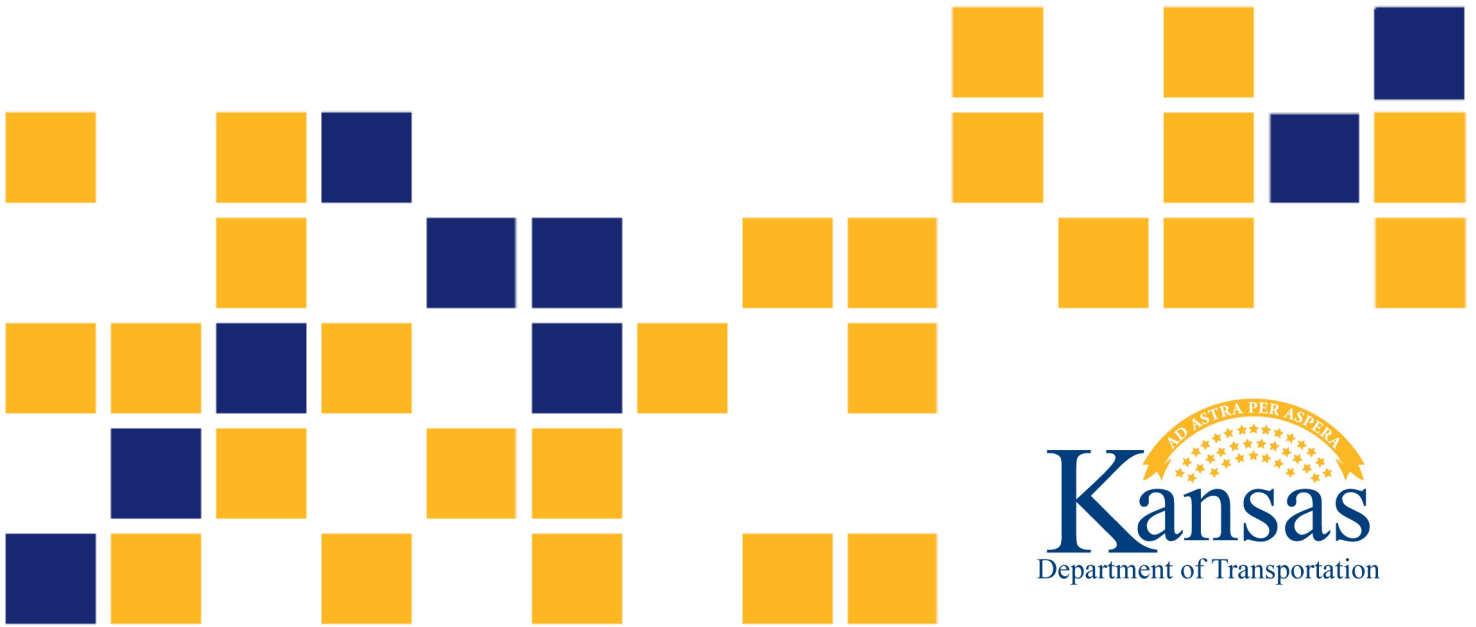


Development of the KDOT Lane Closure Guide for Wichita, Kansas Metropolitan Area

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Final Report

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PREFACE

The Kansas Department of Transportation's (KDOT) Kansas Transportation Research and New-Developments (K-TRAN) Research Program funded this research project. It is an ongoing, cooperative and comprehensive research program addressing transportation needs of the state of Kansas utilizing academic and research resources from KDOT, Kansas State University and the University of Kansas. Transportation professionals in KDOT and the universities jointly develop the projects included in the research program.

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The authors and the state of Kansas do not endorse products or manufacturers. Trade and manufacturers names appear herein solely because they are considered essential to the object of this report.

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Abstract

Each year construction events occur on interstates and highways to repair the road network. To perform these activities a work zone, or a temporary closing of a lane or shoulder, is required. However, work zones can have significant impacts on traffic flow, especially during peak travel times. To mitigate the impact of work zones, the Kansas Department of Transportation (KDOT) has developed a Lane Closure Guide to assist KDOT personnel and contractors in determining times during the day and days of the week that a lane can be closed to traffic.

Data were gathered from WICHway, the Intelligent Traffic System (ITS), for the Wichita, Kansas, region. Fifteen-minute traffic-count data were collected from WICHway for the three-and-a-half years from January 2016 through June 2019. The data were cleaned and put into two resources for contractors, a Microsoft Access Database and an ESRI Dashboard. The Access Database allows the user to identify a segment of interest from a list and see what times during the week a lane could be closed without slowing traffic flows. The ESRI Dashboard brings a spatial element to the same dataset that shows the highway links of interest on a map along with the traffic flow. These tools help contractors determine when and where lanes can be reasonably closed for construction efforts.

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Glossary of Acronyms

Acronym	Definition
AADT	Average Annual Daily Travel
ADT	Average Daily Travel
LCG	Lane Closure Guide
KDOT	Kansas Department of Transportation
FHWA	Federal Highway Administration
VPHPL	Vehicles Per Hour Per Lane

Chapter 1: Project Details

1.1 Background

The daily transportation of people, goods, and services through the Wichita, Kansas area makes the consistent maintenance of infrastructure essential. Infrastructure needs to be maintained at high levels of service to minimize traffic congestion (Federal Highway Administration, 2004). Maintenance and rehabilitation must occur on roadways for them to perform as designed. Maintenance often requires that lanes must be closed to ensure safety and efficiency of movement for both construction crews and motorists.

1.2 Research Objectives

The primary objective of this project is to update the Lane Closure Guide for the Wichita area using WICHWay data and to develop an associated online mapping application (Kansas Department of Transportation, 2016). This Lane Closure Guide provides guidance to contractors regarding when to close a lane for construction while minimizing impacts on traffic flow. The research team also added a spatial complement using the ESRI Dashboard format.

1.3 WICHway

WICHway is the Intelligent Transportation System (ITS) for the City of Wichita, Kansas. WICHway is a network of traffic sensors primarily used for incident management for events that cause non-recurring congestion, such as accidents or other anomalies. This system collects traffic-count data and can provide real-time video to the WICHway team. TranSystems (located at 245 N. Waco St. in Wichita, Kansas) is the contractor that collects and maintains the data for WICHway.

WICHway traffic sensors are located along the following Wichita area highways for the distance described in parentheses: US Interstate Highway 135 (13.5 miles), US Interstate Highway 235 (16.5 miles), Kansas Highway 96 (9.6 miles), US Highway 54 (13.4 miles), and Airport Road (1 mile). These segments and the location of the sensors are shown in Figure 1.1.



Figure 1.1: Project Sensor Locations and Routes

WICHway collects vehicle data using Wavetronix sensors. These multi-lane side-fire radar instruments project two “lines” across the roadway to create a measuring zone. Vehicles crossing this zone are counted and measured for length. Sensor data are relayed to the WICHway traffic management center in Wichita every thirty seconds. These data are then aggregated into 15-minute bins (S. Patil, personal communication, September 23, 2019).

The Wavetronix sensors are typically mounted on a pole outside of a highway clear zone or in a protected area in the roadway median. In addition to Wavetronix sensors, WICHway often installs pan/tilt/zoom (PTZ) cameras to view roadway segments monitored by the Wavetronix sensors (S. Patil, personal communication, September 23, 2019). Typically, one PTZ camera is paired with one Wavetronix sensor to complement the traffic-count data with video. Through their length detection feature, Wavetronix sensors can identify vehicle types as specified by the Federal Highway Administration’s (FHWA) classification of vehicles. Only two classes are used however

by WICHway: long vehicles (50 feet and longer) and short vehicles (less than 50 feet) (S. Patil, personal communication, April 28, 2020).

All Wichita highways covered by the existing Kansas Department of Transportation (KDOT) Lane Closure Guide were selected to be updated with the WICHway data. Using the existing KDOT Lane Closure Guide as a starting point, each highway route was divided into segments, which were defined as the distances between interchanges. Interchanges were used as the main basis for separating segments since interchanges are easily identifiable landmarks for KDOT personnel and contractors. Furthermore, interchanges reflect places where traffic flows are likely to change as vehicles enter and exit highways. This update preserved the segment schema used in the existing KDOT Lane Closure Guide. Typically, there is only one sensor per segment, but in the 10 cases in which a predefined segment has more than one sensor, the resulting data were averaged to provide a single segment value in the accompanying Access Database. (For the purposes of more nuanced visual presentation, segments with multiple sensors were subdivided in the ESRI Dashboard.) The WICHway sensors associated with existing KDOT Lane Closure Guide segments were identified in both travel directions using the sensor latitude and longitude information.

Chapter 2: Literature Review

A literature review was completed to ensure that the most relevant and recent information was used to inform this study. Literature was pulled from as many disciplines as possible with a heavy engineering focus. This literature review covers work-zone capacities, lane closure approaches in other states, and areas for advancing practice in Kansas.

2.1 Work Zone Capacity

Temporary work zones affect a traffic lane's ability to operate without congestion. The goal of this project is to update the KDOT Lane Closure Guide for the City of Wichita to minimize the effects of construction on congestion. Congestion can be caused by different events, from collisions to road maintenance. This literature review and subsequent project focus on temporary work zones. Temporary work zones are placed alongside roadway shoulders when applicable, however sometimes roadways need to be closed to provide access or safety to workers (Ravani & Wang, 2018). The decision to close a lane or only a shoulder of the roadway is the responsibility of either the contractor or the governing public agency (Abdelmohsen & El-Rayes, 2018). Road construction is primarily completed by outside contractors. States throughout the nation have looked into ways to create a guide for contractors to decide, based on traffic flows, when it is acceptable to close a lane (Iowa Department of Transportation, 2014; KDOT, 2016; Louisiana Department of Transportation & Development, 2015). The plans and tools for contractors vary in complexity from simple statements regarding capacity levels to a robust online tool as shown in Figure 2.1 (Iowa Department of Transportation, 2014; Louisiana Department of Transportation & Development, 2015).

