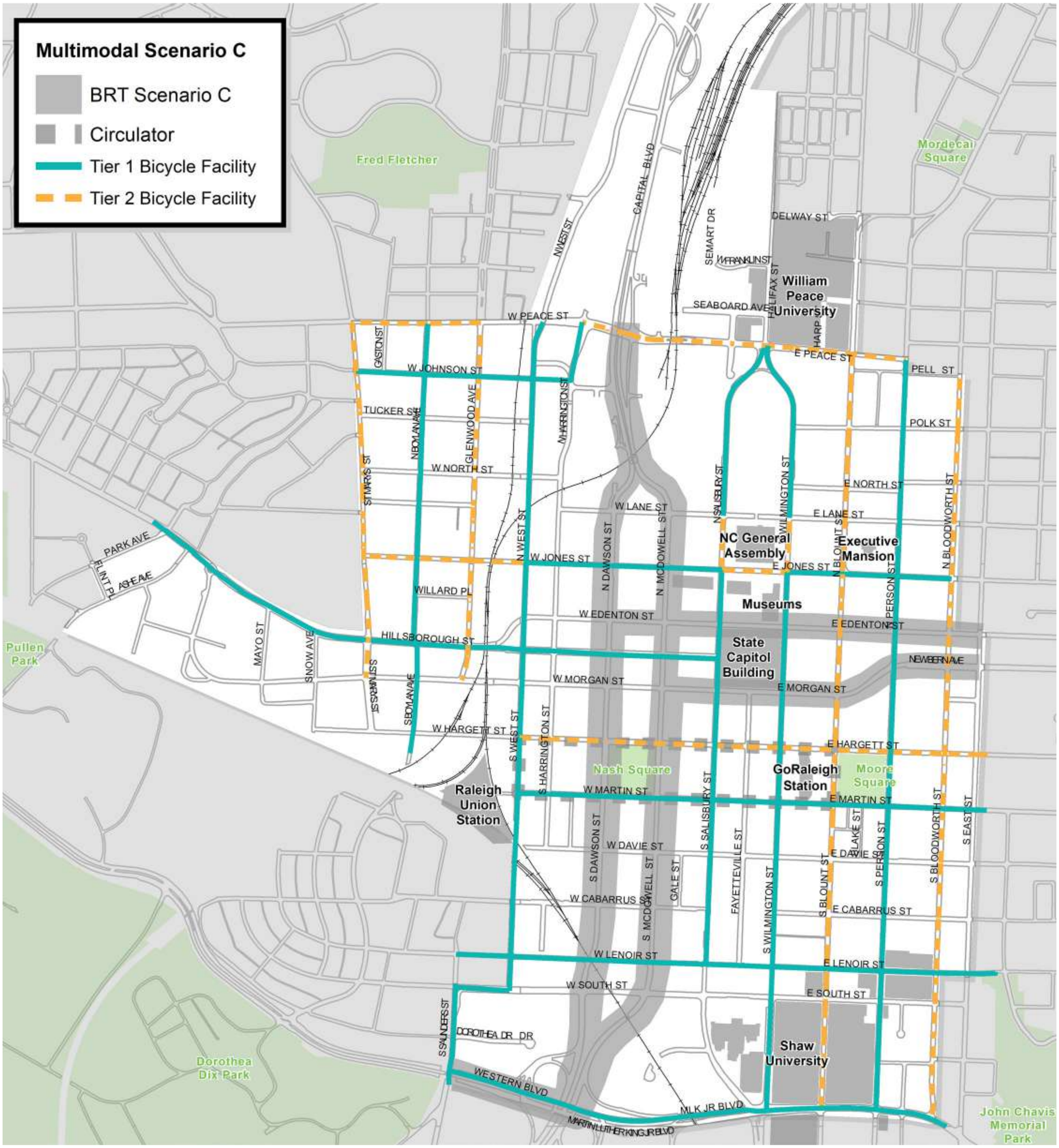


EXHIBIT A.12 — MULTIMODAL SCENARIO D

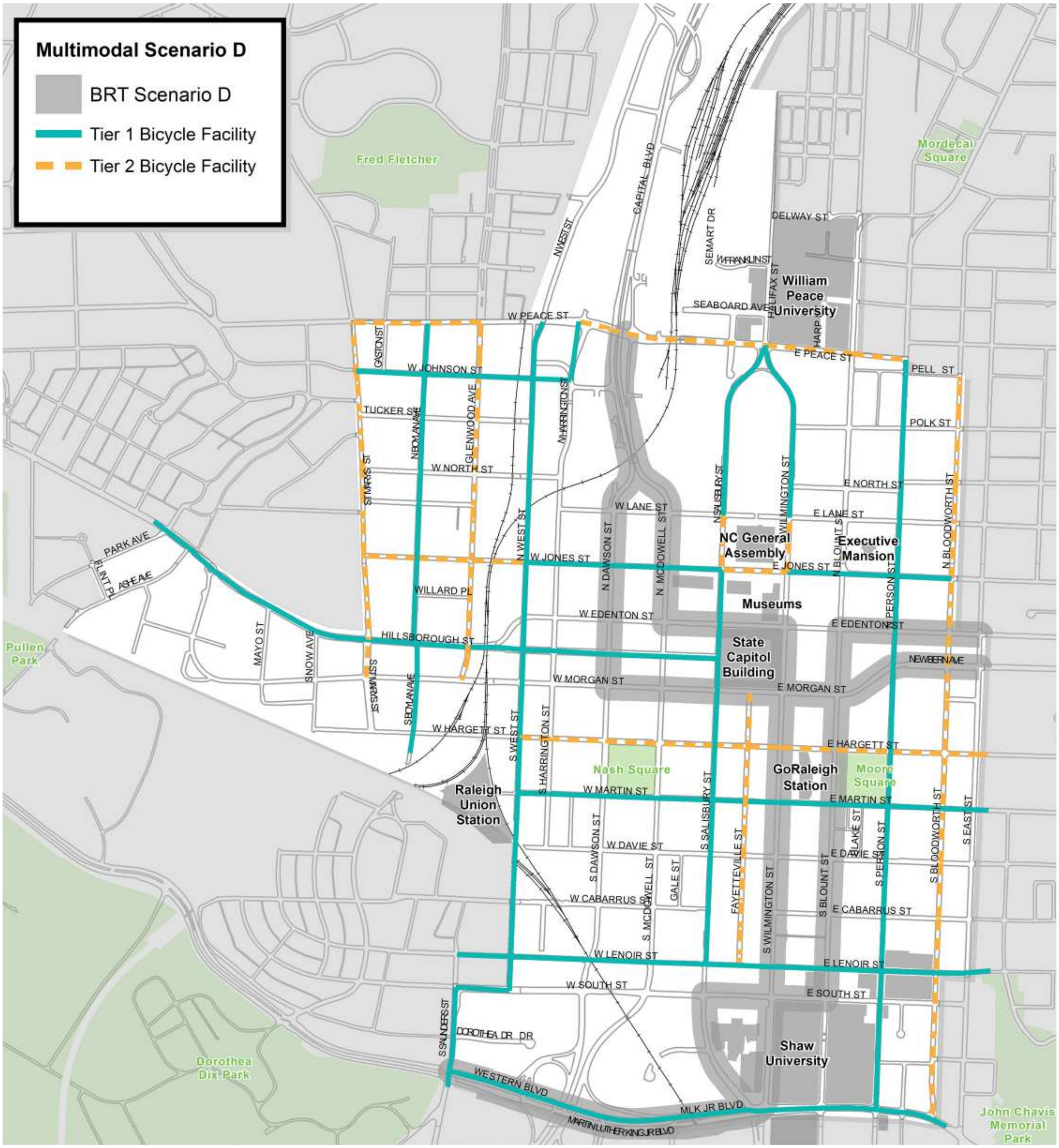


EXHIBIT A.13 — BRT SCENARIO A STATION ASSUMPTIONS

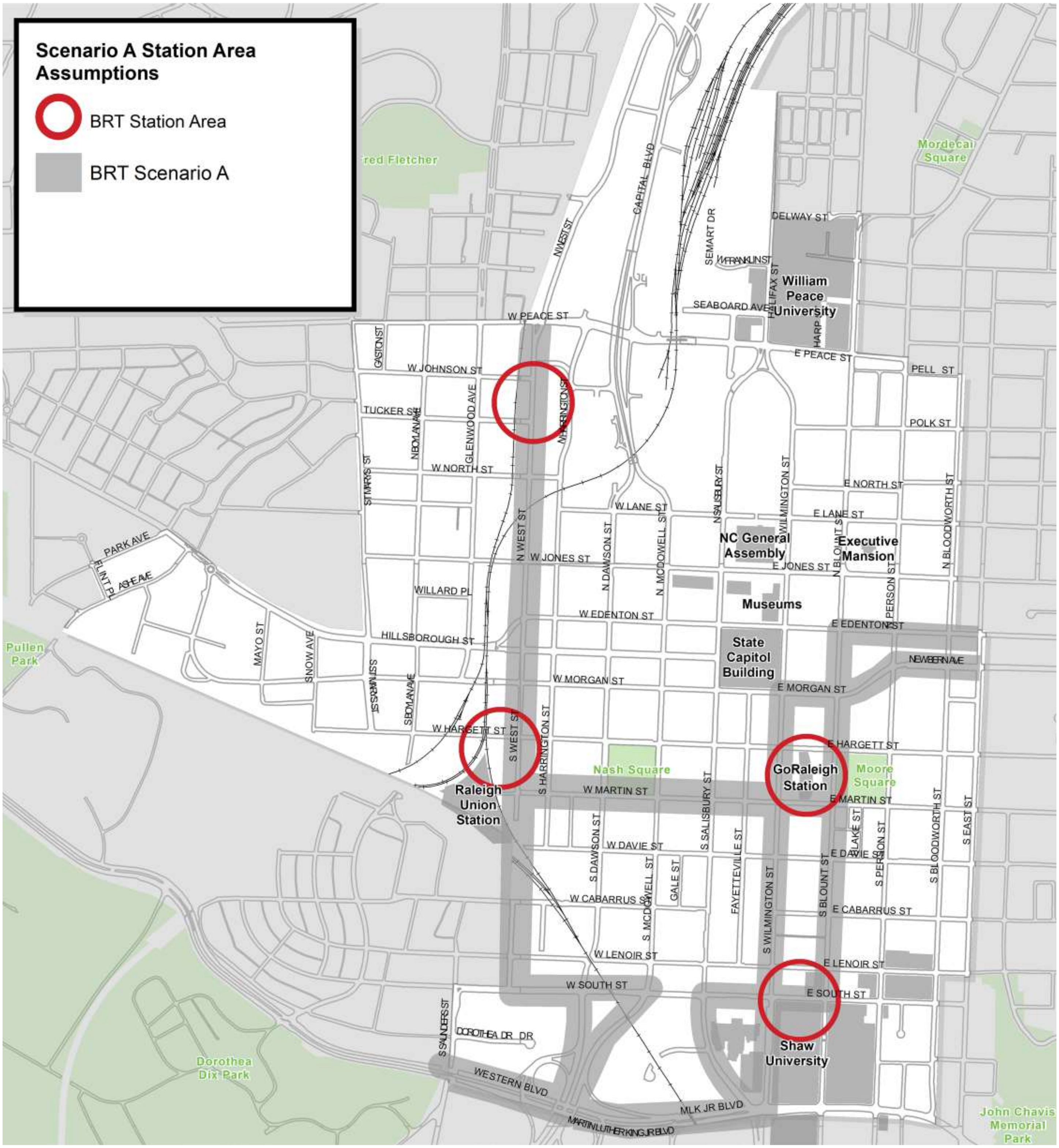


EXHIBIT A.14 — BRT SCENARIO B STATION ASSUMPTIONS

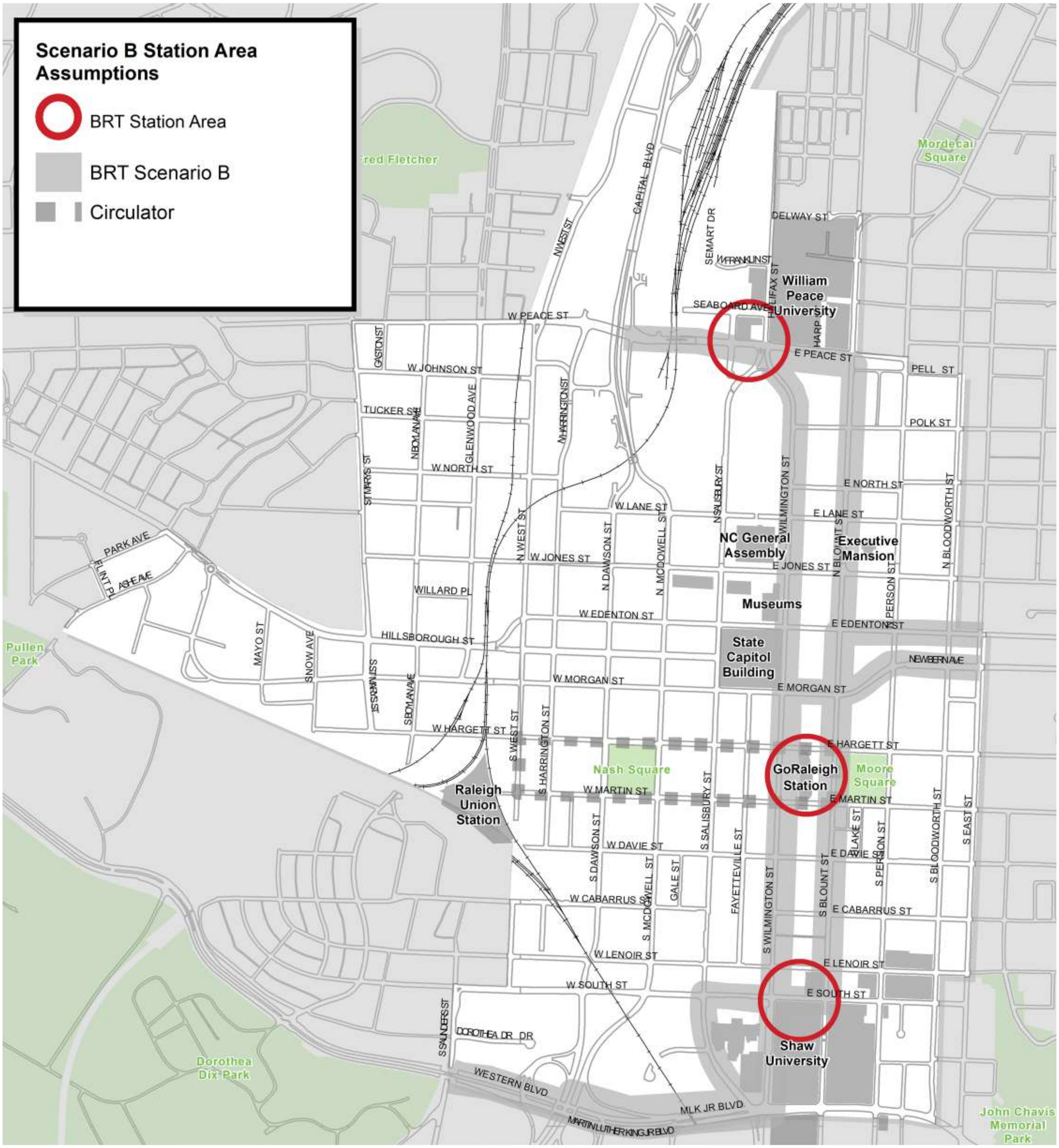


EXHIBIT A.15 — BRT SCENARIO C STATION ASSUMPTIONS

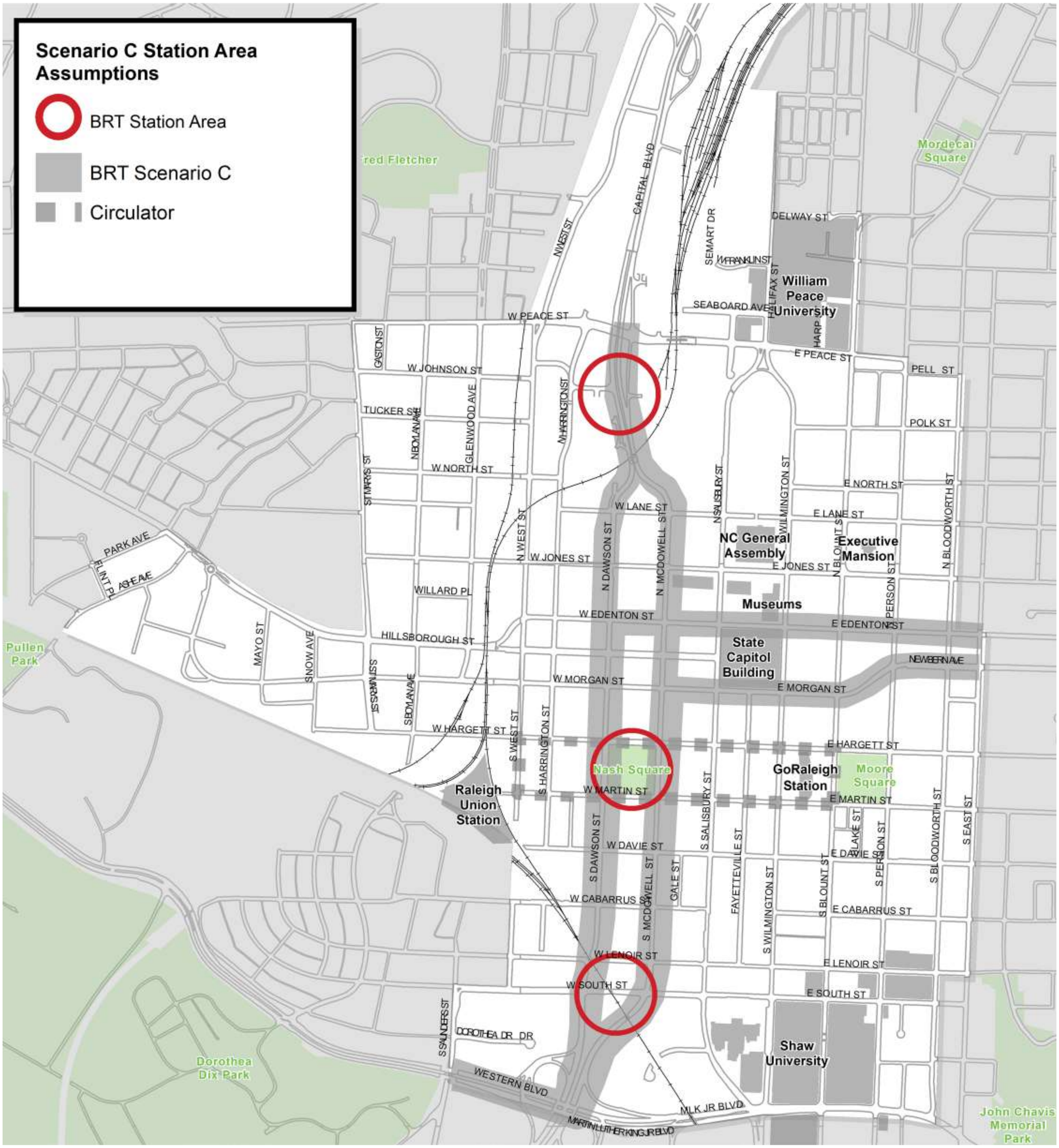


EXHIBIT A.16 — BRT SCENARIO D STATION ASSUMPTIONS

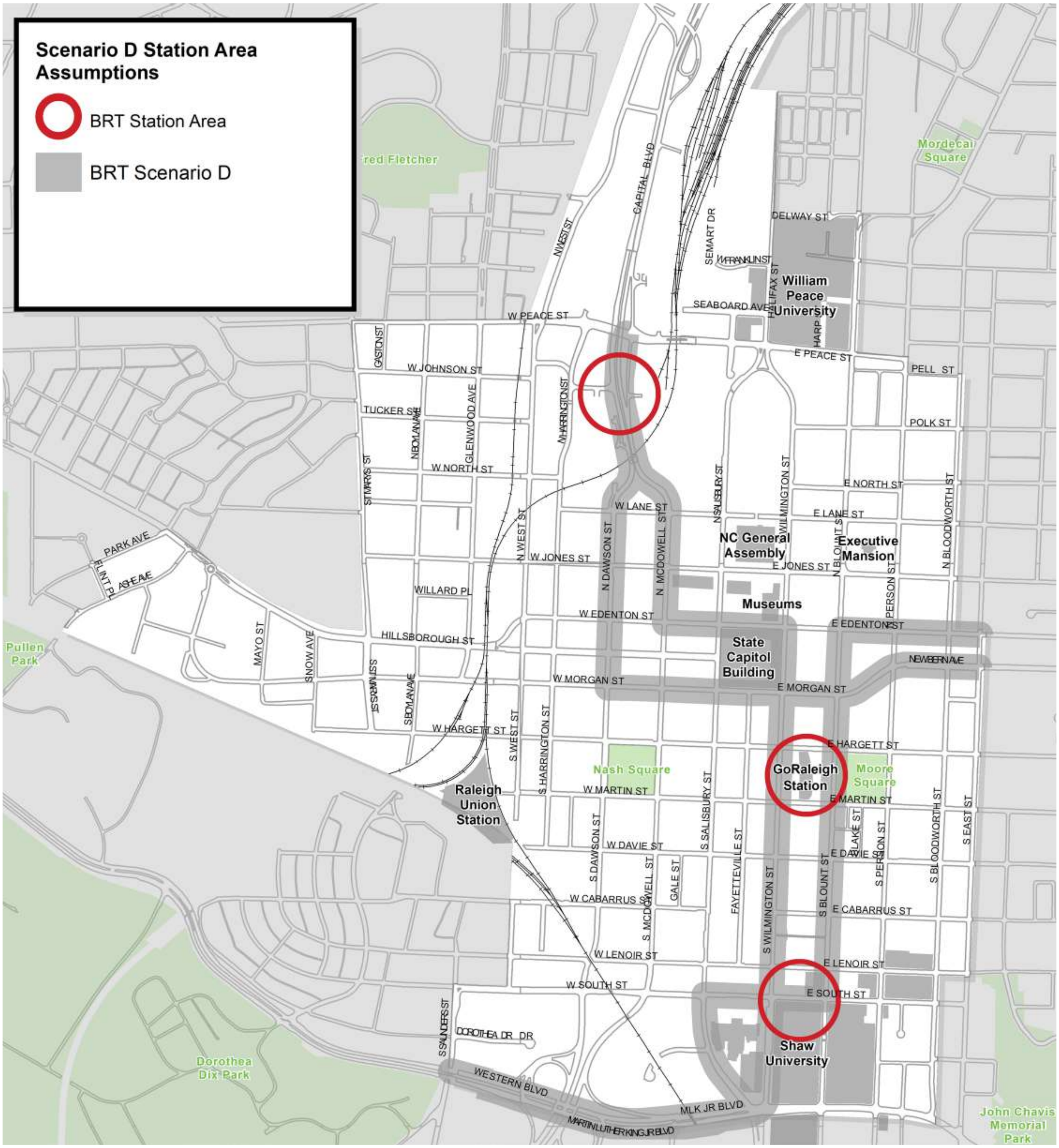


