Prepared for Texas Women's University

Texas Women's University Traffic Study

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walterpmoore.com

Walter P. Moore and Associates, Inc.
500 N Akard St, Suite 2300
Dallas, TX 75201

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CHAPTER 1: INTRODUCTION

PURPOSE OF STUDY

As Texas Women's University (TWU) continues to implement it Campus Master Plan including expansion to the east side of campus, the goal is to tame and transform Bell Avenue and make the campus a more walkable area of the City. The street closure of Bell Avenue between Administration Drive and Chapel Drive is one of the key elements to achieve the goal of taming and transforming Bell Avenue. Before this can be implemented it is important to understand the impacts of removing vehicle traffic from Bell Avenue on the surrounding transportation system. This traffic impact analysis has been developed in conjunction with the City of Denton and TWU to evaluate the impact of closing Bell Avenue.

STUDY AREA

TWU is the largest publicly funded university with a focus primarily on Women in the United States. It is located just to the northeast of downtown Denton. It is home to approximately 15,000 students who make this area unique with its focus on liberal arts, nursing, health sciences, business, and education.

The TWU campus is located south of University Avenue (US 380), west of Locust St, Ruddell Street on the east, and Texas Street and Mingo Road on the south. Bell Avenue travels north-south in the center of campus between Mingo Road and University Avenue.

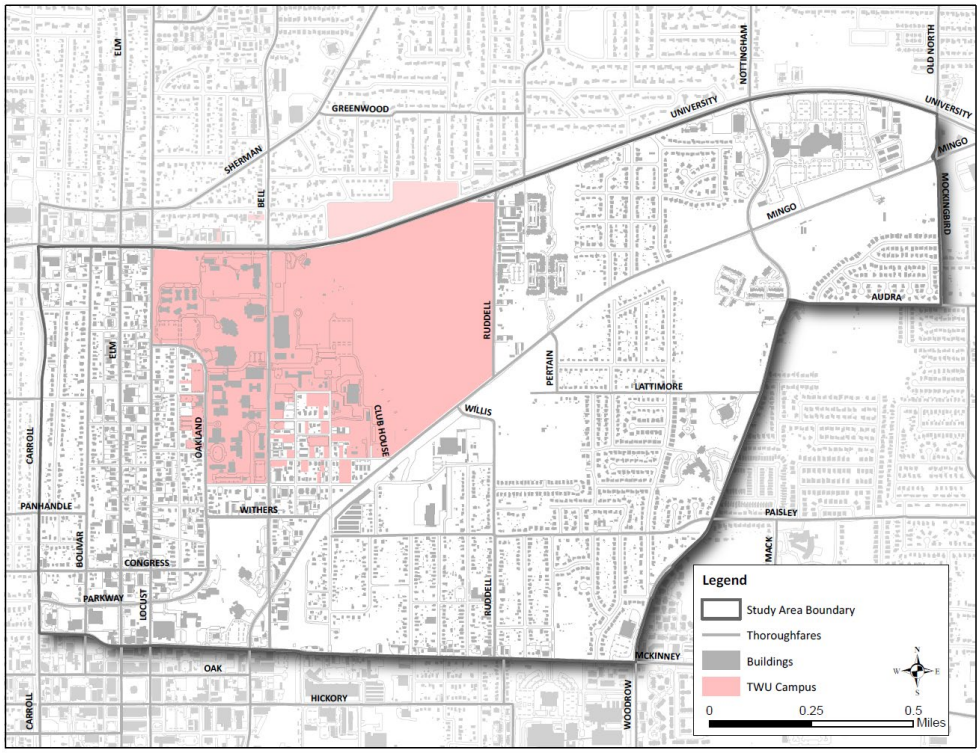

Figure 1: Texas Women's University Study Area

The study area for the purpose of this traffic analysis extends beyond the boundaries of the TWU Campus to understand the different travel patterns that occur with this portion of Denton. The study area for this traffic analysis is bounded by University on the north, McKinney on the south, Carroll on the west, and Mockingbird on the east.

TIMELINE

The traffic study began with data collection in September 2019 and the final documentation to the City of Denton and TWU was in October of 2020. The schedule showing in **Figure 2** demonstrates the timeline of the project.

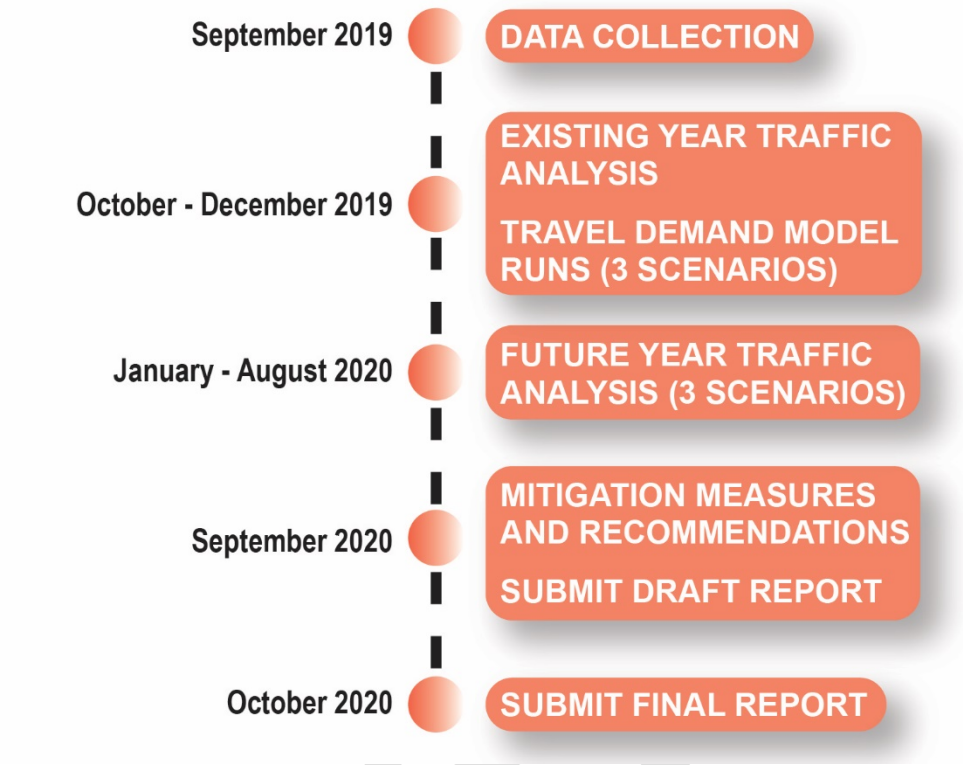

Figure 2: Project Schedule

METHODOLOGY

The following chapters summarize the methodology utilized to analyze the current and future traffic conditions, potential roadway changes, and recommended improvements within the study area. An extensive data collection effort was conducted on Wednesday, September 25, 2019 to establish the base conditions for the study area. All collected vehicular, bicycle, and pedestrian data can be found in **Appendix A**.

A transportation planning program called TransCAD was used to run network scenarios and determine the traffic impacts on the existing network and to estimate the potential growth of traffic within the study area. Synchro, a traffic macroscopic program, was used to analyze the intersection operations and to test intersection operation improvements for all study scenarios.

CHAPTER 2: EXISTING CONDITIONS

To better understand the implications and impacts of testing the closure of streets within the study area, a detailed traffic analysis was conducted for the existing year 2019.

ROADWAY NETWORK

The TWU campus area has a number of roadway types that are classified from the Denton Mobility Plan including primary arterials, secondary arterials, collectors, and local streets, as indicated in **Figure 3**. There are no freeways in the study area. Each of the roadway types has different design criteria based on the surrounding land use and traffic volumes.

University Avenue creates a northern boundary for the study area and provides the highest volume of traffic in the area. This corridor provides an important east-west connection for the City of Denton and for North Texas.

Carroll Boulevard is the a primary arterial on the western portion of the study area. This is also one of the higher volume corridors in the study area with daily traffic volumes ranging from 28,000 to 37,000.

Secondary arterials in the study area provide much of the direct connection to the TWU Campus and the surrounding neighborhoods on the one-way couplet streets of Elm and Locust Streets and also Bell Avenue and Mingo Road.