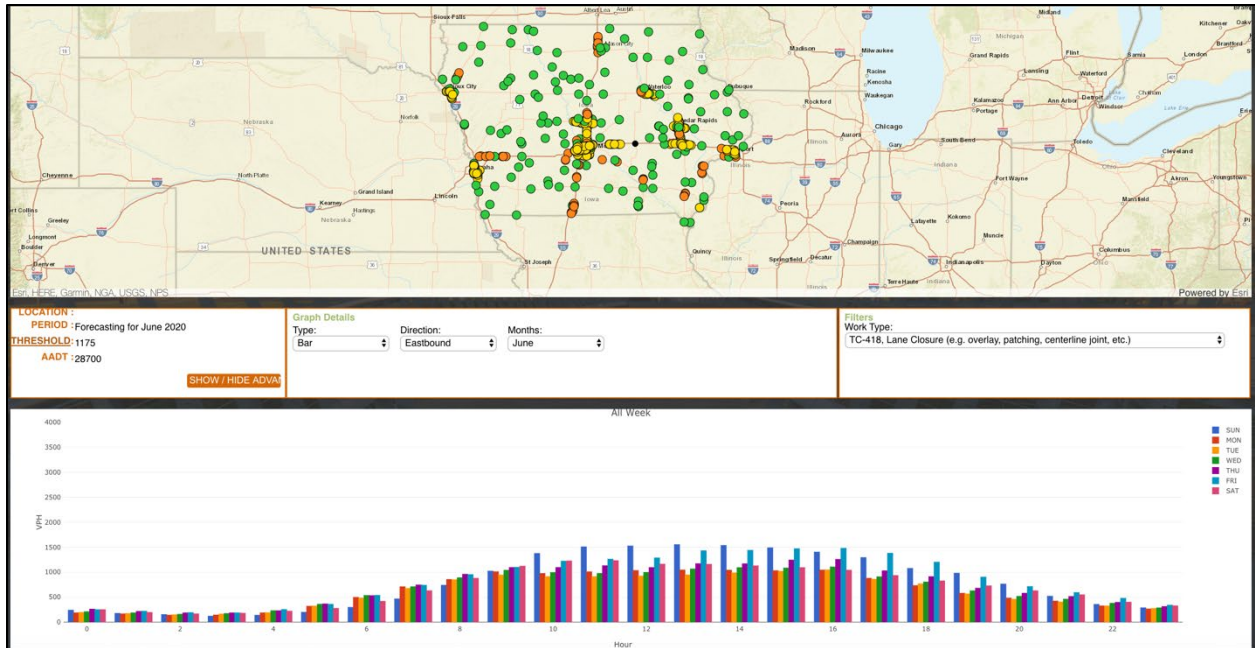


Figure 2.1: Iowa DOT Lane Closure Planning Tool

The end goal of this project is that the KDOT Lane Closure Guide be updated with suggestions for future resource development.

Using a lane closure tool to decide when it is appropriate for a contractor to close a lane is beneficial to state Departments of Transportation that want to limit congestion. Some states rely on local entities to create these resources so that the data involved in their creation are local and ideally more accurate (Illinois Department of Transportation, 2017).

A guide or a manual that is used to inform a contractor’s ability to close a lane or not are based on the lane’s capacity to move the average amount of traffic that is expected during a given time period (Louisiana Department of Transportation & Development, 2015; Nye, 2017). States have differing values and assumptions when it comes to these thresholds. The State of Louisiana, for example, uses the value of 1,309 vehicles per hour per lane (VPHPL). The threshold as used by the State of Kansas is 1,500 VPHPL (Dissanayake & Ortiz, 2015; Nye, 2017). Once a lane exceeds this threshold it is considered congested.

2.2 Work Elsewhere

The Federal Highway Administration (2019) has highlighted selected states' attempts to craft Lane Closure Guides tailored to their transportation networks and needs. The four states highlighted by the FHWA along with the State of Iowa approaches are listed below:

Table 2.1: Lane Closure Guide Formats by State

State	Who Manages	Last Update	User Format
Ohio	Local Government	2016	Dynamic Table
Colorado	State DOT	2014-2019	Technical Reports by Region
Indiana	State DOT	2010	Static Maps and Reports
Maryland	State DOT	2006	Technical Report
Iowa	State DOT	2014	Interactive Map with Tables

(DeVries et al., 2014., Indiana Department of Transportation, 2010; Iowa Department of Transportation, 2014; Maryland State Highway Administration, 2006; Ohio Department of Transportation, 2016).

Each state has recognized the need to limit congestion caused by temporary work zones (FHWA, 2019). Some states have added a dynamic graphic element, meaning that user inputs are used to create an answer which would make it easier for a contractor to use this data such as Iowa and Ohio (Iowa Department of Transportation, 2014; Ohio Department of Transportation, 2016), while other states have left their information in technical reports. Static graphics are used in several states, such as Colorado and Indiana (DeVries et al., 2014; Indiana Department of Transportation, 2010). All of the methods provide information to contractors for when they can or cannot close a lane. The State of Kansas currently uses a dynamic table method (KDOT, 2016).

Thresholds vary per state as well as the methodology used to communicate this information (DeVries et al., 2014; Indiana Department of Transportation, 2010; Iowa Department of Transportation, 2014; Louisiana Department of Transportation & Development, 2015; Maryland State Highway Administration, 2006; Ohio Department of Transportation, 2016). Figure 2.2 shows the thresholds per state.

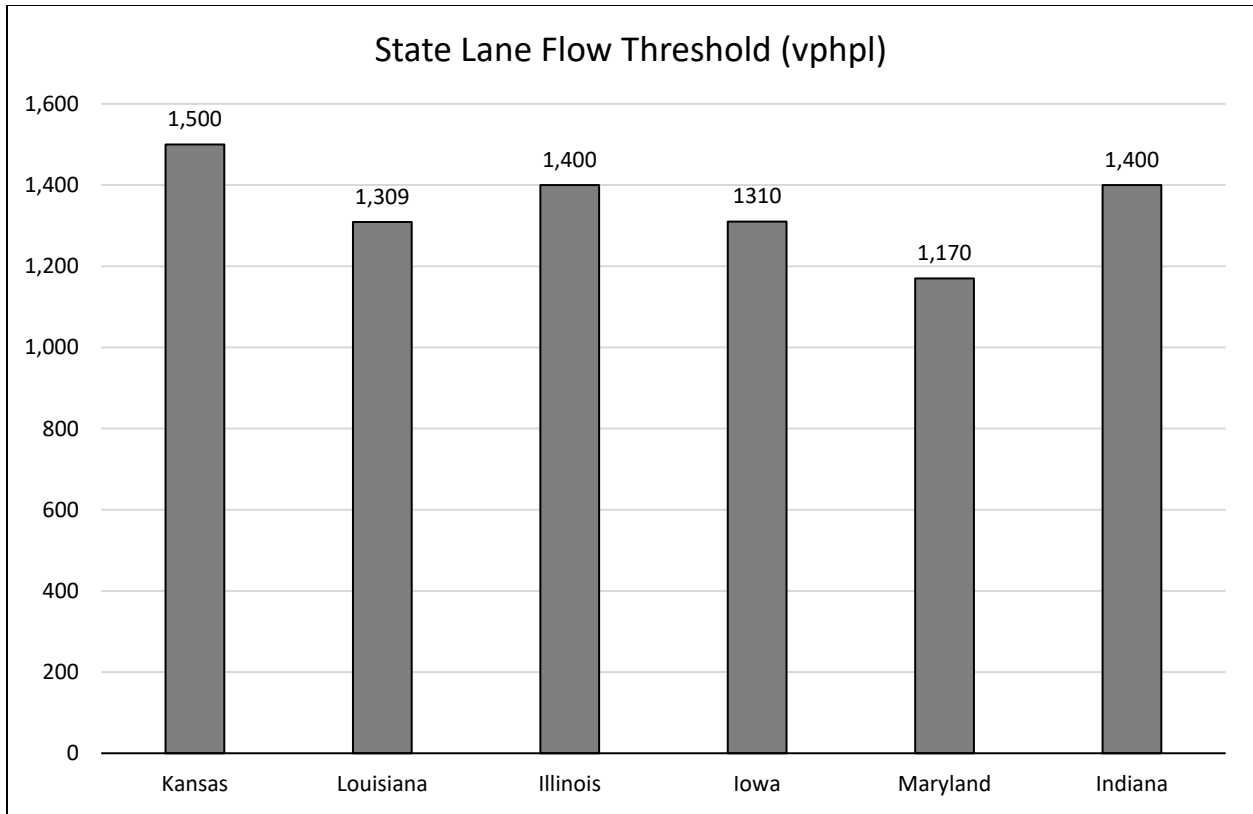


Figure 2.2: Capacity Thresholds by State

(Dissanayake & Ortiz, 2015; Illinois Department of Transportation, 2017; Indiana Department of Transportation, 2010; Iowa Department of Transportation, 2014; Louisiana Department of Transportation & Development, 2015; Maryland State Highway Administration, 2006)

States have different needs regionally and this was reflected in their methodologies. Rural areas, where funding and technology are less able to support these closure guides, are typically maintained by the state (DeVries et al., 2014). Ohio only requires certain regions create a Lane Closure Guide and this is maintained by communities that have the need and resources to do so. Areas of greater population were able to create these Lane Closure Guides while less populous places did not (Ohio Department of Transportation, 2016). Only two of the states recommended by the FHWA as a basis for creating a Lane Closure Guide had statewide systems, Iowa and Colorado, while other plans were centered around population centers (Maze & Weigand, 2007). The examples provided by the FHWA were used to inform the updates to the KDOT Lane Closure Guide.

2.3 Advancing the KDOT Lane Closure Guide

The literature reviewed suggests potential future areas for enriching the KDOT Lane Closure Guide. Currently, KDOT does quinquennial traffic studies to calculate the AADT of a road section (Kansas Department of Transportation, 2019; Nye, 2017); gathering this information more frequently than every five years might be important for responding to changes in regional traffic patterns. Aggregating traffic data over time might be a useful approach to ensure the robustness of the readings. This research project addresses these two specific concerns through the use of remotely collected traffic-sensor data.

Another area of future enrichment might be to consider the intensity of the expected construction work. Several states and foreign countries employ such a construction intensity variable (Edara et al., 2018). Kansas might expand the categories of construction from shoulder work and lane closure work to a more diverse set of options, such as is used in Iowa, which also includes contra flow routing and bridge work among others (Iowa Department of Transportation, 2014; KDOT, 2016). Incorporating such nuance may be a future direction of research but is not directly included in this Lane Closure Guide update.

