USAA ATM
527 MAPLE AVENUE EAST

Traffic Impact Study

DRAFT

PREPARED FOR

KFW Engineers & Surveying

OCTOBER 25, 2017

Prepared By:

Kimley»Horn

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INTRODUCTION

This report presents the results of a traffic analysis to support a conditional use permit (CUP) for the proposed development of a drive-thru USAA ATM at 527 Maple Avenue East in Vienna, Virginia. The proposed USAA will retrofit a vacant ATM window. The property was previously occupied by another bank, but has been vacant for more than two years. This ATM is not anticipated to generate more trips than the previous tenant, however, a traffic evaluation was performed for the Town of Vienna as part of the CUP to ensure that the proposed use will not adversely impact the traffic circulation on-site. The ATM will be automated which requires no staffing increase and will be accessible at any time. Due to the nature of the proposed use the impact on surrounding properties in respect to litter, air quality, and sounds levels will be negligible. The date of operation for the proposed ATM is January 2018.

Access to the ATM is provided via three driveways: two driveways on East Street SE and one driveway on Maple Avenue E. Though these driveways are full-movement driveways, the ATM trips would need to follow the circulation patterns shown in Figure 1. The general site plan detail for the proposed development is included in Appendix A.

This report describes the area transportation system, traffic generated by the proposed development in the AM and PM peak periods, on-site circulation patterns and queue estimates, and ADT and peak hour traffic on adjacent roadways (Maple Avenue E and East Street SE).

The following traffic study was prepared based on discussions with the Town of Vienna. A copy of this email correspondence is included in Appendix B.

SITE LOCATION AND STUDY AREA

The proposed USAA will retrofit a vacant ATM window. The property was previously occupied by another bank, but has been vacant for more than two years. Access to the ATM is provided by three driveways: two ingress driveways, one on Maple Avenue E and one on East Street SE, and one egress driveway on East St SE. These correspond to driveways 1, 2 and 3, respectively, in Figure 1. Though these driveways are full-movement driveways, the ATM trips will need to follow these circulation patters, as the drive-thru is a one-way single lane. The site location, access driveways, and circulation patterns are shown in Figure 1.

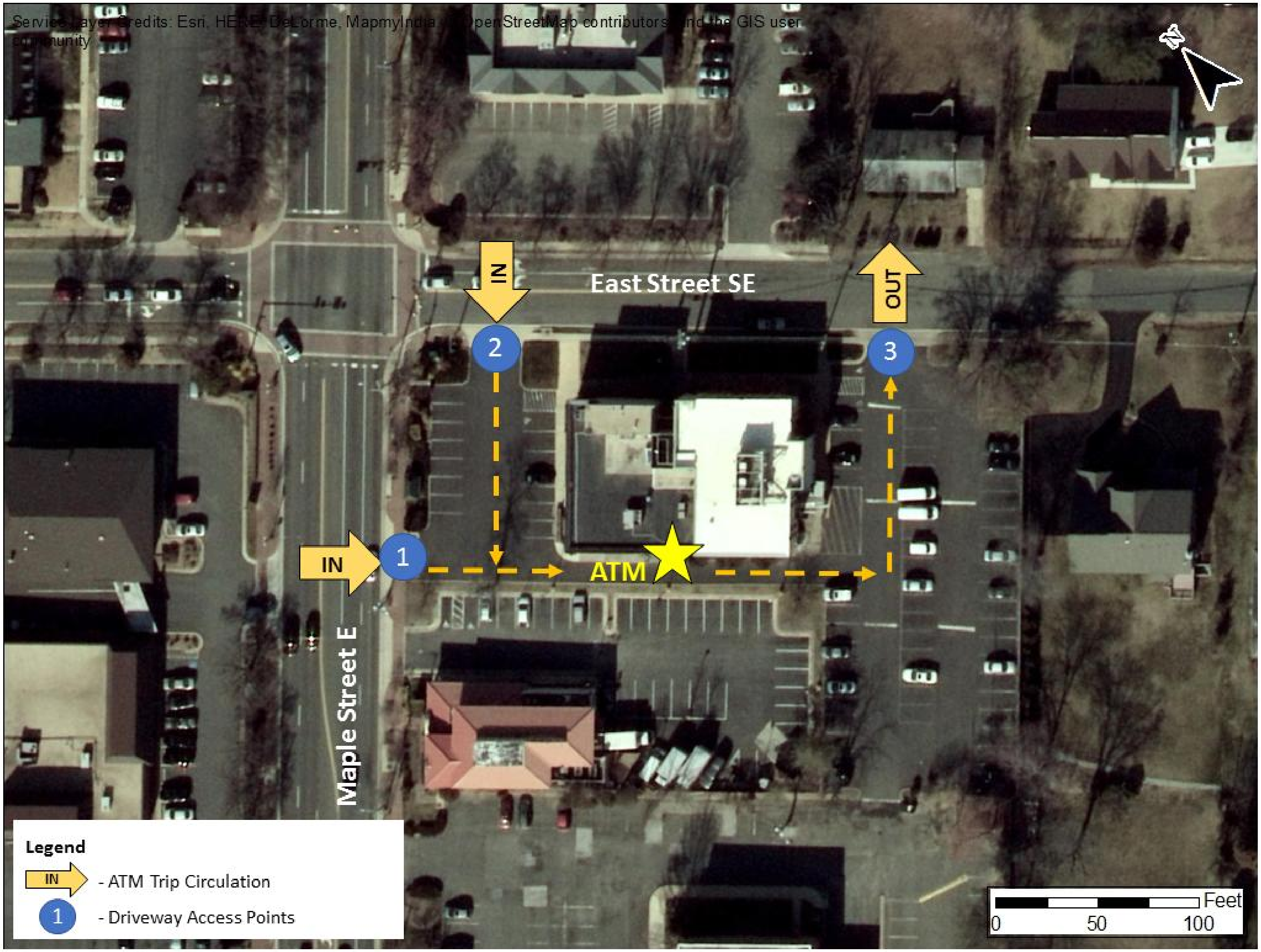
EXISTING AREA ROADWAYS

Roadways in the study area include Maple Avenue E and East Street SE.

Maple Avenue E (VA 123) - This is a four-lane undivided principal arterial roadway that runs northeast-southwest through the study area. The speed limit is 30 mph and it carries approximately 28,300 vehicles per day. Driveway 1, as shown in Figure 1, is located on this roadway.

East Street SE - This is a two-lane local road that runs northwest-southeast through the study area. The speed limit is 25 mph and it carries approximately 1,000 vehicles per day. Driveways 2 and 3, as shown in Figure 1, are located on this roadway.

Figure **1** – Site Vicinity Map & Circulation Patterns



EXISTING CONDITIONS

Existing traffic data was obtained from the *Traffic Signal System Review and Optimization* prepared for the Town of Vienna by Gorove-Slade in August 2015, as Virginia Department of Transportation (VDOT) did not have traffic data for the full study area. Based on data collected in the 2015 study, Gorove-Slade estimated average daily traffic (ADT) volumes using peak hour counts and k-factors. The reported ADTs for this study area were approximately 1,000 vehicles per day on East Street SE adjacent to the site, and approximately 28,300 vehicles per day on Maple Avenue E adjacent to the site. These values are also shown on Figure 2.

TRIP GENERATION & DISTRIBUTION

USAA bank representatives provided daily transactions for an existing drive-thru ATM. This drive-thru ATM experiences at highest, approximately 100 transactions per day of the month. There are three typical peaks at USAA drive-thru ATMs- morning, midday and evening. This ATM example provided by USAA, which is in an area comparable to Vienna, VA, has a morning peak of 9 a.m. to 10 a.m., a midday peak of 12 p.m. to 2 p.m. and an evening peak of 6 p.m. to 7 p.m. The transactions during each of those times are tabulated in Table 1.