EXHIBIT A.17 — BRT SCENARIO C STATION ASSUMPTIONS

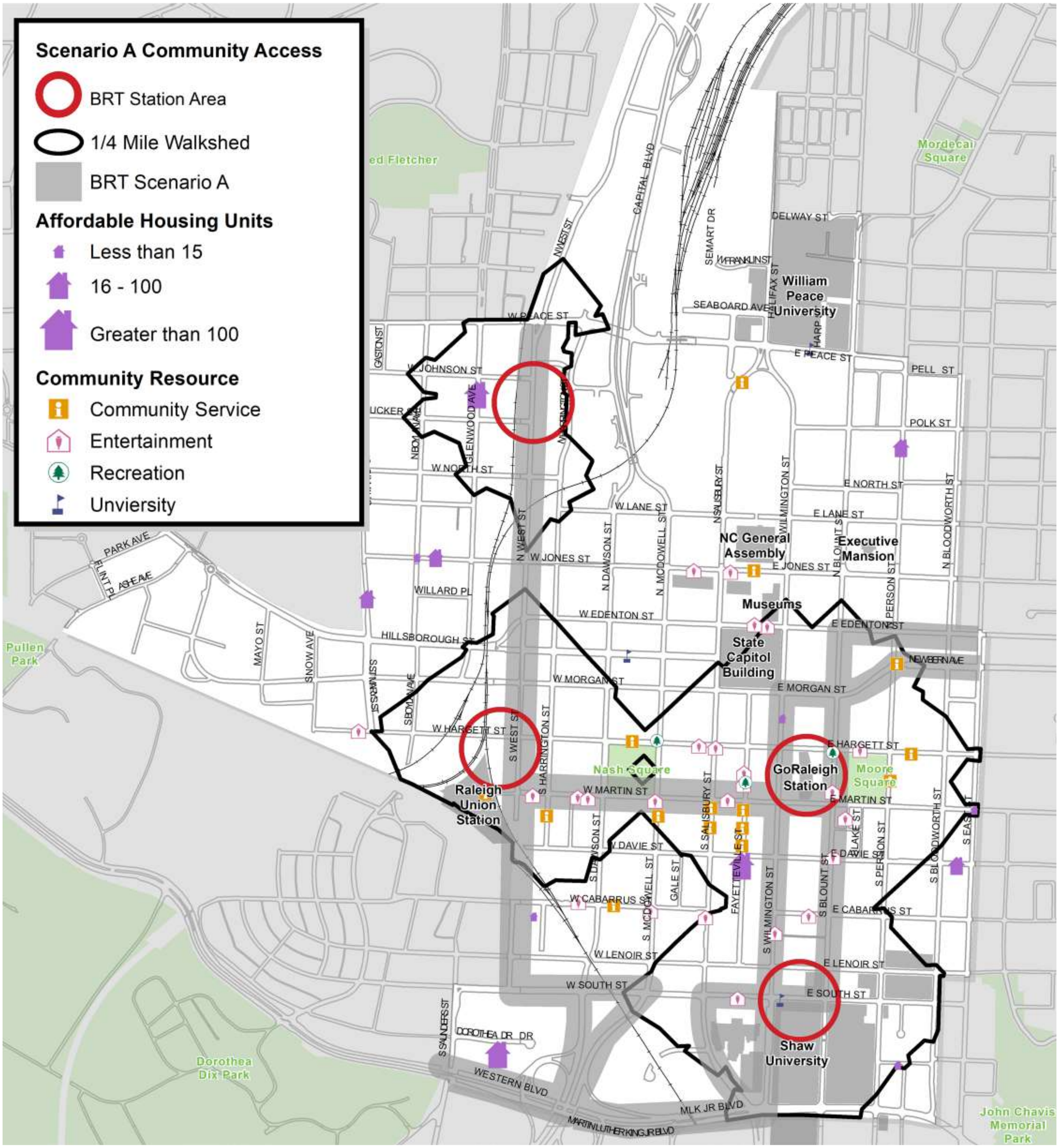


EXHIBIT A.18 — BRT SCENARIO D STATION ASSUMPTIONS

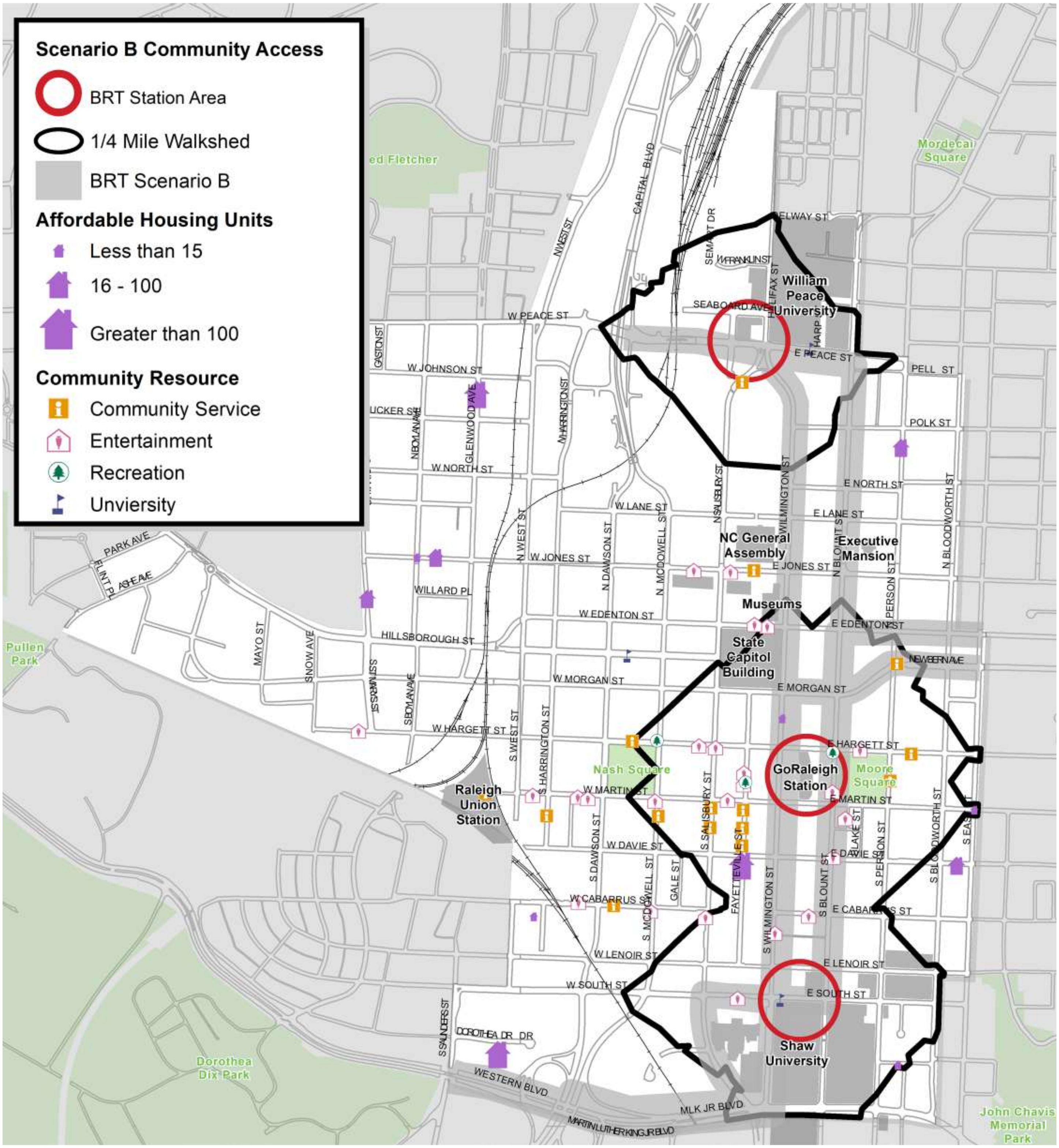


EXHIBIT A.19 — BRT SCENARIO C STATION ASSUMPTIONS

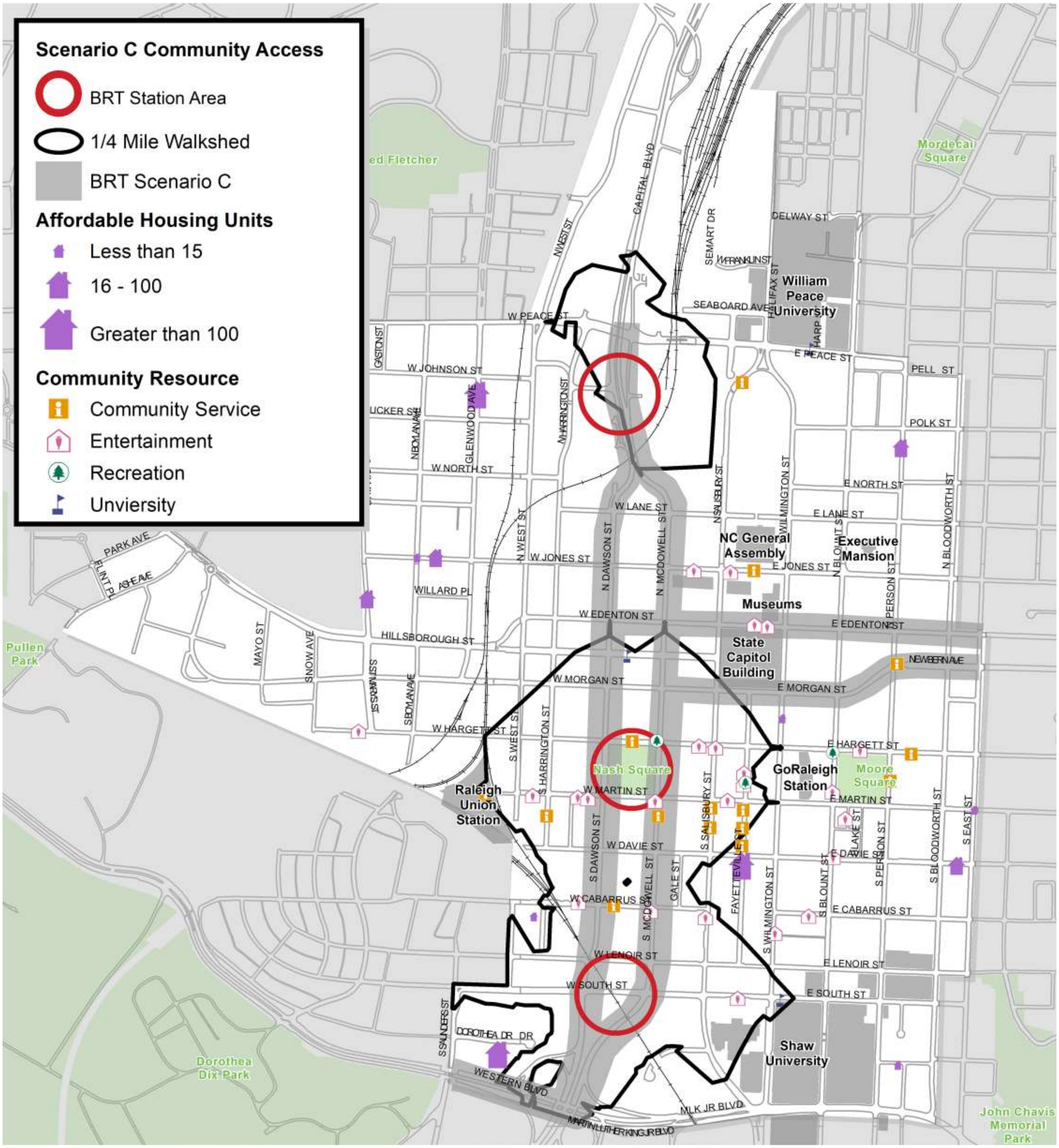


EXHIBIT A.20 — BRT SCENARIO D STATION ASSUMPTIONS

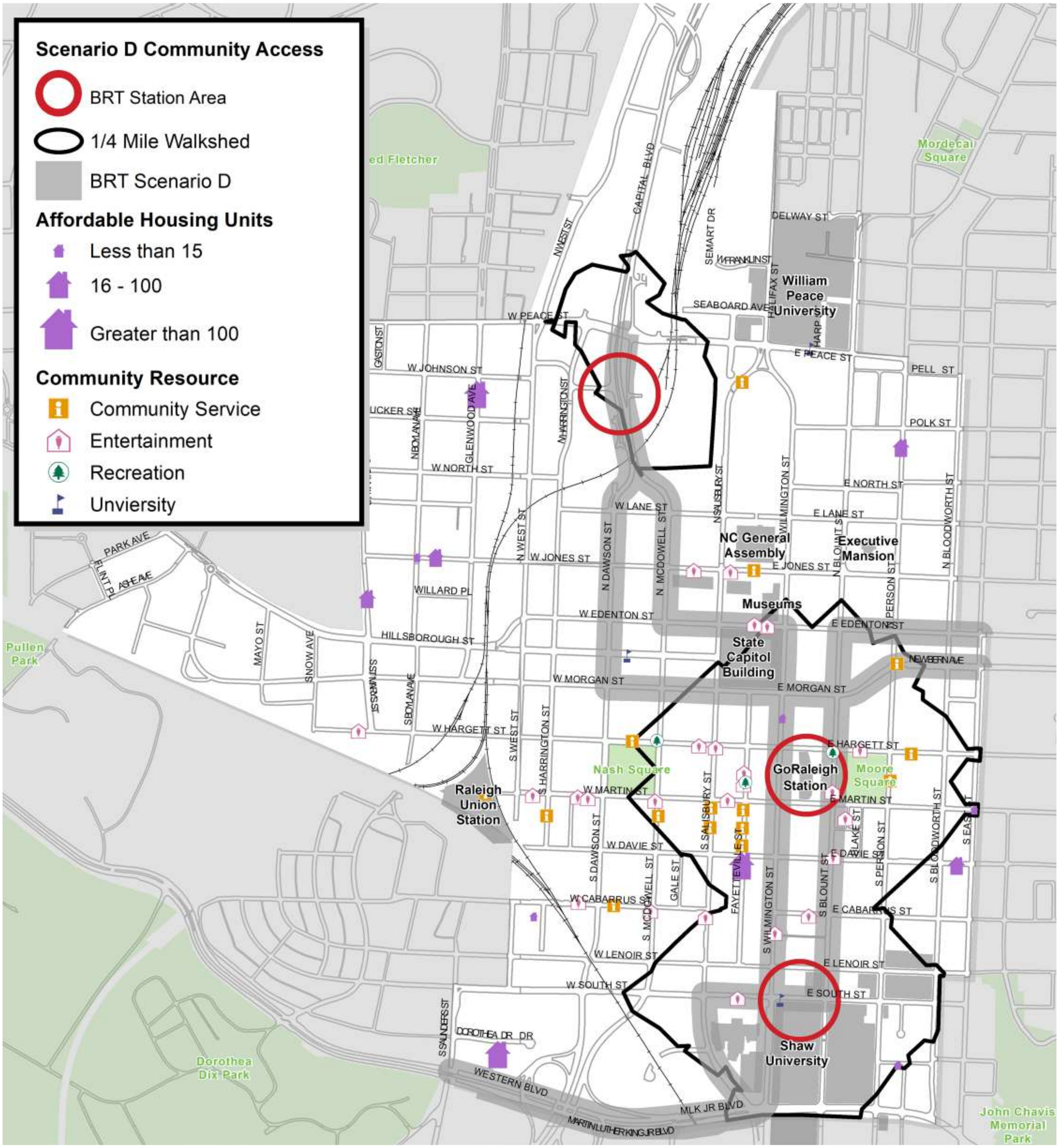


EXHIBIT A.21 — EXISTING (2013) POPULATION

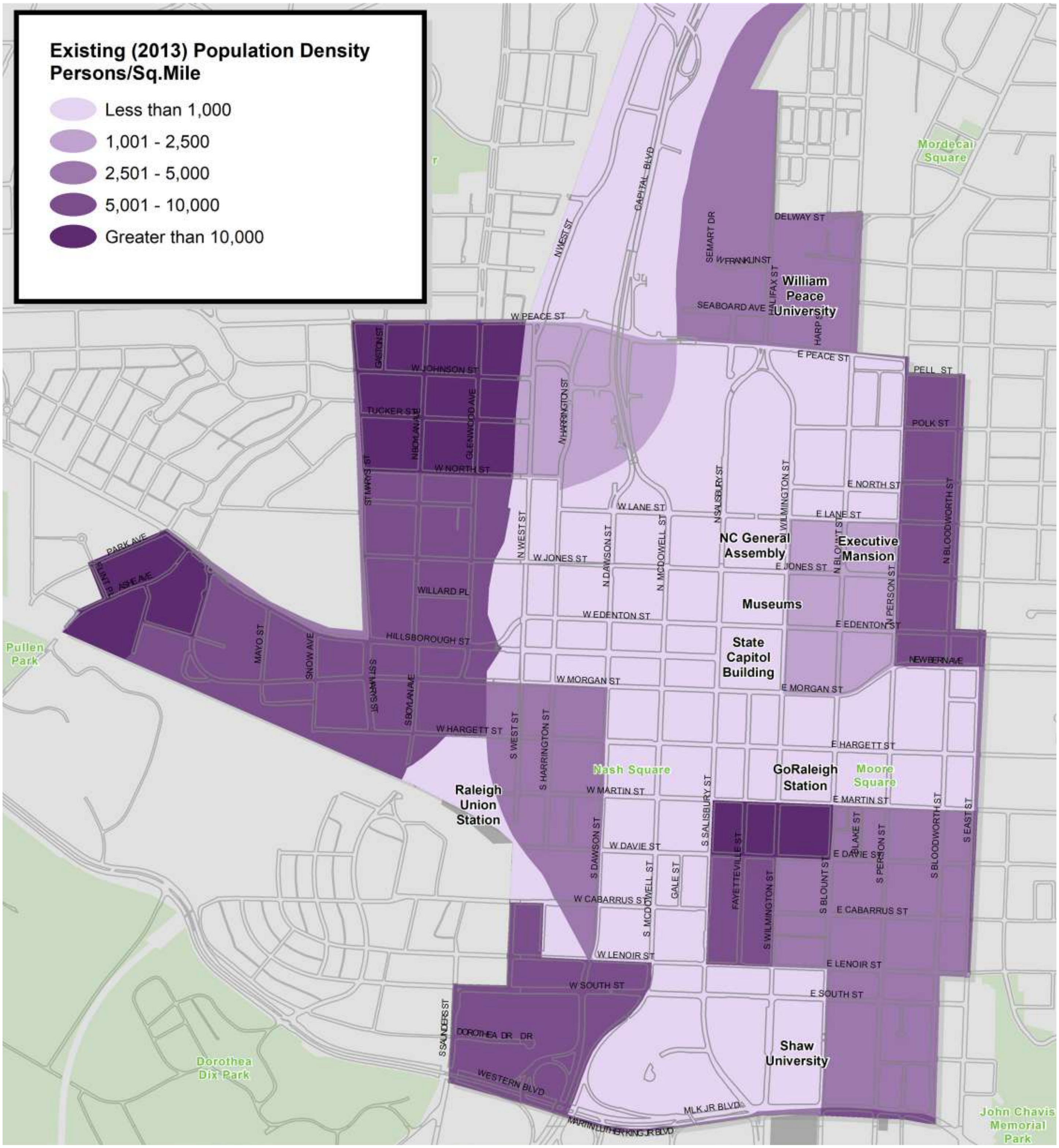