Ruddell, Paisley, Oakland, and Bolivar are classified as collectors in the study area and provide an important connection to the campus and to other larger roadway facilities.

Traffic control for intersections in the study area varies, between signalized and unsignalized. Signals are located along corridors that have higher traffic and pedestrian volumes.

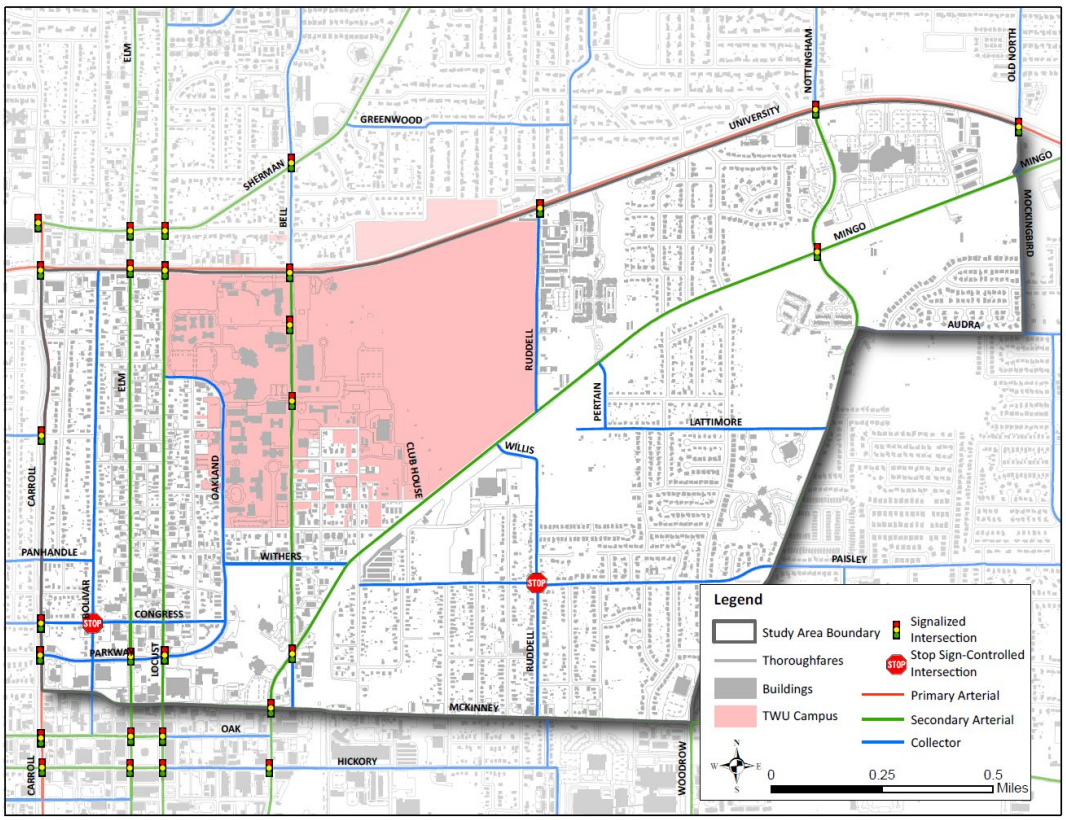

Figure 3: Thoroughfare Plan and Existing Traffic Control

24-HOUR TUBE COUNTS

24-hour traffic counts were collected at 16 locations to understand traffic patterns throughout the day including when peak traffic periods occur. Count locations were placed strategically in mid-block locations that would have minimal impact from nearby cross streets or driveways. These counts were collected by placing rubber pneumatic tubes across the travel lanes that record the number of times vehicles cross the path. Both directions of travel were counted on the roadways with the exception of one-way streets. The location and resulting daily volume for each of the collected counts are indicated in **Figure 4**. The 24-Hour tube counts were combined and analyzed to determine the study area weekday peak hours; 7:30-8:30 AM, 12:00-1:00 PM, and 4:45-5:45 PM.

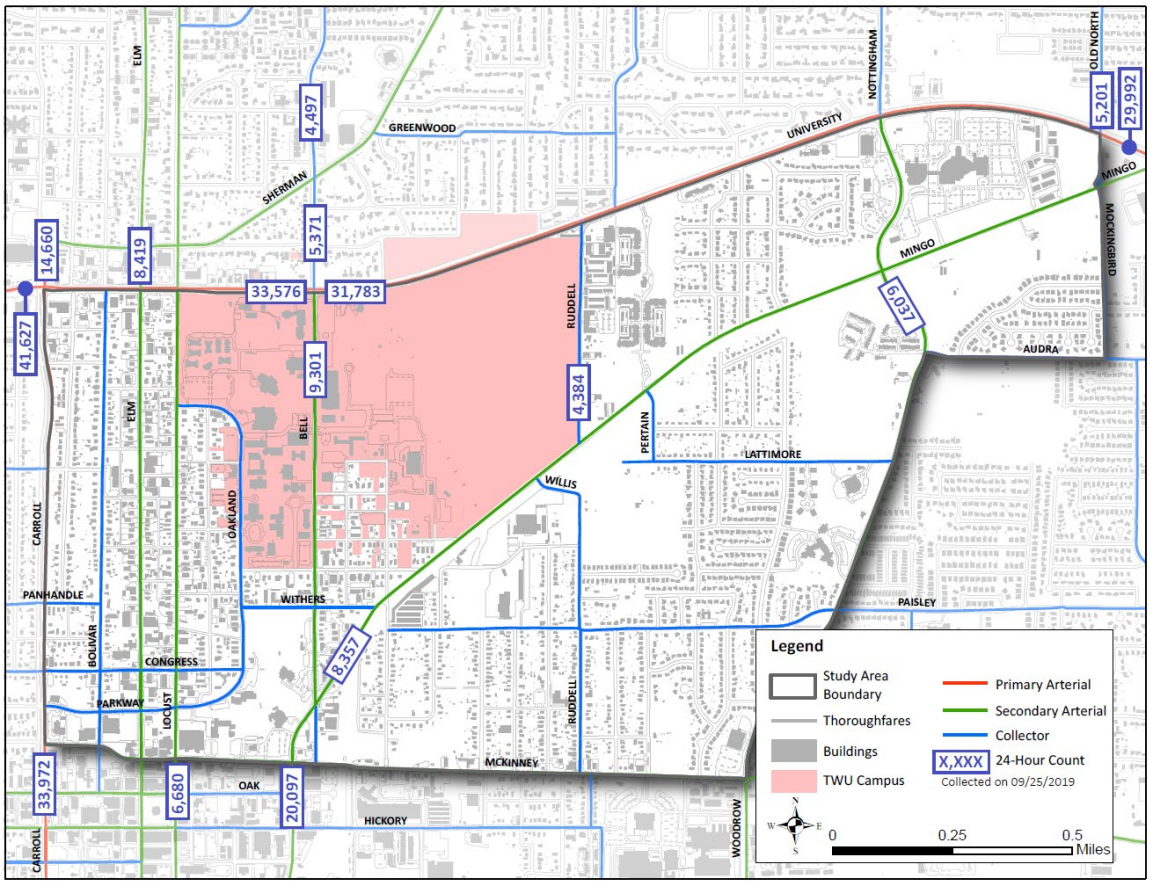

Figure 4: Base Daily Traffic Volumes

TURNING MOVEMENT COUNTS

Turning movement counts (TMC) were collected at 21 intersections throughout the study area, as shown in **Figure 5**. TMCs were collected to analyze the detailed traffic movements at each intersection. Three specific time periods of data were collected; AM peak period was collected between 7:00 AM and 9:00 AM, the Mid-Day peak period was collected from 11:00 AM and 1:00 PM, and the PM peak period was collected from 4:00 PM to 6:00 PM.