Finally, as a spatial network, highways are well suited for mapping. The Iowa Department of Transportation, for example, represents its lane closure requirements using a geographic information systems (GIS) interface (Iowa Department of Transportation, 2014). This research will complement the existing KDOT Lane Closure Guide with some pilot online mapping tools.

This literature review was beneficial to the project as it gave examples for where the State of Kansas could grow their resources. It demonstrated that the organization, traffic volume thresholds, and presentation of the guides vary by state. This review structured the current projects incorporation of a large volume of recent data from traffic sensors and the pilot development of a GIS presentation of those data.

Chapter 3: Data Verification

WICHway verifies that their sensors are properly collecting data in several ways. When originally installing the machine there are several field checks that are made to check counting, speed assessment, and vehicle length identification. When installing, a manual count is conducted making sure that the sensor is reading correctly. The sensor is run during a 15-minute interval and the installer does a manual count to compare with the machine count. Then a speed check is done on five vehicles as they pass by the sensor. The installer uses a hand radar gun to confirm that the speed values from the sensor and from the hand radar gun are within 10% of each other. Then 10 large vehicles are manually counted to ensure that the sensor properly classified those large vehicles (S. Patil, personal communication, February 3, 2020).

Monthly checks are completed on the sensor data to make sure that there is not a significant unexpected drop off between time periods. The sensor data yields monthly ADT reports that are compared to those of the previous months to assess change. These are reviewed in light of known external factors, such as construction along a segment, to determine that the sensors are continuing to work properly (S. Patil, personal communication, February 3, 2020).

Chapter 4: Methodology

4.1 KDOT Lane Closure Guide

KDOT originally created the current Lane Closure Guide to assist contractors when determining if a lane on a highway can be closed for a work zone. The KDOT Lane Closure Guide is a Microsoft Access relational database that includes US Interstates, US Highways, and State Highways in and around major cities. The purpose of the KDOT Lane Closure Guide is to prevent work-related lane closures reducing capacity enough to cause congestion. Figure 4.1 shows the general form of the current KDOT Lane Closure Guide, a file that can be downloaded through the KDOT website for offline use.

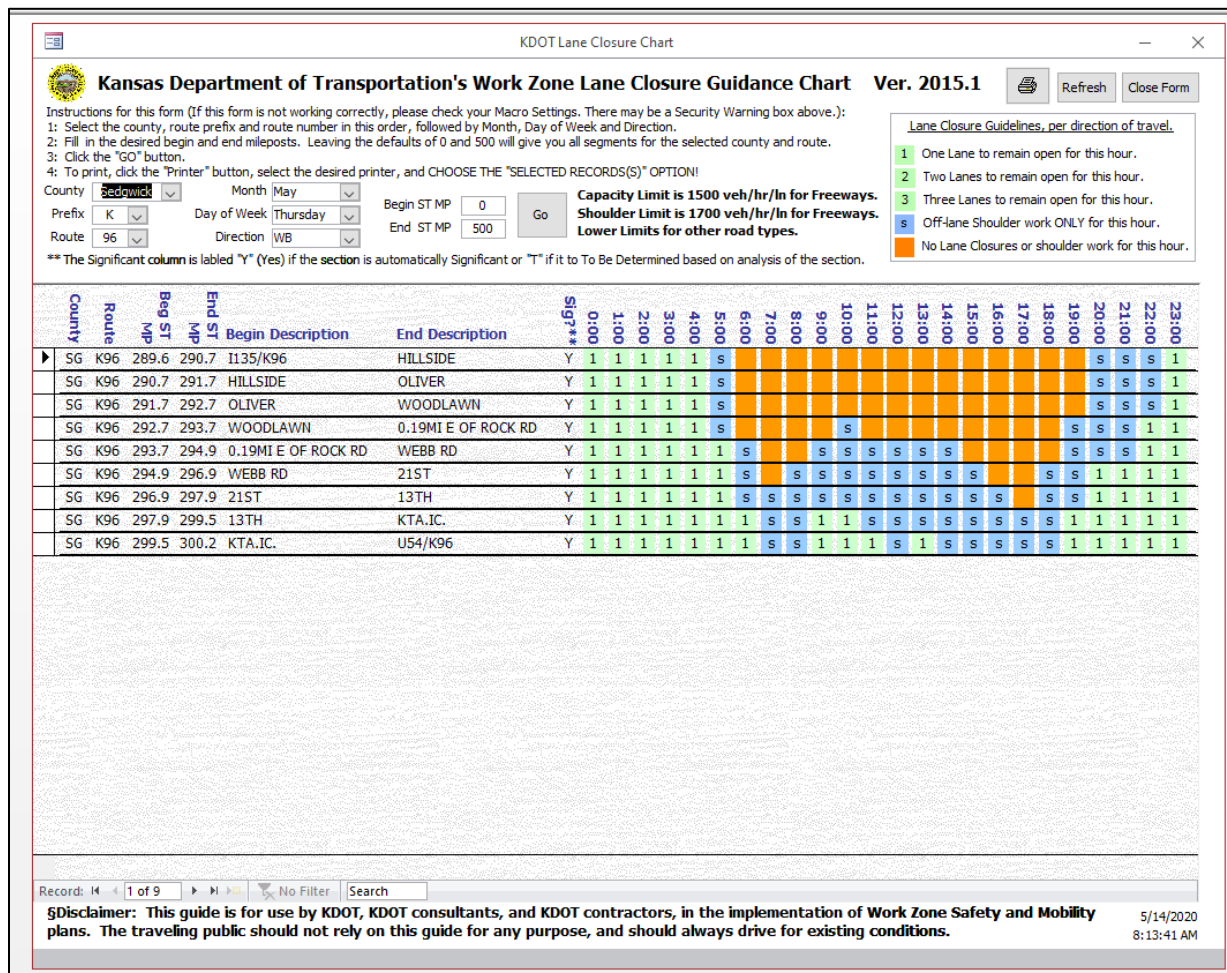


Figure 4.1: KDOT Lane Closure Guide

The upper portion of the interface includes instructions for using the guide. The upper section is where the user selects the county or counties and the roadways (including direction of travel) where construction is to occur. This section also allows for a selection of the day of the week and the specific segment of roadway.

4.2 Incorporating WICHway Data

The interface described in the previous section queries multiple tables within a relational database file using selected parameters.

Table 4.1: Tables for Kansas Lane Closure Guide

Name of Table	Contents
County	Assigns county number and abbreviation
Direction	Assigns each direction a number
DirHrFacs	Hourly directional factor and k factor for each segment
Dist_Routes	List of routes, their county, their prefix and direction
DOW	Assigns a number to each day of the week
DOWFac	Each segments day of the week factor
MonthFac	Each segments month factor
MonthLU	Assigns a number to each month
SegList	Contains the thresholds and base data of segments

This project derived tables with the same structure from the WICHway data to integrate within the existing KDOT Lane Closure Guide structure. This involved removing unnecessary data columns from the WICHway stream, renaming columns, and restructuring the traffic data. This processing was conducted in the R statistical environment using the R Studio editor. To facilitate replicating this work in the future, the R code is made available as an appendix.

The County table assigns a number to each county. For this project the entire site was within Sedgewick County. Sedgewick County is Number 87.

The Direction table assigns a value to each direction: 1 for northbound, 2 for eastbound, 3 for southbound, and 4 for westbound.

The Day of the Week table assigns a number to each day of the week. Sunday is coded as 1 and the codes proceed sequentially through Saturday, which is coded as 7.

The Month table assigns a numerical value to each month. January is coded as 1 and the codes proceed sequentially through December, which is coded as 12. Additionally, three other values are assigned in the Month table, including 13 for the average value of May through October, 14 for the average value for November through April, and 15 for a year-long average.

There is a need to designate who has jurisdiction and the design type of each road segment. The Dist_Route table creates each route used within the Lane Closure Guide and then assigns a prefix (“I” for interstate, “K” for Kansas highway, and “U” for U.S. highway) based on road type. The route is also assigned a direction and county number. All routes are within Sedgewick County for this project therefore each is coded 87 and then the appropriate direction.

The SegList table creates segments along each route and assigns key information for the querying and calculations for each segment. Information used with the query includes beginning and ending milepost, county number, and direction indicator. To determine the number of lanes required to be open a combination of the number of lanes, two-way volume, lane volume, shoulder volume, month, day, and hourly factors are used.

There was a need for defining an average day’s travel so that it can be applied to WICHway data to decide the capacity of a road section at any point. For this project, each highway segment was assigned an average annual daily traffic value (AADT). AADT is defined as the annual average daily number of vehicles traveling, in both directions, on that segment. AADT used in the KDOT Lane Closure Guide was collected from KDOT traffic studies performed every five years. KDOT uses multiple methods to collect this data when doing their five-year updates. The historic data for Wichita were obtained for 2018. The associated AADT map for Wichita is shown in Figure 4.2 and an updated map can be seen on the KDOT website as they become available.