EXHIBIT A.22 — FUTURE (2045) POPULATION

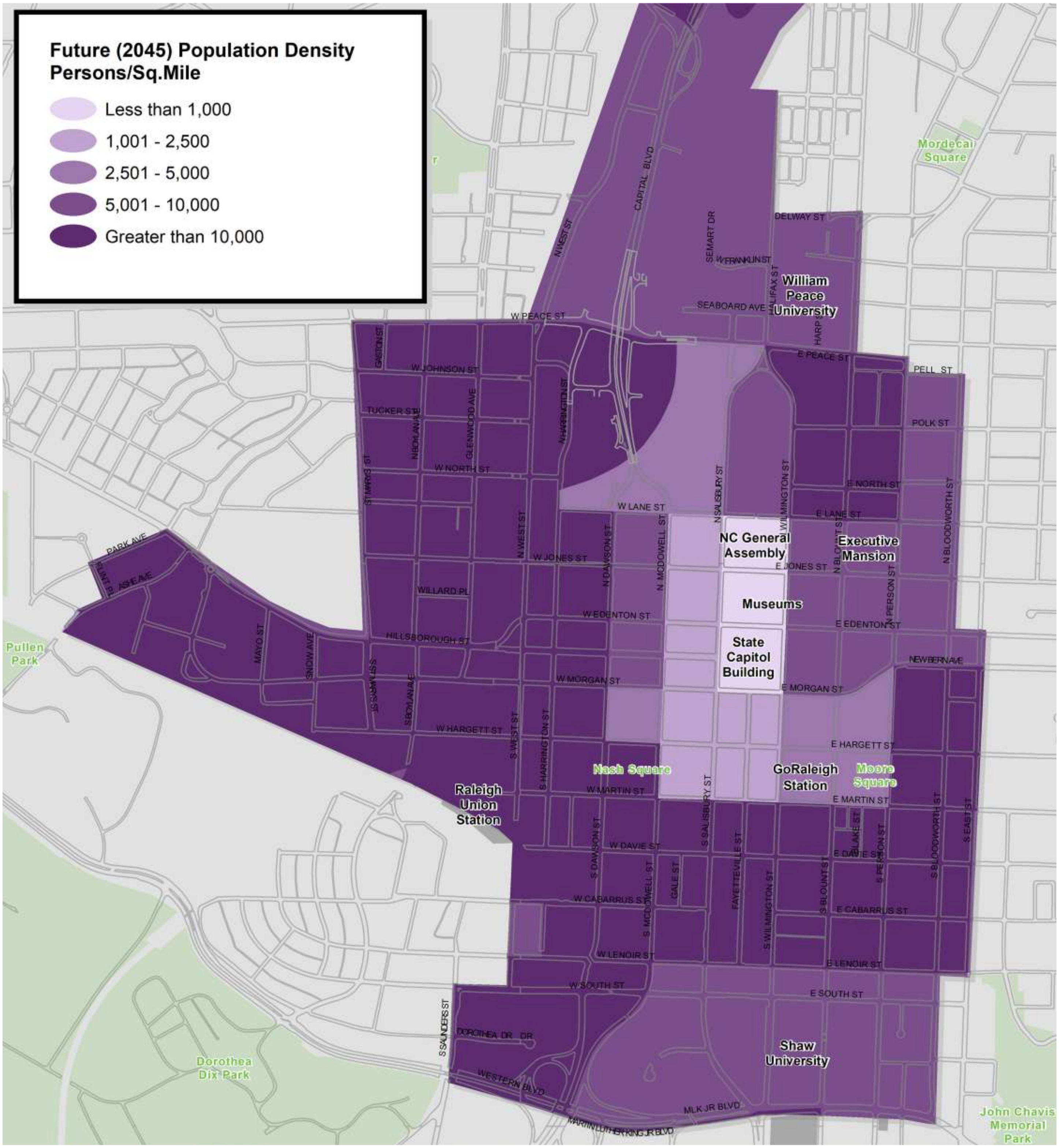


EXHIBIT A.23 — EXISTING (2013) EMPLOYMENT

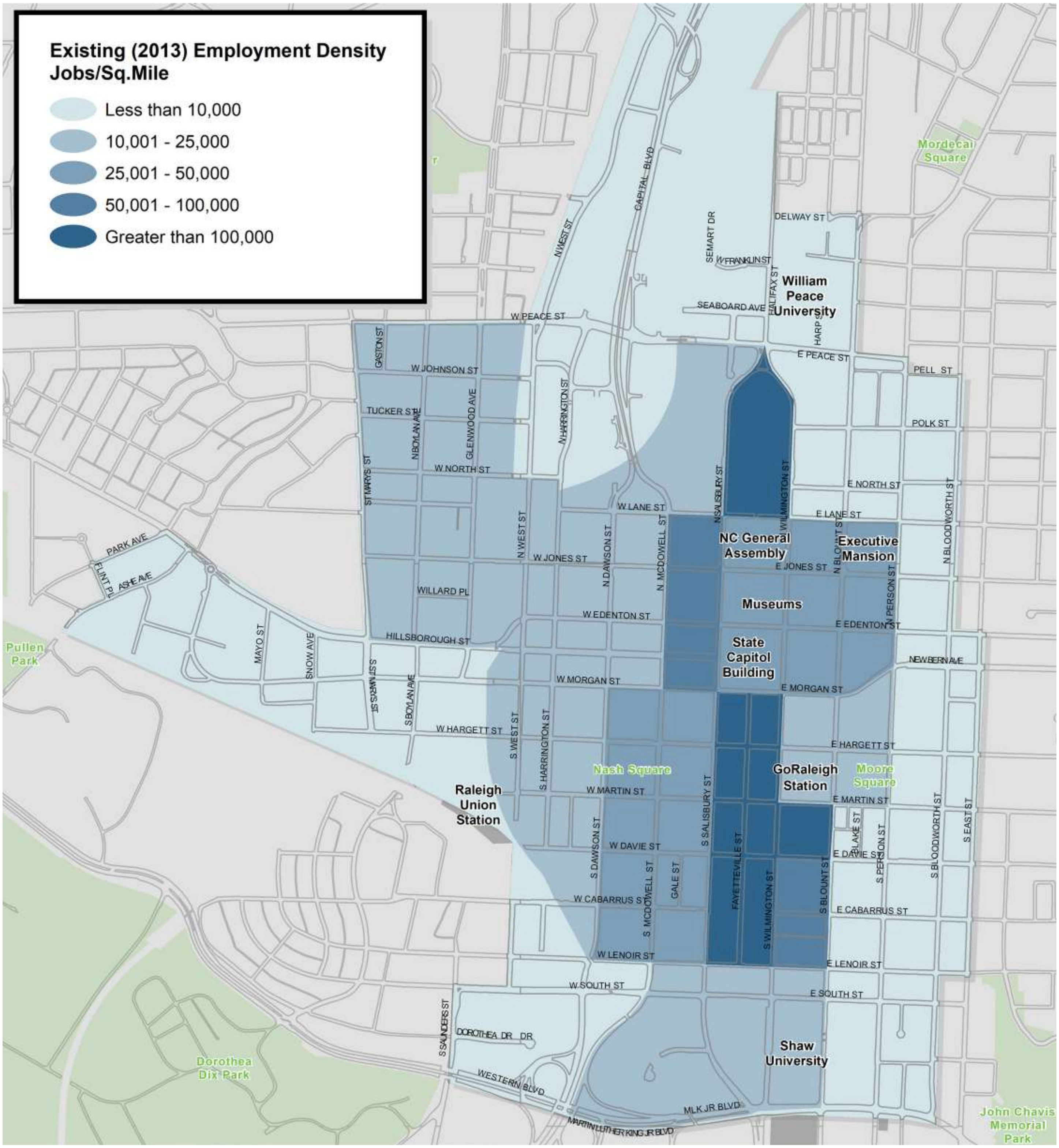


EXHIBIT A.24 — FUTURE (2045) EMPLOYMENT

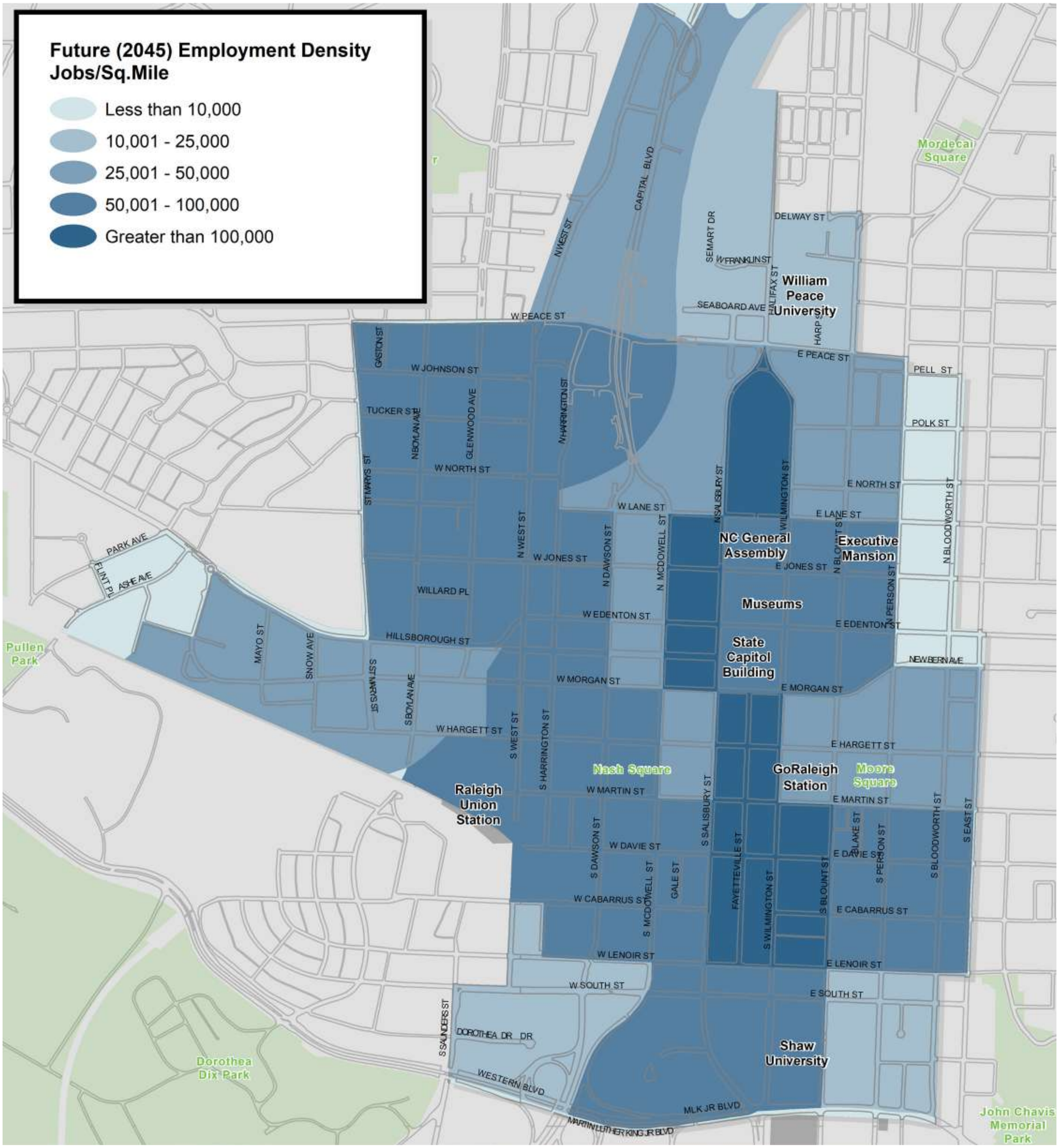


EXHIBIT A.25 — EXISTING (2013) EMPLOYMENT

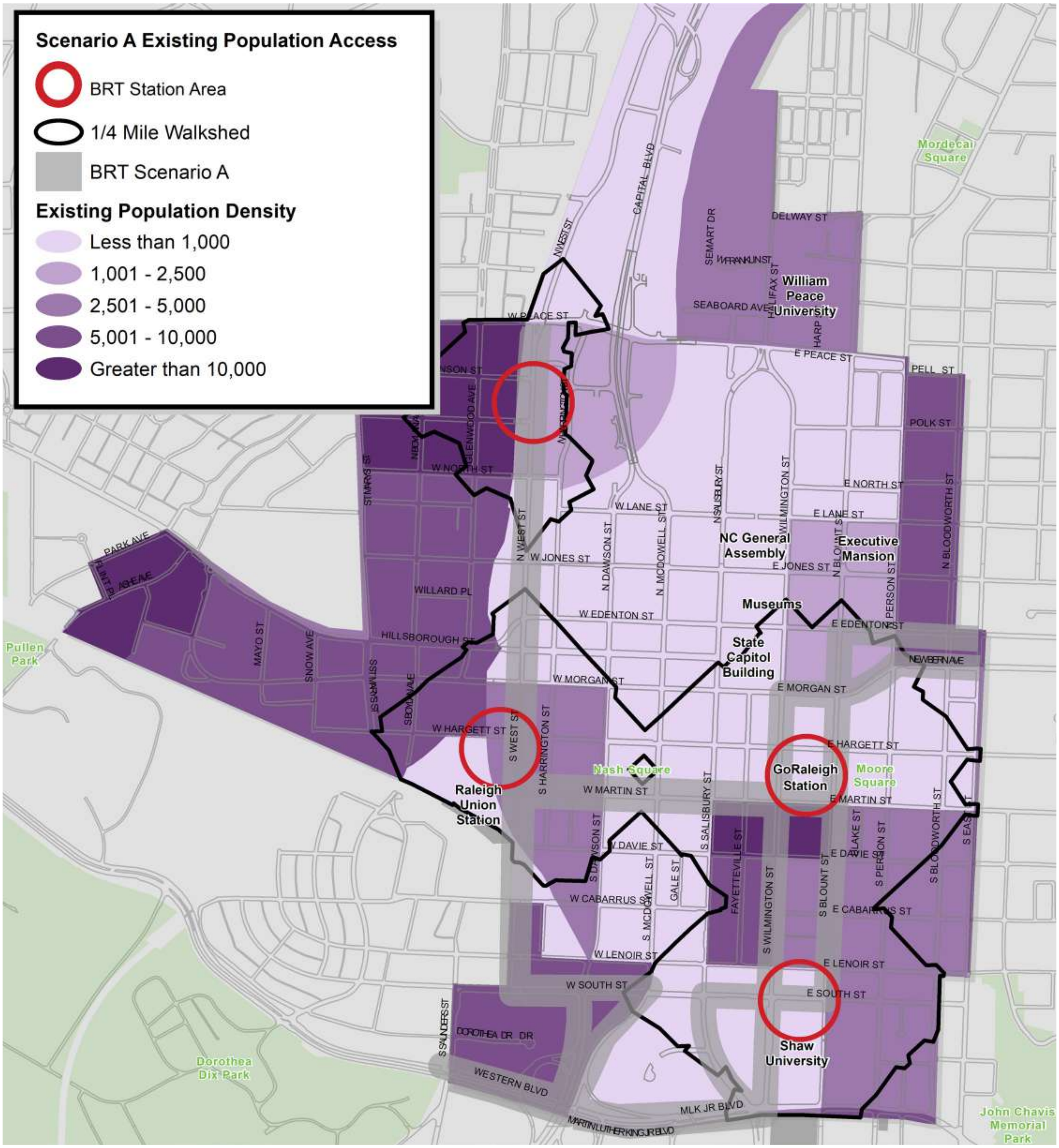


EXHIBIT A.26 — FUTURE (2045) EMPLOYMENT

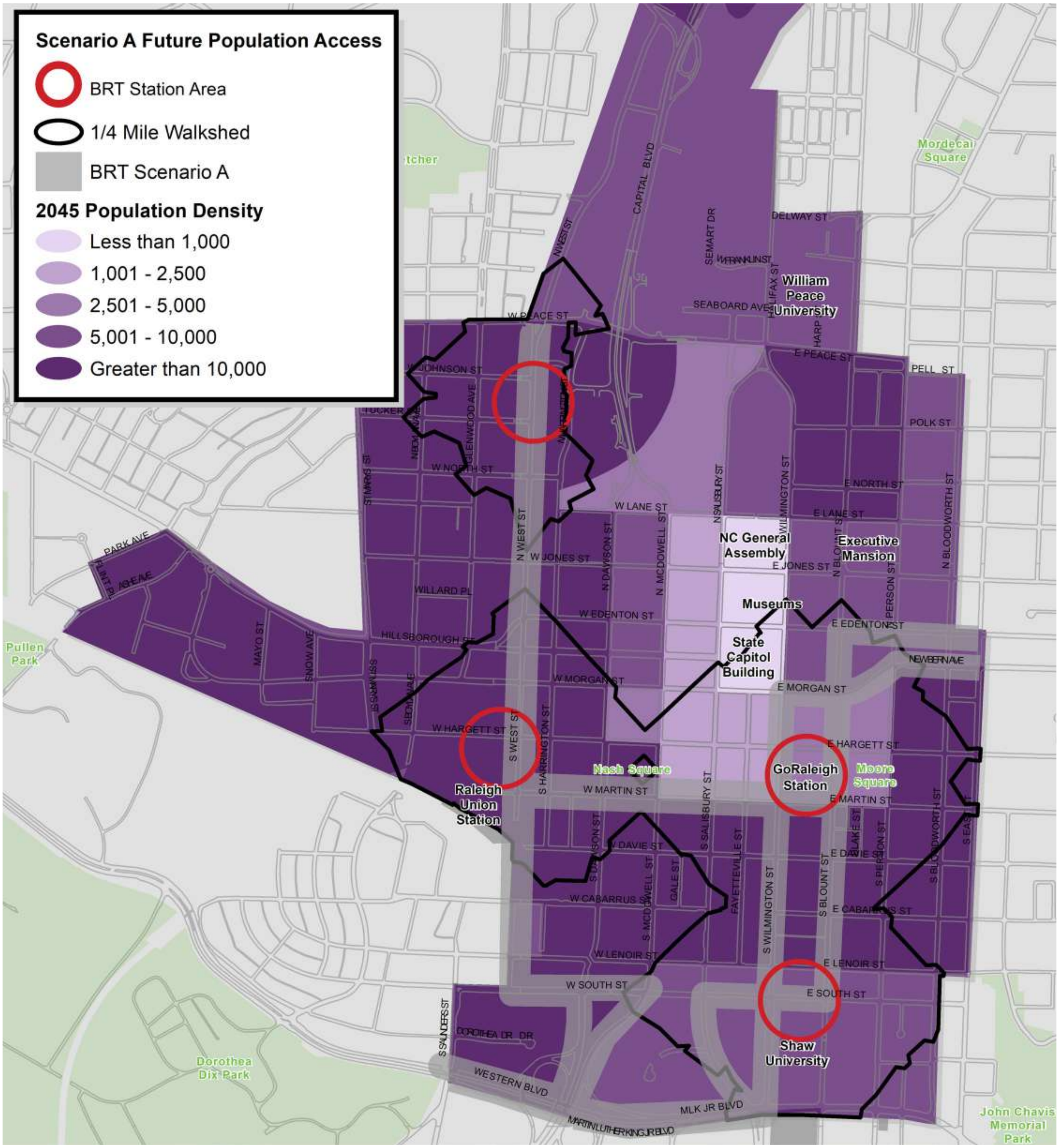


EXHIBIT A.27 — EXISTING (2013) EMPLOYMENT