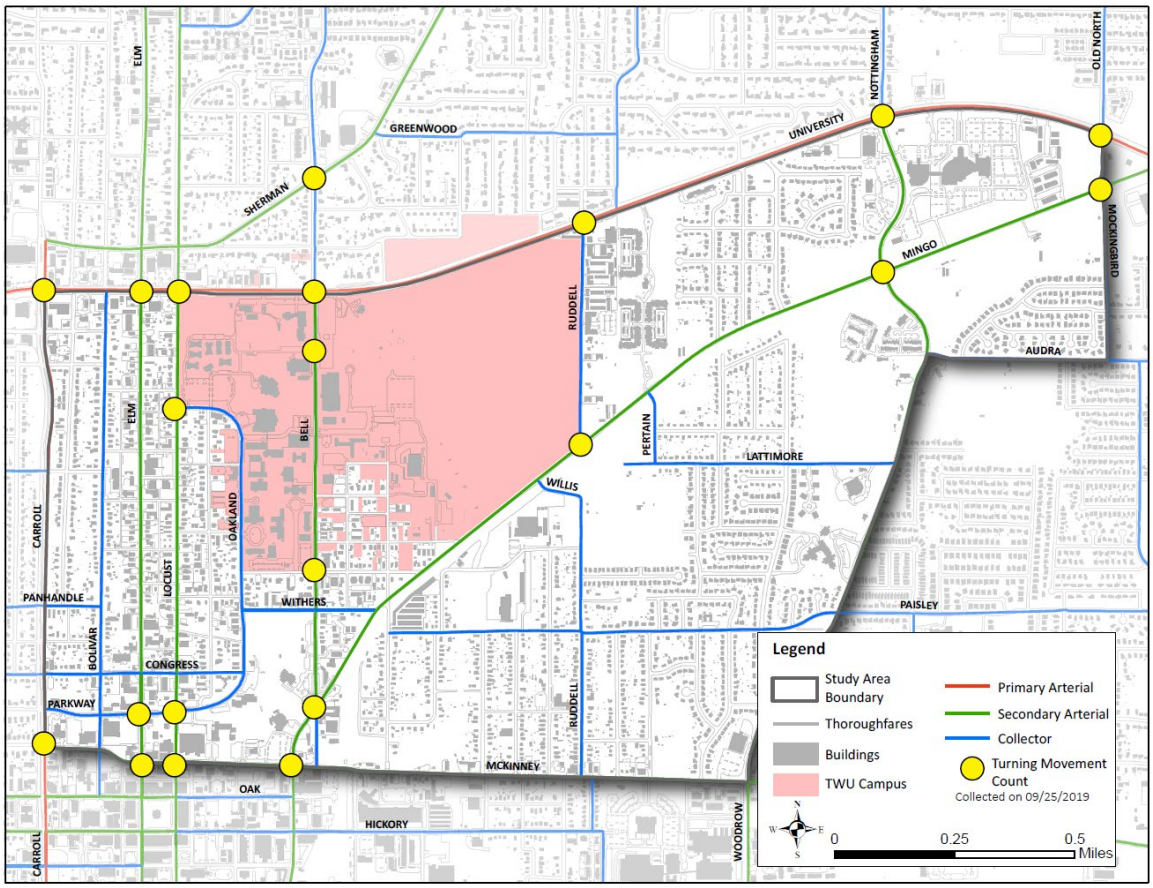

Figure 5: Traffic Count Locations

TRANSIT SERVICE

Transit service within the study area is provided by the Denton County Transportation Authority (DCTA). As represented in **Figure 6**, the three primary routes that serve the study area are routes 4, 5, and 6. Routes 5 and 6 both travel north on Bell from the Downtown Transit Center to areas in north Denton. Route 4 is a primary east-west bus routes that connects the MedPark Station with Rayzor Ranch. Currently there are no DCTA transit routes that provide transit service on Carroll, Elm, Locust, and Mingo.

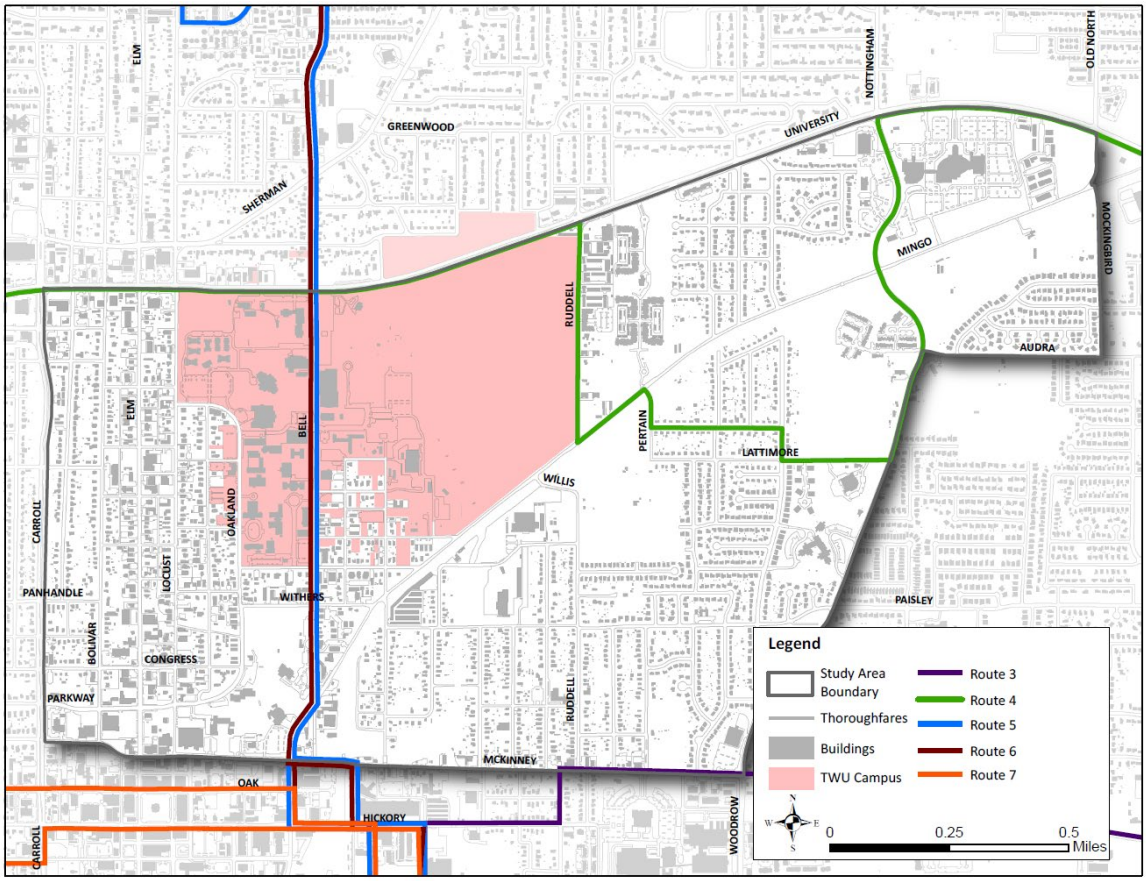

Figure 6: Transit Service

BICYCLE AND PEDESTRIAN FACILITIES

Many of the paths and walkways on the TWU Campus share both bicycle and pedestrian traffic and are identified as shared pathways throughout the campus with appropriate signage along each route. The shared pathways connect to the surrounding City of Denton bicycle network at intersections and gateways to the campus.

The Denton Mobility Plan identifies several different types of bicycle facility types: on-street bicycle facilities, sidepaths, and off-street trails. On-street bicycle facilities are typically marked portions of the roadway that are designed for exclusive use by bicycles. Typical width for a bike lane is 5 feet with a 6-inch wide stripe in accordance with the Manuel on Uniform Traffic Control Devices (MUTCD) and the American Association of State Highway and Transportation Officials (AASHTO) standards. Sidepaths are off-street pathways that parallel roadways and have a width greater than 8 feet. Off-street trails are outside of the roadways right-of-way and can follow natural features such as creeks and rivers.

Roadways within the study area with an on-street bike lane include:

- N Bell Avenue between Texas Street and University Avenue
- N Locust Street between Oakland Street and University Avenue

Roadways within the study area with a shared bicycle facility include:

- Oakland Street between N Locust Street and back to N Locust Street
- Bolivar Street between Congress Street and Crescent Street
- Congress Street between Oakland Street and Carroll Boulevard

The data was collected in the fall of 2019 that counted the number of bicyclists and pedestrians at each intersection between the hours of 11:00 AM and 5:00 PM. The data identified several intersections that have a high volume of pedestrian traffic during the typical weekday and minimal bicycle traffic. The intersection of Bell Avenue and Chapel Drive and the intersection of Bell Avenue and Texas Street had the highest volumes of pedestrian traffic at 578 and 198 daily pedestrians respectively. The intersections of Elm and University, Locust and Parkway, and Carroll and University had the highest amount of bicycle traffic in the study area with 17 and 16.