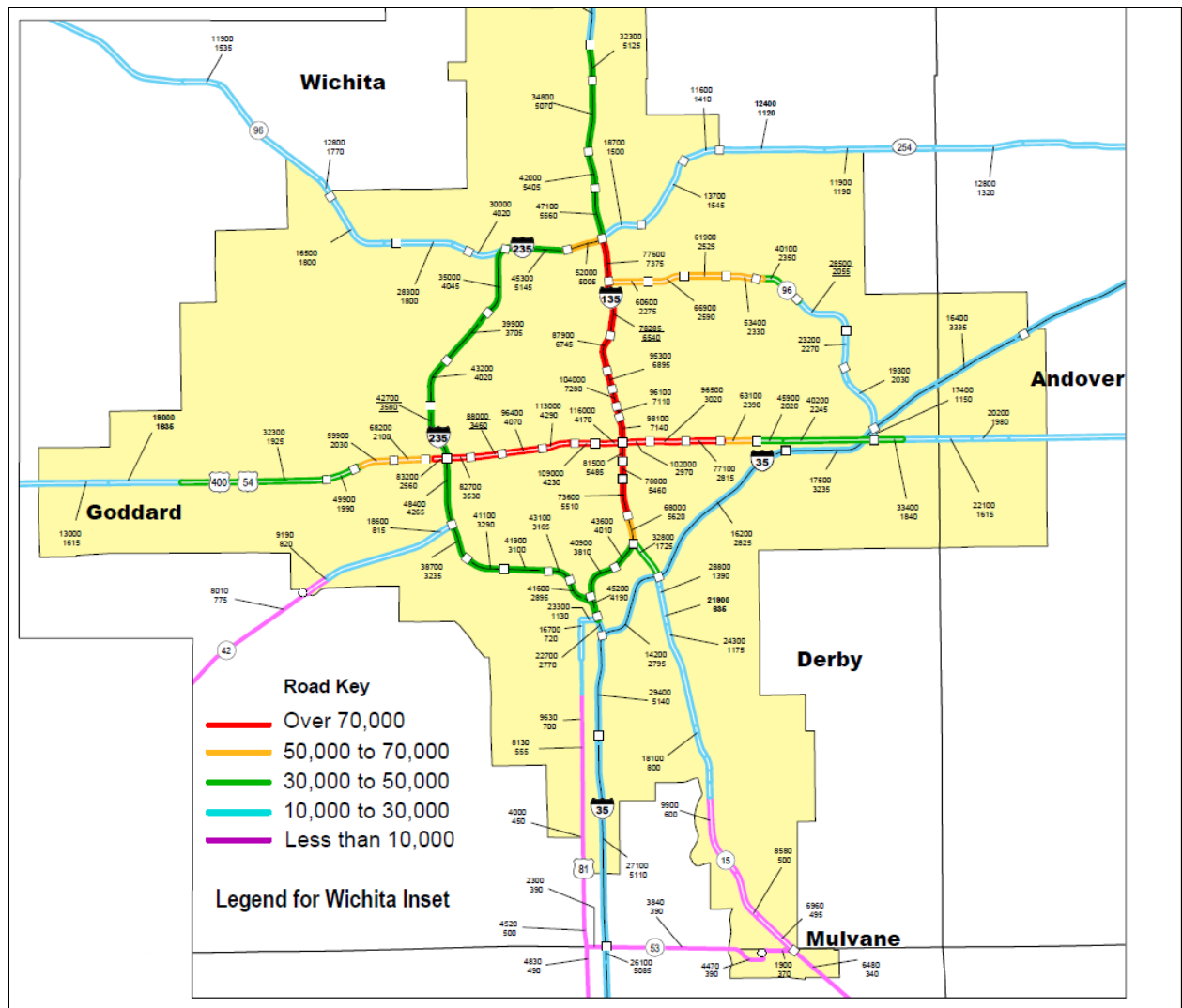


Figure 4.2: KDOT AADT Map for Wichita

Direction plays an important factor in deciding if lanes can be closed or not. To minimize congestion, it is important to not have lanes headed into the city closed during the morning hours and vice versa. The directional factor was calculated for each hour of the day. The directional factor was factored for every hour of the day. The directional factor is the percentage of travel going in a certain direction. On any given hour the travel would be aggregated and then the directional split would be calculated. Say for instance that at 6:00 a.m. the total travel is 100 vehicles. Thirty of the vehicles are traveling eastbound on the segment, therefore the eastbound directional factor would be 0.30 and the westbound would be 0.70 (Nye, 2017).

$$\frac{\text{Segments ADT in one direction}}{\text{AADT of the given segment}} = \text{Directional Factor}$$

Next a “k” factor was calculated and applied to each highway segment. The “k” factor is the percentage of the AADT during any given hour. If at 6:00 a.m. we still have the same 100 vehicles but the AADT for that segment is 120 vehicles the k factor for that segment would become 0.83 (Nye, 2017).

$$\frac{\text{ADT of that segment}}{\text{AADT of the given segment}} = k \text{ Factor}$$

The next factors calculated were the day of the week factor and the month factor. These two factors were determined by dividing the average daily traffic (ADT) by the AADT. For example, if the ADT for all Fridays was 82,000 and the AADT for that segment was 74,000, the day of week factor would be 1.11 (Nye, 2017).

$$\frac{\text{Any segment and day of the week's ADT}}{\text{AADT of the given segment}} = \text{DOWFac}$$

$$\frac{\text{Any segment and month's ADT}}{\text{AADT of the given segment}} = \text{MonFac}$$

KDOT uses two capacity values to determine the number of lanes required to be open during a temporary work zone: 1,500 vehicles per hour per lane (VPHPL) for work zones involving lane closure and 1,700 VPHPL for a work zone that only requires shoulder work. Each segment must be able to meet the capacity requirements to allow for a lane to shut down.

The number of lanes required to be open was found by taking the average vehicles per hour for the entire dataset and dividing by the lane requirement. The resulting number was rounded up due to the inability to close a portion of a lane. If this number equaled the number of lanes that were available a lane could not be closed during that period for work. (Dissanayake & Ortiz, 2015).

$$\text{Number of Lanes Required to be Open} = \frac{\text{Vehicles per Hour}}{1500 \text{ vphpl}}$$

For example, if a contractor were to propose work along a segment that had 2 lanes in each direction and selected a time that had an hourly volume of 2,700 vehicles, the Lane Closure Guide would say that work is allowed. This is because it would fall beneath the 3,000 VPH requirement of closing a lane and the 3,400 VPH of shoulder work. If the hourly volume for the segment of road were to be greater than 3,000 VPH then a lane could not be closed and if the VPH were greater than 3,400 then no work could be done during that time period (Nye, 2017).

For example, if a temporary work zone was on the shoulder of a highway segment (with two lanes in each direction and an hourly volume of 3,300 vehicles), a minimum of 1.94 lanes would be required to remain open. This would round up to 2 (Nye, 2017). The Lane Closure Guide would show that work could be done on the shoulder without causing disruption to traffic. However, if the number of vehicles on a specified highway segment were to increase beyond 3,400 VPH, no work could be done during that timeframe.

4.3 Data Extraction

This research project focused on Wichita, working only in areas in which WICHway sensors were located. The research team met with WICHway to request data from their servers. A thumb drive containing data from 2016 through June of 2019 was delivered to Kansas State University. The decision was made to include the half year 2019 data because certain segments of the highway loop had been under nearly constant construction from 2016-2018. The raw data came in the format shown in Figure 4.3.

Detector_id	Detector_name	Highway	At	Street	Direction	Lane	Date	Time	Volume	Occupancy	Speed	Long_volume
54220743	US-54 at Armour - WB - L3	USS4	at	Armour	WB	L3	2/1/2017	12:00:00 AM	20	0	54	0
54211232	US54 at Dugan-EB-L2	USS4	at	Dugan	EB	L2	2/1/2017	12:00:00 AM	116	0	60	12
54211233	US54 at Dugan-EB-L3	USS4	at	Dugan	EB	L3	2/1/2017	12:00:00 AM	260	1	56	12
135005522	I-135 at Lincoln- West-SB-L2	I-135	at	Lincoln-West	SB	L2	2/1/2017	12:00:00 AM	172	0	62	12
135005523	I-135 at Lincoln- West-SB-L3	I-135	at	Lincoln-West	SB	L3	2/1/2017	12:00:00 AM	228	1	61	24
135005521	I-135 at Lincoln- West-SB-L1	I-135	at	Lincoln-West	SB	L1	2/1/2017	12:00:00 AM	20	0	65	4
135005564	I-135 at Lincoln- West-SB (Ent/Exit)-L4	I-135	at	Lincoln-West	SB	(Ent/Exit)-L4	2/1/2017	12:00:00 AM	128	1	61	56
962918311	K-96 at Hillside - EB - L1	K-96	at	Hillside	EB	L1	2/1/2017	12:00:00 AM	16	0	64	0
962918313	K-96 at Hillside - EB - (Ent.) L3	K-96	at	Hillside	EB	(Ent.) L3	2/1/2017	12:00:00 AM	8	0	47	4
962918321	K-96 at Hillside - WB - L1	K-96	at	Hillside	WB	L1	2/1/2017	12:00:00 AM	76	0	65	0
962918322	K-96 at Hillside - WB - L2	K-96	at	Hillside	WB	L2	2/1/2017	12:00:00 AM	172	0	63	12
962926322	K-96 at Oliver - WB - L2	K-96	at	Oliver	WB	L2	2/1/2017	12:00:00 AM	184	0	61	16
962926311	K-96 at Oliver - EB - L1	K-96	at	Oliver	EB	L1	2/1/2017	12:00:00 AM	0	0	0	0
962926312	K-96 at Oliver - EB - L2	K-96	at	Oliver	EB	L2	2/1/2017	12:00:00 AM	144	0	62	12
962934313	K-96 at Chisholm Creek - EB - (Ent.) L3	K-96	at	Chisholm Creek	EB	(Ent.) L3	2/1/2017	12:00:00 AM	64	0	52	4
962934312	K-96 at Chisholm Creek - EB - L2	K-96	at	Chisholm Creek	EB	L2	2/1/2017	12:00:00 AM	112	0	64	8
962934311	K-96 at Chisholm Creek - EB - L1	K-96	at	Chisholm Creek	EB	L1	2/1/2017	12:00:00 AM	0	0	0	0
135007621	I-135 at 9th-SB-L1	I-135	at	9th	SB	L1	2/1/2017	12:00:00 AM	40	0	64	4
135007622	I-135 at 9th-SB-L2	I-135	at	9th	SB	L2	2/1/2017	12:00:00 AM	184	1	60	20
962957313	K-96 at Webb- EB -(Ext.)L3	K-96	at	Webb	WB	(Ext.)L3	2/1/2017	12:00:00 AM	0	0	0	0
962970321	K-96 at Greenwich - WB - L1	K-96	at	Greenwich	WB	L1	2/1/2017	12:00:00 AM	8	0	66	4
54220742	US-54 at Armour - WB - L2	USS4	at	Armour	WB	L2	2/1/2017	12:00:00 AM	132	0	54	20
54220732	US-54 at Armour - EB - L2	USS4	at	Armour	EB	L2	2/1/2017	12:00:00 AM	148	0	57	16
54221343	US-54 at Eastern - WB - L3	USS4	at	Eastern	WB	L3	2/1/2017	12:00:00 AM	24	0	48	0
54221342	US-54 at Eastern - WB - L2	USS4	at	Eastern	WB	L2	2/1/2017	12:00:00 AM	144	1	47	20
54221333	US-54 at Eastern - EB - L3	USS4	at	Eastern	EB	L3	2/1/2017	12:00:00 AM	80	1	44	28
135004011	I-135 at Pawnee - NB - L1	I-135	at	Pawnee	NB	L1	2/1/2017	12:00:00 AM	28	0	60	0
135004023	I-135 at Pawnee - SB - L3	I-135	at	Pawnee	SB	L3	2/1/2017	12:00:00 AM	296	2	64	80
135003211	I-135 at K-15 - NB - L1	I-135	at	K-15	NB	L1	2/1/2017	12:00:00 AM	28	0	61	12
135209742	US-54 at Tyler - WB - L2	USS4	at	Tyler	WB	L2	2/1/2017	12:00:00 AM	132	0	59	28
135208943	US-54 at Maize - WB - L3	USS4	at	Maize	WB	L3	2/1/2017	12:00:00 AM	0	0	0	0
135208941	US-54 at Maize - WB - L1	USS4	at	Maize	WB	L1	2/1/2017	12:00:00 AM	16	0	67	0
135208932	US-54 at Maize - EB - L2	USS4	at	Maize	EB	L2	2/1/2017	12:00:00 AM	88	0	58	8
54211242	US54 at Dugan-WB-L2	USS4	at	Dugan	WB	L2	2/1/2017	12:00:00 AM	172	1	58	32
135209731	US-54 at Tyler - EB - L1	USS4	at	Tyler	EB	L1	2/1/2017	12:00:00 AM	16	0	59	0
135209732	US-54 at Tyler - EB - L2	USS4	at	Tyler	EB	L2	2/1/2017	12:00:00 AM	72	0	60	12
135209733	US-54 at Tyler - EB - L3	USS4	at	Tyler	EB	L3	2/1/2017	12:00:00 AM	80	0	59	12
135208942	US-54 at Maize - WB - L2	USS4	at	Maize	WB	L2	2/1/2017	12:00:00 AM	132	1	60	28