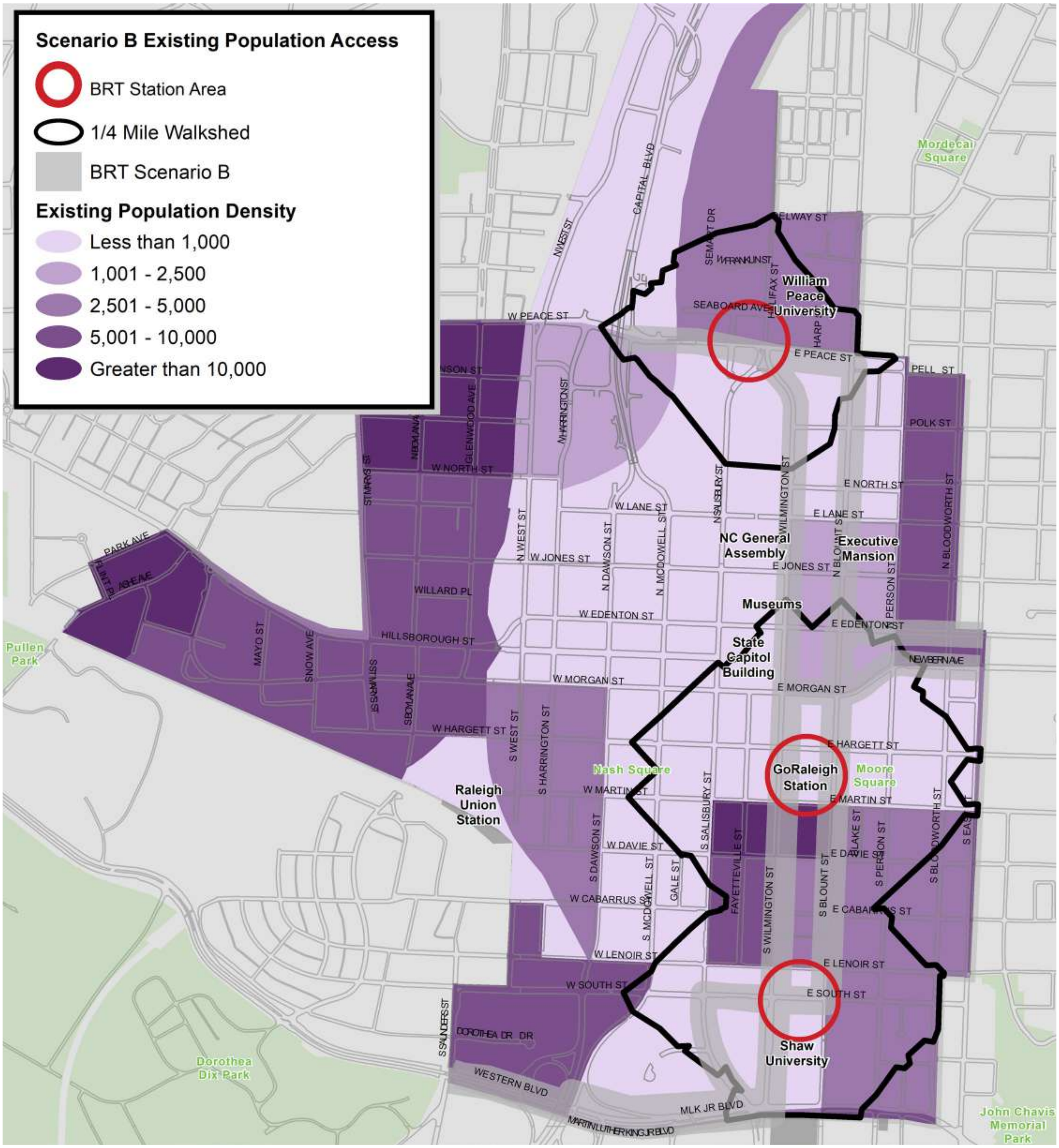


EXHIBIT A.28 — FUTURE (2045) EMPLOYMENT

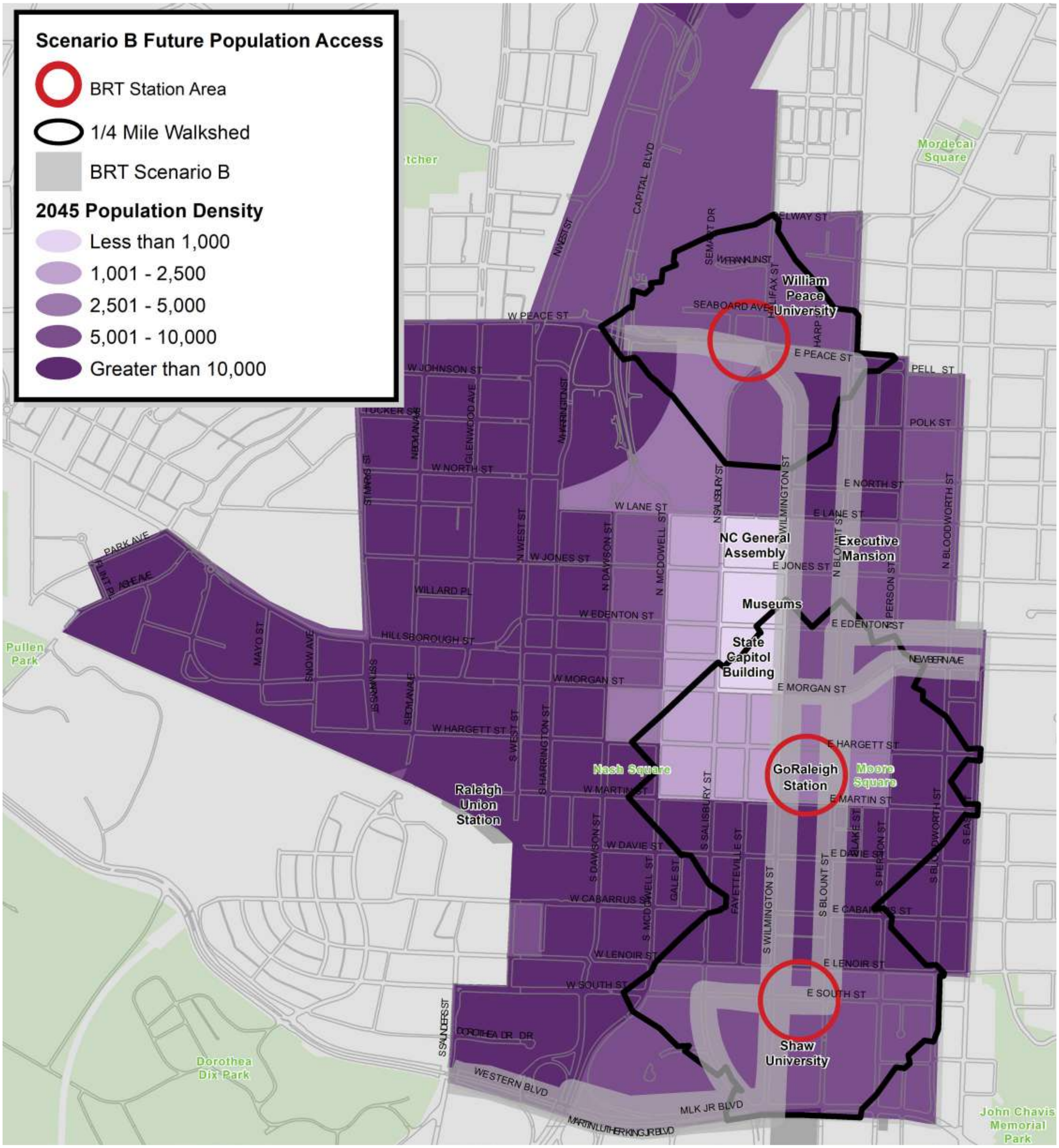


EXHIBIT A.29 — EXISTING (2013) EMPLOYMENT

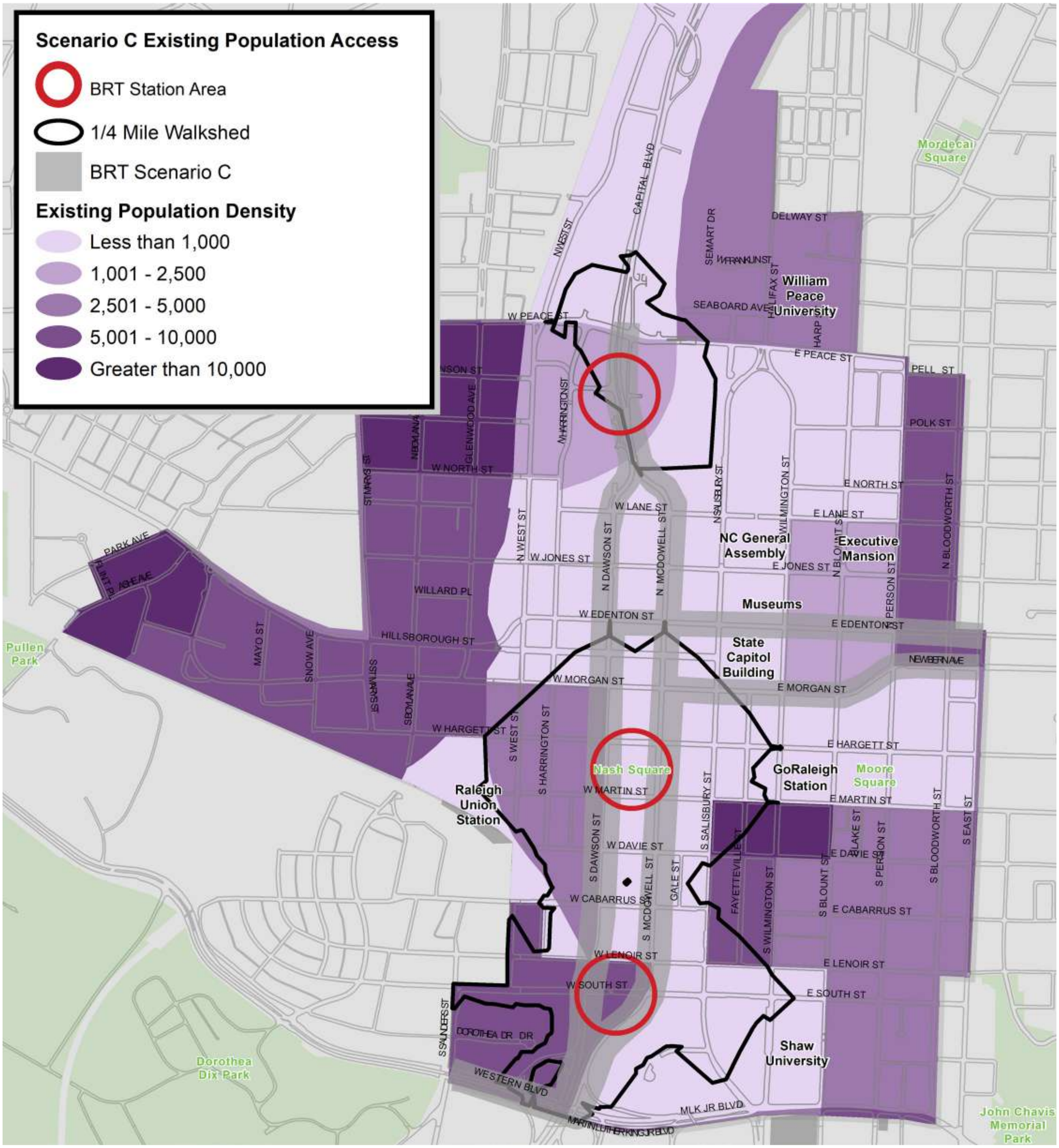


EXHIBIT A.30 — FUTURE (2045) EMPLOYMENT

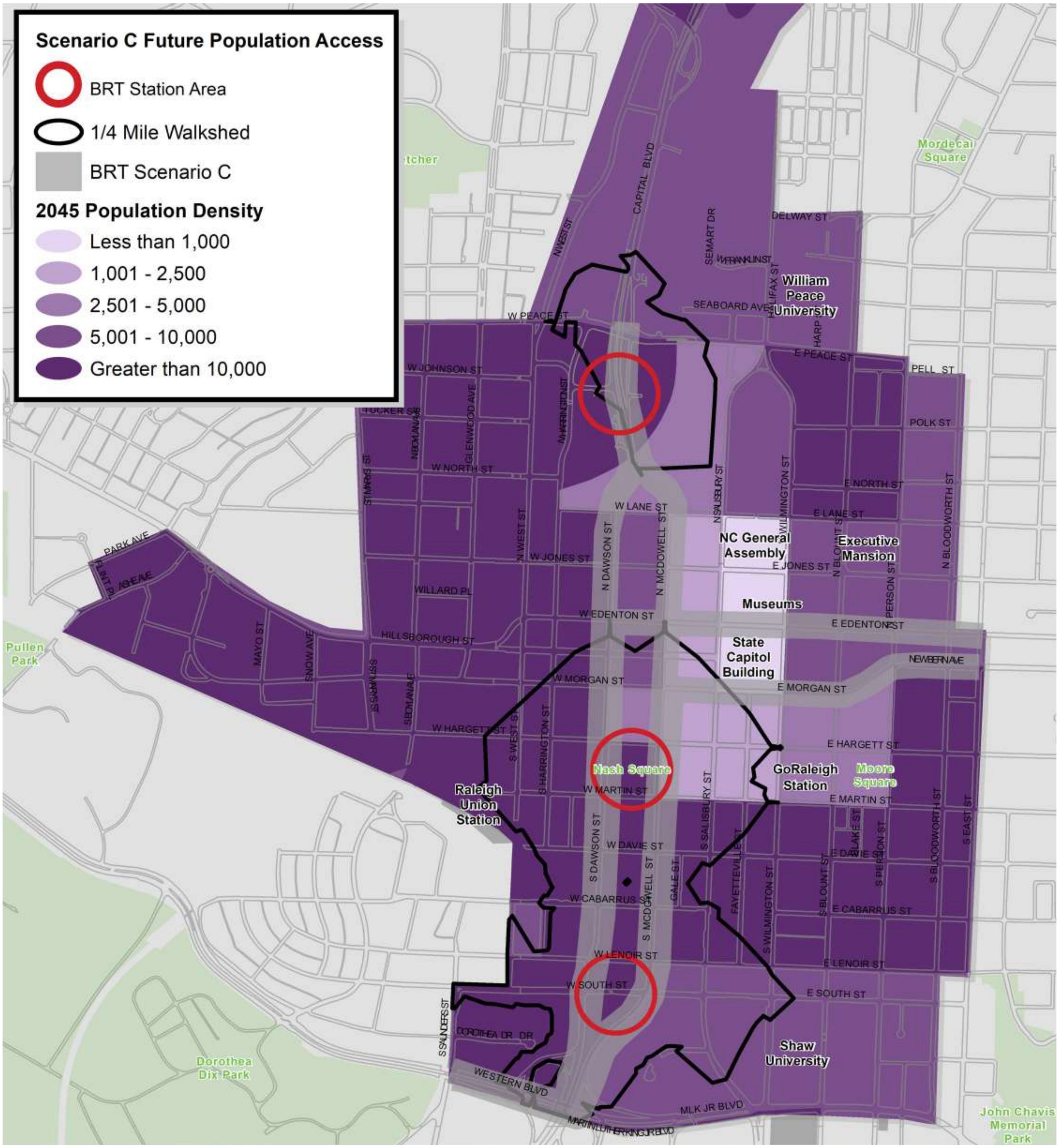


EXHIBIT A.31 — EXISTING (2013) EMPLOYMENT

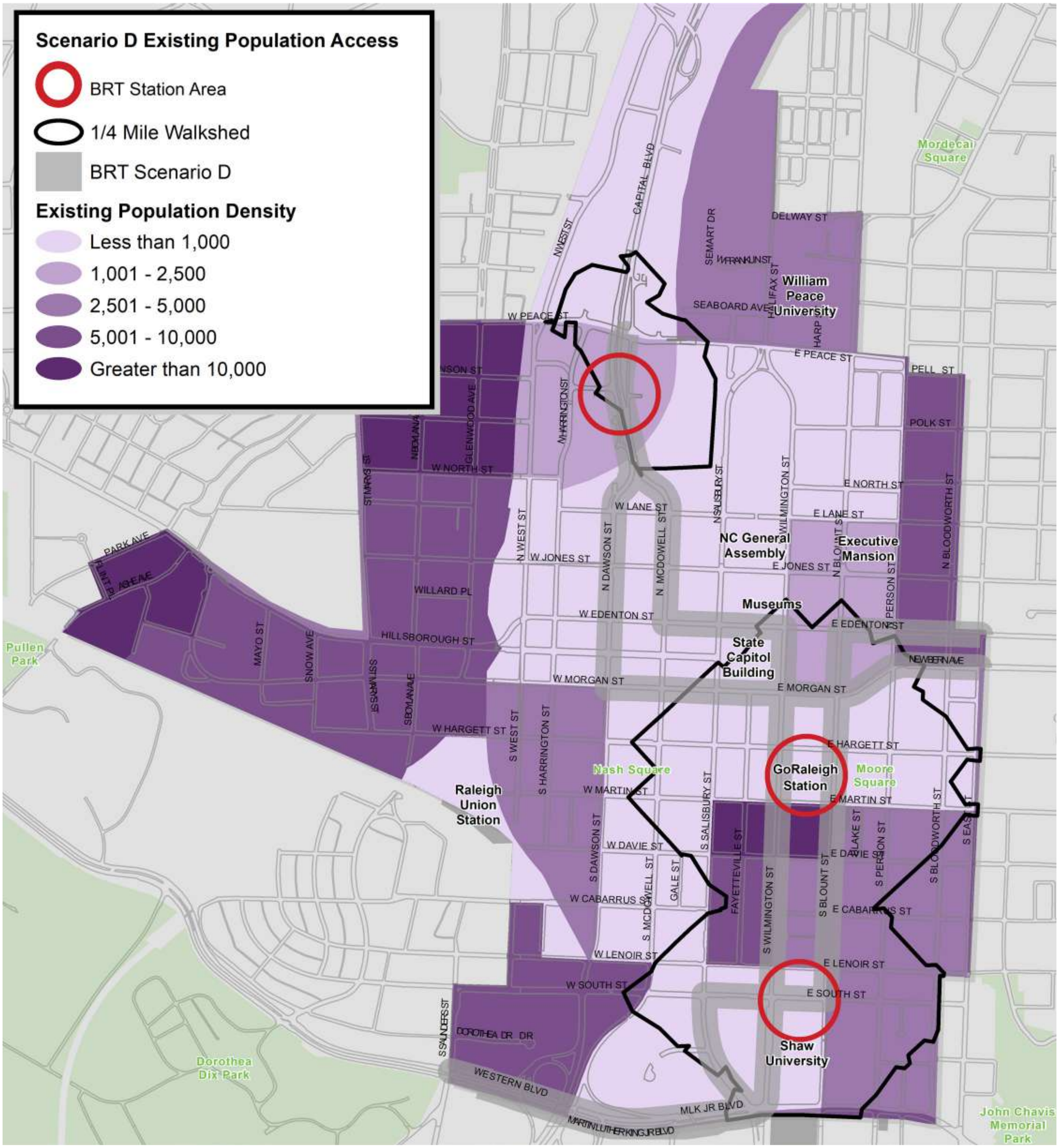


EXHIBIT A.32 — FUTURE (2045) EMPLOYMENT

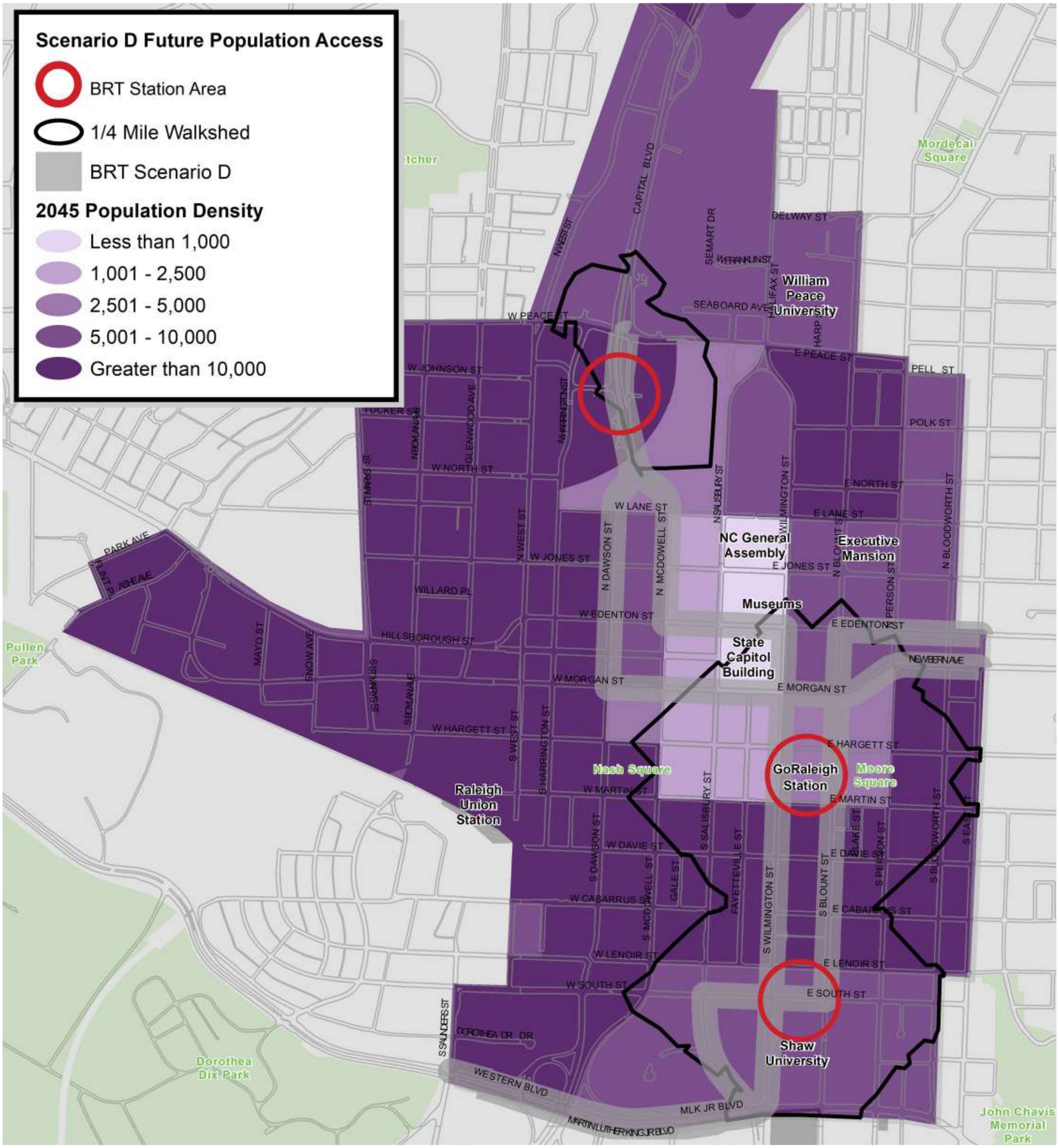


EXHIBIT A.33 — EXISTING (2013) EMPLOYMENT