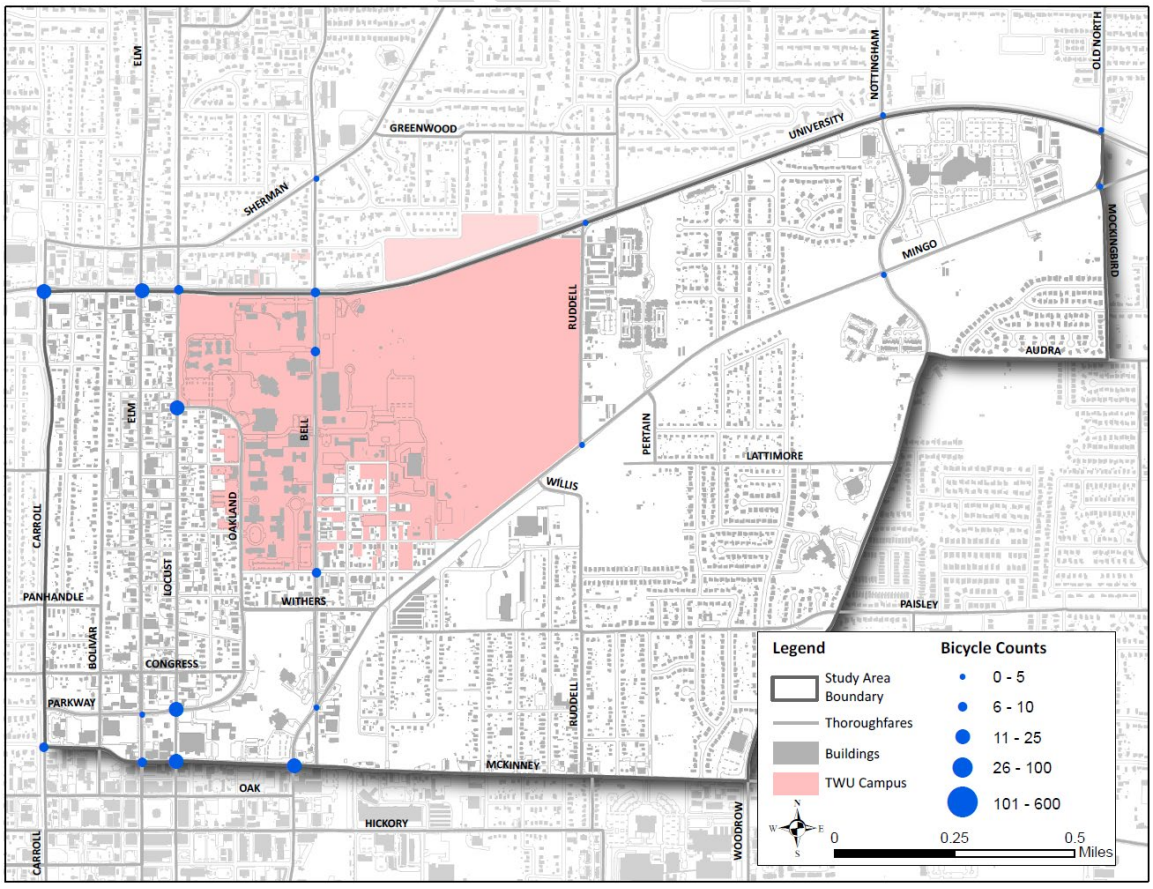

Figure 7: Bicycle Counts

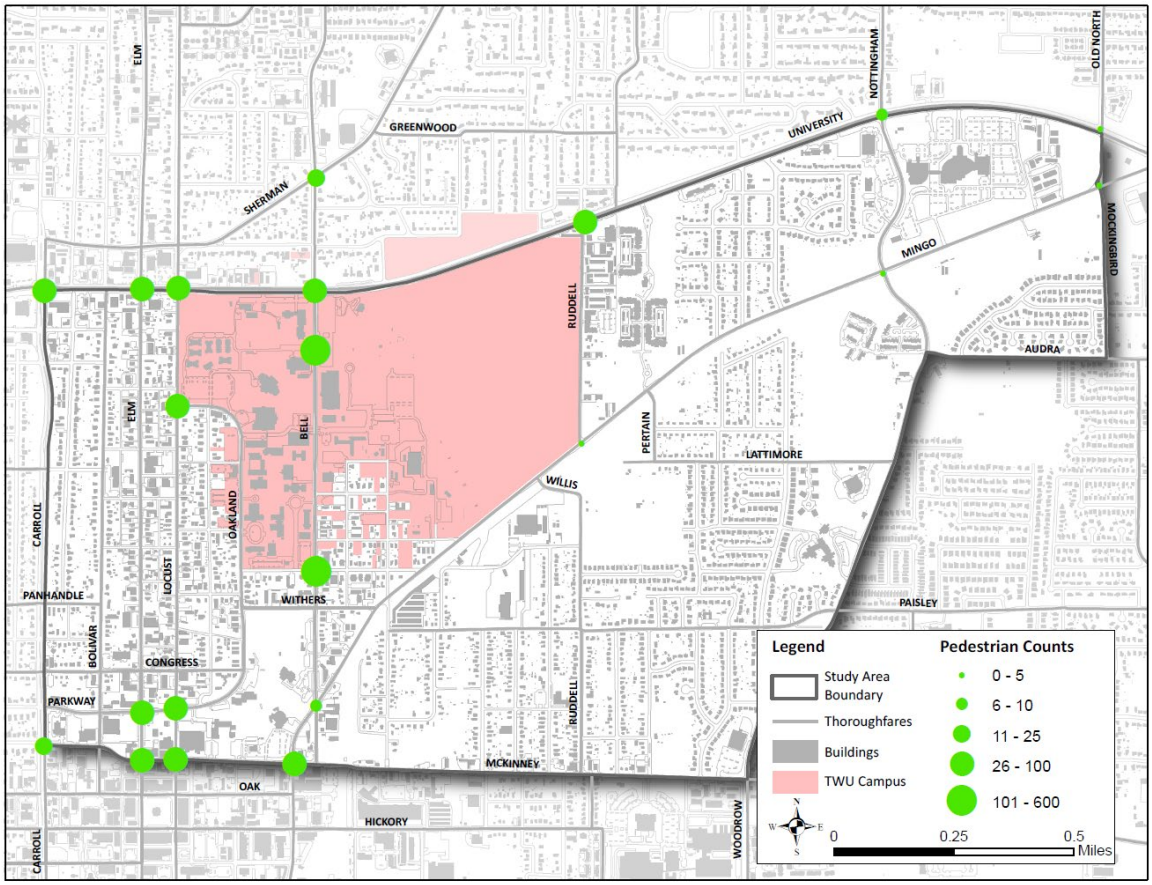

Figure 8: Pedestrian Counts

CHAPTER 3: DEFINING FUTURE MOBILITY CONDITIONS

To evaluate the impacts of closing Bell Avenue within the TWU campus a comprehensive analysis was conducted utilizing the traffic data collected and described in Chapter 2. Software models were used to evaluate travel pattern changes and to determine recommendations anticipated to improve multi-modal traffic circulation in the study area. The two models that

were used was the City of Denton's travel demand model and a Synchro model that was developed for this analysis to understand the intersection level impacts.

SCENARIOS

The Denton Travel Demand Model was updated to reflect the changes that have occurred in the study area since the last model update in 2015. These changes included the demographic data by traffic analysis zone (TAZ) and the roadway network. Data collected was utilized to calibrate the base year model to 2019. Volumes within +/- 15% were standard thresholds for validation. Although the entire model was used, only the traffic data collected in the study area was used for calibration.