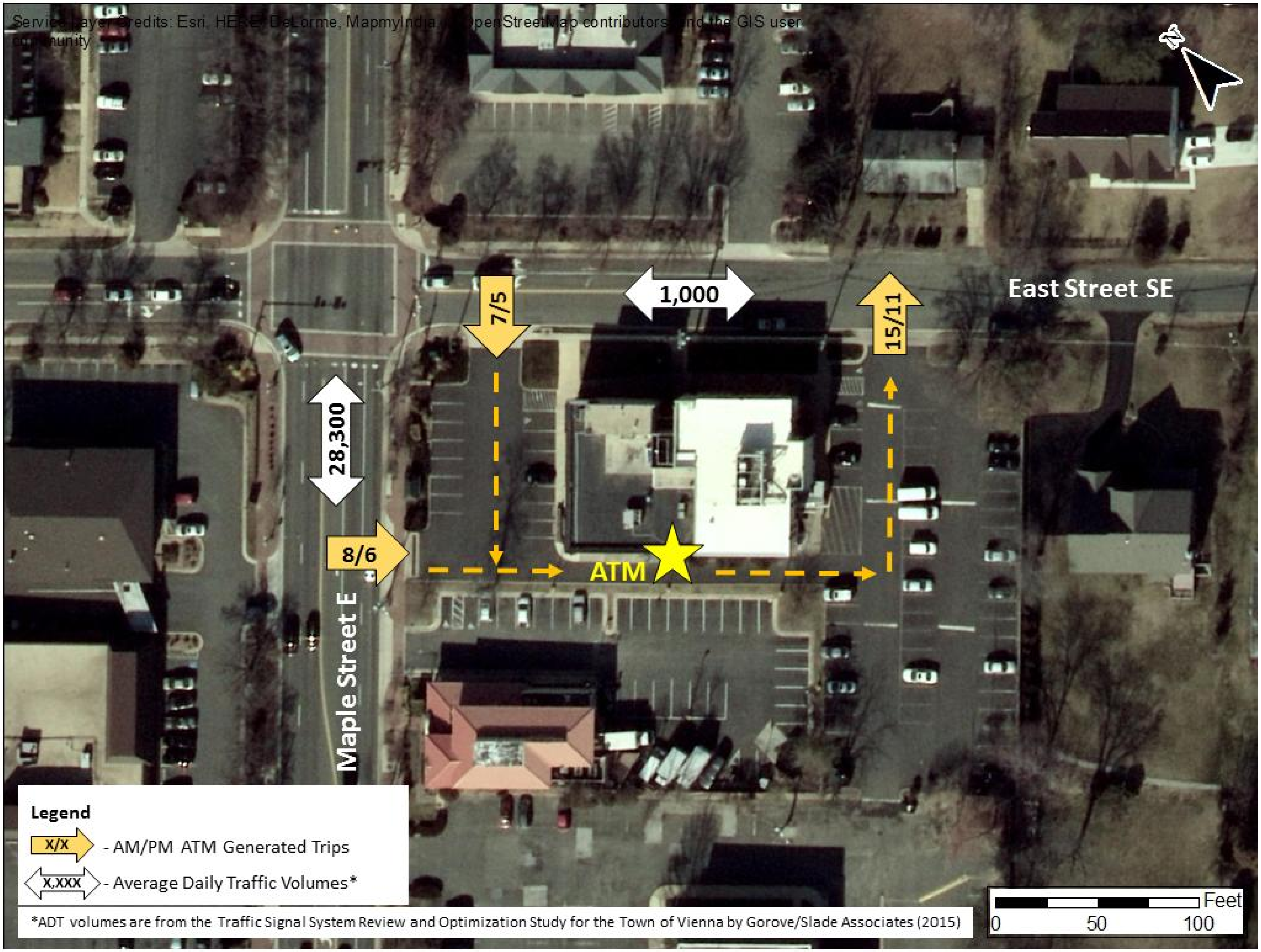
.

Table 1 - USAA Drive-thru ATM Transactions Sample Summary

Peak Period	Transactions
9 AM – 10 AM	15
12 PM – 2 PM	10
6 PM – 7 PM	11

Based on the data provided in Table 1, it is estimated that approximately 15 vehicles may be added to the adjacent roadway network during the morning peak hour, and approximately 11 vehicles in the evening peak hour. Assuming a 50%/50% split of the two entrance driveways, this is approximately 7 to 8 trips per hour per driveway in the morning and 5 to 6 trips per hour per driveway in the evening, as shown in Figure 2. This number of trips is negligible to the surrounding roadway network over the course of an hour, equating to less than 4 trips every 15 minutes in the morning and less than 3 trips every 15 minutes in the evening.

Figure 2 – 2015 Average Daily Traffic Volumes and Peak Hour USAA ATM Trips



QUEUING ANALYSIS

Understanding the negligible effect to the adjacent street traffic, a queuing analysis was performed to evaluate on-site queuing. The traffic operations at the drive-thru lanes can be modeled as a queue based on vehicles arriving at random intervals to the drive-thru ATM and exiting the drive-thru after completing their transaction. A stochastic, or statistical model of such multichannel system has been developed for use in analyzing the queues that forms at drive-thru banks[1]. The statistical analysis uses the mean arrival rate and mean service rate as the basis for all calculations and the model accounts for the likely variability in operating conditions.

Based on the data provided by USAA, the peak morning and evening arrival rates were 15 transactions per hour and 11 transactions per hour, respectively. To be conservative, the maximum observed hourly arrival rate of 15 vehicles per hour, as shown in Table 1, will be used to calculate probable queues at the proposed drive-thru ATM.

The service rate is the number of vehicles that can be served by the ATM in a given time interval. Using a previously performed study for Comerica Bank by Kimley-Horn and Associates[2], shown in Appendix C, it was determined that an average drive-thru ATM service rate is about 1 minute and 34 seconds. This aligns with the estimate provided by USAA bank representatives of just over one minute per transactions.

The analysis results in probabilities of vehicles waiting to be serviced by an ATM being equal or less than n, a variable reflecting the number of vehicles in the queue. The analysis results reported do not include the total number of vehicles in the system. For general queueing analysis, the system is defined as the service position, plus vehicle(s) waiting behind the service position.

Appendix D provides the queue calculation worksheets used to produce these results.

Table 2 shows the resulting probabilities of vehicles waiting to be serviced by the ATM lane using the average arrival and service rates. Appendix D provides the queue calculation worksheets used to produce these results.

Table 2 –USAA ATM Drive-Thru Queue Probability Summary

Vehicles Waiting (n)	Probability of n or fewer vehicles waiting	Cumulative Percent
0	84.7%	84.7%
1	9.3%	94%
2	3.7%	97.7%
3	1.4%	99.1%
4	0.6%	99.7%
≥5	0.3%	100%

The results show that under the observed mean arrival and service rate, the drive-thru ATM lane is expected to have one vehicle waiting to be serviced in the queue 9.3% of the time during the peak hour,

[1] The stochastic queuing model is taken from the standard manual *Traffic Flow Fundamentals*, Adolf D. May, 1990.