Figure 4.3: Raw data from WichWay

Data sets came in different formats; therefore, each year of data had to be cleaned and altered to match the others for the analysis. The process of cleaning this data included migrating the Device_id field to the 2017 data using detector ids as the joining field. Other data cleaning processes included converting the time field to an hourly 24-hour format (shown in Section A.3), parsing out direction for the 2019 data (shown in Section A.4), and adding day and month numbers (shown in Section A.3). An example of the cleaned dataset that was used is shown in Figure 4.4.

	Time	Device_id	Flow	DOWNum	MonNum
1	0	505421123	782.25	6	1
2	0	505421123	810.00	6	1
3	0	505421183	567.00	6	1
4	0	505421183	847.75	6	1
5	0	505421233	566.25	6	1
6	0	505421233	756.00	6	1
7	0	505421273	725.00	6	1
8	0	505421273	889.00	6	1
9	0	505421323	746.00	6	1
10	0	505421323	986.00	6	1
11	0	505421363	834.00	6	1
12	0	505421363	1014.00	6	1
13	0	505421423	902.00	6	1
14	0	505421423	1126.00	6	1
15	0	505421483	815.00	6	1
16	0	505421483	1015.00	6	1
17	0	505421523	969.00	6	1
18	0	505421523	1249.00	6	1
19	0	505421583	1028.50	6	1
20	0	505421593	868.00	6	1
21	0	505421643	1111.00	6	1
22	0	505421643	1163.00	6	1
23	0	505421683	849.00	6	1
24	0	505421683	783.00	6	1
25	0	505421743	707.00	6	1
26	0	505421743	1042.00	6	1
27	0	505421783	1186.00	6	1
28	0	505421783	659.00	6	1
29	0	505421863	1162.00	6	1
30	0	505421863	1051.00	6	1
31	0	505421923	963.00	6	1
32	0	505421923	862.00	6	1

Figure 4.4: Cleaned Data Snippet

Data at WICHway sensor locations are verified by TranSystems and WICHway before they were sent to the research team. This verification involves comparing monthly temporal trends to determine if traffic volumes for a specific hour differed widely. After WICHway reviewed the data from all sensors included in this research project, no anomalies were detected from the selected sensors.

For the scope of this project, the research team used aggregated data per hour to match the existing Lane Closure Guide, which simplified the analysis substantially. The aggregation provided an average for each hour over the entire year for each WICHway sensor. The data shown in Figure 4.5 and Figure 4.6 are for US-54 and I-235 in Wichita.