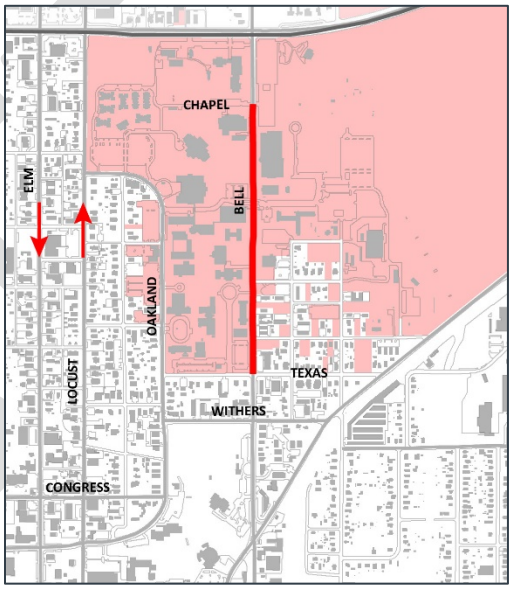

Figure 9: Scenario 1 Limits

Through the study evaluation, it was recommended to test one scenario with the closure of Bell Avenue between Texas Street and Chapel Drive with Elm and Locust remaining as a one-way couplet. **Figure 9** demonstrate the extents of the Bell Avenue closure through the TWU campus. This scenario was tested for the forecast year of 2045.

The forecast base 2045 travel demand model roadway volumes were used to compare to the roadway volumes with the Bell Avenue closure scenario. Roadway volumes from the 2045 base travel demand model are represented in **Figure 10**. The Bell Avenue closure scenario resulted in a different traffic distribution due to the unique network configuration.

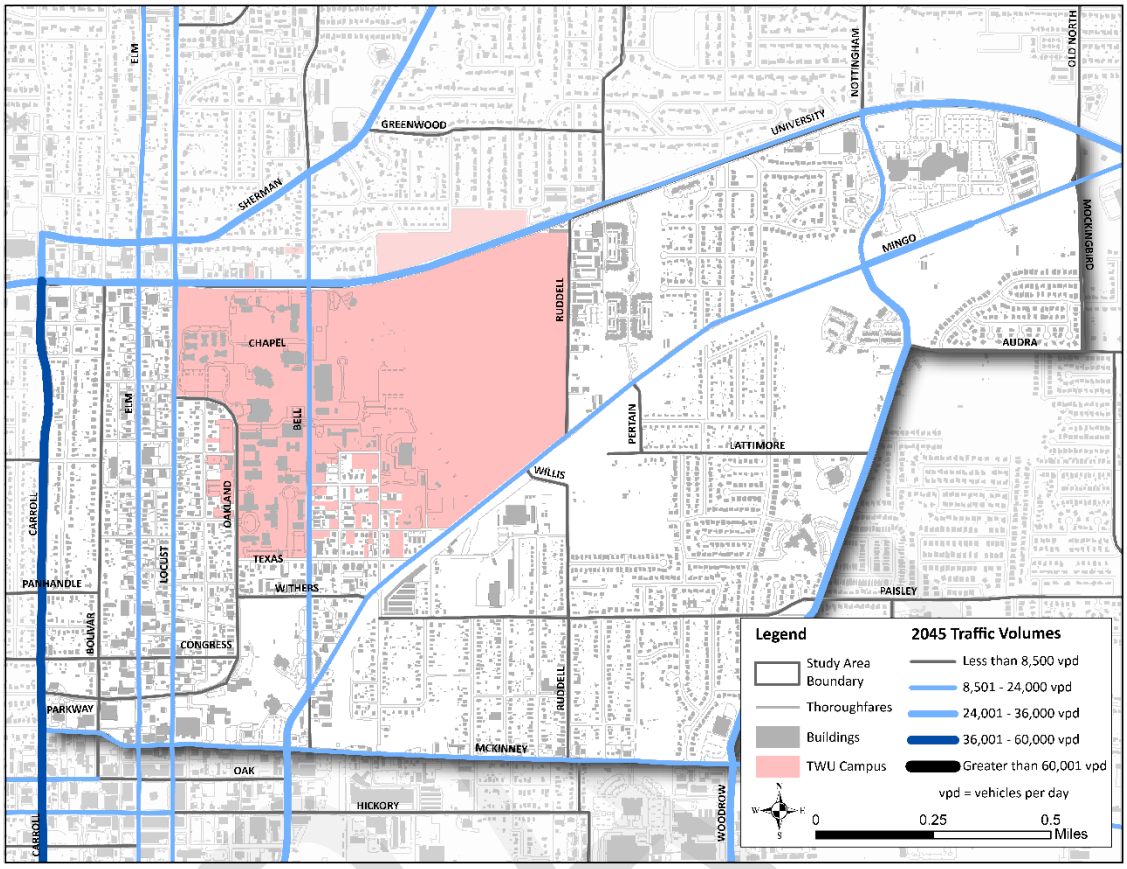

Figure 10: 2045 Roadway Network Model Volumes

SCENARIO 1 RESULTS

As mentioned earlier, this scenario involved the closure of Bell Avenue between Texas Street and Chapel Drive with Elm and Locust remaining as one-way couplets. In this scenario, the projected volumes with the closure of Bell Avenue were compared to the forecast year 2045 to determine traffic redistribution based on the closure. In this scenario, the volumes on Bell Avenue are reduced by 100% because the trips originally on that roadway that bisected the TWU campus in the base condition are now being redistributed to other roadways. The increase in traffic as a result of the closure of Bell Avenue is indicated by the darker blue lines in **Figure 11**. Mingo Road, Carroll Boulevard, N Elm Street, N Locust Street, Bolivar Street and Oakland Street are primarily impacted by the trip redistribution of Bell Avenue.

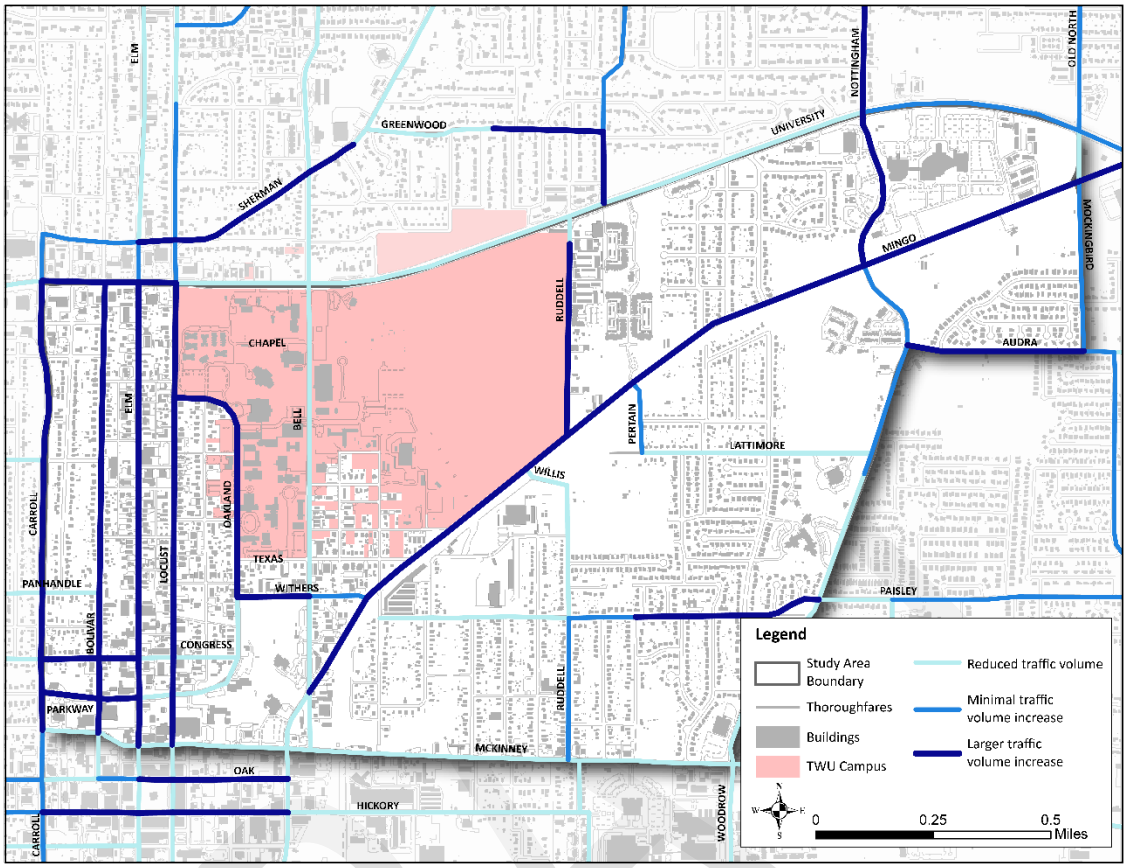

Figure 11: Scenario 1 Travel Demand Model Results

INTERSECTION AND ROADWAY CAPACITY ANALYSIS

To understand the impacts of traffic around the TWU Campus contributing from increased enrollments, population growth, and potential changes in the roadway network, a detailed intersection analysis was conducted. As volumes change in the study area, intersections may experience an increase in delay and reduction in level of service if nothing is done to mitigate traffic conditions. Chapter 2 described the traffic data collected at the beginning of the project to assist in the intersection analysis and evaluation. Each of the 21 intersections in which traffic data was collected was modeled in Synchro for year 2019 and year 2045 with and without Bell Avenue, representing Scenario 1 discussed previously.