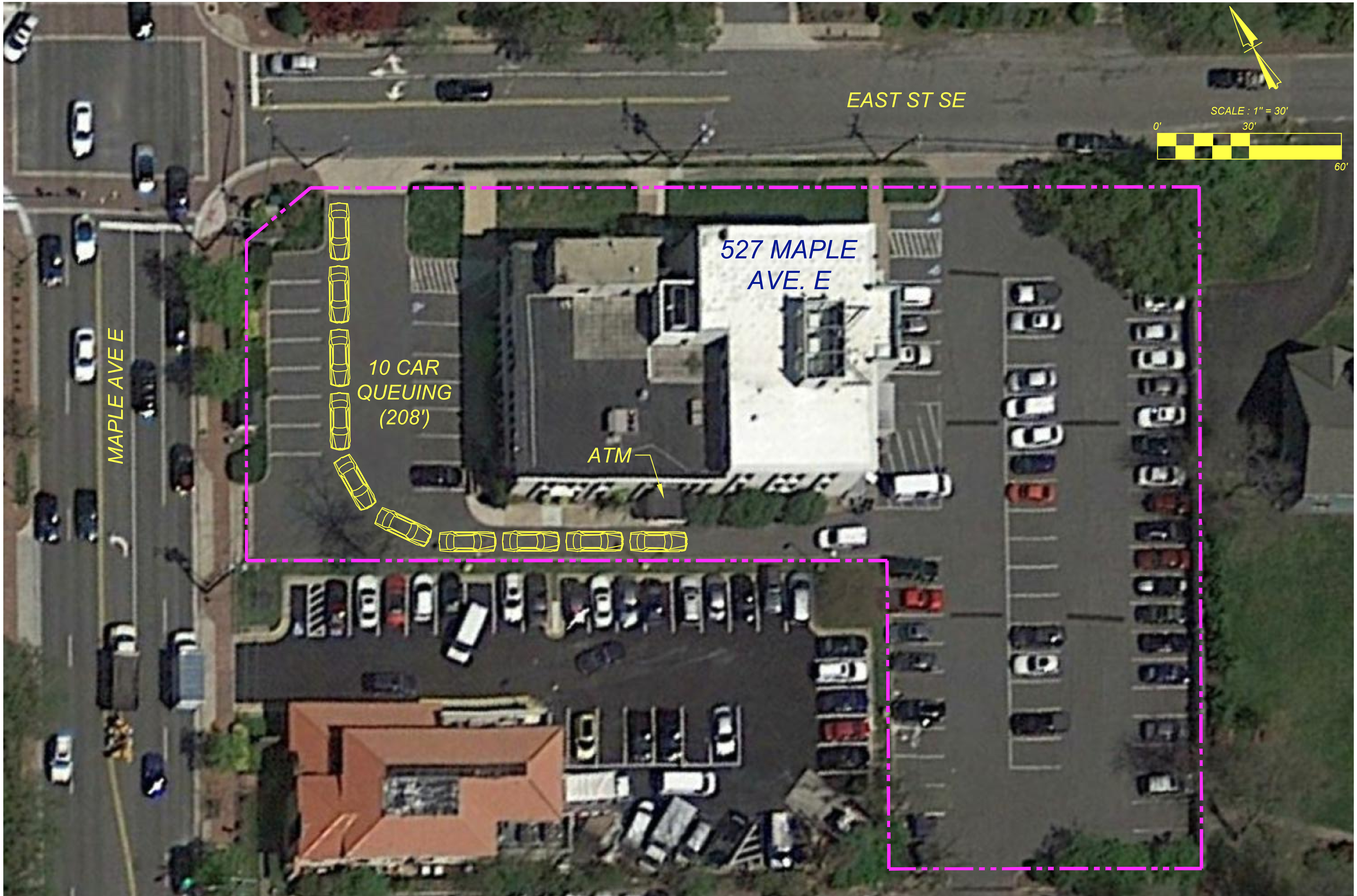
[2] *Drive-Thru Queuing Study for Comerica Bank Sites*. Kimley-Horn. May, 2008.

two vehicles waiting in the queue 3.7% of the time, and three vehicles waiting in the queue 1.4 % of the time. In fact, there is 0.3% probability that the ATM lane queue will be longer than 4 vehicles. Including the vehicle being serviced, this 5-vehicle total queue is very unlikely to occur.

QUEUING CAPACITY

Figure 3 shows the car queuing capacity available on-site, with enough stacking space for a 10-vehicle queue. Given that there is a 0.3% probability that the number of vehicles waiting to be serviced in the ATM queue would be longer than 4 vehicles (or 5 vehicles total to include the vehicle being serviced), there should be more than adequate space on-site to accommodate peak ATM conditions.

Figure 3 - On-site Queuing Capacity



ENGINEERS + SURVEYING

ISSUE DATE

REVISIONS

USAA ATM - 527 MAPLE AVE EAST
EAST ST SE QUEUING EXHIBIT

JOB NO.: 298-08-09
DATE: SEPT. 2017
DRAWN: - CHECKED: -

SHEET NUMBER:
EX 1

Date: Sep 21, 2017, 2:18pm User ID: acarruth
File: P:\298\08\09\Design\Exhibits\CAD\170919 - Queuing Exhibit.dwg

CONCLUSIONS AND RECOMMENDATIONS

As a result of this study, it is concluded that the on-site circulation and area roadway network will accommodate the proposed development. During the busiest times of the month, the peak arrival rate to the drive-thru ATM is estimated to be 15 vehicles per hour in the morning and 11 vehicles per hour in the evening. Based on stochastic queuing models of an arrival rate of 15 vehicles per hour and an ATM service rate of one minute and 34 seconds, the probability that the queue of vehicles waiting to be serviced is greater than four is 0.3% of the time during the peak hour. Including the vehicle being serviced, this 5-vehicle queue is very unlikely to occur. However, in the event that this 5-vehicle queue does occur, the stacking space available on-site could accommodate twice that length. The results show that even with conservative demand assumptions used for the drive-thru ATM, the site and surrounding roadway network can accommodate the proposed development in the peak hours.

APPENDIX A

Site Plan

USAA

Loc#: 0335

527 Maple Ave E
Vienna, VA 22180

ICON

We Brand Your
Places & Spaces

Drawing prepared by:

ICON

SITE PLAN

Location:
527 Maple Ave E
Vienna, VA 22180

Proj #: 3221

Loc #: 0335

File Path:
Active\BANKS\U\USAA\Locations\3221_0335_Vienna_VA_R1.cdr

Drawing prepared for:

USAA

Rev #:	Req#:	Date:	Req. By:	Drawn By:	Revision Description:
Original	257201	08/29/17	SL	NPP	
Rev 1	258624	09/27/17	SL	NPP	Rmv Sign2 Opt2. Add DU Wall Surround w/ Bump Out
Rev 2	000000	00/00/00	XXX	XXX	
Rev 3	000000	00/00/00	XXX	XXX	
Rev 4	000000	00/00/00	XXX	XXX	
Rev 5	000000	00/00/00	XXX	XXX	
Rev 6	000000	00/00/00	XXX	XXX	

Rev #:	Req#:	Date:	Req. By:	Drawn By:
Rev 7	000000	00/00/00	XXX	XXX
Rev 8	000000	00/00/00	XXX	XXX
Rev 9	000000	00/00/00	XXX	XXX
Rev 10	000000	00/00/00	XXX	XXX

1

2

3

4

5

6

Drawing prepared by: ICON

OVERVIEW PHOTOS

Location:
527 Maple Ave E
Vienna, VA 22180

Proj #: 3221

Loc #: 0335

File Path:
Active\BANKS\U\USAA\Locations\3221_0335_Vienna_VA_R1.cdr

Drawing prepared for: USAA

Rev #:	Req#:	Date:	Req. By:	Drawn By:	Revision Description:
Original	257201	08/29/17	SL	NPP	
Rev 1	258624	09/27/17	SL	NPP	Rmv Sign2 Opt2. Add DU Wall Surround w/ Bump Out
Rev 2	000000	00/00/00	XXX	XXX	
Rev 3	000000	00/00/00	XXX	XXX	
Rev 4	000000	00/00/00	XXX	XXX	
Rev 5	000000	00/00/00	XXX	XXX	
Rev 6	000000	00/00/00	XXX	XXX	

Rev #:	Req#:	Date:	Req. By:	Drawn By:
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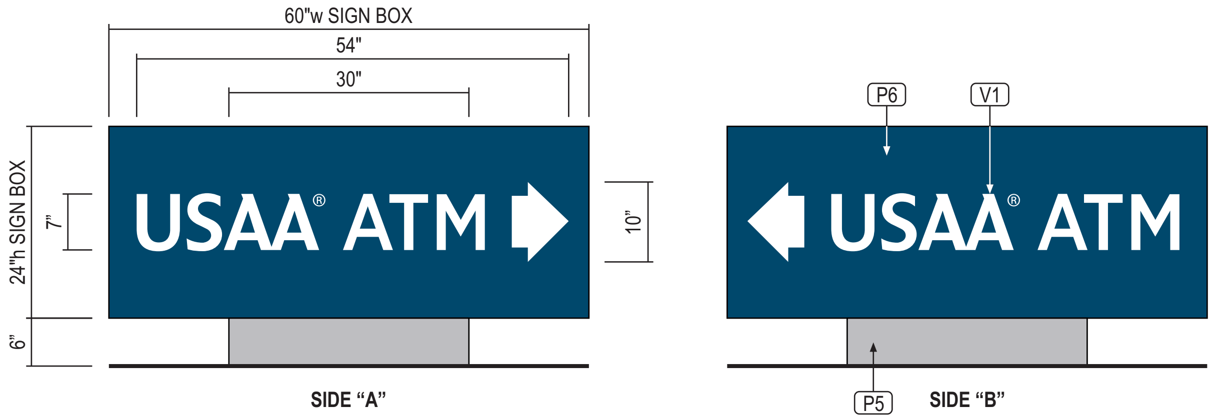
Rev 8	000000	00/00/00	XXX	XXX
Rev 9	000000	00/00/00	XXX	XXX
Rev 10	000000	00/00/00	XXX	XXX