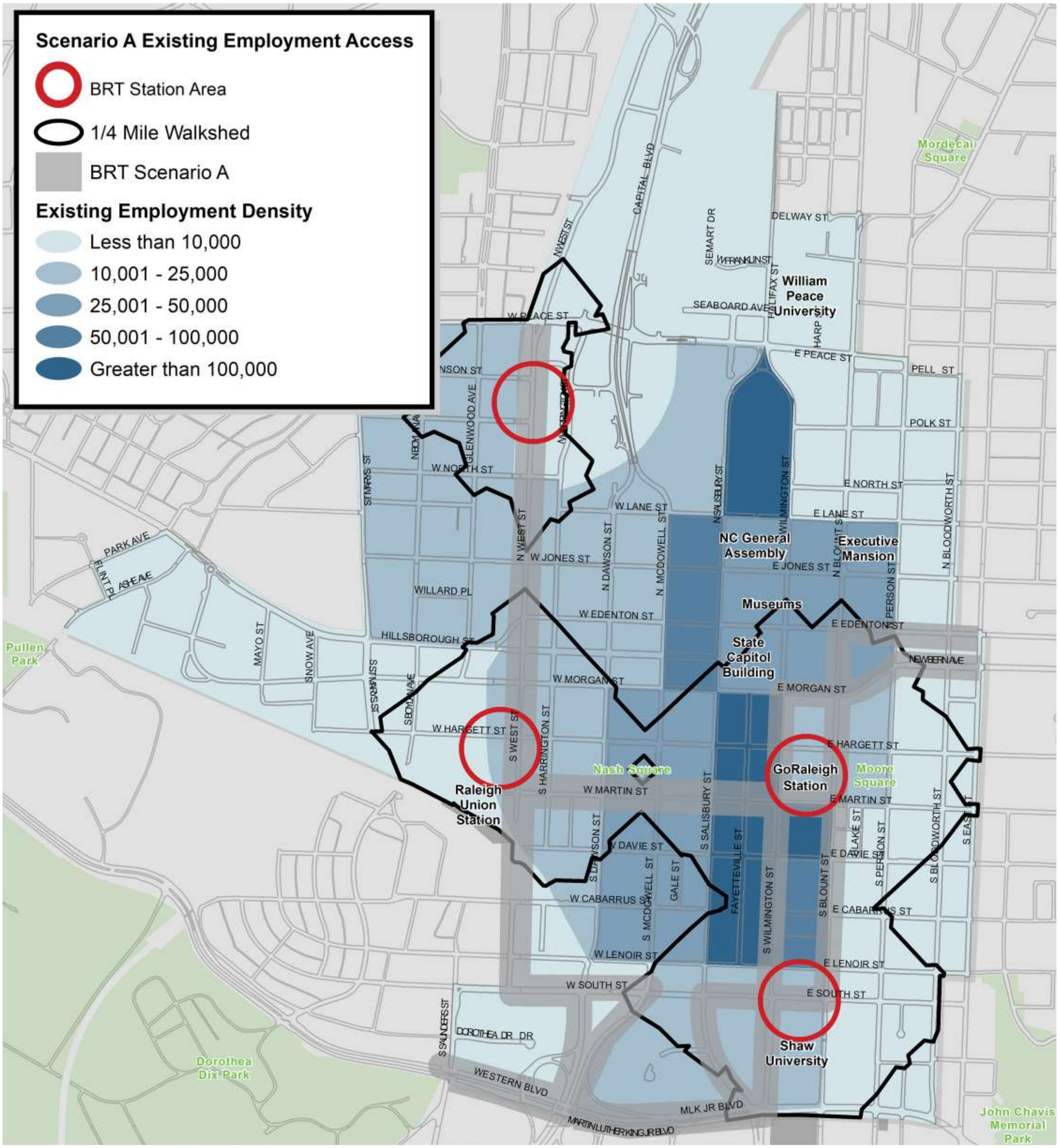


EXHIBIT A.34 — FUTURE (2045) EMPLOYMENT

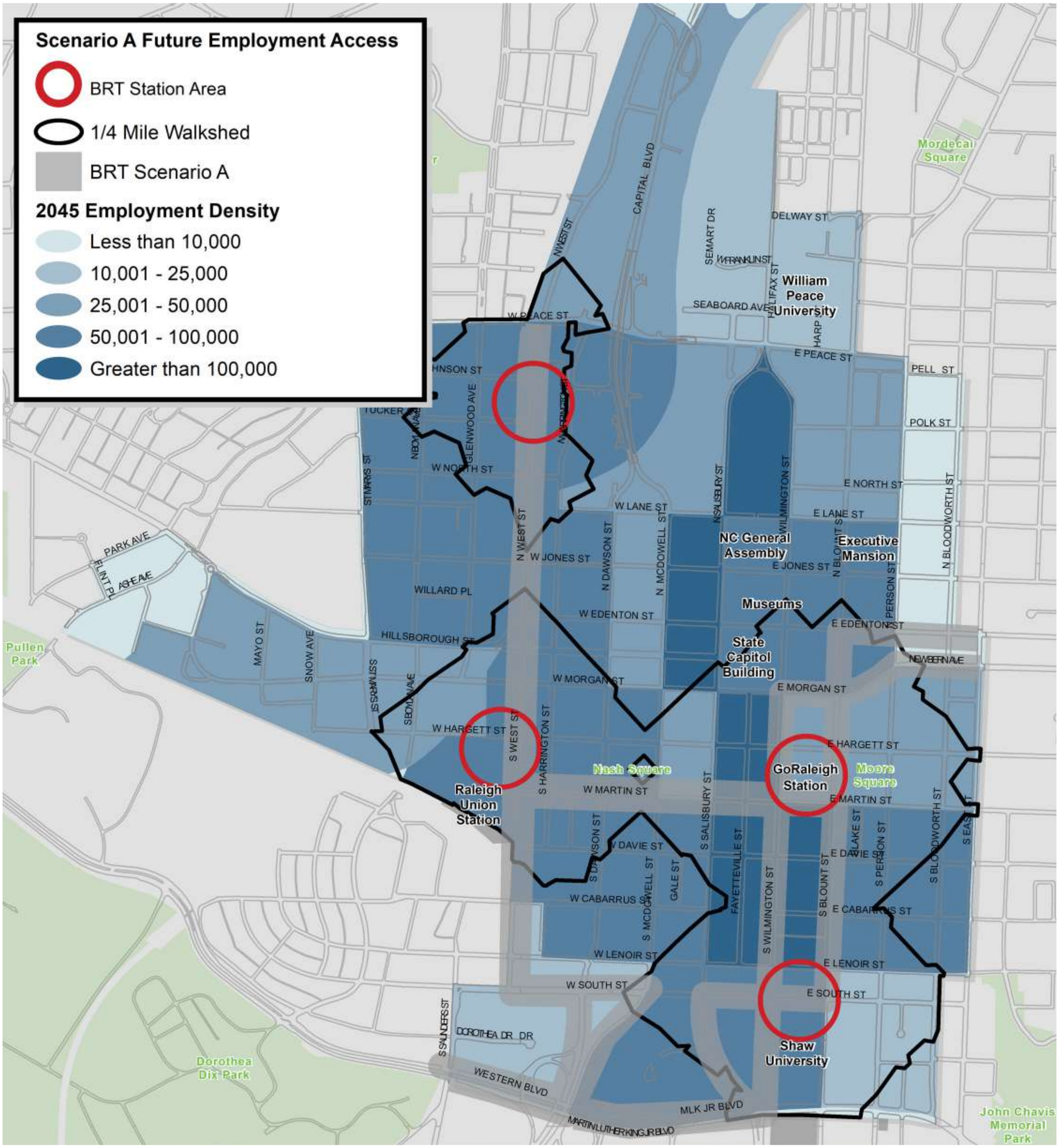


EXHIBIT A.35 — EXISTING (2013) EMPLOYMENT

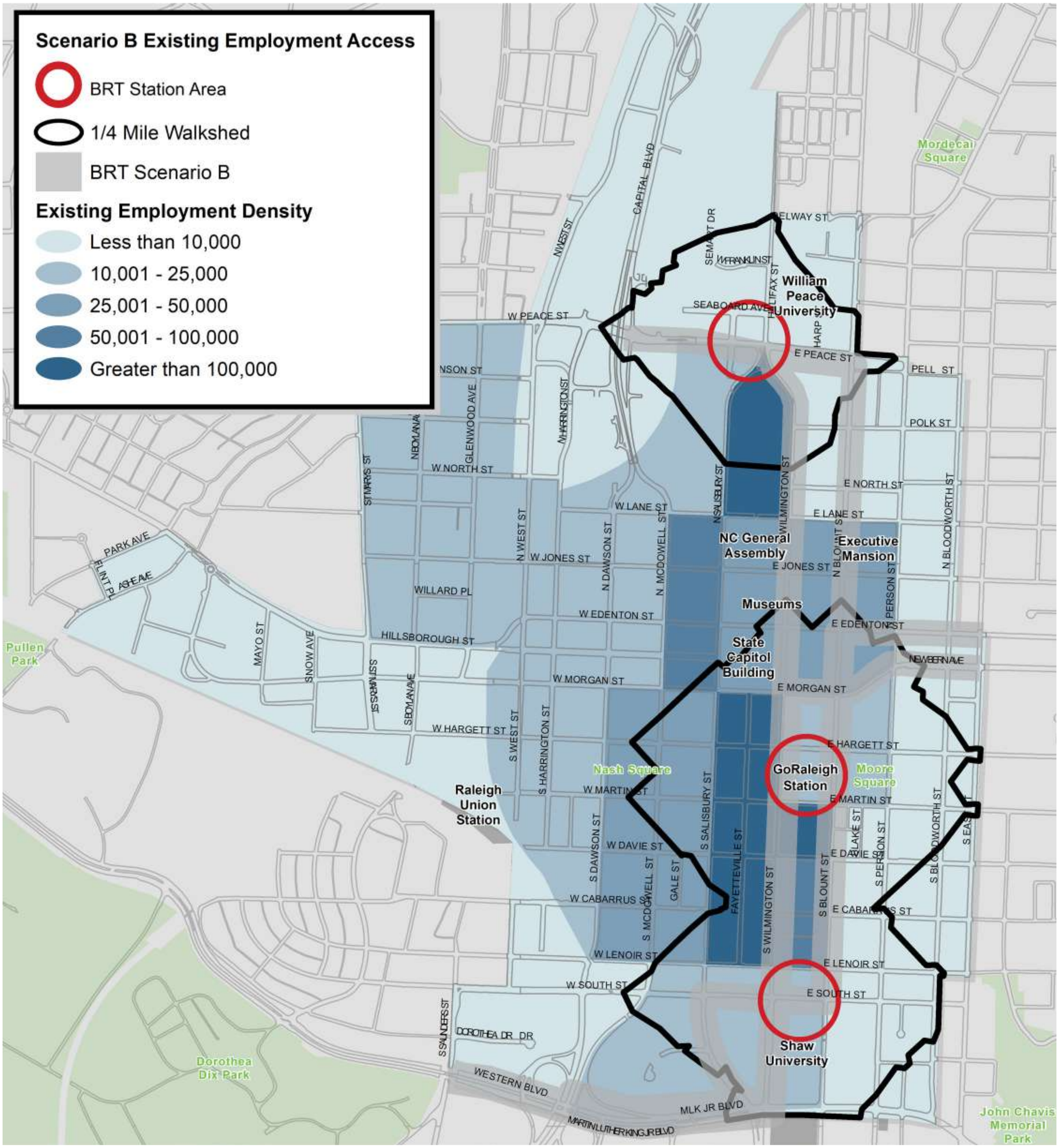


EXHIBIT A.36 — FUTURE (2045) EMPLOYMENT

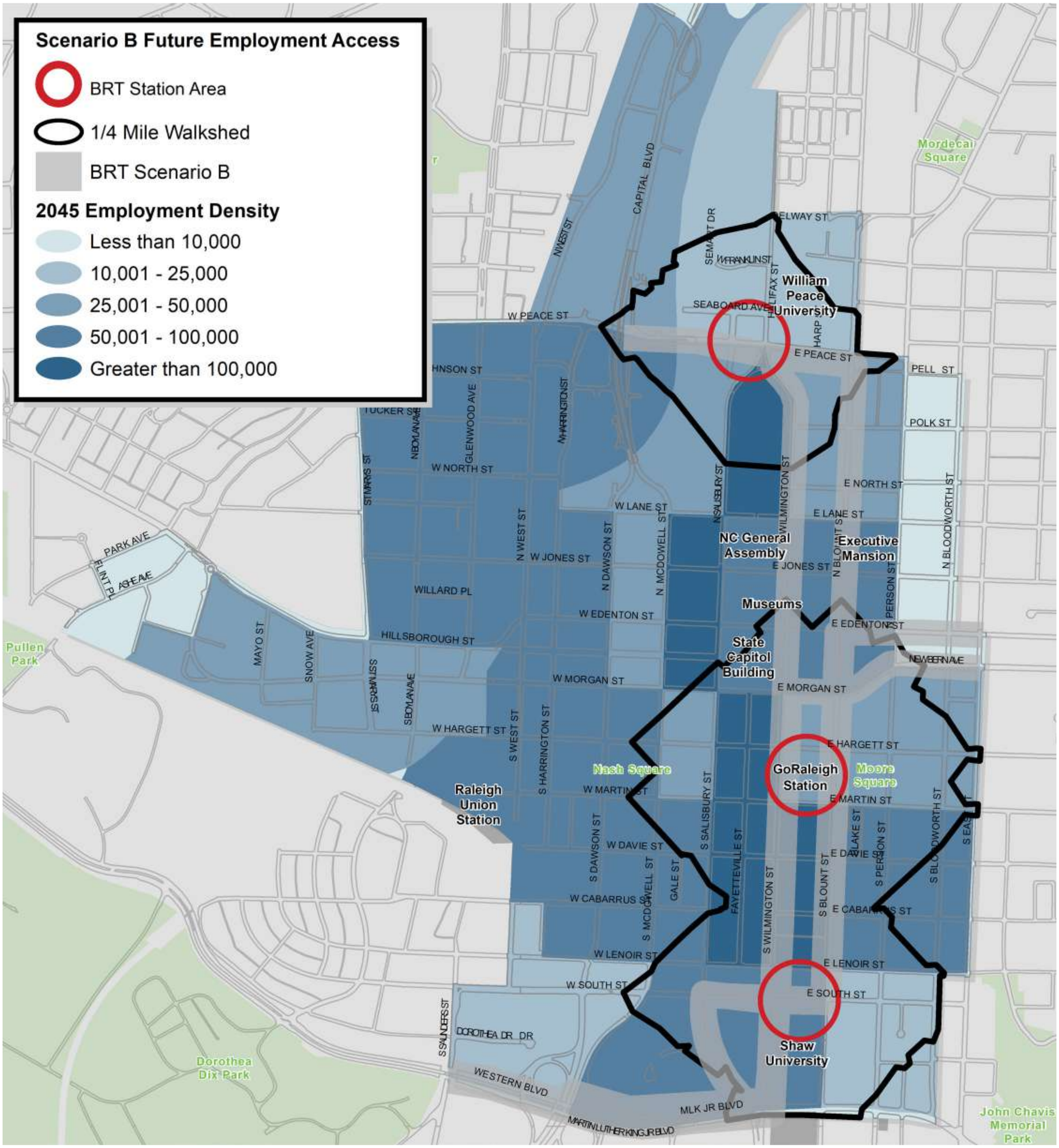


EXHIBIT A.37 — EXISTING (2013) EMPLOYMENT

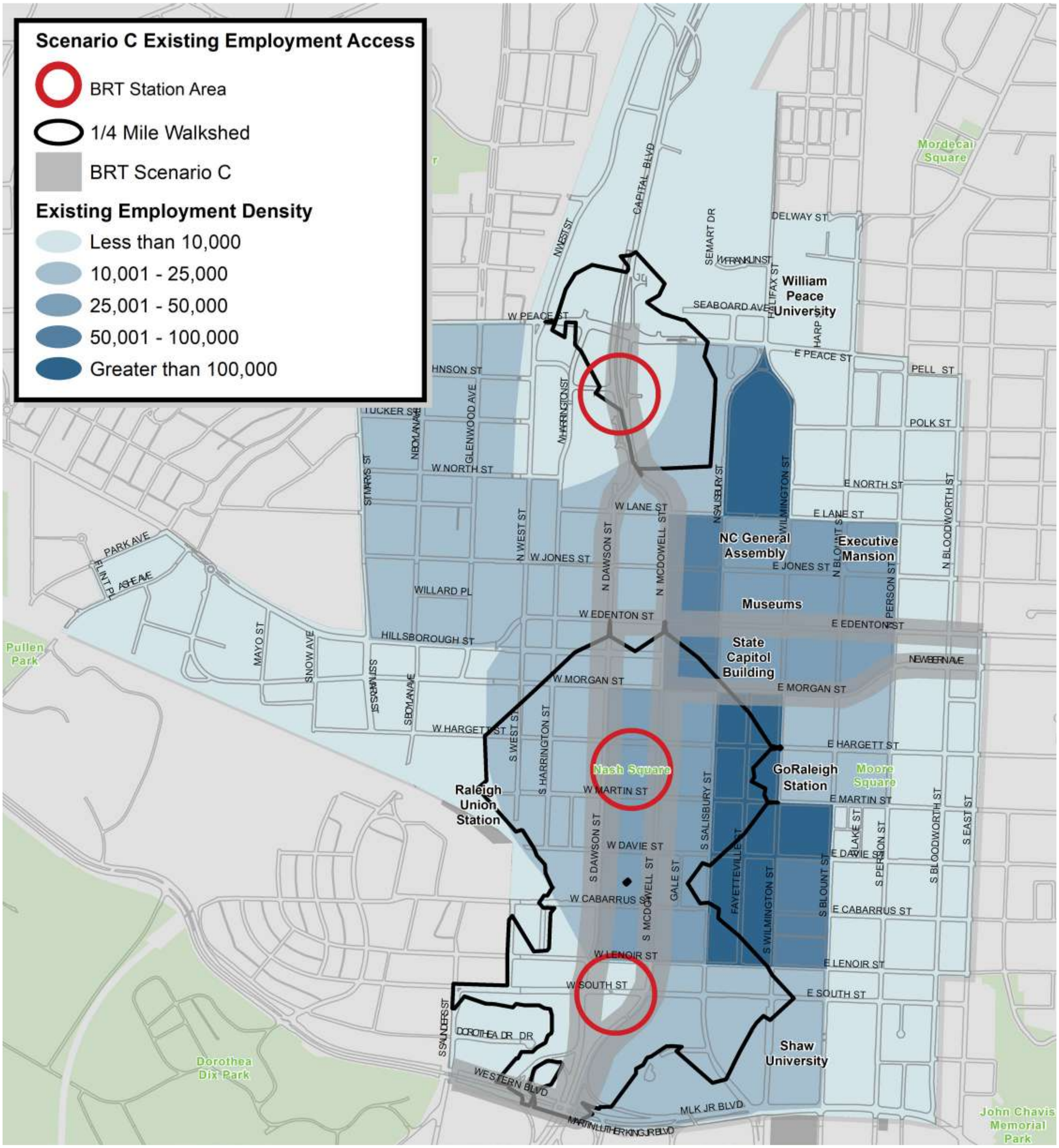


EXHIBIT A.38 — FUTURE (2045) EMPLOYMENT

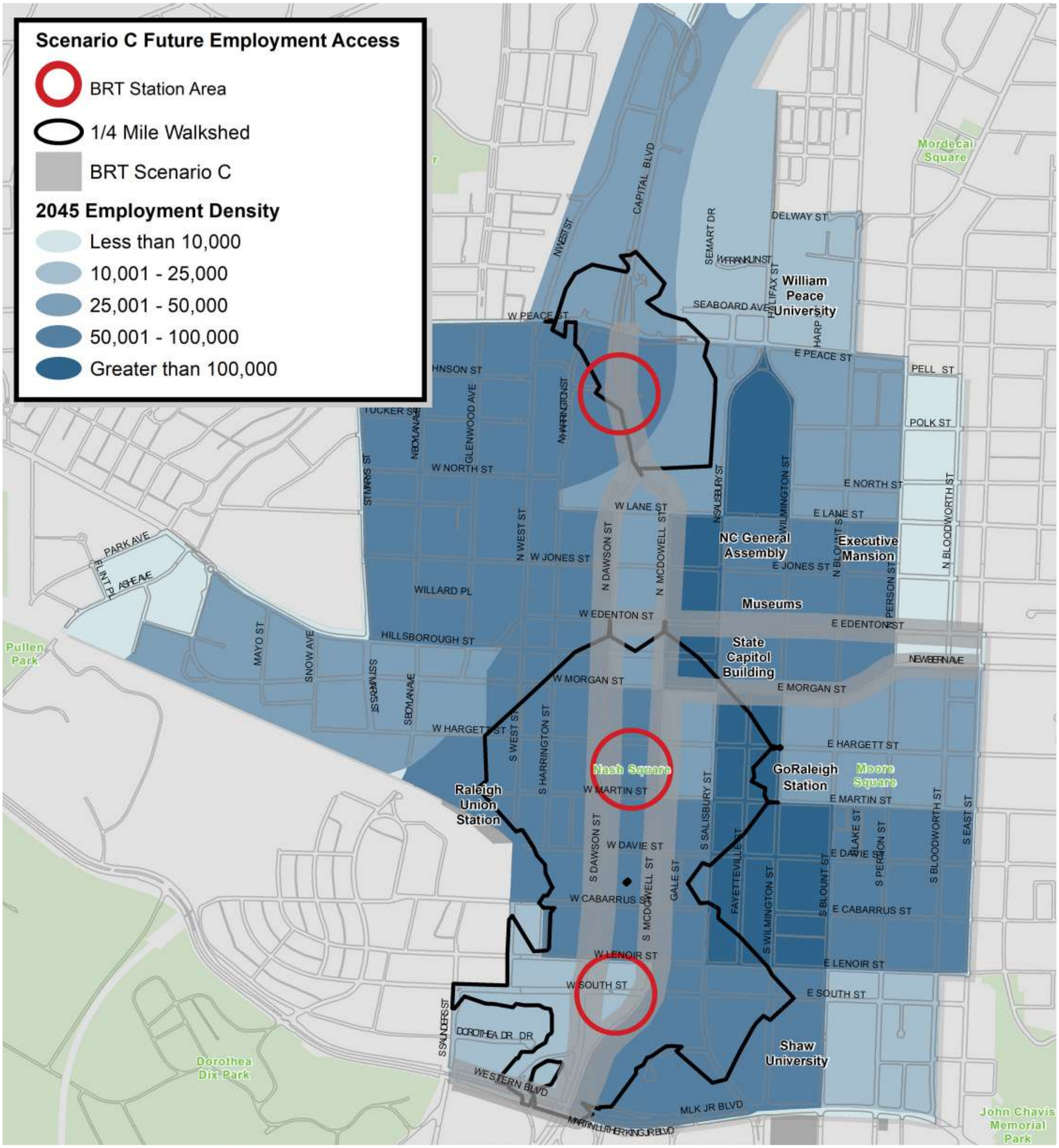