The level of service criteria for signalized intersections, along with a brief description of the conditions experienced for each level of service grade, can be seen in **Table 1**. The level of service criteria for unsignalized intersections can be seen in **Table 2**.

Level of Service	Stopped Delay (seconds/vehicle)	Description
A	≤ 10	At a single intersection most vehicles do not stop at all. When linked with other signals, vehicles progress through intersections without stopping.
B	> 10 and ≤ 20	At a single intersection some vehicles stop before getting a green signal. When linked with other signals, some vehicles may have to stop but most progress through the intersection without stopping.
C	> 20 and ≤ 35	At a single intersection, a significant number of vehicles must stop and wait for a green signal. Some vehicles may have to wait through one full signal cycle before being able to move through the intersection.
D	> 35 and ≤ 55	At this level, congestion is noticeable. Many vehicles have to stop while waiting for a green signal. A noticeable number of vehicles have to wait through one full cycle before being able to continue through the intersection.
E	> 55 and ≤ 80	At this level, almost all vehicles have to wait through one or more full signal cycles before moving through the intersection. When linked with other signals, progression is slow.
F	> 80	At this level, the number of vehicles entering the intersection exceeds its capacity. Vehicles have to wait through multiple full signal cycles before moving through the intersection.

Table 1: Level of Service Criteria for Signalized Intersections

Level of Service	Avg. Total Delay (seconds/vehicle)	Description
A	≤ 10	At most, one vehicle is waiting to move through the intersection when the driver reaches the stop sign. Most often, the driver pulls up to the stop sign and is immediately free to proceed through the intersection.
B	> 10 and ≤ 15	When the driver reaches the intersection, one or two vehicles are in front of him. Once those vehicles proceed through the intersection, the driver is able to continue without opposition.
C	> 15 and ≤ 25	At this level, several vehicles may be in front of the driver at a two-way stop-controlled intersection. At an all-way stop-controlled intersection, there may be two or more vehicles at each approach that the driver has to wait for before getting his turn.
D	> 25 and ≤ 35	At this level, there are at least four vehicles in front of the driver and several vehicles at the other approaches. Also, for two-way stop-controlled conditions, the volume of traffic on the uncontrolled street may be high.
E	> 35 and ≤ 50	When the driver reaches the intersection, there are between five and eight vehicles in front of him and many vehicles at the other approaches that must also proceed through the intersection before the driver may continue.
F	> 50	At this level, the driver must wait for eight to ten vehicles at his approach to move through the intersection along with at least five vehicles at the other approaches. This level can also occur at two-way stop-controlled intersections when the uncontrolled street has such a high volume that no gaps are available in the traffic stream for the vehicles at the cross street to continue.

Table 2: Level of Service Criteria for Unsignalized Intersections

EXISTING 2019 INTERSECTION ANALYSIS

The TMCs collected in September 2019 were inputted into the Synchro model to determine existing intersection operations during all identified peak hours. The model automates a delay for each intersection turning movement based on a grading scale called level of service (LOS). LOS criteria vary for signalized and unsignalized intersections, with signalized intersections having a higher driver delay tolerance. The most favorable intersection conditions are designated with a LOS A and the poorest conditions are indicated with a LOS F. For this study, LOS D or better is considered to be a satisfactory LOS experienced by motorist. Refer to **Appendix B** for intersection capacity result tables and detailed Synchro reports.

There was only one intersection within the study area that results with a LOS E or LOS F for a minimum of one peak hour in existing year 2019. There were two intersections that exhibited LOS D for a minimum of one peak hour, as shown in **Table 3**.

Study Intersection	Control Type	Movement	AM Peak		MD Peak		PM Peak	
			Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Old North Rd at University Dr	Signal	All	33.2	C	34.9	C	33	C
Mockingbird Ln at Mingo Rd	AWSC	All	10.9	B	8.4	A	12.2	B
Nottingham Dr at University Dr	Signal	All	31.3	C	38	D	33.1	C
Nottingham Dr at Mingo Rd	Signal	All	18.9	B	18.1	B	19.1	B
Ruddell St at University Dr	Signal	All	22.9	C	26.6	C	17.4	B
Ruddell St at Mingo Dr	TWSC	SB	15.8	C	11.1	B	18.7	C
N Bell Ave at Sherman Dr	Signal	All	9.2	A	8.2	A	9.4	A
N Bell Ave at University Dr	Signal	All	20.2	C	24.5	C	23	C
N Bell Ave at Chapel Dr	Signal	All	2.7	A	4.5	A	4.3	A
N Bell Ave at Texas St	TWSC	EB	20.3	C	13.9	B	14.3	B
		WB	20.8	C	15.3	C	16.7	C
N Bell Ave at Mingo Rd	Signal	All	15.5	B	19.9	B	19	B
N Bell Ave at E McKinney St	Signal	All	17.9	B	14	B	17.3	B
N Locust St at University Dr	Signal	All	11.8	B	15.1	B	31.4	C
N Locust St at Oakland St	TWSC	WB	9.6	A	11.4	B	14.5	B
N Locust St at E Parkway St	Signal	All	5.3	A	9.2	A	9.8	A
N Locust St at E McKinney St	Signal	All	21.7	C	27	C	21	C
N Elm St at University Dr	Signal	All	18.6	B	12.8	B	14	B
N Elm St at E Parkway St	Signal	All	10.8	B	7.9	A	8.3	A
N Elm St at E McKinney St	Signal	All	13	B	15.2	B	13.6	B
N Carroll Blvd at University Dr	Signal	All	28.4	C	31.6	C	36.3	D
N Carroll Blvd at W McKinney St	TWSC	EB	16.5	C	13.4	B	15.3	C
		WB	16.2	C	19.2	C	52.2	F

Table 3: Intersection Level of Service Existing Year 2019 Peak Hour

EXISTING 2019 ROADWAY CAPACITY ANALYSIS

An existing roadway segment capacity analysis was conducted by utilizing the collected 24-Hour volumes. The volume ratio for each segment was calculated using the daily bi-directional volumes for each segment over the North Central Texas Council of Governments (NCTCOG) capacity criteria per lane. As **Figure 12** shows, Carroll Boulevard resulted as nearing capacity with a LOS E.