CUSTOM D/F NON-ILLUMINATED DIRECTIONAL SIGN

QTY: 1
SCALE: 1/2"=1'-0"
STANDARD SPECS - SEE COLOR SPECIFICATION LIBRARY

EXISTING

PROPOSED

Drawing prepared by: ICON

SIGN 1

Location:
527 Maple Ave E
Vienna, VA 22180

Proj #: 3221

Loc #: 0335

File Path:
Active\BANKS\U\USAA\Locations\3221_0335_Vienna_VA_R1.cdr

Drawing prepared for: USAA

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Rev 3	000000	00/00/00	XXX	XXX	
Rev 4	000000	00/00/00	XXX	XXX	
Rev 5	000000	00/00/00	XXX	XXX	
Rev 6	000000	00/00/00	XXX	XXX	

Rev #:	Req#:	Date:	Req. By:	Drawn By:
Rev 7	000000	00/00/00	XXX	XXX
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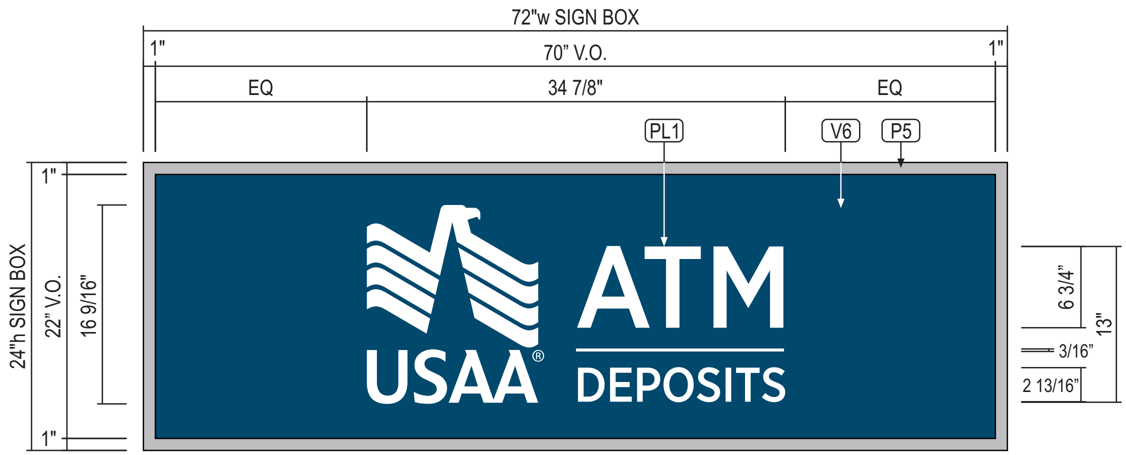
Rev 10	000000	00/00/00	XXX	XXX



REPLACEMENT FACE for ILLUMINATED WALL SIGN @ REMOTE ATM

QTY: 1

SCALE: 3/4"=1'-0"

STANDARD SPECS - SEE COLOR SPECIFICATION LIBRARY

EXISTING

PROPOSED

Drawing prepared by: ICON

SIGN 2

Location:
527 Maple Ave E
Vienna, VA 22180

Proj #: 3221

Loc #: 0335

File Path:
Active\BANKS\U\USAA\Locations\3221_0335_Vienna_VA_R1.cdr

Drawing prepared for: USAA

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Rev 2	000000	00/00/00	XXX	XXX		Rev 7	000000	00/00/00	XXX	XXX
Rev 3	000000	00/00/00	XXX	XXX		Rev 8	000000	00/00/00	XXX	XXX
Rev 4	000000	00/00/00	XXX	XXX		Rev 9	000000	00/00/00	XXX	XXX
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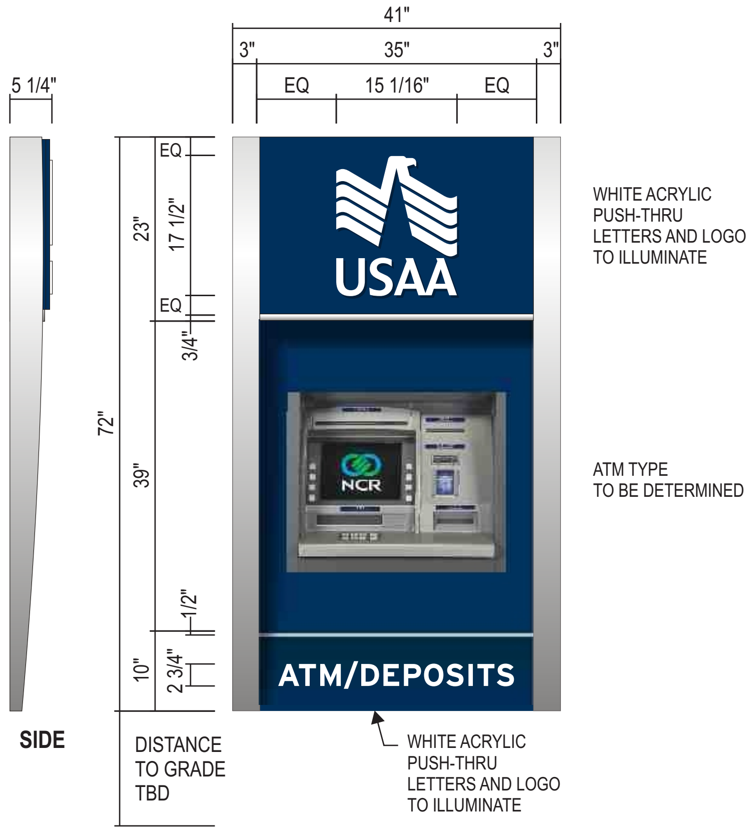
Rev 6	000000	00/00/00	XXX	XXX						



DRIVE-UP ATM WALL SURROUND

QTY: 1

SCALE: 1/2"=1'-0"

EXISTING

PROPOSED

Drawing prepared by:

SIGN 3

Location:
527 Maple Ave E
Vienna, VA 22180

Proj #: 3221

Loc #: 0335

File Path:
Active\BANKS\U\USAA\Locations\3221_0335_Vienna_VA_R1.cdr

Drawing prepared for:

Rev #:	Req#:	Date:	Req. By:	Drawn By:	Revision Description:
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Rev 1	258624	09/27/17	SL	NPP	Rmv Sign2 Opt2. Add DU Wall Surround w/ Bump Out
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Rev #:	Req#:	Date:	Req. By:	Drawn By:
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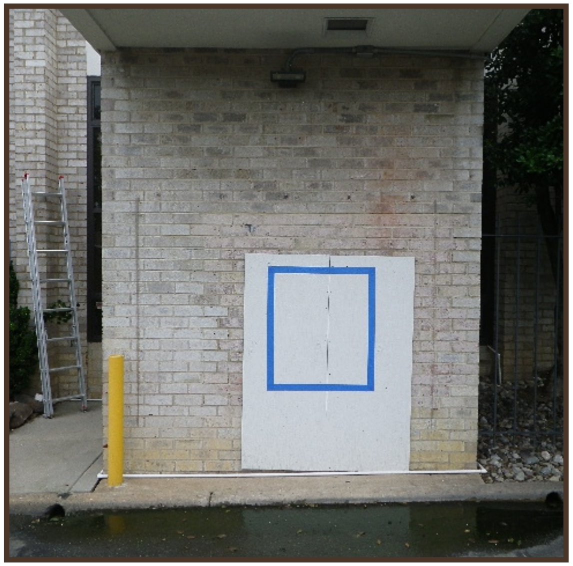