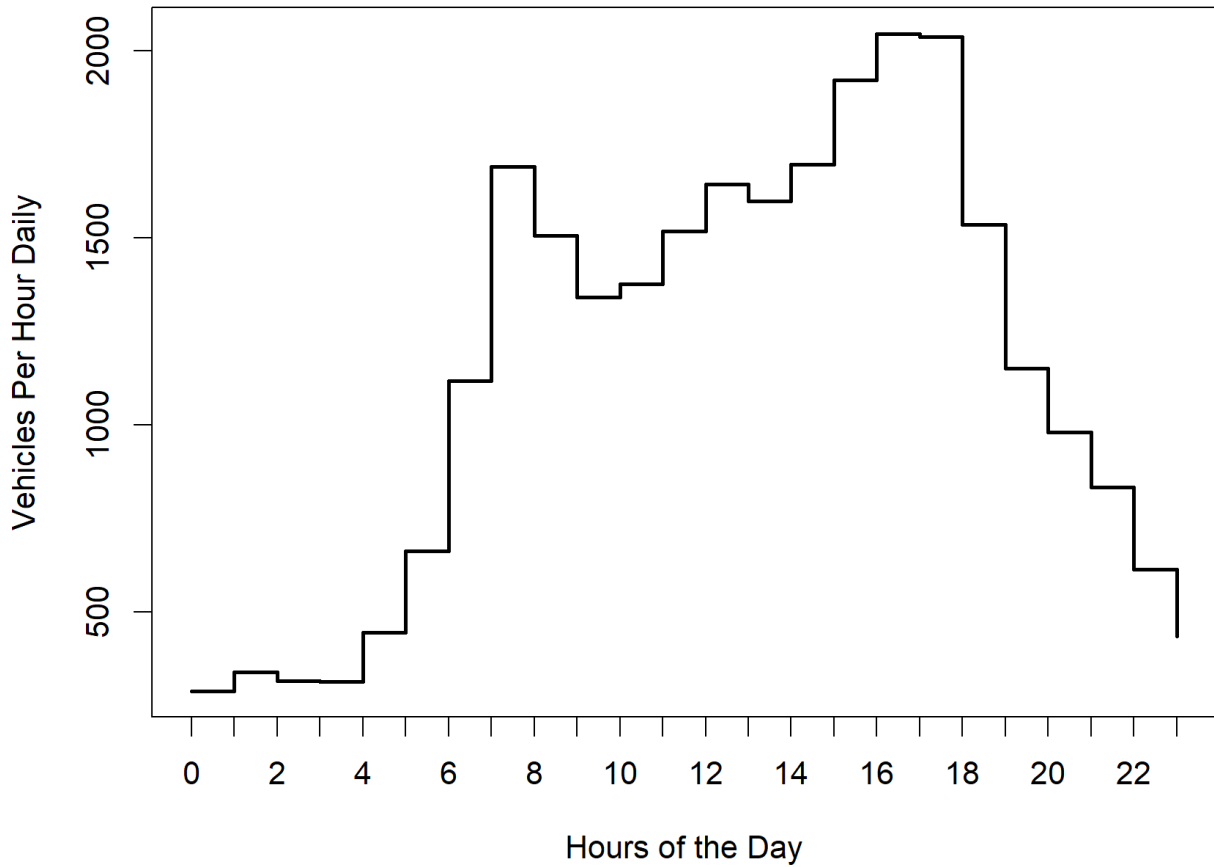


Figure 4.5: Average Hourly Travel for US-54

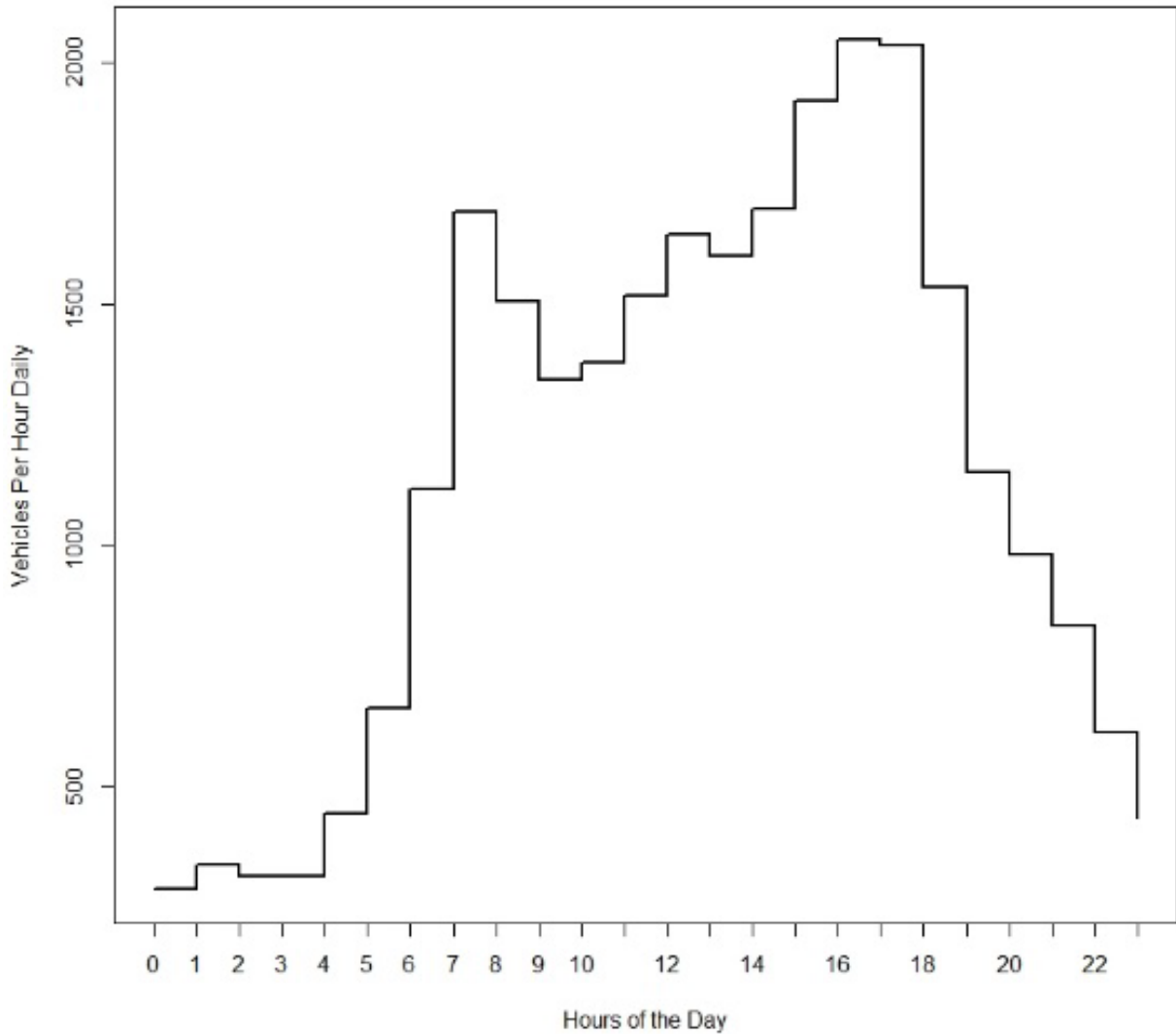


Figure 4.6: Average Hourly Travel I-235

In order to update the existing KDOT Lane Closure Guide, two pieces of information were needed for every segment at each hour of the day: a “k” factor and a directional factor. The “k” factor is the percentage of total highway volume for one hour in both directions (Nye, 2017). The “k” factor was used in the calculations to determine hourly flow from the total volume of the roadway.

The directional hour factor is the percentage of volume in one direction for one hour (Nye, 2017). The directional hour factor was used to determine the hourly split of traffic for a specific hour. This was necessary because the data was initially all aggregated. The directional hour factor

is significant to the Lane Closure Guide because the difference in hourly volumes may change when and what type of work is allowed.

4.4 Lane Closure Guide Updates

Four tables within the Access database were updated: DirHrFacs, DOWFac, MonFac, and SegList. The first table, DirHrFacs, contained the segment name, day of week, direction, directional hour factor, and “k” factor (KDOT, 2016). The naming convention for each segment matched the existing KDOT Lane Closure Guide. WICHway sensors were attributed to the roadway segment that they fell within.

The day of the week convention followed the existing Lane Closure Guide’s convention in which Sunday was labeled as 1 and Saturday was labeled as 7 (KDOT, 2016). A directional hour factor and “k” factor were updated for each day of the week.

The SegList table was also updated. The AADT was updated in this table while all other information remained the same due to no changes in this data. This project only updated road segments covered by the WICHway network.

Chapter 5: GIS Dashboard

To further this research project a pilot online Environmental System Research Institute (ESRI) Geographic Information System (GIS) Dashboard was created. This model used the WICHway sensor data to provide a visual aid to contractors when selecting segments to shut down. The dashboard was based on the Iowa Department of Transportation Lane Closure Planning Tool. The dashboard is designed so that contractors can select the highway, the location of the section based on milepost, the day of the week, and the hours of operation. Figure 5.1 below demonstrates this functionality.

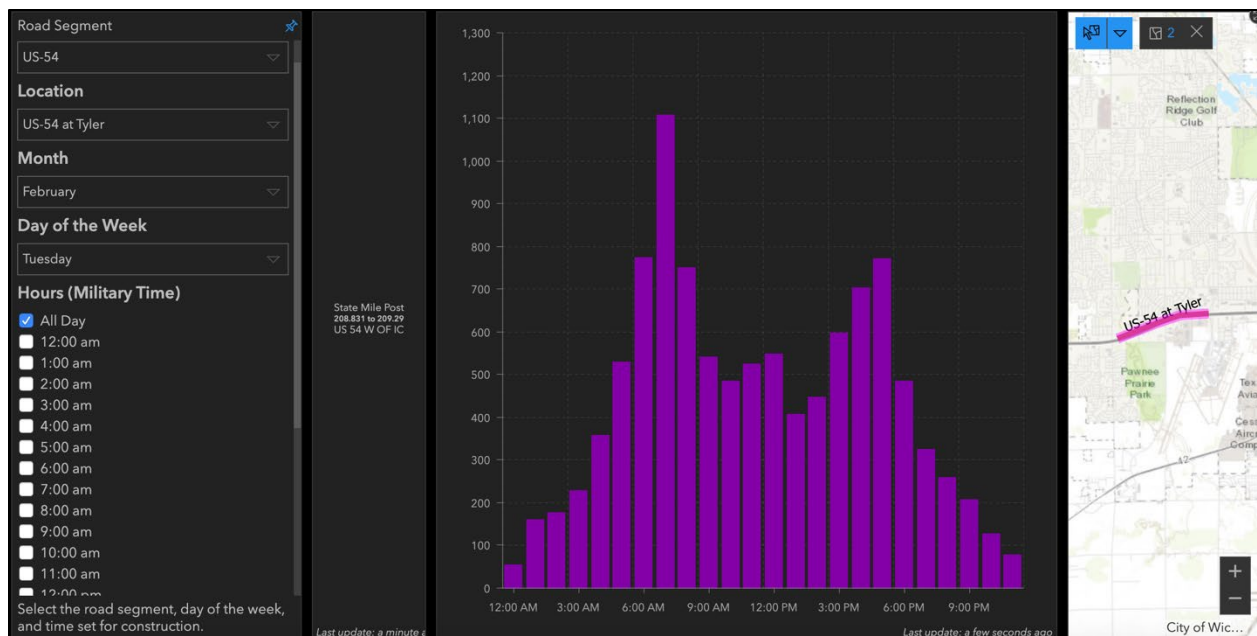


Figure 5.1: Image of ESRI Dashboard Created

This tool was created using the preset formats of the ESRI Dashboard. The format of these dashboards allows for the selection of keys that link to the charts and map to filter the correct pieces so that the desired road segment is highlighted. A sliding panel allows the user to select the highway, segment location, month, day of the week, and hours of construction.

The resulting dashboards use the dataset received from WICHway to create maps and charts to provide contractors with the information they need to plan lane closures. This format could complement the Access Database for contractors to provide an integrated map option.

Clicking on a road segment or segments for the lane closure on the map or the drop down will sort the chart in the middle. Once the locational selections are made the user can select date and time factors from the slide panel. The chart in the middle will react to these changes in choice. Thresholds for each roadway are found on the chart once the vehicle count bars exceed the thresholds for the selected segment that road would be congested.

The pilot Dashboard is presented as a potential complement to the existing Access Database to provide spatial context and a different interface for accessing traffic flow information. The information on the Dashboard is sufficient to give contractors a rough idea on the impacts of closing a lane. They should still rely on the Access Database for a more detailed answer on traffic flows.

The Dashboard provides mile post and route name information so that there is a link between the two formats and can easily be linked. The datasets that were required to create the online Dashboard and the necessary linking information are shown below in Table 5.1.

Table 5.1: Access Datasets and Linking Information used to Create Online Dashboard

Key Datasets	Key Data	Linking Data
Routes	Major Route Names	Route Name
Location	Individual Segment Names	Segment Name
Month	Segment Name and Month	Segment Name
Day of the Week	Segment Names and Day of the week data	Segment Name
Hours	Hourly Vehicles Aggregation	Segment Name and Hours
WICHway Dataset	Key Data	Key Dataset Link
Hourly Segment	Hourly Vehicle Flows	Segment Name, Hours
Thresholds	Lane Capacity	Segment Name

ESRI is constantly updating their dashboard software to add new features. As continual updates are made to the dashboard new opportunities to make the Lane Closure Guide more robust will present themselves. A static dashboard is helpful in planning project. Minimal maintenance will keep the dashboard up to date and useful for years to come.

Chapter 6: Conclusions

Minimizing traffic congestion and delays in densely populated areas is crucial to the functionality of highway networks. One way to reduce congestion and traffic delays is to implement scheduling of work zones. Work zones that occur during peak traffic times reduce highway capacity and cause unnecessary congestion. KDOT created the Lane Closure Guide to minimize the impact of work zones on traffic.

The Lane Closure Guide provides a schedule for contractors and KDOT employees to use to determine when it is appropriate to close lanes for construction work. The Lane Closure Guide uses 1,500 VPHPL as the lane capacity during work zone activities (Nye, 2017).

Once information about capacity was found, the Lane Closure Guide was updated with the most current information available from WICHway, a network of sensors and cameras that collect traffic data in the Wichita area.

This study updated two major tables in the Lane Closure Guide: directional hour factors and segment list. Compared to the previous Lane Closure Guide, the updated Lane Closure Guide provides increased accuracy of traffic patterns. The Lane Closure Guide was not updated for roads outside the WICHway network, including areas in Kansas City, Topeka, Manhattan, and Lawrence, Kansas.

6.1 Contributions to Highway Safety and Operations

The research completed in this research project will contribute to highway safety and operations. One contribution is to KDOT design engineering and contractors working on interstates and highways in the Wichita, KS, area. The updated Lane Closure Guide separates the travel direction and provides a more accurate picture of the expected traffic flows during the week. This allows contractors to see when appropriate capacity is needed during possible construction times.

6.2 Areas for Construction

After running these tools, there are roadway segments in the Wichita urban area that indicate no lane closures can be accomplished without inducing congestion. This would be along US-54. This road is a major highway that cuts across the city of Wichita and according to the data provided is always near full capacity. Conversely, K-96 is quite able to take on construction activities outside of peak commute hours. This information helps in determining the degree of mobility impacts any construction activity will have throughout the Wichita urban area and highlights segments that may need additional countermeasures enacted/applied while working toward a safer and better transportation system.