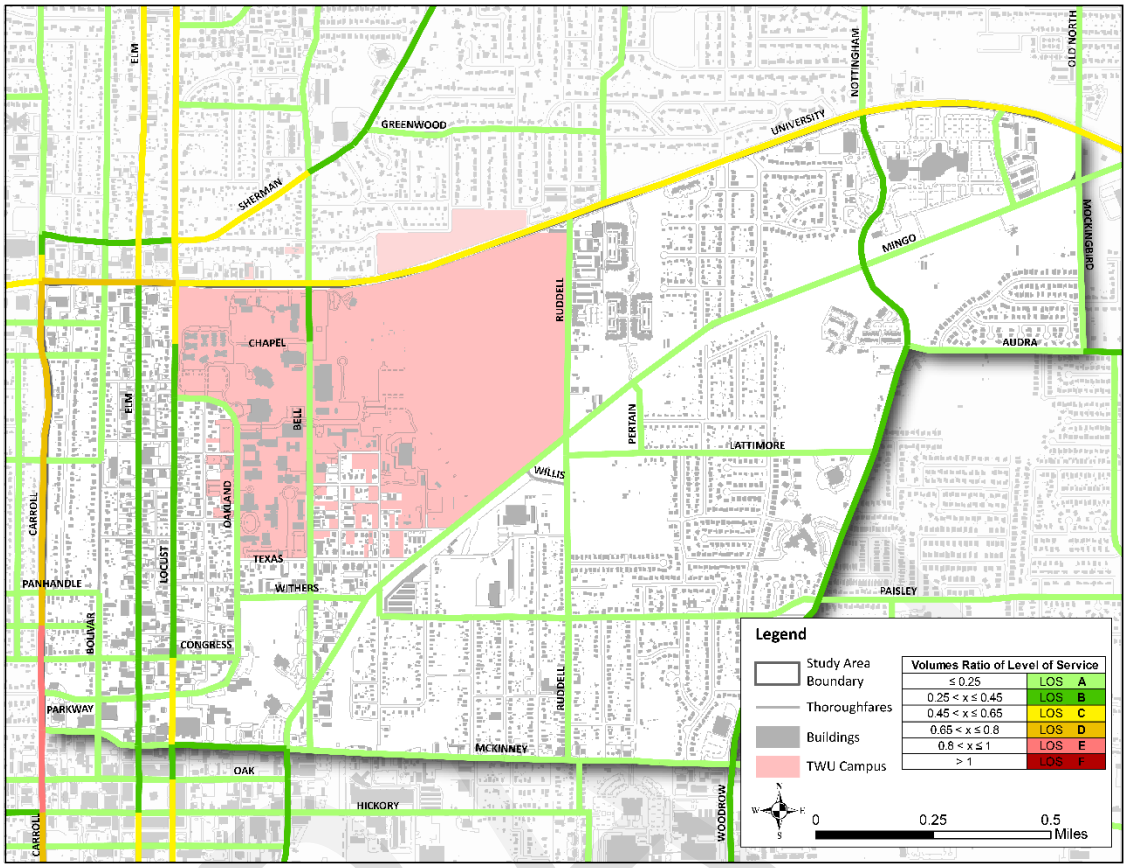

Figure 12: Rodway Capacity Analysis Existing Year 2019

2045 BASE SCENARIO INTERSECTION ANALYSIS

A total of three intersections within the study area resulted with a LOS E or LOS F for a minimum of one peak hour in the future year 2045, as shown in **Table 4**. The analysis of the intersection delay and level of service indicates that mitigation is needed based on projected background volume growth and anticipated roadway conditions.

Study Intersection	Control Type	Movement	AM Peak		MD Peak		PM Peak	
			Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Old North Rd at University Dr	Signal	All	33.3	C	31.9	C	33.6	C
Mockingbird Ln at Mingo Rd	AWSC	All	15.5	C	9.1	A	18.7	C
Nottingham Dr at University Dr	Signal	All	30.9	C	34	C	32.3	C
Nottingham Dr at Mingo Rd	Signal	All	22	C	18.7	B	18.4	B
Ruddell St at University Dr	Signal	All	19.5	B	18.6	B	14.8	B
Ruddell St at Mingo Dr	TWSC	SB	22.6	C	12.6	B	39.1	E
N Bell Ave at Sherman Dr	Signal	All	10.3	B	8.6	A	10.9	B
N Bell Ave at University Dr	Signal	All	21.8	C	24.1	C	28	C
N Bell Ave at Chapel Dr	Signal	All	3	A	4.8	A	4.6	A
N Bell Ave at Texas St	TWSC	EB	36.6	E	18.3	C	19.4	C
		WB	33.1	D	20.3	C	24	C
N Bell Ave at Mingo Rd	Signal	All	17.8	B	19.5	B	20.5	C
N Bell Ave at E McKinney St	Signal	All	17.2	B	17.2	B	22.8	C
N Locust St at University Dr	Signal	All	18.4	B	23.4	C	48	D
N Locust St at Oakland St	TWSC	WB	10.1	B	13	B	19.7	C
N Locust St at E Parkway St	Signal	All	5.4	A	9.5	A	9.7	A
N Locust St at E McKinney St	Signal	All	19.9	B	23.7	C	15.2	B
N Elm St at University Dr	Signal	All	21.5	C	14.6	B	15.8	B
N Elm St at E Parkway St	Signal	All	10.7	B	8.1	A	8.7	A
N Elm St at E McKinney St	Signal	All	12.8	B	14.9	B	14.1	B
N Carroll Blvd at University Dr	Signal	All	32.8	C	36.2	D	43.4	D
N Carroll Blvd at W McKinney St	TWSC	EB	21.2	C	15.5	C	18.9	C
		WB	23	C	35	E	258.3	F

Table 4: Intersection Level of Service Base 2045 Peak Hour

2045 BASE ROADWAY CAPACITY ANALYSIS

A 2045 No Build roadway segment capacity analysis was conducted by dividing the roadway volumes by capacity for the future year with Bell Avenue still functionable traversing the TWU campus. **Figure 13** shows that Carroll Boulevard, Woodrow Lane, Audra Lane, Mingo Road and Sherman Drive resulted with an overcapacity LOS F.

Bell Avenue operates at an acceptable level of service for the future year 2045 even as population, employment and school enrollment increases.

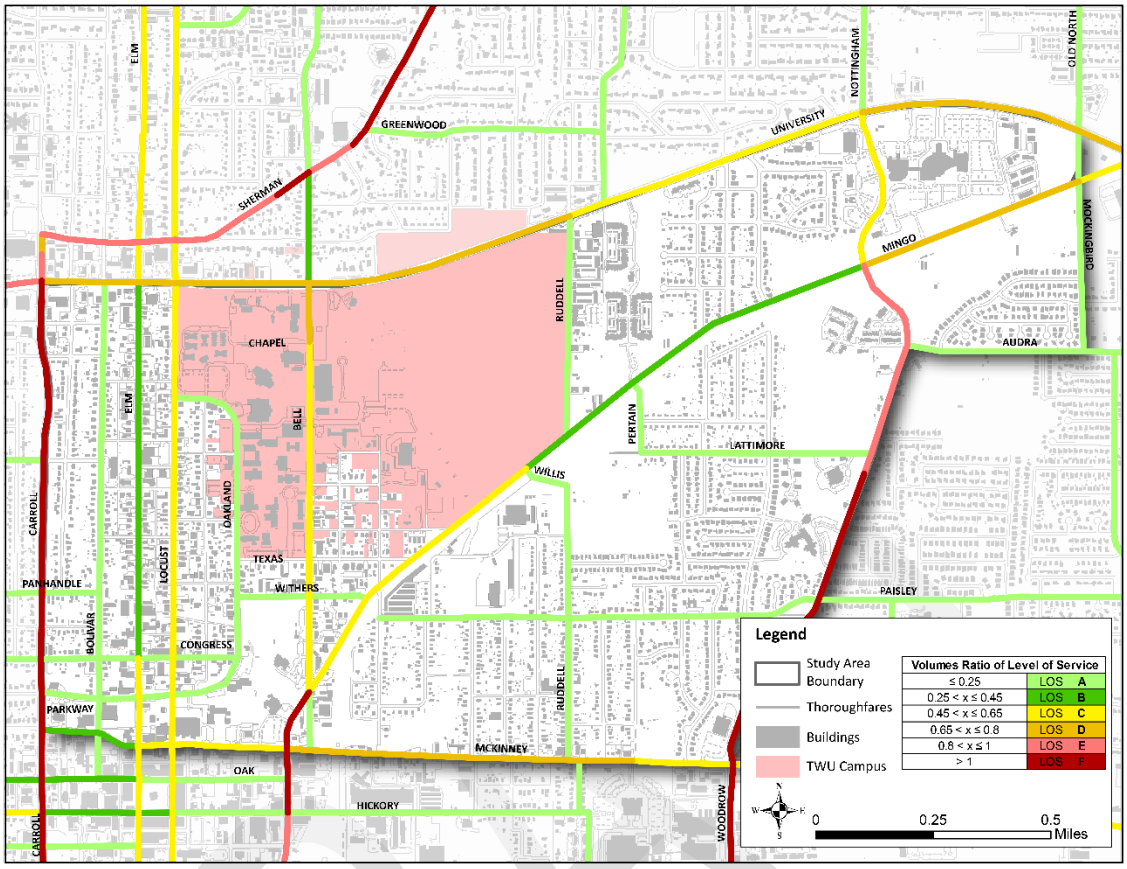

Figure 13: Rodway Capacity Analysis Forecast Year 2045

SCENARIO 1 INTERSECTION ANALYSIS - BELL AVENUE CLOSURE

To determine the anticipated impacts on traffic for the Bell Avenue closure, the 2045 peak hour volumes were adjusted based on results from the travel demand model. The adjusted volumes resulted in revised travel patterns and peak hour turning movement volumes for this scenario. **Table 5** display the intersection level of service based on redistributed traffic volumes due to the Bell Avenue closure.