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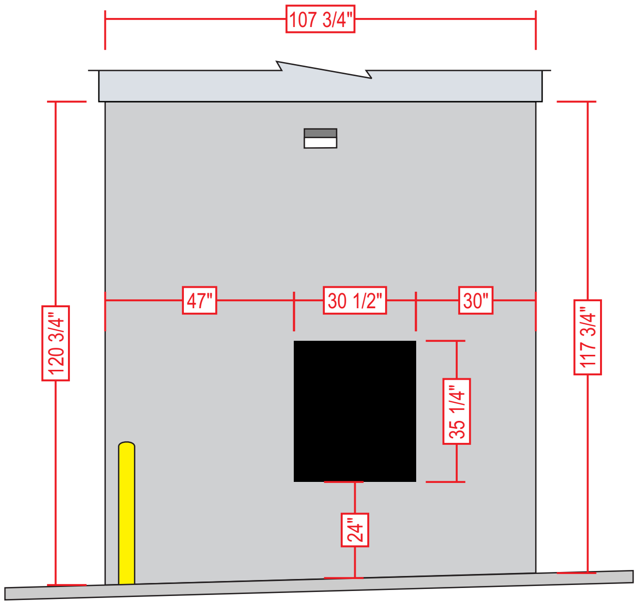
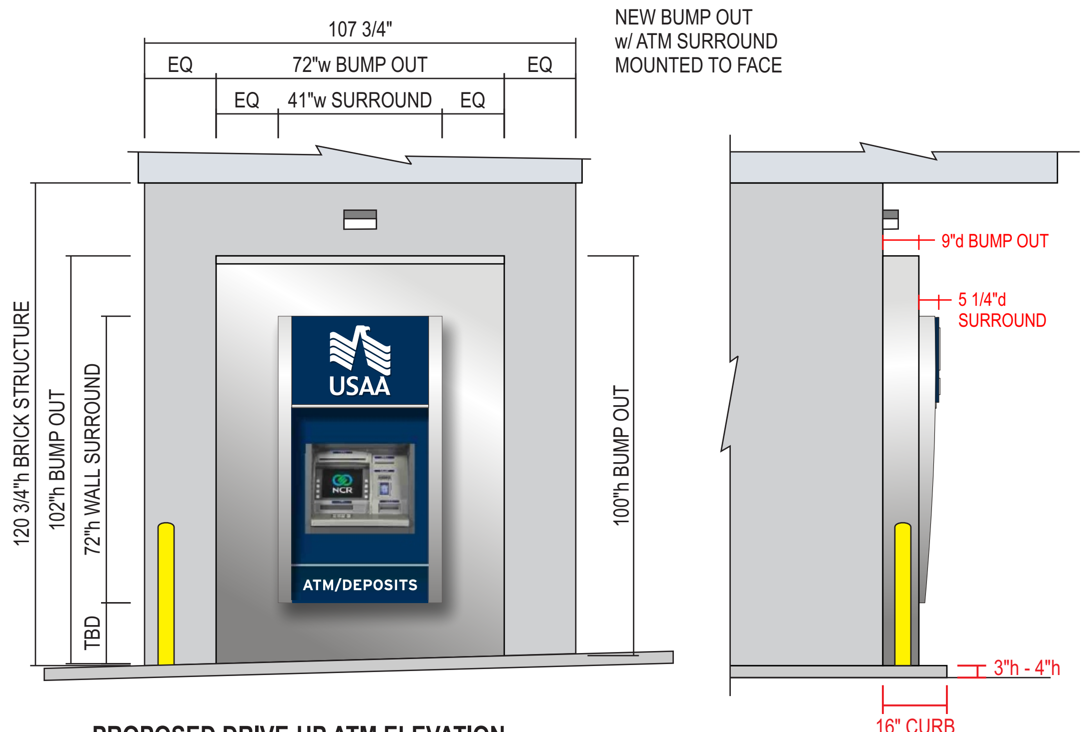


EXISTING DRIVE-UP ATM ELEVATION

SCALE: 1/4"=1'-0"



PROPOSED DRIVE-UP ATM ELEVATION

BUMP OUT WITH ATM SURROUND MOUNTED TO BRICK FACING.

SCALE: 1/4"=1'-0"

Drawing prepared by:

SIGN 3

Location:
527 Maple Ave E
Vienna, VA 22180

Proj #: 3221

Loc #: 0335

File Path:
Active\BANKS\U\USAA\Locations\3221_0335_Vienna_VA_R1.cdr

Drawing prepared for:

USAA

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Rev 4	000000	00/00/00	XXX	XXX	
Rev 5	000000	00/00/00	XXX	XXX	
Rev 6	000000	00/00/00	XXX	XXX	

Rev #:	Req#:	Date:	Req. By:	Drawn By:
Rev 7	000000	00/00/00	XXX	XXX
Rev 8	000000	00/00/00	XXX	XXX
Rev 9	000000	00/00/00	XXX	XXX
Rev 10	000000	00/00/00	XXX	XXX

APPENDIX B

Scoping Discussion

Knox, Sarah (Hardingham)

From:	Knox, Sarah (Hardingham)
Sent:	Wednesday, October 18, 2017 11:29 AM
To:	'D'Orazio, Michael'; Ameel, Adrienne
Cc:	Sergent, John
Subject:	RE: USAA ATM - 527 Maple Avenue East - Traffic Analysis

Hello all,

John Jay and I just spoke regarding the USAA ATM traffic analysis, and I wanted to document our approach so all are aware. We plan to provide the following:

- Trip generation for the ATM in the AM and PM peak hours
- Queuing estimations on-site
- Queue stacking space on-site (figure already developed)
- Review ADTs on East St and provide daily trip generation for the ATM
- Additional peak hour trips at the site entrances along East St
- Narrative and graphics describing what impact (if any) these additional trips may have on East St traffic during the peak hours
- We will not be analyzing any intersection delay or queuing through Synchro traffic analysis software

Please let me know if I have misstated any of this information. If not, we will move forward with this approach.

Thank you,
Sarah

Sarah Knox (Hardingham), P.E. (VA)
Kimley-Horn | 11400 Commerce Park Dr, Suite 400, Reston, VA 20191
Direct: 703-674-1327 | Main: 703-674-1300

From: D'Orazio, Michael [mailto:MDOrazio@viennava.gov]
Sent: Monday, October 16, 2017 4:41 PM
To: Ameel, Adrienne <Adrienne.Ameel@kimley-horn.com>
Cc: Knox, Sarah (Hardingham) <Sarah.Knox@kimley-horn.com>; Sergent, John <john.sergent@viennava.gov>
Subject: RE: USAA ATM - 527 Maple Avenue East - Traffic Analysis

Adrienne,

I'm going to have an engineer from Public Works look at what you are proposing and making sure it is adequate. We'll get back to you shortly.

Thanks,

Michael D'Orazio, AICP
Principal Planner
Town of Vienna
127 Center Street, South
Vienna, VA 22180
(703) 255-6316 (Voice)

(703) 255-5722 (Fax)
mdorazio@viennava.gov
www.viennava.gov

From: Ameel, Adrienne [mailto:Adrienne.Ameel@kimley-horn.com]
Sent: Monday, October 16, 2017 4:17 PM
To: D'Orazio, Michael
Cc: Knox, Sarah (Hardingham)
Subject: RE: USAA ATM - 527 Maple Avenue East - Traffic Analysis

Thank you Michael for your effort in trying to track down another CUP traffic analysis example. We currently do not have any existing traffic counts on the adjacent streets or intersections surrounding the site. With the aggressive schedule to finish the traffic analysis this week to meet the CUP submittal, we were not anticipating collecting data. We are currently proposing to complete a trip generation for the AM and PM peak periods, review the on-site circulation patterns, complete an on-site queuing analysis for the ATM. We were not anticipating analyzing the driveways or adjacent intersection or roadways since there was a bank previously at the site and this is for just an ATM. Please let me know if you believe this is acceptable or if you have any comments.

Thanks again!