EXHIBIT A.39 — EXISTING (2013) EMPLOYMENT

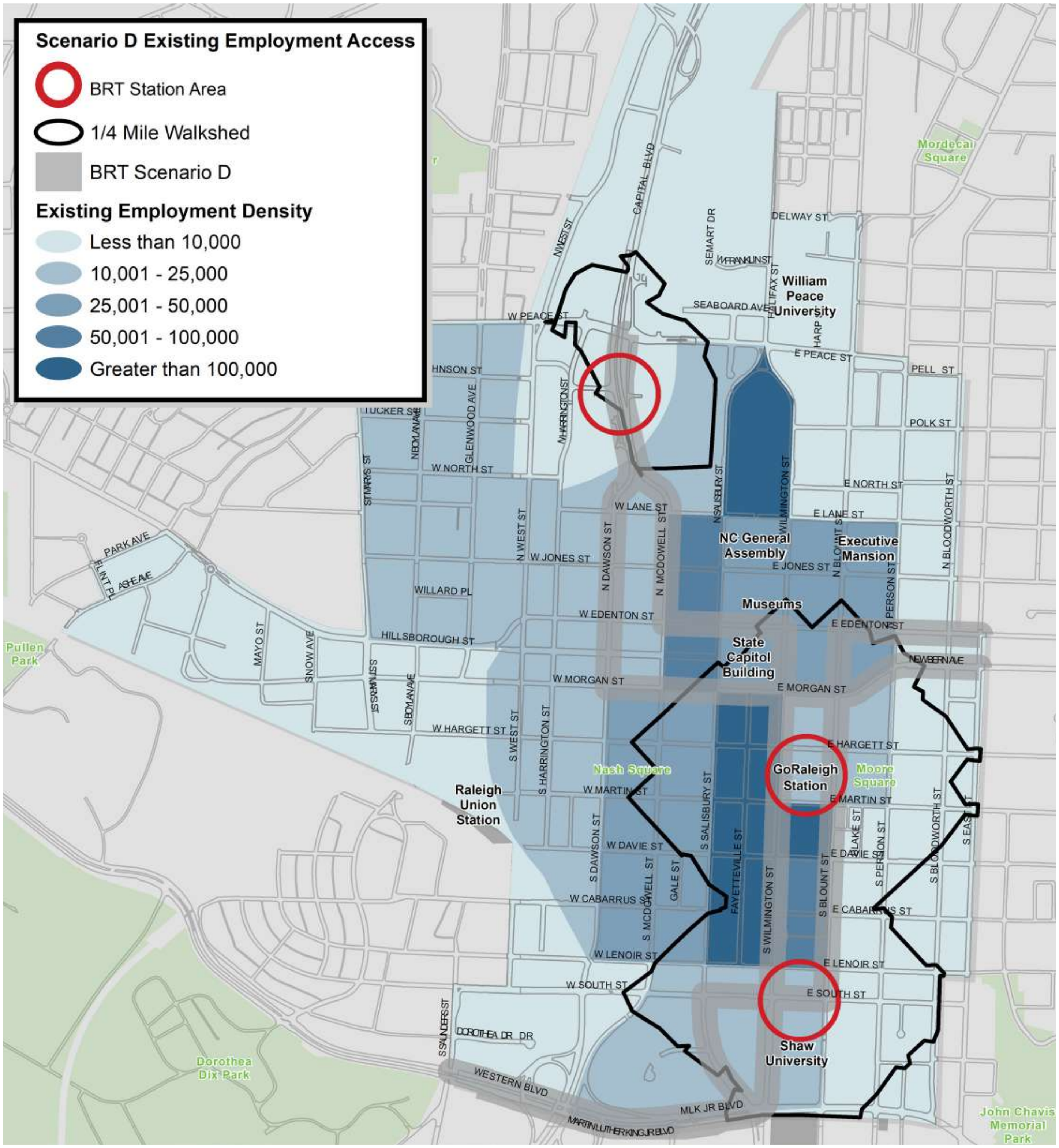


EXHIBIT A.40 — FUTURE (2045) EMPLOYMENT

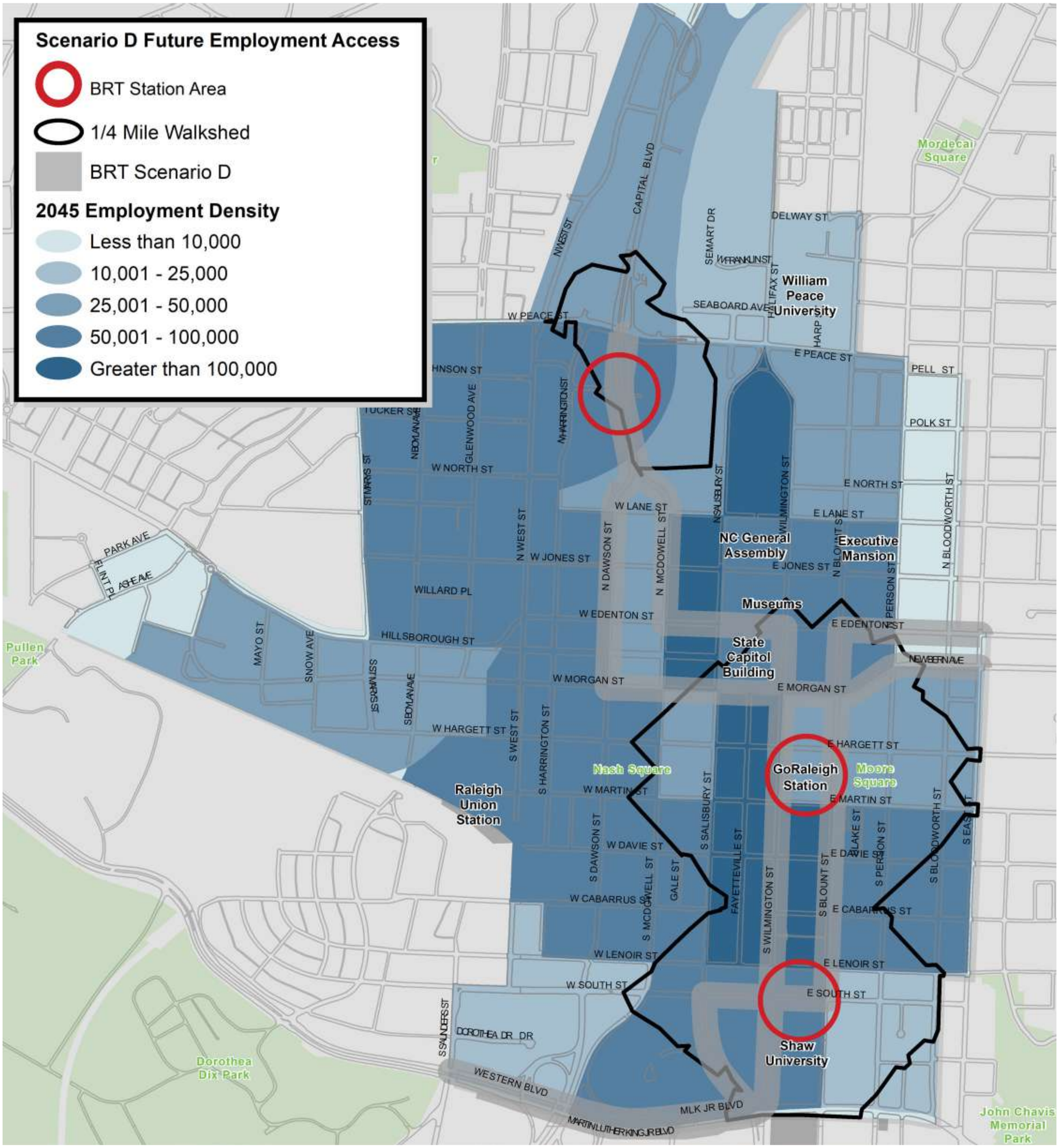


EXHIBIT A.41 — SCENARIO A LOW STRESS ISLAND ANALYSIS

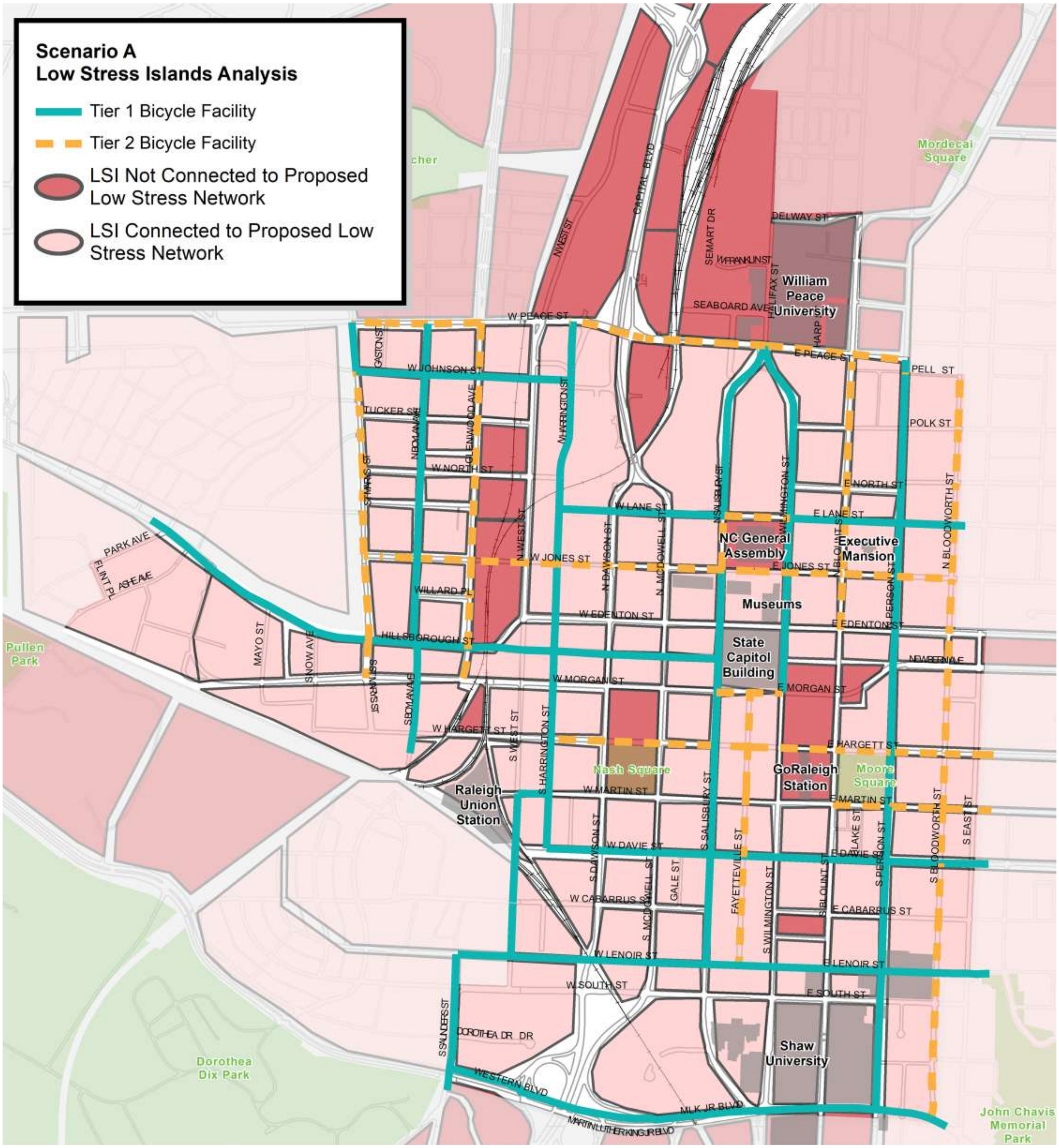


EXHIBIT A.42 — SCENARIO B LOW STRESS ISLAND ANALYSIS

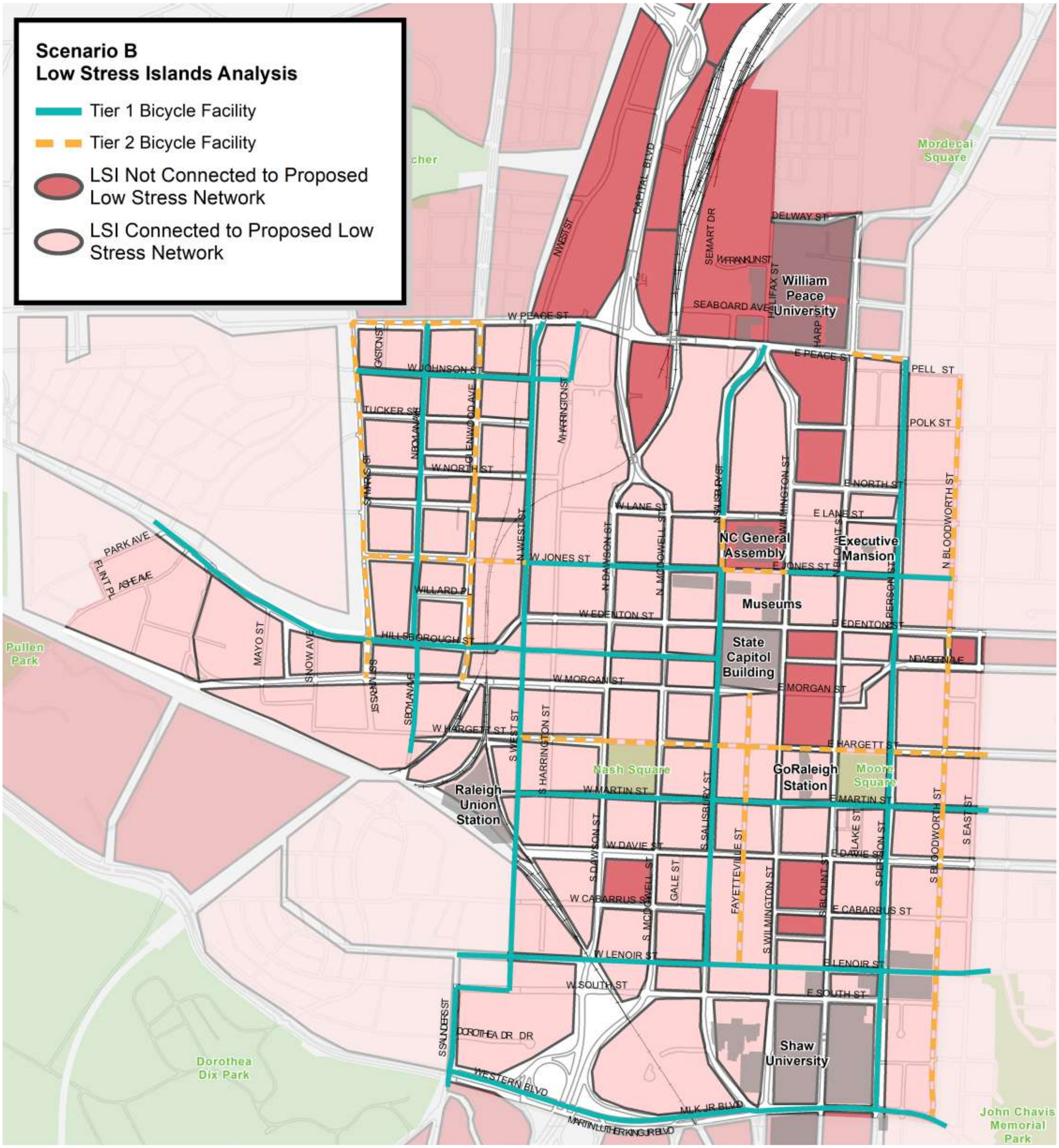


EXHIBIT A.43 — SCENARIO C LOW STRESS ISLAND ANALYSIS

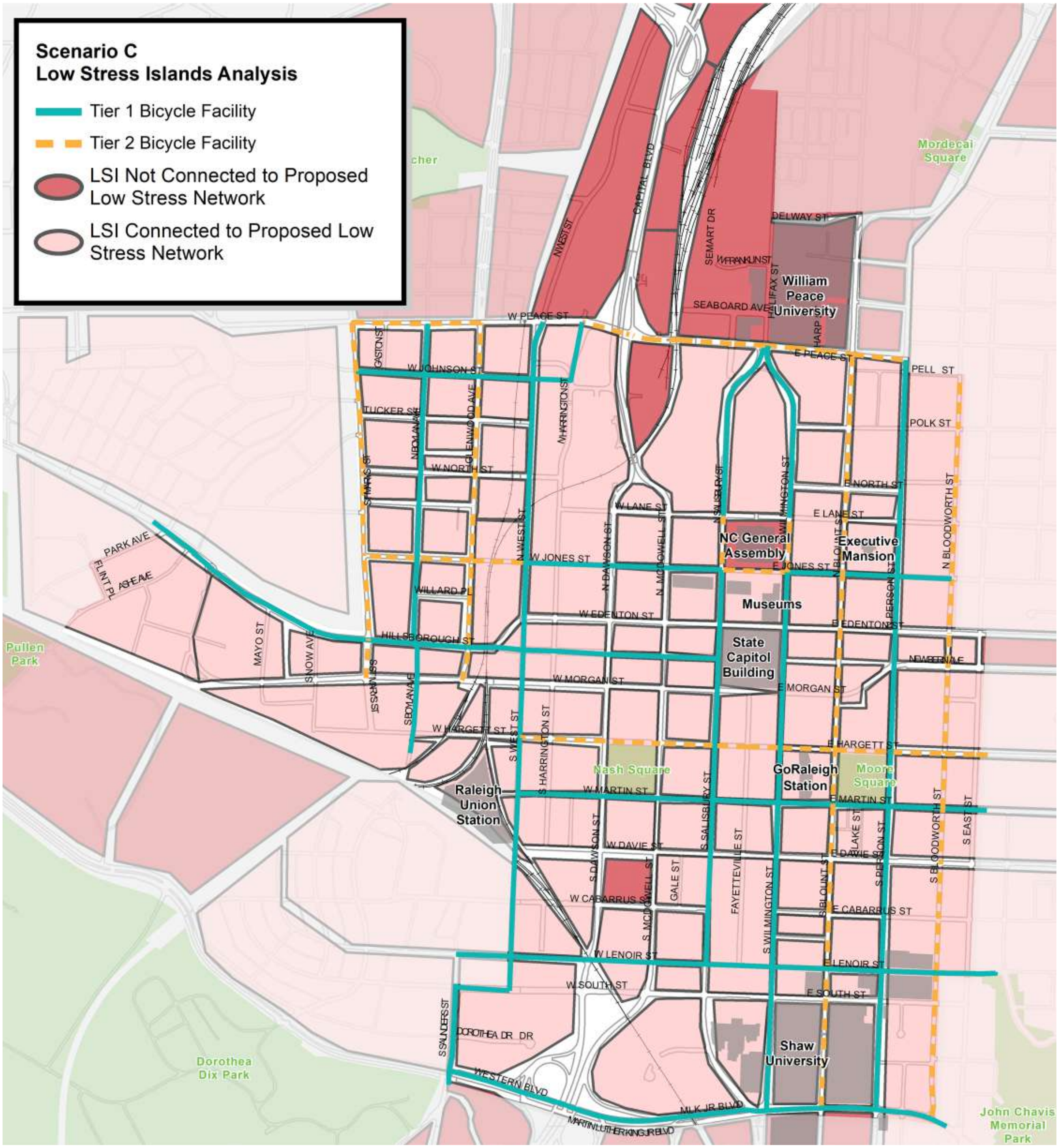