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Appendix A: R Code

A.1 k Factor

This section of code brought in the necessary cleaned datasets and then used the WICHway traffic data to calculate the k factor that was used in updating the Access database. The k factor is used in the formulas that drive the Access database. These were updated using the WICHway data.

```
#####K Factor Creation#####
library(tidyverse)
library(data.table)
setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Read in Cleaned
Versions#####
d<-read.csv("Twenty16.csv")#####2016 Data after cleaning#####

s2017<-read.csv("F2017.csv")#####2017 Data after Cleaning#####
s2017<-data.table(s2017)#####Convert to data table for speed and ease of use#####

d<-data.table(d)#####Convert to data table for speed and ease of use#####

d<-d[,-c("Date")]#####Getting rid of unnecessary columns#####
s2017<-s2017[,-c("X")]#####Getting rid of unnecessary columns#####

d3 <- rbind(d, s2017, use.names = TRUE,fill=TRUE)#####Combining Datasets#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Tables_Cleaned")##set the working
drive###
r<-read.csv("2018.csv")#####2018 data after cleaning
r<-data.table(r)#####Converting to data table#####
r<-r[,-c("X","Volume","Long_volume")]#####Getting rid of unnecessary Columns#####

r1<-r[,
  .(Flow=sum(Vol4)),
  by=(Date,Time,Direction,Device_id)]##Aggregating and Summarizing data by meaningful factors##

r1$DOWNum<-wday(as.Date(r1$Date,'%m/%d/%Y'))##Adding a Day of the Week as a Number##
r1$MonNum<-month(as.Date(r1$Date,'%m/%d/%Y'))#####Adding a Month number#####
r1<-r1[,-c("Date")]#####Getting rid of unnecessary columns
d4<-rbind(d3,r1, use.names= TRUE)#####Combining 2016-2017-2018#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")##Setting the Working
Drive##

s<-read.csv("Twenty19.csv")#####2019 DATA#####

s$Time<-gsub(":.:",",",s$Time)#####Aggregating Data by Hour#####

s<-data.table(s)#####Converting to a data table

s<-s[,-c("X")]#####Getting rid of Unnecessary Columns
```

```

s$DOWNum<-wday(as.Date(s$date, '%m/%d/%Y'))##Adding a Day of the Week as a Number##
s$MonNum<-month(as.Date(s$date, '%m/%d/%Y'))#####Adding a month Number
s<-s[,-c("Date")]#####Getting rid of Unnecessary Columns
Twenty16_19<-rbind(d4,s,use.names=TRUE)#####Combing all Data Together#####
setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Tables_Cleaned")#####Setting the
Work Drive#####
AADT<-read.csv(("AADT.csv"))#####Bringing in KDOT AADT values for the City of Wichita
t<-data.table(AADT)#####Converting to data table
t<-t[,
.(AADT=sum(AADT)),
by=(Device_id)]#####Aggregating by Device ID#####
Fin<-merge(Twenty16_19,AADT, by = "Device_id", all.y = TRUE)#####Combing the AADT data and the
WichWay data#####
setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Reading in the
Segment List data from original Access form#####
SegList<-read.csv("SegList_Access.csv")#####Read in the Data#####
y<-data.table(SegList)#####Convert to data table#####
y<-y[,-c("LRS_KEY","ROUTE_NUMBER","LOCATION_DESCRIPTION","MonthFacSrc","DirHrFacSrc")]##Getting rid of
unnecessary columns
leg<-merge(SegList,AADT, by="Device_id",all.y = TRUE)##Creating a "legend" of AADT & Segments
write.csv(leg, "C:\\Users\\scottha\\OneDrive - Kansas State
University\\WichWay\\Data_3_2\\Legend.csv")##Writing to CSV to clear up an issue with NAs#####
legend<-read.csv("Legend_Fixed.csv")#####Reading it back in after correction#####Would Not
read segment WICATRS in to the correct Device Id so I fixed it manually after confirming it was correct segments to
device ids#####
legend<-data.table(legend)#####Convert to data table#####
legend<-legend[,
c("LRS_KEY","ROUTE_NUMBER","LOCATION_DESCRIPTION","MonthFacSrc","DirHrFacSrc","X","LATITUDE","LONGI
TUDE","Location","MilePost")]#####Getting rid of Unneccessary columns
FD<-merge(Fin,legend, by="Device_id", all.y = TRUE, allow.cartesian = TRUE)#####Merging everything
together
FD<-FD[,
c("LATITUDE","LONGITUDE","Location","MilePost","OBJECTID.x","RouteName.x","AADT.x","Heavy_AADT.x","OBJE

```

```

CTID.y","RouteName.y","Heavy_AADT.y"]#####Getting rid of Unnecessary columns

FD<-data.table(FD)

Fk<-FD[,
  .(Sum_Flow=mean(Flow)),
  by=(DOWNum,DOWFacSrc,Time)]#####Aggregating by Day of the week and hour#####

Fk<-merge(Fk,legend,by="DOWFacSrc", all.y = TRUE, allow.cartesian = TRUE)##Merging everything together)

Fk$kFac<-Fk$Sum_Flow/Fk$AADT

Fk1<-Fk[,
  .(kFactor=sum(kFac)),
  by=(DOWNum,DOWFacSrc,Time)]##Aggregating by Day of the week and the hour#####

write.csv(Fk1, "C:\\Users\\scottha\\OneDrive - Kansas State
University\\WichWay\\Data_3_2\\Outputs\\k_Factor.csv", row.names = TRUE) ###WRITING DATA OUT TO SEE IF
VALUES SEEM REASONABLE####

##Data read out was transposed in EXCEL for researcher Ease and then imported to the Access table to Update the
LCG##

```

A.2 Directional Factor

This code was used to calculate the directional split of travel along segments. This was used in the Access database. This code calculated the percentage of travel in each direction for each segment.

```
#####Directional Work#####
library(tidyverse)

library(data.table)

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Read in Cleaned
Versions#####

d<-read.csv("Twenty16.csv")#####2016 Data after cleaning#####

s2017<-read.csv("F2017.csv")#####2017 Data after Cleaning#####

s2017<-data.table(s2017)#####Convert to data table for speed and ease of use#####

d<-data.table(d)#####Convert to data table for speed and ease of use#####

d<-d[,-c("Date")]#####Getting rid of unnecessary columns#####

s2017<-s2017[,-c("X")]#####Getting rid of unnecessary columns#####

d3 <- rbind(d, s2017, use.names = TRUE,fill=TRUE)#####Combining Datasets#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Tables_Cleaned")##set the working
drive##
r<-read.csv("2018.csv")#####2018 data after cleaning

r<-data.table(r)#####Converting to data table#####

r<-r[,-c("X","Volume","Long_volume")]#####Getting rid of unnecessary Columns#####

r1<-r[,
  .(Flow=sum(Vol4)),
  by=(Date,Time,Direction,Device_id)#####Aggregating and Summarizing data by meaningful
factors#####

r1$DOWNum<-wday(as.Date(r1$Date,'%m/%d/%Y'))#####Adding a Day of the Week as a
Number#####

r1$MonNum<-month(as.Date(r1$Date, '%m/%d/%Y'))#####Adding a Month number#####
r1<-r1[,-c("Date")]#####Getting rid of unnecessary columns

d4<-rbind(d3,r1, use.names= TRUE)#####Combining 2016-2017-2018#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Setting the
Working Drive back to cleaned version#####

s<-read.csv("Twenty19.csv")#####2019 DATA#####
```



```

s$Time<-gsub(":.*", "", s$Time)#####Aggregating Data by Hour#####
s<-data.table(s)#####Converting to a data table###
s<-s[, -c("X")]#####Getting rid of Unnecessary Columns###
s$DOWNum<-wday(as.Date(s$Date, '%m/%d/%Y'))##Adding a Day of the Week as a Number#####
s$MonNum<-month(as.Date(s$Date, '%m/%d/%Y'))##Adding a month Number###
s<-s[, -c("Date")]#####Getting rid of Unnecessary Columns###
Twenty16_19<-rbind(d4,s,use.names=TRUE)#####Combing all Data Together#####
setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Tables_Cleaned")#####Setting the
Work Drive#####
AADT<-read.csv(("AADT.csv"))####Bringing in KDOT AADT values for the City of Wichita###
t<-data.table(AADT)#####Converting to data table###
t<-t[,
.(AADT=mean(AADT)),
by=(Device_id)#####Aggregating by Device ID#####
Fin<-merge(Twenty16_19,AADT, by = "Device_id", all.y = TRUE)##Combing the AADT data and the WichWay
data##
setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Reading in the
Segment List data from original Access form#####
SegList<-read.csv("SegList_Access.csv")#####Read in the Data#####
y<-data.table(SegList)#####Convert to data table#####
y<-y[, -c("LRS_KEY", "ROUTE_NUMBER", "LOCATION_DESCRIPTION", "MonthFacSrc", "DirHrFacSrc")]#####Getting
rid of unnecessary columns
leg<-merge(SegList,AADT, by="Device_id",all.y = TRUE)#####Creating a "legend" of AADT & Segments
write.csv(leg, "C:\\Users\\scottha\\OneDrive - Kansas State
University\\WichWay\\Data_3_2\\Legend.csv")#####Writing to CSV to clear up an issue with NAs#####
legend<-read.csv("Legend_Fixed.csv")#####Reading it back in after correction#####Would Not
read segment WICATRS in to the correct Device Id so I fixed it manually after confirming it was correct segments to
device ids#####
legend<-data.table(legend)#####Convert to data table#####
legend<-legend[, -
c("LRS_KEY", "ROUTE_NUMBER", "LOCATION_DESCRIPTION", "MonthFacSrc", "DirHrFacSrc", "X", "LATITUDE", "LONGI
TUDE", "Location", "MilePost")]#####Getting rid of Unnecessary columns

```

```

FD<-merge(Fin,legend, by="Device_id", all.y = TRUE, allow.cartesian = TRUE)##Merging everything together

rm(y,Twenty16_19,SegList,t,s2017,s,r1,r,Fin,AADT,d,d3,d4,Final,leg,legend)###removing unnecessary data sets to
increase the speed###

FD<-FD[,
c("LATITUDE","LONGITUDE","Location","MilePost","OBJECTID.x","RouteName.x","AADT.x","Heavy_AADT.x","OBJE
CTID.y","RouteName.y","Heavy_AADT.y")]#####Getting rid of Unnecessary columns

FD<-data.table(FD)

FDir<-FD[,
.(Dir=sum(Flow)),
by=(DOWNum,DOWFacSrc,Direction,Time)]#####Aggregating by Direction#####

FHour<-FD[,
.(Hour=sum(Flow)),
by=(DOWNum,DOWFacSrc,Time)]#####Getting the Hourly Data to Divide against#####

FDir$Joinid<-paste(FDir$DOWFacSrc,FDir$Time,FDir$DOWNum,sep = "")#####Creating a unique
ID#####

FHour$Joinid<-paste(FHour$DOWFacSrc,FHour$Time,FHour$DOWNum,sep = "")#####creating a unique ID

Direc<-merge(FDir,FHour, by = "Joinid",allow.cartesian = TRUE)#####MERGING Datasets

Direc$DirFac<-Direc$Dir/Direc$Hour#####Calculating the Directional Factor#####

Fin_Dir<-Direc[,c("Joinid","Time.y","DOWFacSrc.y")]#####Getting rid of Unnecessary columns

write.csv(Fin_Dir, "C:\\Users\\scottha\\OneDrive - Kansas State
University\\WichWay\\Data_3_2\\Outputs\\Directional_Factor.csv", row.names = TRUE) #####WRITING
DATA OUT TO SEE IF VALUES SEEM REASONABLE#####

#####Data read out was transposed in EXCEL for researcher Ease and then imported to the
Access table to Update the LCG#####