Adrienne

Kimley»Horn
Adrienne C. Ameel, P.E. (DC, VA)
Kimley-Horn | 11400 Commerce Park Drive, Suite 400, Reston, VA 20191
Direct: 703 674 1340 | Mobile: 517 214 1963 |
Connect with us: Twitter| LinkedIn | Facebook | YouTube

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From: D'Orazio, Michael [mailto:MDOrazio@viennava.gov]
Sent: Monday, October 16, 2017 3:42 PM
To: Ameel, Adrienne <Adrienne.Ameel@kimley-horn.com>
Cc: Knox, Sarah (Hardingham) <Sarah.Knox@kimley-horn.com>
Subject: RE: USAA ATM - 527 Maple Avenue East - Traffic Analysis

Adrienne,

I'm having a little trouble locating one. The only one I could find was part of a rezoning application so the traffic impact analysis was a little more substantial. I think we would need a very basic analysis that meets the requirements of the Code (https://library.municode.com/va/vienna/codes/code_of_ordinances?nodeId=PTIICOOR_CH18ZO_ART21COUSPE_S18-210USPERE):

"A traffic analysis providing information that would include, but not be limited to: estimates of the number of vehicle trips and the amount of vehicular stacking that would occur daily and during a.m./p.m. peak hours; trip generation by use type; estimated internal and external traffic flows; parking and vehicular stacking spaces that would be provided on-site; and data on existing traffic conditions and the traffic-handling capacity of roads fronted by the proposed use. In addition, the analysis would discuss sight distances at points of ingress and egress, pedestrian and bicycle traffic, and any other site-specific traffic factors or public safety issues associated with the application."

Let me know if you would like to meet tomorrow to discuss this further.

Thanks,

Michael D'Orazio, AICP
Principal Planner
Town of Vienna
127 Center Street, South
Vienna, VA 22180
(703) 255-6316 (Voice)
(703) 255-5722 (Fax)
mdorazio@viennava.gov
www.viennava.gov

From: Ameel, Adrienne [mailto:Adrienne.Ameel@kimley-horn.com]
Sent: Monday, October 16, 2017 8:25 AM
To: D'Orazio, Michael
Cc: Knox, Sarah (Hardingham)
Subject: RE: USAA ATM - 527 Maple Avenue East - Traffic Analysis

Thank you Michael for the quick response after you just returned from vacation. Yes an example of a CUP application drive-through facility traffic analysis would be perfect.

Thanks again!

Adrienne

Kimley»Horn
Adrienne C. Ameel, P.E. (DC, VA)
Kimley-Horn | 11400 Commerce Park Drive, Suite 400, Reston, VA 20191
Direct: 703 674 1340 | Mobile: 517 214 1963 |
Connect with us: Twitter| LinkedIn | Facebook | YouTube

From: D'Orazio, Michael [mailto:MDOrazio@viennava.gov]
Sent: Monday, October 16, 2017 8:22 AM
To: Ameel, Adrienne <Adrienne.Ameel@kimley-horn.com>
Cc: Knox, Sarah (Hardingham) <Sarah.Knox@kimley-horn.com>
Subject: RE: USAA ATM - 527 Maple Avenue East - Traffic Analysis

Hi Adrienne,

APPENDIX C

Comerica Bank Study

Kimley-Horn
and Associates, Inc.

May 8, 2008

Suite 1800
12700 Park Central Drive
Dallas, Texas
75251

Larry Kelling, Project Manager
CB Richard Ellis
10601 Forest Lane, Suite 200
Dallas, TX 75243

Re: Drive-Thru Queuing Study for Comerica Bank Sites

Dear Mr. Kelling:

Kimley-Horn and Associates, Inc. has been retained by CB Richard Ellis to conduct a drive-thru lane queuing study for six of Comerica Bank's existing locations in the Dallas/Fort Worth and Houston metro-areas. This study was conducted to determine the queuing (vehicle stacking) requirements needed for each bank drive-thru lane serving a teller or ATM (automated teller machine) transaction station.

Drive-Thru Lane Queuing Observations

Comerica Bank representatives identified the bank branches (locations) for observation and the Friday midday observation period from 11 AM to 3 PM. Comerica Bank representatives stated that the Friday midday time period is typically the busiest time of the week for drive-thru lane demand.

Observations were conducted on two consecutive Fridays (March 14th and March 21st, 2008) from 11 AM to 3 PM at the following Comerica Banks to assess the existing vehicle queues:

- 128 N. Denton Tap Road in Coppell, Texas
- 2820 Gessner in Houston, Texas
- 1525 Hwy 6 in Sugar Land, Texas
- 1503 Eldridge Parkway in Houston, Texas

Additional vehicle stacking observations were conducted on Friday, April 18th and Friday, April 25th, 2008 from 11 AM to 3 PM at the following Comerica Bank branches:

- 4901 N. Beltline Road in Irving, Texas
- 4950 N. Garland Avenue in Garland, Texas

TEL 972 770 1300
FAX 972 239 3820

Table 1 summarizes the number and type of drive-thru lanes (photos attached) in use at each of the existing Comerica Bank branches identified above during the Friday observations. The number of general drive-thru lanes includes the commercial lanes at each bank branch, which was one lane at each location except for the Coppell branch. The Coppell bank branch did not have a designated commercial lane during the peak period observations.

Table 1 – Drive-Thru Lanes at each Comerica Bank Observed

Location	ATM	General
Coppell		
Physical Lanes	1	4
Operating Lanes[1]	1	4
Operating Lanes[2]	1	3
Total Observations	79	105
Gessner		
Physical Lanes	1	4
Operating Lanes	1	4
Total Observations	31	75
Hwy 6		
Physical Lanes	1	3
Operating Lanes	1	3
Total Observations	10	43
Eldridge Parkway		
Physical Lanes	1	3
Operating Lanes	1	2
Total Observations	15	11
Irving		
Physical Lanes	1	3
Operating Lanes	1	3
Total Observations	15	25
Garland		
Physical Lanes	1	3
Operating Lanes	1	3
Total Observations	24	33

Notes:

1. Illustrates the number of operating lanes on Friday, March 14, 2008.
2. Illustrates the number of operating lanes on Friday, March 21, 2008.

During the four-hour observation periods at each of the Comerica Bank sites, the following information was collected for each vehicle using a drive-thru lane:

- Time when each vehicle entered the drive-thru lane
- Drive-thru lane used by each vehicle
- Queue (stacking) position when entering the drive-thru lane, where zero indicates there were no vehicles waiting and the vehicle could begin transaction immediately
- Time when each vehicle started transaction with teller or ATM
- Time when each vehicle left the drive-thru lane

Queuing Analysis

The traffic operation at the drive-thru lanes can be modeled as a queue where vehicles arrive at random intervals and exit or leave the system after they are serviced by a teller or ATM machine. A stochastic, or statistical, model of such multichannel systems has been developed for use in analyzing the queues that form at banks and airport check-in counters[1]. The statistical analysis uses the mean arrival rate and mean service rate as the basis for all calculations, and the model takes into account the likely variability in operating conditions.

For each of the six Comerica Bank branches observed, the arrival rate per hour was calculated by adding up all of the vehicles that arrived each hour in each lane type (ATM or general) and then taking the average across all of the locations. This procedure removes the variability due to the number of lanes actually in operation at each location, and results in the basic rate of arrivals at the location. The average arrival rate per hour was observed to be 4 vph (vehicles per hour) using an ATM lane and 6 vph using a general drive-thru lane.

The service rate is the number of vehicles that can be served by the ATM or a teller in a given time interval. The average service rates were calculated to be 1 minute and 34 seconds for an ATM lane, and 3 minutes and 50 seconds for a general drive-thru lane.

Table 2 shows the arrival rates per hour and service rates observed for each branch. The arrival rate, or demand for service, varies significantly by branch, but also appears to be somewhat correlated to the total number of drive-thru lanes at a branch. With Comerica and other banks pursuing a strategy of having many smaller branches, future Comerica sites can be expected to experience demands on the low end of the observed spread. Compared to the arrival rates, the average service rates within each category are fairly constant between locations. The last line of **Table 2** summarizes the average arrival and service rates per ATM and general drive-thru lane type observed during the observation period. These observed values are

[1] The stochastic queuing model is taken from the standard manual *Traffic Flow Fundamentals,* Adolf D. May, 1990.

assumed to be representative of Comerica bank branches of similar size and location and are used for the stochastic model of queuing behavior. Excel spreadsheets that show the raw data collected at each Comerica Bank branch are attached.