EXHIBIT A.44 — SCENARIO D LOW STRESS ISLAND ANALYSIS

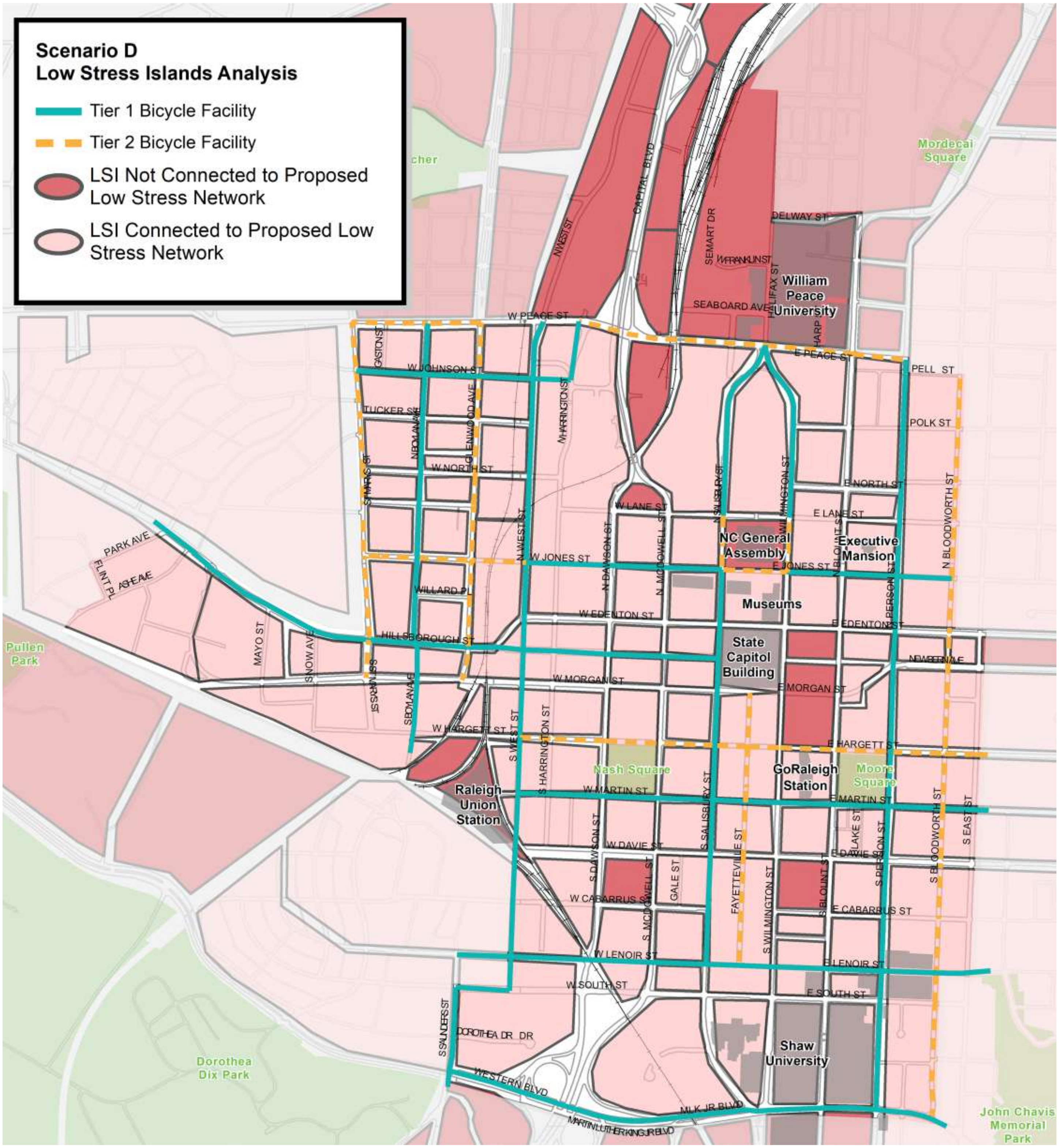


EXHIBIT A.45 — SCENARIO A BICYCLE SHED

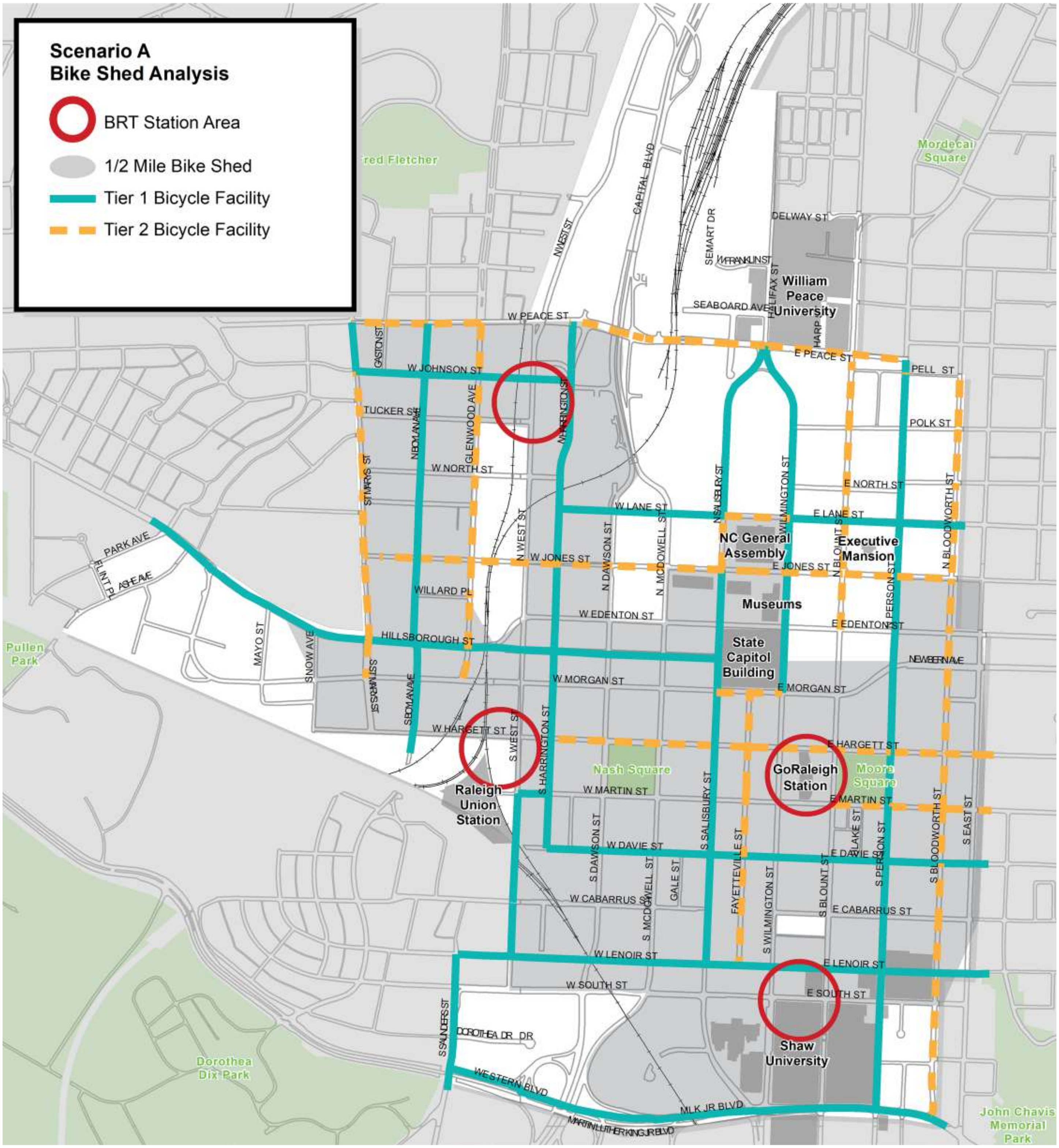


EXHIBIT A.46 — SCENARIO B BICYCLE SHED

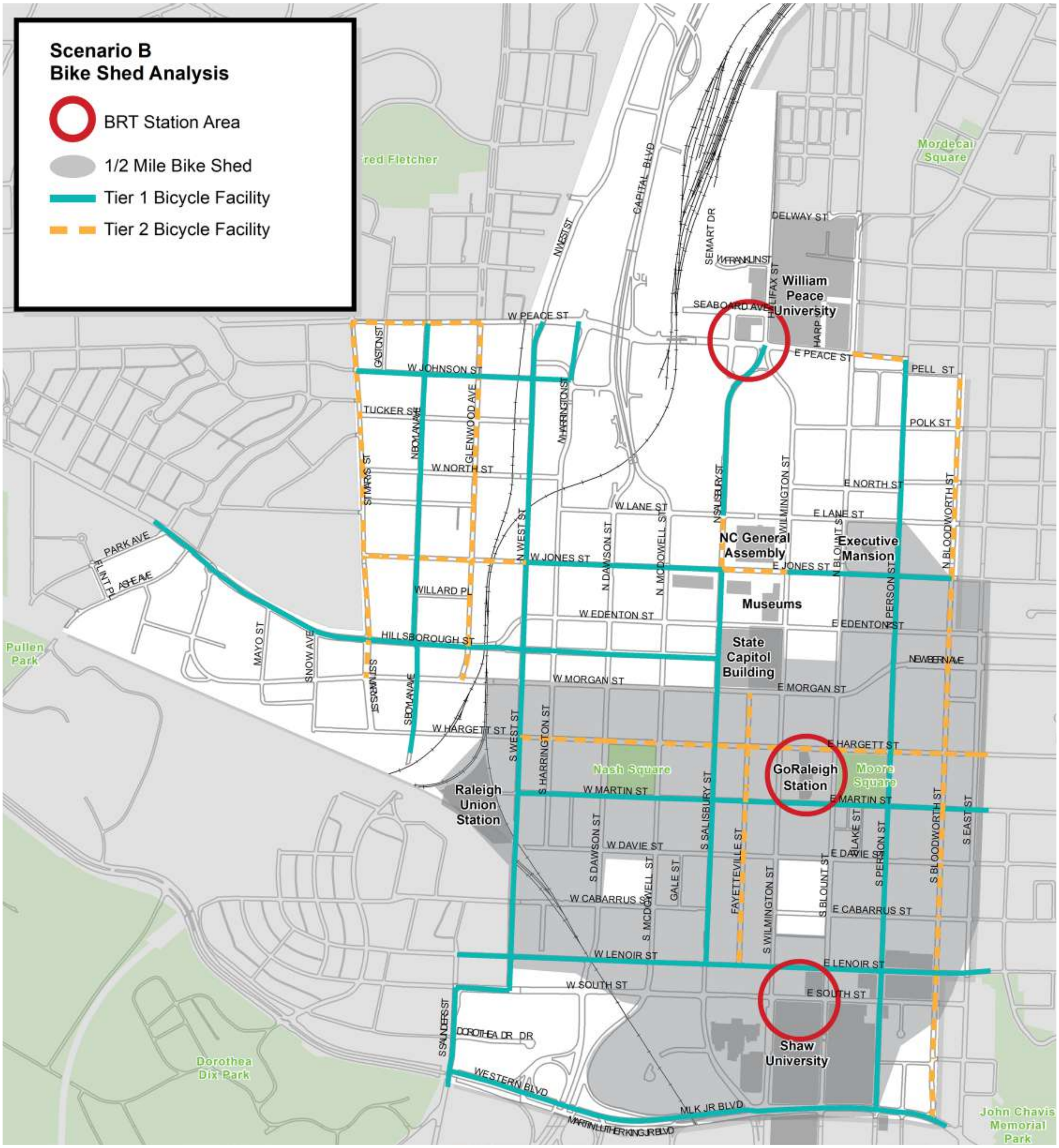


EXHIBIT A.47 — SCENARIO C BICYCLE SHED

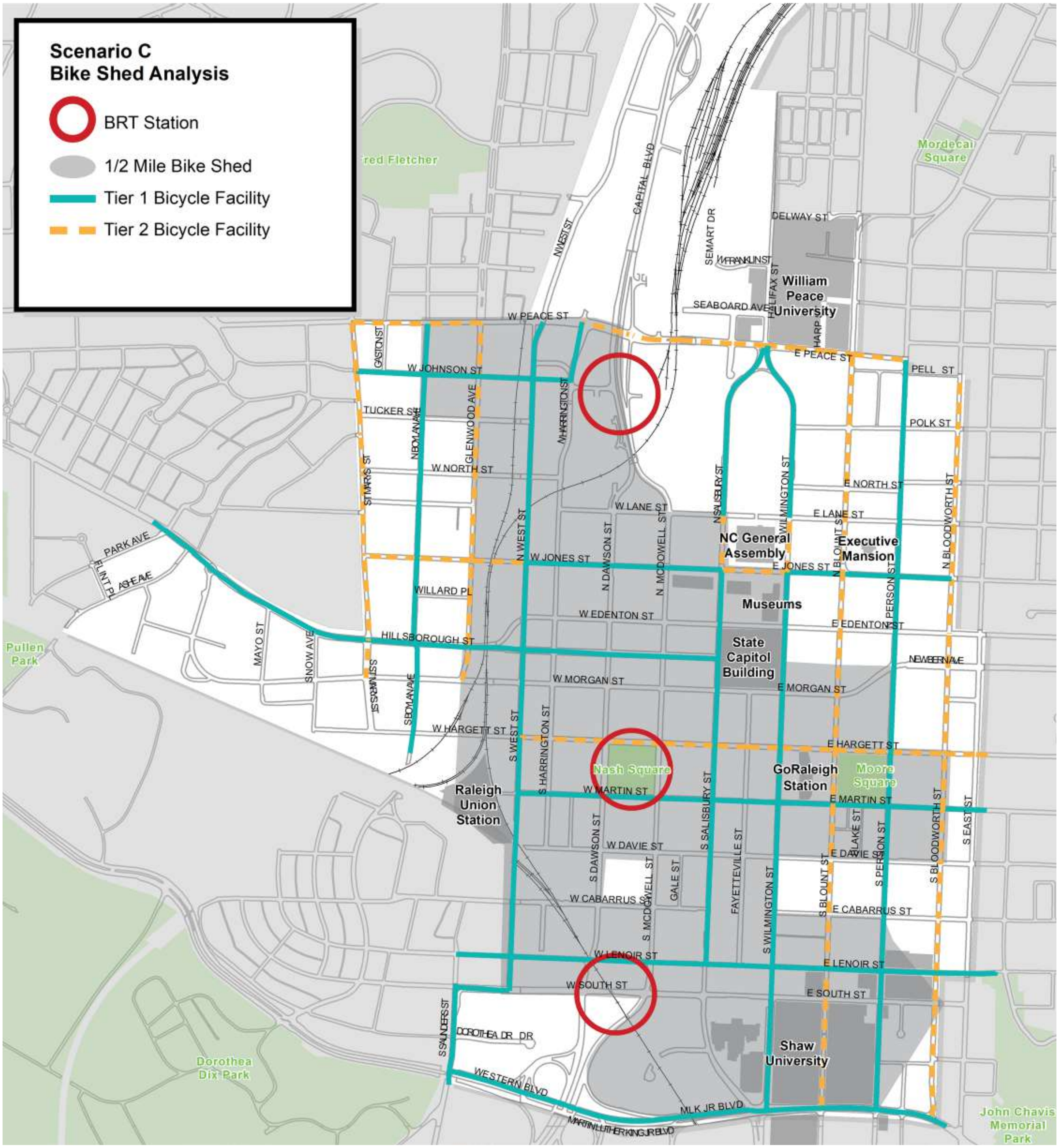


EXHIBIT A.48 — SCENARIO D BICYCLE SHED

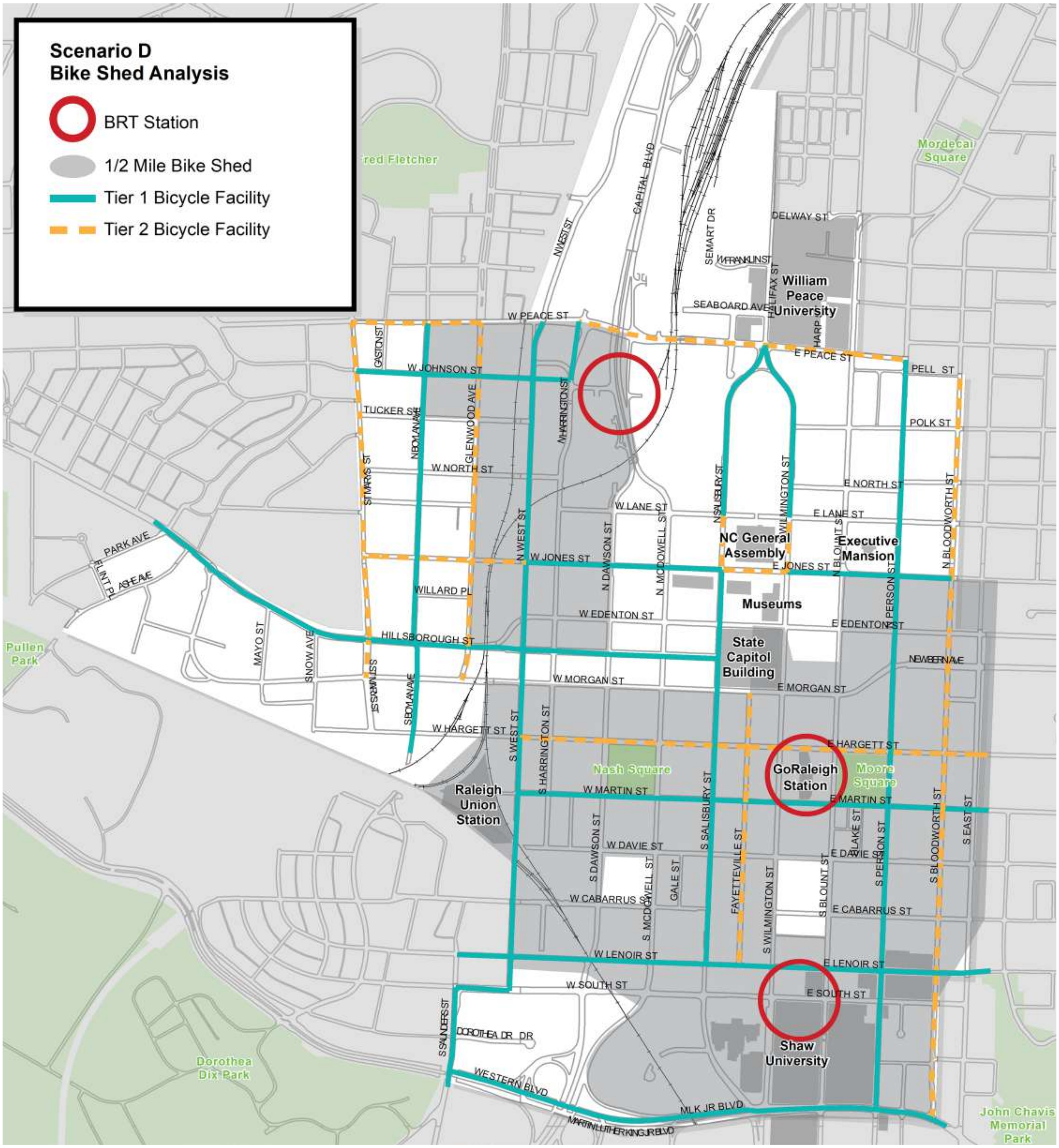


EXHIBIT A.49 — SCENARIO A EXISTING ON-STREET PARKING AND LOADING ZONE IMPACTS

