Existing and Future No-Build Traffic Analysis Report

I-45N: Beltway 8 North to Loop 336 South (Conroe)

Planning and Environmental Linkages (PEL) Study

February 2020

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1. Executive Summary

A traffic operational analysis was conducted along the I-45N study corridor between Beltway 8 North and Loop 336 South for existing year 2017 conditions and the future year 2045 no-build scenario. This traffic analysis, which used Level of Service (LOS) and travel time reliability as the primary performance measures, determined that many freeway sections and intersections in the study corridor currently experience congestion during the weekday peak periods (6-9 AM and 4-7 PM). Without any improvements, this congestion is expected to worsen in both time and distance based on projected increases in population, employment, and travel demands in the study corridor and throughout the Houston area. Key results from this traffic analysis include the following:

Freeways

- **Recurring poor LOS** – High traffic volumes and recurring bottlenecks result in poor LOS D to LOS F conditions along many sections of the corridor today, especially between Hardy Toll Road and Woodlands Parkway, and near Beltway 8N. This poor LOS results in slow operating speeds and long traffic queues, which makes lane changing difficult and increases the risk for collisions. These poor LOS conditions are projected to worsen in the year 2045 no-build scenario.

- **Significant day-to-day variance** – Traffic conditions along the study corridor vary significantly from day-to-day due to the existing high traffic volumes that leave little room to absorb effects of crashes, inclement weather, and bottlenecks. Day-to-day variability can be quantified by reliability performance measures such as a Planning Time Index (PTI). PTI identifies the amount of travel time someone should plan to arrive on time at their destination 95% of the time (i.e. arrive late about once per month in their daily commute). A PTI of 1.0 represents the travel time needed to traverse the approximately 25 mile study corridor at the posted speeds (no congestion), which is about 22 minutes. Existing PM Peak PTI for the analysis limits was observed to be about 2.1, or approximately 46 minutes. The PM peak PTI is projected to increase to 2.9, which would result in a total travel time of approximately 64 minutes.

- **Future congestion expected to spread in time and distance** – The poor traffic conditions in the study corridor today are expected to further deteriorate in the future with projected increases in population growth, employment, and travel demands. Estimated future year 2045 LOS is expected to degrade to LOS F (stop and go conditions) for most of the corridor. Existing bottlenecks are projected to worsen, resulting in longer traffic queues with longer durations. Future congestion may begin each weekday around 6 am and not clear until 10 pm for sections of the corridor near Beltway 8N and the Woodlands.

Intersections

- **Limited instances of poor traffic operations** – Of the 17 interchanges analyzed in the study corridor, six have intersections currently operating at LOS E or LOS F during both the AM and PM peaks. LOS E and F conditions indicate that the intersections are operating at or near capacity, which can result in vehicles waiting for more than one traffic signal cycle to travel through the intersection.

- **Significant deterioration of intersection operations expected** – The analysis of the future year 2045 no-build showed that all the interchanges in the study corridor would have at least one intersection operating at LOS E or LOS F during peak periods with increased traffic volumes. Intersections already operating at LOS E or LOS F today would experience higher delays and longer queues in 2045.

2. Mainlane Freeway Traffic Operations

Freeway traffic operations along the I-45N study corridor were analyzed in two scenarios:

- Existing Year 2017 (6-9 AM and 4-7 PM Peak)
- Future Year 2045 – No-Build (6-9 AM and 4-7 PM Peak, and Daily (24 hours))

The traffic analysis focused on three performance measures for each scenario:

- Level of Service (LOS)
- Speeds / Bottlenecks
- Travel Time Reliability

Existing field data and Highway Capacity Manual 6 (HCM 6) methodologies were used to evaluate these performance measures for existing year operations. Existing speed data was obtained from the Federal Highway Administration (FHWA) National Performance Management Research Data Set (NPMRDS). Future year analysis relied on modeling using HCM 6 methodologies.

Freeway modeling was performed using FREEVAL software, which implements the macroscopic HCM 6 freeway analysis methodology. This software was selected due to its ability to analyze travel time reliability, LOS, and queue spillback from overcapacity segments. FREEVAL was selected over the Highway Capacity Software (HCS) because of its additional flexibility in modeling high occupancy vehicle (HOV) lanes. FREEVAL was first developed from the second Strategic Highway Research Program (SHRP 2) L08 project "Incorporating Travel Time Reliability into the Highway Capacity Manual," and the most recent version of the software was used for this study (version 20180328).