Table 2 – Summary of Comerica Bank Sites Drive-Thru Lane Operations

Location	Average Arrival Rate per Hour		Average Service Rate	
	ATM	General	ATM	General
Coppell	10	13	1:37	3:12
Gessner	4	9	1:44	4:37
Hwy 6	1	5	1:21	3:49
Eldridge	2	1	1:36	3:56
Irving	2	3	1:18	3:43
Garland	3	4	1:49	3:42
Average Rates	***4***	***6***	***1:34***	***3:50***

<u>Queuing Results – Average Rates</u>

The analysis results in probabilities of the vehicles waiting to be serviced by an ATM or teller being equal or less than n, a variable reflecting the number of vehicles in the queue. The analysis results reported do not include the total number of vehicles in the system. For general queuing analysis, the system is defined as the service position, plus any vehicles waiting behind the service position. **Tables 3, 4** and **5** show the resulting probabilities of vehicles waiting to be serviced by an ATM lane, two general drive-thru lanes, and three general drive-thru lanes using the average arrival and service rates.

Table 3 – Queue Probabilities – One ATM Lane (Average Arrival Rate)

Entry	Vehicles Waiting	Probability of n or fewer vehicles waiting	Cumulative Percent
One ATM Lane	0	98.9%	98.9%
	1	1.0%	99.9%
	≥ 2	0.1%	100.0%

Table 4 – Queue Probabilities – Two General Lanes (Average Arrival Rate)

Entry	Vehicles Waiting	Probability of *n* or fewer vehicles waiting	Cumulative Percent
Two Drive-Thru Lanes	0	98.8%	98.8%
	1	1.0%	99.8%
	≥ 2	0.2%	100.0%

Table 5 – Queue Probabilities – Three General Lanes (Average Arrival Rate)

Entry	Vehicles Waiting	Probability of *n* or fewer vehicles waiting	Cumulative Percent
Three Drive-Thru Lanes	0	99.9%	99.9%
	≥ 1	0.1%	100.0%

The results show that under the observed mean arrival and service rate, an ATM lane is expected to have one vehicle waiting to be serviced in the queue 1% of the time during the Friday midday peak period. In fact, there is only a 0.1% chance that the ATM lane queue will be longer than 2 vehicles during the Friday midday peak period.

If two general drive-thru lanes were provided, the observed mean arrival and service rates result in zero vehicles stacked or waiting in the drive-thru lane 98.8% of the time and one vehicle waiting to be serviced 1% of the time during the Friday midday peak period. If three general drive-thru lanes are open, then 99.9% of the time the drive-thru lanes are expected to have zero vehicles stacked or waiting to be serviced and only a 0.1% probability that one vehicle will be waiting in the drive-thru lane to be serviced.

Queuing Results – Highest Observed Arrival Rate

An alternative queuing analysis was conducted that used the highest arrival rate in both the ATM and general drive-thru lane, which occurred at the Coppell branch during the peak period observed. **Tables 6, 7** and **8** show the probabilities of vehicles waiting to be serviced by an ATM lane, two general drive-thru lanes, and three general drive-thru lanes using the highest arrival rate experienced during the observations and the average service rates.

Table 6 – Queue Probabilities – One ATM Lane (Highest Observed Arrival Rate)

Entry	Vehicles Waiting	Probability of n or fewer vehicles waiting	Cumulative Percent
One ATM Lane	0	93.2%	93.2%
	1	5.0%	98.2%
	2	1.3%	99.5%
	3	0.3%	99.9%
	≥ 4	0.1%	100.0%

Table 7 – Queue Probabilities – Two General Lanes (Highest Observed Arrival Rate)

Entry	Vehicles Waiting	Probability of n or fewer vehicles waiting	Cumulative Percent
Two Drive-Thru Lanes	0	89.9%	89.9%
	1	5.9%	95.8%
	2	2.5%	98.3%
	3	1.0%	99.3%
	4	0.4%	99.7%
	5	0.2%	99.9%
	≥ 6	0.1%	100.0%

Table 8 – Queue Probabilities – Three General Lanes (Highest Observed Arrival Rate)

Entry	Vehicles Waiting	Probability of n or fewer vehicles waiting	Cumulative Percent
Three Drive-Thru Lanes	0	98.4%	98.4%
	1	1.2%	99.6%
	2	0.3%	99.9%
	≥ 3	0.1%	100.0%

The results show that under the observed highest arrival rate and mean service rate, an ATM lane is expected to have one vehicle waiting to be serviced in the queue 5% of the time during the Friday midday peak period. In fact, there is only a 1.7% chance that the ATM lane queue will be longer than 2 vehicles during the Friday midday peak period.

If two general drive-thru lanes are provided, the observed highest arrival rate and average service rate results in at most one vehicle stacked or waiting in the drive-thru lanes 95.8% of the time. There is a 2.5% probability that two total vehicles will be stacked or waiting in drive-thru lanes during the Friday midday peak period. The observations and queue analysis indicates that there is less than a 2% chance that there will be more than 3 vehicles stacked or waiting to be serviced in the drive-thru lanes.

If three general drive-thru lanes are open under the highest arrival rate experienced during the observation period, then 98.4% of the time the drive-thru lanes are expected to have zero vehicles stacked or waiting to be serviced and only a 1.6% probability that more than one vehicle will be waiting in a drive-thru lane to be serviced.

Conclusion

The Friday midday peak period arrival rates and service rates for ATM and teller lanes at a typical Comerica bank drive-thru were determined by observations at six existing locations. The queuing analysis using the average peak period arrival and service rates shows that 99.8% of the time the number of vehicles waiting per lane is two or fewer for the ATM lane, a two-lane drive-thru, or a three-lane drive-thru.

The more conservative queuing analysis using the maximum observed peak period arrival rates and the average service rates shows that 99.5% of the time the number of vehicles waiting is two or less for the ATM lane. 98.3% of the time the number of vehicles waiting per lane is two or fewer for the two-lane drive-thru, or 99.3% for three or fewer. 99.9% of the time the number of vehicles waiting is two or fewer for the three-lane drive-thru.

These results show that even with the most conservative assumptions about demand for the drive-thru services at modern Comerica bank facilities, ATM lanes and drive-thru lanes with three teller service lanes should be provided with two stacking positions for each lane. Drive-thru lanes with two teller service lanes should be provided with three stacking positions for each lane.

Please contact me if you have any questions.

Very truly yours,

KIMLEY-HORN AND ASSOCIATES, INC.

Scot Johnson, P.E.

Scot A. Johnson, P.E., PTOE
Project Manager

APPENDIX D

Queuing Worksheets

Drive-Thru ATM Lane

(Peak Hour Arrival and Average Service Rate)

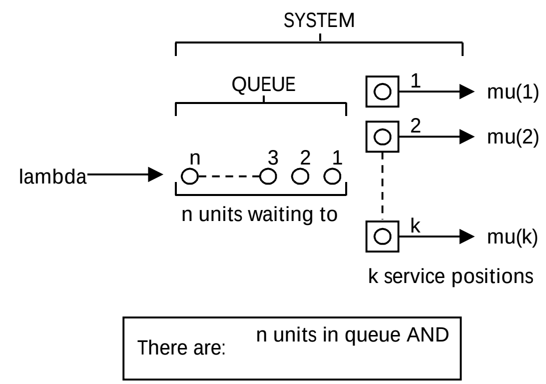
M/M/1 QUEUE WORKSHEET

NOTES: If all parameters are known, simply enter the value for the corresponding parameters. If one parameter is not known, you must have a performance measure. In this case, go to the section labeled "Numerical Solver," select the unknown and known variable, enter the value,

Time Period: 1 hr

Parameter	***Value***	
Mean Arrival Rate (λ):	15.00	(15/hr)
Mean Service Rate (μ):	38.30	(38.3/hr)
# of Service Positions:	1	
n (# of units):	0	

Performance Measures	***Value***		
Probability of Exactly n Units (Queue / System):	0.847	/	0.608
Probability that # of Units <= n (Queue / System):	0.847	/	0.608
Average Number in Queue / System:	0.252	/	0.644
Average Time in Queue / System:	0.017	/	0.043



Note: In the M/M/k Queue model, the arrival rate lambda must be less than the departure rate mu times the number of service positions. Without this condition, the queue increases without bound and the system becomes unstable.