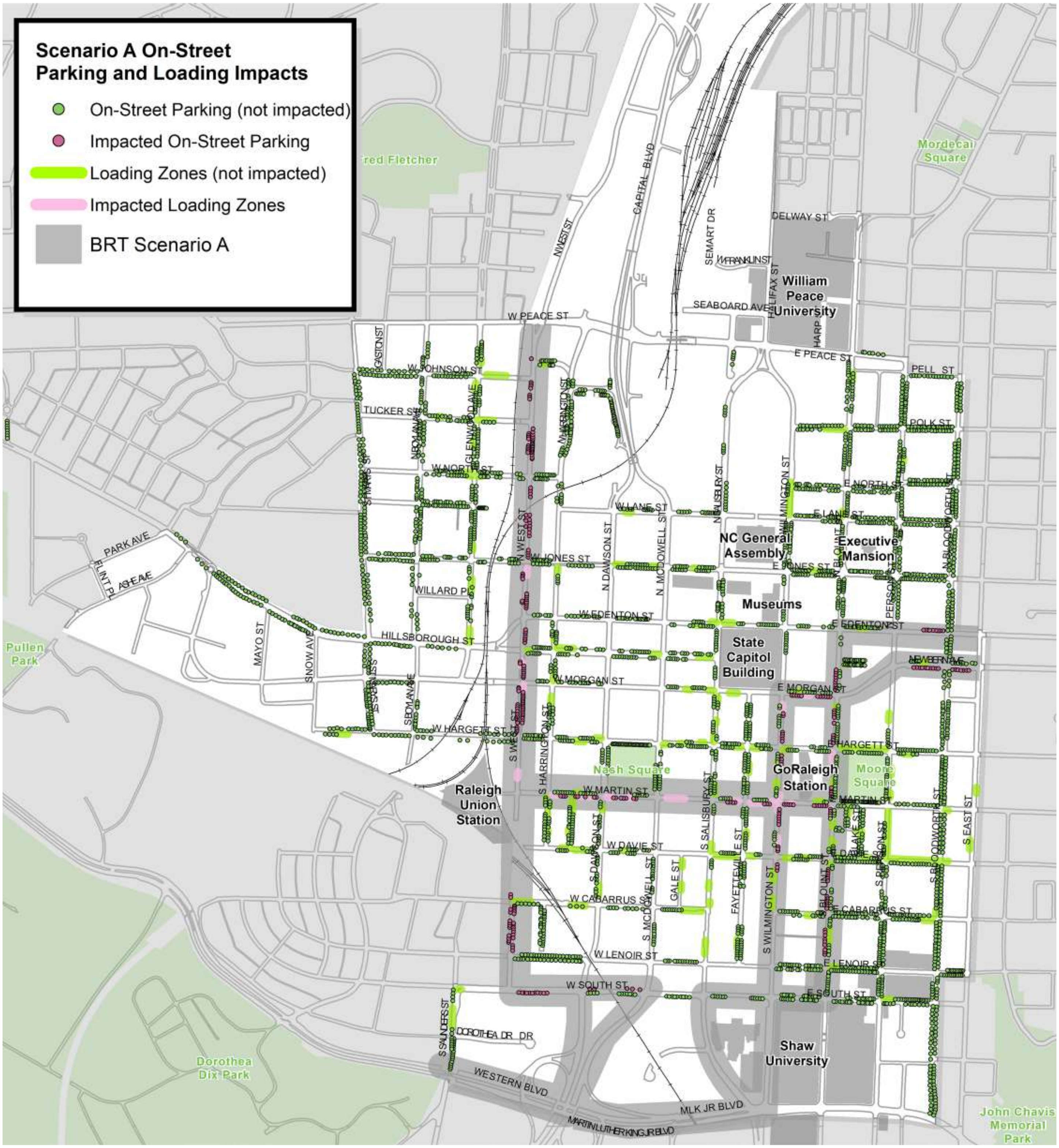


EXHIBIT A.50 — SCENARIO B EXISTING ON-STREET PARKING AND LOADING ZONE IMPACTS

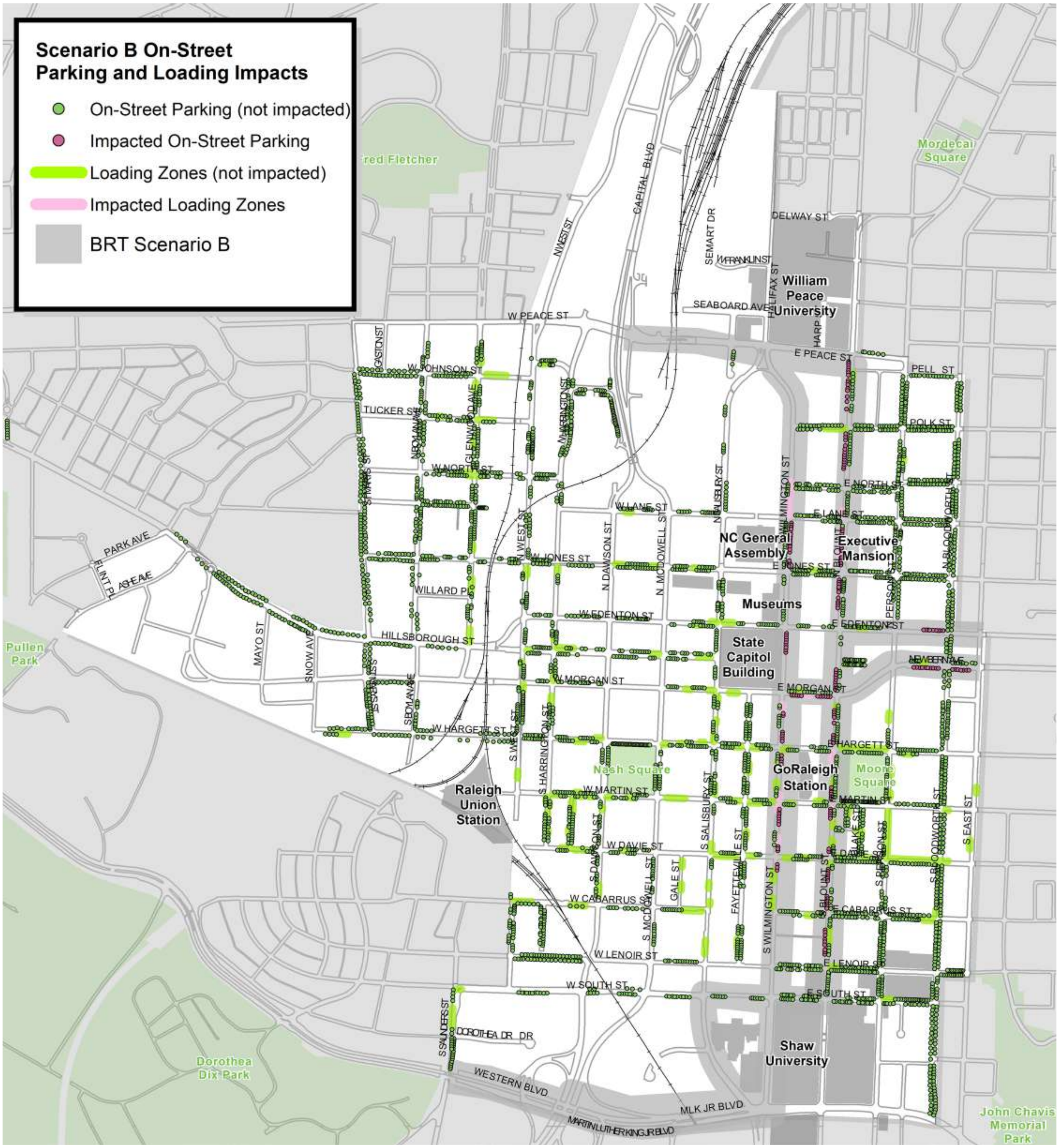


EXHIBIT A.51 — SCENARIO C EXISTING ON-STREET PARKING AND LOADING ZONE IMPACTS

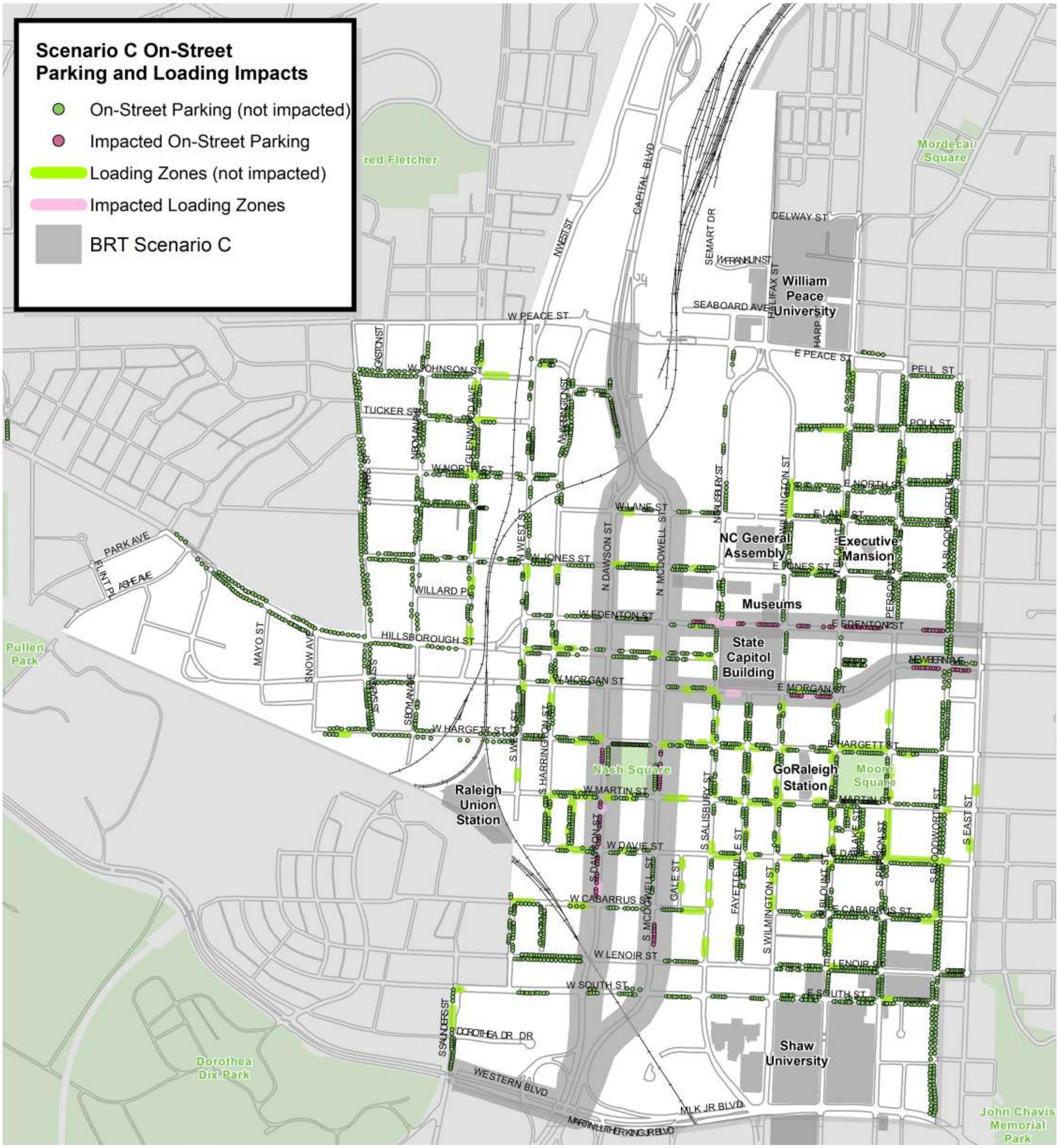
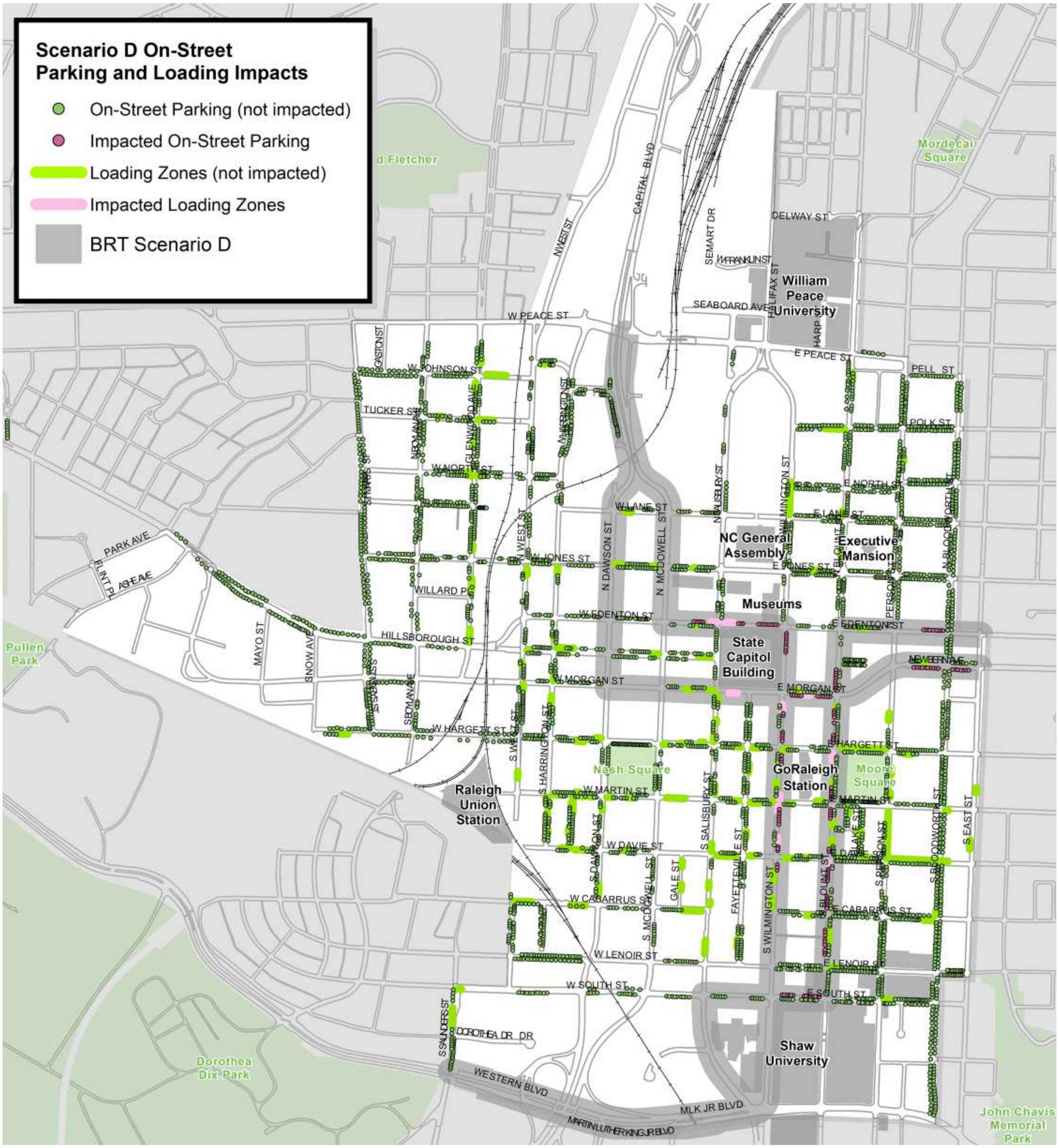


EXHIBIT A.52 — SCENARIO D EXISTING ON-STREET PARKING AND LOADING ZONE IMPACTS



Appendix B

SEE ELECTRONIC FILES

Appendix C

SEE ELECTRONIC FILES