2.1. Existing Year 2017

2.1.1. Existing Year 2017 Traffic Volumes

Existing peak hour mainlane and ramp traffic volumes used for evaluating traffic operations are shown in **Exhibit 1**.

- Mainlane traffic ranges from about 130,000 to 260,000 vehicles per day, generally increasing along I-45N from Conroe toward Houston.
- About 6% to 10% of the daily traffic occurs during AM or PM peak periods.

The traffic volumes shown in **Exhibit 1** were estimated using traffic counts collected during May and October 2017. Because all traffic counts were not taken on the same day, they were balanced for input into the FREEVAL analysis software. The traffic volume balancing procedure involved:

- **Dividing the day into three hour time periods** – Rather than considering only one hour of traffic in the AM and PM peaks, traffic counts were aggregated into larger three hour periods. This allowed estimation of the total traffic demand occurring during the 6-9 AM and 4-7 PM peaks because congestion causes hourly and sub-hourly counts to be unbalanced and underestimates travel demand. Traffic counts for the remaining 18 hours of the day were also aggregated into three or four hour periods to accommodate the start and end times of the AM and PM peaks.
- **Balancing each time period** – An optimization procedure was used to adjust the aggregated three hour traffic counts to create a balanced set of volumes. The goal of the optimization was to minimize the difference between the input counts and output balanced demands.
- **Applying a flow profile** – Traffic counts were recorded in 15 minute intervals. This provided the basis for creating a sub-hourly traffic profile that was applied to the balanced daily volumes. This is analogous to

how intersection traffic analysis works where a peak hour factor is applied to hourly demands. The end result was a set of 15 minute traffic volumes that balance for each three hour time period as well as on the daily level. These traffic volumes, shown in **Exhibit 1**, were then input into FREEVAL software for LOS and reliability analysis.

I-45N has buffer separated HOV lanes north of FM 1960 and a barrier separated reversible HOV lane south of FM 1960. The proportion of total traffic utilizing the HOV lanes typically depends on day-to-day and hourly variances in congestion on the adjacent general purpose lanes. Observed peak traffic volumes in the buffer separated HOV lanes ranged from about 2% to 5% to a high of 14% of the mainlane traffic volumes. Traffic volume observed in the HOV barrier separated sections was about 3% to 8% of the mainlane volume in the peak periods.

Peak period truck traffic was observed to be about 2% to 3% single unit (SU) trucks and 3% to 4% tractor-trailers, for a total of 5% to 7% trucks depending on time and location. Truck traffic counts were not collected at every ramp or freeway segment in the corridor. For the high-level freeway analysis, the observed truck percentages were used to estimate a uniform corridor-wide truck percentage for each peak period.

2.1.2. Level of Service (LOS)

LOS provides a qualitative assessment of traffic operations for a given scenario. In accordance with the HCM, LOS for freeways is based on density of traffic, measured in passenger car equivalent vehicles per mile per lane (pc/mi/ln). LOS ranges from A to F, with LOS A representing free flow traffic and LOS E and F representing poor traffic operations with significant delays and congestion. **Figure 1** displays a visual representation with the pc/mi/ln value for each LOS classification.