```

A.3 Day of the Week and Month Factor

This code was used to calculate the daily and monthly factors that were used to update the Access file. This code used the AADT of the segment and compared to the observed data. This factor allows contractors to plan their construction zones based on temporal data.

```
library(tidyverse)

library(data.table)

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Read in Cleaned
Versions#####

d<-read.csv("Twenty16.csv")#####2016 Data after cleaning#####

s2017<-read.csv("F2017.csv")#####2017 Data after Cleaning#####

s2017<-data.table(s2017)#####Convert to data table for speed and ease of use#####

d<-data.table(d)#####Convert to data table for speed and ease of use#####

d<-d[,-c("Date","Direction")]#####Getting rid of unnecessary columns#####

s2017<-s2017[,-c("X")]#####Getting rid of unnecessary columns#####

d3 <- rbind(d, s2017, use.names = TRUE,fill=TRUE)#####Combining Datasets#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Tables_Cleaned")#####set the
working drive#####

r<-read.csv("2018.csv")#####2018 data after cleaning

r<-data.table(r)#####Converting to data table#####

r<-r[,-c("X","Volume","Long_volume")]#####Getting rid of unnecessary Columns#####

r1<-r[,
  .(Flow=sum(Vol4)),
  by=(Date,Time,Direction,Device_id)]##Aggregating and Summarizing data by factors##

r1$DOWNum<-wday(as.Date(r1$Date,'%m/%d/%Y'))##Adding a Day of the Week as a Number##

r1$MonNum<-month(as.Date(r1$Date,'%m/%d/%Y'))##Adding a Month number#

r1<-r1[,-c("Date","Direction")]#####Getting rid of unnecessary columns

d4<-rbind(d3,r1, use.names= TRUE)#####Combining 2016-2017-2018#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Setting the
Working Drive back to cleaned version#####

s<-read.csv("Twenty19.csv")#####2019 DATA#####
```

```

s$Time<-gsub(":.*", "", s$Time)#####Aggregating Data by Hour#####

s<-data.table(s)#####Converting to a data table

s<-s[, -c("X")]#####Getting rid of Unnecessary Columns

s$DOWNum<-wday(as.Date(s$Date, '%m/%d/%Y'))####Adding a Day of the Week as a Number#

s$MonNum<-month(as.Date(s$Date, '%m/%d/%Y'))##Adding a month Number

s<-s[, -c("Date", "Direction")]#####Getting rid of Unnecessary Columns

Twenty16_19<-rbind(d4,s,use.names=TRUE)##Combing all Data Together#####

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Tables_Cleaned")#####Setting the
Work Drive#####

AADT<-read.csv(("AADT.csv"))#####Bringing in KDOT AADT values for the City of Wichita

t<-data.table(AADT)#####Converting to data table

t<-t[,
  .(AADT=mean(AADT)),
  by=(Device_id)]#####Aggregating by Device ID#####

Fin<-merge(Twenty16_19,AADT, by = "Device_id", all.y = TRUE)##Combing the AADT data and the WichWay
data##

setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\Data_3_2")#####Reading in the
Segment List data from original Access form#####

SegList<-read.csv("SegList_Access.csv")#####Read in the Data#####

y<-data.table(SegList)#####Convert to data table#####

y<-y[, -c("LRS_KEY", "ROUTE_NUMBER", "LOCATION_DESCRIPTION", "MonthFacSrc", "DirHrFacSrc")]#####Getting
rid of unnecessary columns

leg<-merge(SegList,AADT, by="Device_id",all.y = TRUE)#####Creating a "legend" of AADT & Segments

legend<-read.csv("Legend_Fixed.csv")#####Reading it back in after correction#####

legend<-data.table(legend)#####Convert to data table#####

legend<-legend[, -
c("LRS_KEY", "ROUTE_NUMBER", "LOCATION_DESCRIPTION", "MonthFacSrc", "DirHrFacSrc", "X", "LATITUDE", "LONGI
TUDE", "Location", "MilePost")]#####Getting rid of Unnecessary columns

Final<-merge(Fin,legend, by="Device_id", all.y = TRUE, allow.cartesian = TRUE)#####Merging everything
together

rm(y, Twenty16_19, SegList, t, s2017, s, r1, r, Fin, dataset, temp_data, AADT, d, d1, d2, d2017, d3, d4)#####removing
unnecessary data sets to increase the speed#####

```

```

n<-Final[,
  .(Dly=sum(Flow)/1344),#####AGGREGATING DATA BY DAY OF THE WEEK AND THE SEGMENT
NAMING CONVENTION#####
  by=.(DOWNum,DOWFacSrc)#####NUMBER OF SEGMENTS TIMES 24 EQUALS THE 1344 TO FIND
THE DAILY VALUE#####

leg1<-data.table(legend)#####CONVERTING TO DATA TABLE#####

leg1<-leg1[,
  .(AADT1=mean(AADT)),
  by=.(DOWFacSrc)#####AGGREGATING AADT BY THE SEGMENT
NAME#####

DOWfac<-merge(n,leg1, by="DOWFacSrc",allow.cartesian=TRUE,all.y = TRUE)#####MERGING THE
AGGREGATED DATA

DF<-data.table(DOWfac)#####CONVERTING TO DATATABLE#####

DF<-DF[,
c("LRS_KEY","ROUTE_NUMBER","LOCATION_DESCRIPTION","OBJECTID","RouteName","MilePost","Location","LATI
TUDE","LONGITUDE","Heavy_AADT")]#####GETTING RID OF UNNECESSARY COLUMNS#####

DF$DOWFac<-DF$Dly/DF$AADT ##GETTING THE DAY OF THE WEEK FACTOR#####

DF1<-DF[,
  .(Avg_ADT=mean(DOWFac)),
  by=.(DOWNum,DOWFacSrc) #####AVERAGING THE DOWfac by the DAY OF THE WEEK AND THE
SEGMENT NAME

write.csv(DF1, "C:\\Users\\scottha\\OneDrive - Kansas State
University\\WichWay\\Data_3_2\\Outputs\\DOWFac1.csv", row.names = TRUE)
#####WRITING DATA OUT TO SEE IF VALUES SEEM REASONABLE#####

n1<-Final[,
  .(Mtly=sum(Flow)/672),
  by=.(MonNum,DOWFacSrc)#####12 MONTHS TIME 56 SEGMENTS#####

Monfac<-merge(n1,leg1, by="DOWFacSrc",allow.cartesian=TRUE,all.y = TRUE)##MERGING THE DATA
AGGREGATED BY MONTH WITH THE LEGEND DATA#####

MF<-data.table(Monfac)#####CONVERT TO DATA TABLE

MF<-MF[,
c("LRS_KEY","ROUTE_NUMBER","LOCATION_DESCRIPTION","OBJECTID","RouteName","MilePost","Location","LATI
TUDE","LONGITUDE","Heavy_AADT")] #####GETTING RID OF UNNECESSARY COLUMNS#####

MF$MonFac<-MF$Mtly/MF$AADT #####FINDING THE MONTH FACTOR#####

MF1<-MF[,
  .(Avg_ADT=mean(MonFac)),
  by=.(MonNum,DOWFacSrc) ##AVERAGING THE MONTHLY FACTORS OUT BY MONTH AND SEGMENT##

```

```
write.csv(MF1, "C:\\Users\\scottha\\OneDrive - Kansas State  
University\\WichWay\\Data_3_2\\Outputs\\MonFac.csv", row.names = TRUE)#####WRITING DATA OUT  
TO SEE IF VALUES SEEM REASONABLE#####
```

A.4 2019 Alteration

The yearly data all had separate formats that required cleaning. The 2019 data was unique enough in its format that an entirely separate code was needed to write it into a usable format. Assuming that moving forward this data schema will be used this code could be the most useful to future researchers.

```
library(tidyverse)

library(data.table)

library(sf)

library(stringr)

library(dplyr)

#create a list of the files from your target directory
setwd("C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\2019WichWayCSV")
file_list <- list.files(path="C:\\Users\\scottha\\OneDrive - Kansas State University\\WichWay\\2019WichWayCSV")

#initiate a blank data frame, each iteration of the loop will append the data from the given file to this variable
dataset <- data.frame()

#had to specify columns to get rid of the total column
for (i in 1:length(file_list)){
  temp_data <- fread(file_list[i], stringsAsFactors = FALSE) #read in files using the fread function from the data.table
  package
  dataset <- rbindlist(list(dataset, temp_data), use.names = TRUE, fill = TRUE) #for each iteration, bind the new data
  to the building dataset
}

d<-dataset[,-c("Occupancy","Dt","Fail_stat","Summary_period")]##Removes Unnecessary Columns

d1<-d %>%
  mutate(Direction = str_extract(Detector_name, "[:alpha:]{2}(?=\\s?-\\s?:[:alnum:]{2}$)"))##Used to parse out the
  direction of travel
#>      device_name direction
#> 1 US54 @ IKE Pkwy-West - EB - L1    EB
#> 2   Airport North - NB - L1    NB
#> 3    US54 at Dugan-WB-L1    WB
#> 4    K-96 at 21st - SB - L1    SB

write.csv(d2,file = "C:\\Users\\scottha\\OneDrive - Kansas State
University\\WichWay\\Tables_Cleaned\\2019.csv", row.names = TRUE)
```

K-TRAN

KANSAS TRANSPORTATION RESEARCH AND NEW-DEVELOPMENT PROGRAM