The analysis of the Bell Avenue closure in year 2045 shows that the intersections that are highly impacted include Ruddell Street at Mingo Road, N Bell Avenue at Texas Street and N Locust Street at E McKinney Street.

Study Intersection	Control Type	Movement	AM Peak		MD Peak		PM Peak	
			Delay (sec/veh)	LOS	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Old North Rd at University Dr	Signal	All	32.9	C	31.9	C	33.6	C
Mockingbird Ln at Mingo Rd	AWSC	All	16.9	C	9.1	A	18.7	C
Nottingham Dr at University Dr	Signal	All	31.2	C	34.5	C	32.3	C
Nottingham Dr at Mingo Rd	Signal	All	19.5	B	19.4	B	18	B
Ruddell St at University Dr	Signal	All	21.2	C	23.1	C	14.8	B
Ruddell St at Mingo Dr	TWSC	SB	72.1	F	15.4	C	39.1	E
N Bell Ave at Sherman Dr	Signal	All	9.8	A	8.4	A	10.9	B
N Bell Ave at University Dr	Signal	All	15.6	B	23.2	C	27.9	C
N Bell Ave at Chapel Dr	Signal	All	14.2	B	18.2	B	28.5	C
N Bell Ave at Texas St	AWSC	All	9.1	A	7.8	A	7.6	A
N Bell Ave at Mingo Rd	Signal	All	20	C	23.7	C	20.7	C
N Bell Ave at E McKinney St	Signal	All	15	B	14.5	B	22.8	C
N Locust St at University Dr	Signal	All	14.9	B	24.1	C	48	D
N Locust St at Oakland St	TWSC	WB	10.3	B	13.9	B	23.7	C
N Locust St at E Parkway St	Signal	All	3.9	A	8.9	A	8.2	A
N Locust St at E McKinney St	Signal	All	22.5	C	44.8	D	15.3	B
N Elm St at University Dr	Signal	All	23.1	C	16	B	15.8	B
N Elm St at E Parkway St	Signal	All	10.9	B	7.3	A	10.2	B
N Elm St at E McKinney St	Signal	All	11.4	B	13.3	B	14.1	B
N Carroll Blvd at University Dr	Signal	All	33.7	C	37.1	D	43.4	D
N Carroll Blvd at W McKinney St	TWSC	EB	23.3	C	16.3	C	18.9	C
		WB	24.1	C	39.3	E	258.3	F

Table 5: Intersection Level of Service 2045 Scenario 1 Peak Hour

SCENARIO 1 ROADWAY CAPACITY ANALYSIS

As represented in **Figure 14**, a roadway capacity analysis was conducted for the Bell Avenue closure through the TWU campus. Similar to the 2045 future year scenario, Carroll Boulevard, Woodrow Lane, Audra Lane, Mingo Road and Sherman Drive resulted with an overcapacity LOS F. Traffic diverted from the closure of Bell Avenue through the TWU campus was able to be handled by adjacent roadways.

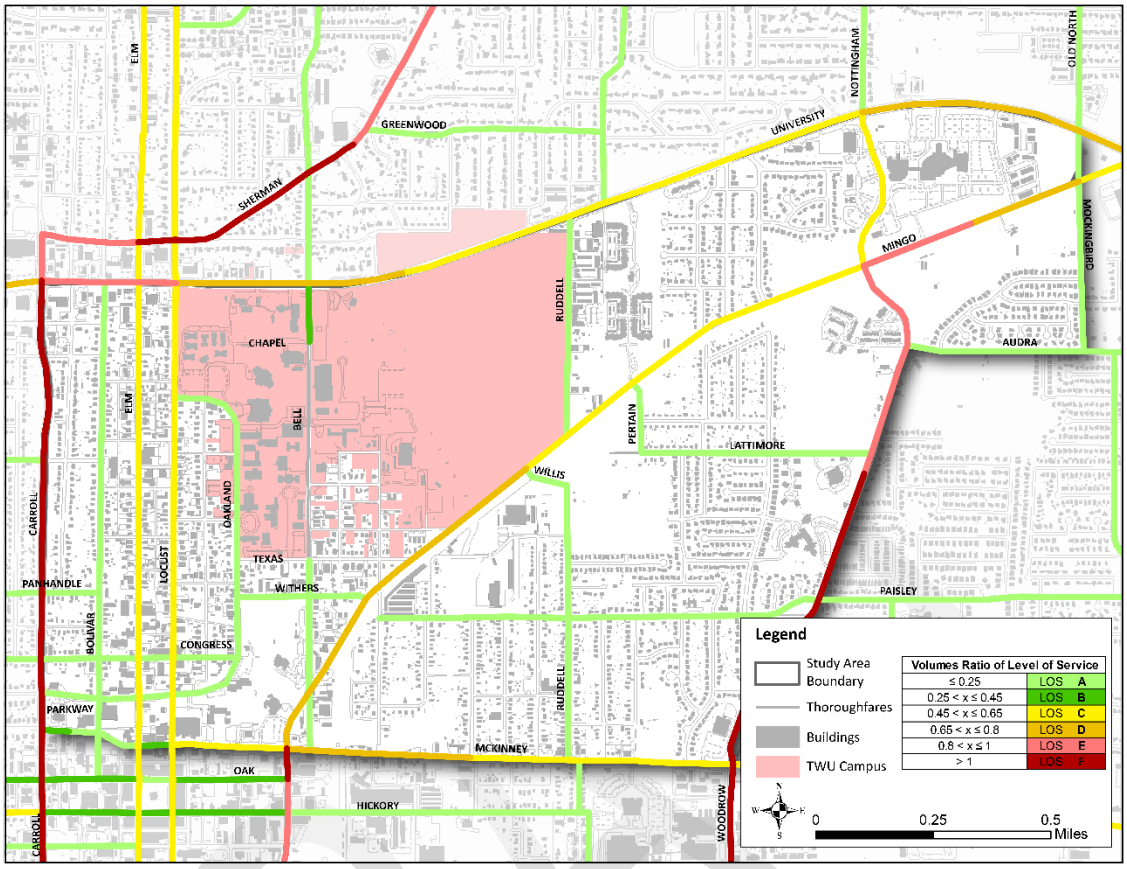

Figure 14: Bell Avenue Closure Rodway Capacity Analysis

CHAPTER 4: RECOMMENDATIONS AND CONCLUSIONS

Twenty-one intersections in the study area were analyzed based on existing roadway conditions as well as year 2045 forecasted traffic volumes. In addition, each of the twenty-one intersections were tested based on the Bell Avenue closure between Texas Street and Chapel Drive with Elm and Locust remaining as a one-way couplet. Coordination between TWU and the City of Denton should occur to improve intersections and roadways adjacent to the TWU campus that were identified as having an unacceptable level of service. Ruddell Street at Mingo Road was the only intersection on the TWU campus that would need improvements. Related improvements could possibly include additional turn lane capacity and queue length as this will be the nearest north-south roadway between Mingo Rd and University Drive.

All recommended intersection control updates including traffic signals, roundabouts, and all-way stop control (AWSC) will need a full warrant and capacity analysis performed prior to

implementation. Sight distance issues can also be a concern at several intersections, and it is recommended to limit potential obstructions that may affect the driver's view. This can be accomplished by removing landscaping and restricting on-street parking at the intersection corners. Pedestrian safety is a priority for TWU and features like ADA compliant ramps and crosswalks should be installed at intersections heavily used by pedestrians.