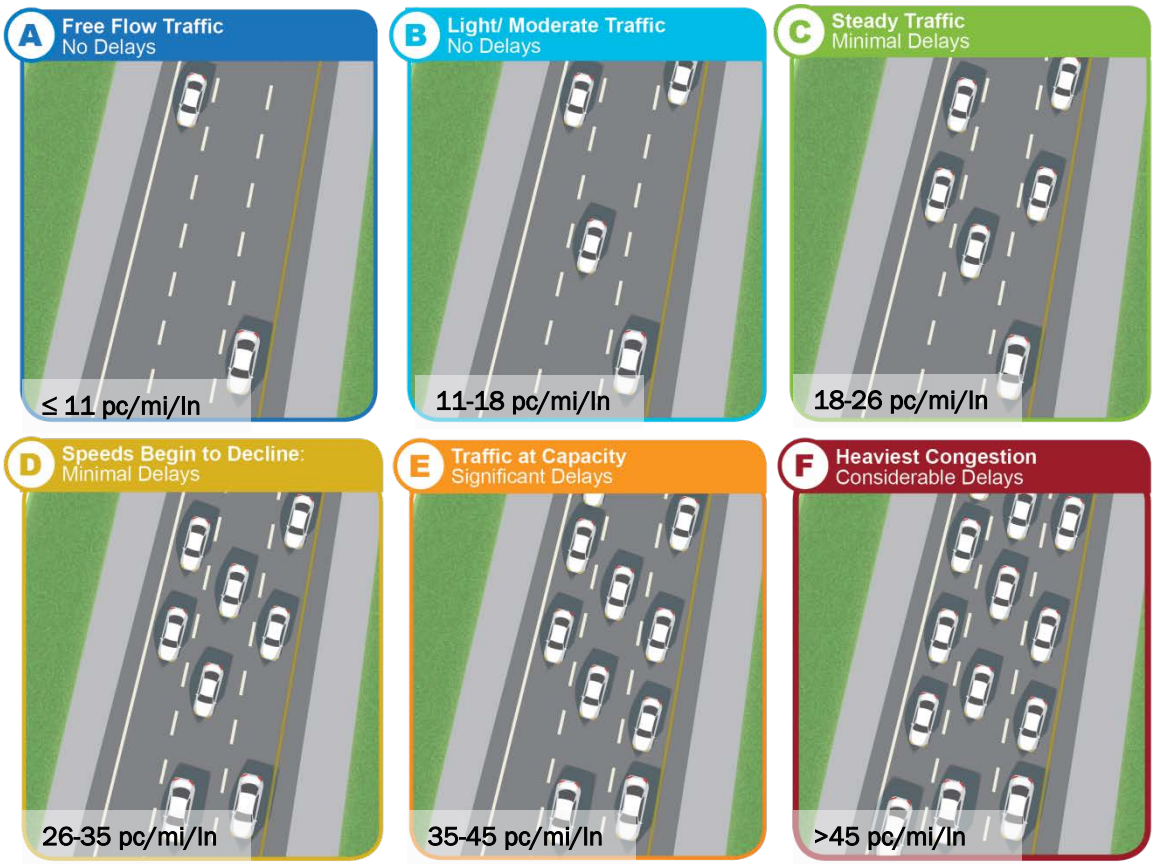


Figure 1. Freeway Level of Service Definition

The LOS analysis for existing conditions had two goals:

- Provide a high-level assessment of traffic operations in the study corridor during AM and PM peaks on a typical weekday.
- Serve as a baseline, or "seed," from which travel time reliability performance measures can be estimated for weekday peak periods.

Congestion in the corridor varies from day to day; therefore, LOS alone does not wholly reflect the variability of traffic operations. While the results may show a particular LOS for a segment, users may encounter better or worse traffic conditions on a daily basis. Travel time reliability is an effective performance measure that better reflects varying traffic operations.

2.1.2.1. Model Calibration

Estimating LOS and travel time reliability required modifications to default HCM parameters and procedures in calibrating FREEVAL to better reflect existing conditions. This calibration primarily used HCM capacity adjustment factors to adjust default capacities in order to reflect actual congestion and bottlenecks, as well as substituting weave analysis with separate merge and diverge analyses. Without calibration, the default HCM 6 procedures can severely misrepresent existing congestion. NPMRDS speed data was used as the observed data set for comparison against the calibrated model. Additional calibration details are provided in **Appendix A**.

The calibration of the FREEVAL model better reflects field conditions as follows:

- Back of queue at bottlenecks matched the nearest crossroad location
- Corridor travel times are within five minutes of observed travel times
- Modeled travel time index distributions are within 5% to 15% of field conditions for reliability analysis

2.1.3. Existing Year 2017 LOS

Table 1 shows that existing traffic operations are generally poor (LOS E and F) for both directions of travel in many sections of the study corridor during both the AM and PM peak periods. The low vehicle speeds and long queues make lane changing difficult. There is limited, if any, spare capacity to absorb the effects of roadway incidents or inclement weather.