Drive-Thru ATM Lane
(Peak Hour Arrival and Average Service Rate)

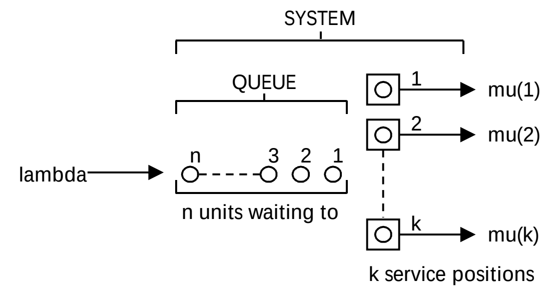
M/M/1 QUEUE WORKSHEET

NOTES: If all parameters are known, simply enter the value for the corresponding parameters. If one parameter is not known, you must have a performance measure. In this case, go to the section labeled "Numerical Solver," select the unknown and known variable, enter the value,

Time Period: 1 hr

Parameter	***Value***	
Mean Arrival Rate (λ):	15.00	(15/hr)
Mean Service Rate (μ):	38.30	(38.3/hr)
# of Service Positions:	1	
n (# of units):	1	

Performance Measures	***Value***
Probability of Exactly n Units (Queue / System):	0.093 / 0.238
Probability that # of Units <= n (Queue / System):	0.940 / 0.847
Average Number in Queue / System:	0.252 / 0.644
Average Time in Queue / System:	0.017 / 0.043



There are: n units in queue AND

Note: In the M/M/k Queue model, the arrival rate lambda must be less than the departure rate mu times the number of service positions. Without this condition, the queue increases without bound and the system becomes unstable.

Drive-Thru ATM Lane

(Peak Hour Arrival and Average Service Rate)

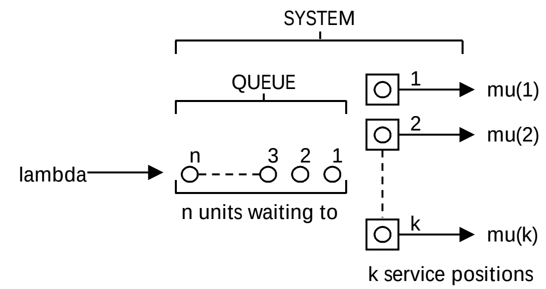
M/M/1 QUEUE WORKSHEET

NOTES: If all parameters are known, simply enter the value for the corresponding parameters. If one parameter is not known, you must have a performance measure. In this case, go to the section labeled "Numerical Solver," select the unknown and known variable, enter the value,

Time Period: 1 hr

Parameter	Value	
Mean Arrival Rate (λ):	15.00	(15/hr)
Mean Service Rate (μ):	38.30	(38.3/hr)
# of Service Positions:	1	
n (# of units):	2	

Performance Measures	Value
Probability of Exactly n Units (Queue / System):	0.037 / 0.093
Probability that # of Units <= n (Queue / System):	0.976 / 0.940
Average Number in Queue / System:	0.252 / 0.644
Average Time in Queue / System:	0.017 / 0.043



There are: n units in queue AND

Note: In the M/M/k Queue model, the arrival rate lambda must be less than the departure rate mu times the number of service positions. Without this condition, the queue increases without bound and the system becomes unstable.

Drive-Thru ATM Lane
(Peak Hour Arrival and Average Service Rate)

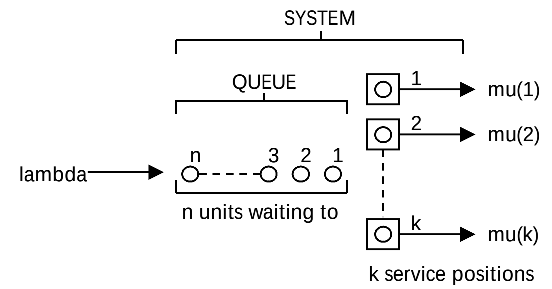
M/M/1 QUEUE WORKSHEET

NOTES: If all parameters are known, simply enter the value for the corresponding parameters. If one parameter is not known, you must have a performance measure. In this case, go to the section labeled "Numerical Solver," select the unknown and known variable, enter the value,

Time Period: 1 hr

Parameter	Value	
Mean Arrival Rate (λ):	15.00	(15/hr)
Mean Service Rate (μ):	38.30	(38.3/hr)
# of Service Positions:	1	
n (# of units):	3	

Performance Measures	Value
Probability of Exactly n Units (Queue / System):	0.014 / 0.037
Probability that # of Units <= n (Queue / System):	0.991 / 0.976
Average Number in Queue / System:	0.252 / 0.644
Average Time in Queue / System:	0.017 / 0.043



There are: n units in queue AND

Note: In the M/M/k Queue model, the arrival rate lambda must be less than the departure rate mu times the number of service positions. Without this condition, the queue increases without bound and the system becomes unstable.

Drive-Thru ATM Lane
(Peak Hour Arrival and Average Service Rate)

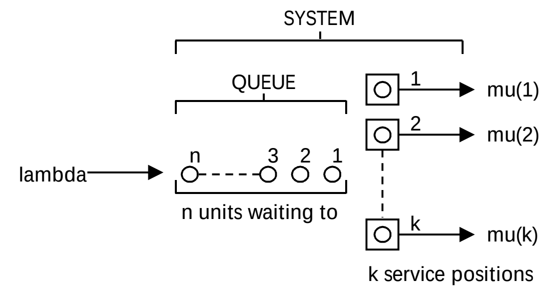
M/M/1 QUEUE WORKSHEET

NOTES: If all parameters are known, simply enter the value for the corresponding parameters. If one parameter is not known, you must have a performance measure. In this case, go to the section labeled "Numerical Solver," select the unknown and known variable, enter the value,

Time Period: 1 hr

Parameter	Value	
Mean Arrival Rate (λ):	15.00	(15/hr)
Mean Service Rate (μ):	38.30	(38.3/hr)
# of Service Positions:	1	
n (# of units):	4	

Performance Measures	Value		
Probability of Exactly n Units (Queue / System):	0.006	/	0.014
Probability that # of Units <= n (Queue / System):	0.996	/	0.991
Average Number in Queue / System:	0.252	/	0.644
Average Time in Queue / System:	0.017	/	0.043



There are: n units in queue AND

Note: In the M/M/k Queue model, the arrival rate lambda must be less than the departure rate mu times the number of service positions. Without this condition, the queue increases without bound and the system becomes unstable.

Drive-Thru ATM Lane
(Peak Hour Arrival and Average Service Rate)

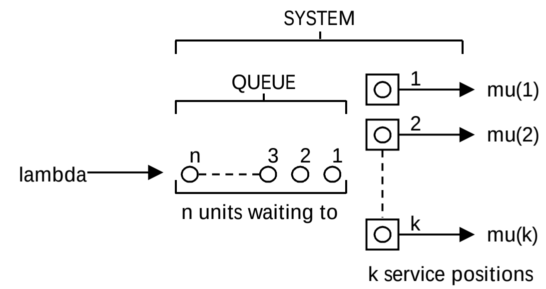
M/M/1 QUEUE WORKSHEET

NOTES: If all parameters are known, simply enter the value for the corresponding parameters. If one parameter is not known, you must have a performance measure. In this case, go to the section labeled "Numerical Solver," select the unknown and known variable, enter the value,

Time Period: 1 hr

Parameter	Value	
Mean Arrival Rate (λ):	15.00	(15/hr)
Mean Service Rate (μ):	38.30	(38.3/hr)
# of Service Positions:	1	
n (# of units):	5	

Performance Measures	Value		
Probability of Exactly n Units (Queue / System):	0.002	/	0.006
Probability that # of Units <= n (Queue / System):	0.999	/	0.996
Average Number in Queue / System:	0.252	/	0.644
Average Time in Queue / System:	0.017	/	0.043



There are: n units in queue AND

Note: In the M/M/k Queue model, the arrival rate lambda must be less than the departure rate mu times the number of service positions. Without this condition, the queue increases without bound and the system becomes unstable.