Although LOS varied along smaller analysis segments within each of the listed sections, the worst LOS within each section is shown in **Table 1** to represent the worst case traffic operations along the study corridor. Detailed LOS results within each section are shown in **Exhibit 2**. In 2017, the percentage of the I-45N study corridor experiencing LOS F ranged from around 20% to 40% depending on the peak and direction.

Congestion south of Beltway 8N can result in traffic queues extending further into the I-45N study corridor, which may result in LOS worse than shown for sections south of Rankin Rd. LOS E and F segments tend to be unstable and can cause congestion in adjacent segments due to day-to-day variations in demand.

The HOV lanes generally operate better than the general purpose lanes. Degraded LOS along the HOV lanes is typically limited to designated access segments where traffic weaves between the general purpose and HOV lanes. While the model shows LOS F for some HOV access segments, the model may be overstating the LOS because congestion did not spillback into adjacent segments. Some degraded traffic performance is expected, but likely varies from day-to-day changes in travel demand and congestion in the general purpose lanes.

Table 1. Summary of Worst Existing Year 2017 LOS Within Each Section of I-45N

	General Purpose Lanes				◊ HOV Lanes			
	AM Peak		PM Peak		AM Peak		PM Peak	
Section	SB	NB	SB	NB	SB	NB	SB	NB
North of LP 336 S	C	C	C	D	C	C	C	C
SH 242 - LP 336 S	E	C	D	E	D	C	C	D
Woodlands Pkwy - SH 242	E	D	E	E	C	C	C	C
Hardy Toll Rd - Woodlands Pkwy	E	F	F	F	D	F*	F*	D
SH 99 - Hardy Toll Rd	E	F	E	F	C	C	C	C
FM 1960 - SH 99	F	E	D	F	D	C	C	F*
Rankin Rd - FM 1960	F	D	D	E	C	Closed NB	Closed SB	C
BW 8N - Rankin Rd	F	C	F	D	C			C
South of BW 8N	E	D	F	D	C			C

Notes:
Buffer separated HOV lanes LOS C indicates a LOS C or better. LOS F* limited to the weaving access segments to/from the general purpose lanes. Degraded operations may be expected, but the magnitude of LOS may vary with daily congestion.
LOS in segments near BW 8N may be worse than shown due to spillback from bottlenecks outside the analysis limits south of BW 8N.

2.1.4. Existing Year 2017 Speeds and Bottlenecks

Speed heat maps shown in **Figure 2** and **Exhibit 3** provide a graphic representation of variations in speeds by time and location along I-45N. The heat maps show the time of day along the x-axis and crossroad locations (bridges) along the y-axis. The speed data was obtained from the FHWA NPMRDS for year 2017, which includes Monday through Friday for every 15 minutes. The 50th percentile (typical) and 5th percentile (nearly slowest) speeds are shown to highlight the range of traffic operations for existing conditions. **Appendix B** shows speeds for each individual day in the year. Speeds recorded from August 25 through September 9, 2017 were excluded from the analysis due to Hurricane Harvey.

Weekday congestion typically occurs daily during the 6:00-9:00 AM and 4:00-7:00 PM peak periods. The worst congestion occurs in the PM peak for both southbound and northbound directions.

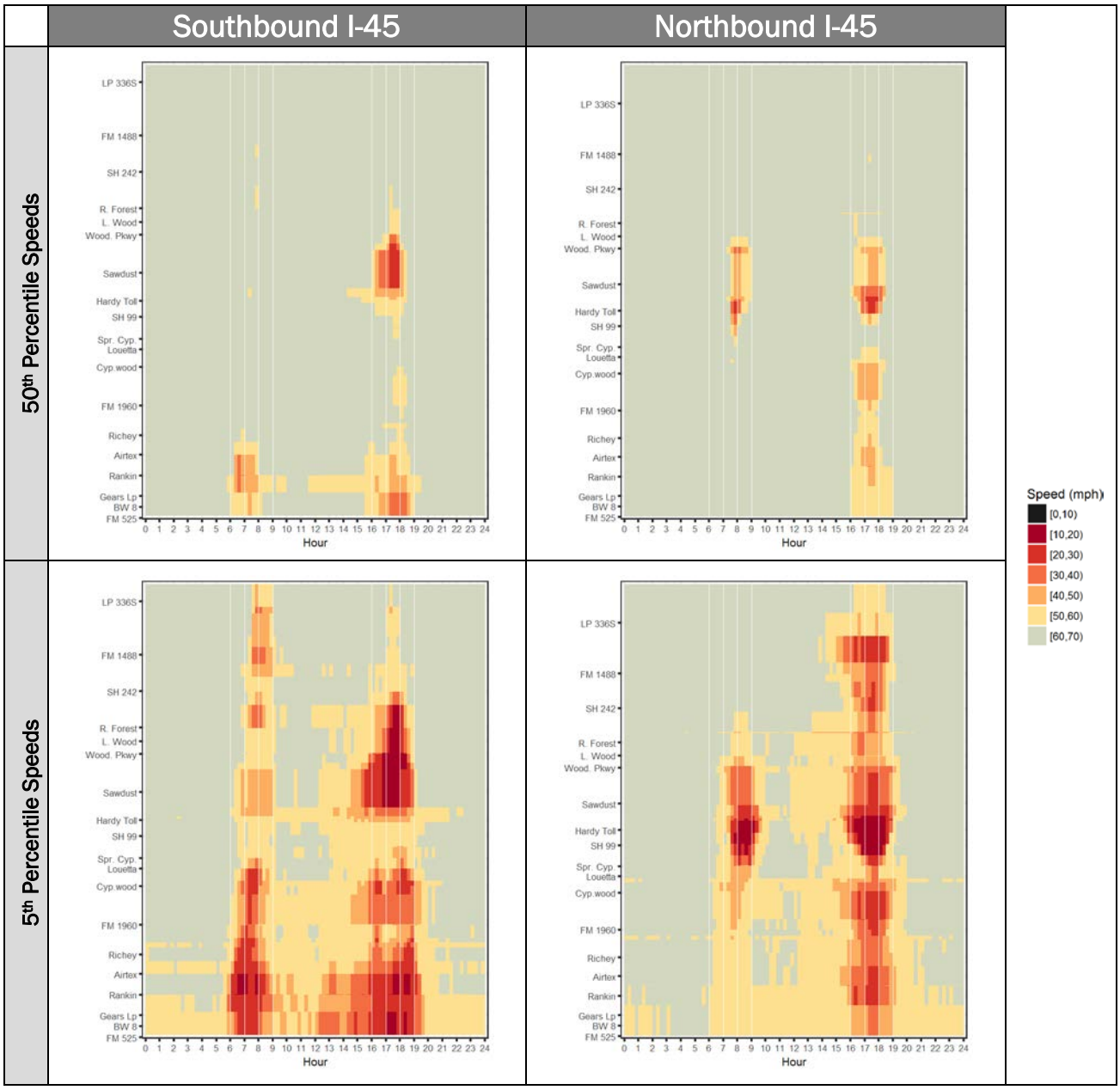


Figure 2. Speeds Along I-45N (Year 2017 NPMRDS 15-Minute Data)

Bottleneck locations are also shown in **Figure 2**. These are the locations at which slow speeds propagate in time and space, typically in a triangular shape where the point of the triangle is near the back of the congestion. The primary locations that experience recurring bottlenecks with 50th percentile speeds less than 40 mph include:

- NB I-45N – Woodlands Parkway Diverge
- NB I-45N – Hardy Toll Road Merge
- SB I-45N – SH 99 and Hardy Toll Road Diverges
- SB I-45N – Beltway 8N Diverge

Exhibit 3 highlights speeds and queues at these bottleneck locations in more detail. **Exhibit 3** also shows additional bottlenecks that are less severe or only occur in the worst conditions. Bottlenecks along I-45N are typically the result of several consecutive high-volume ramps within a short distance. **Figure 3** shows examples of this situation near SH 99, Hardy Toll Road, and Woodlands Parkway. Lane changing from entering and exiting traffic at consecutive ramps overloads the right lanes, causing slow speeds to propagate upstream and along adjacent lanes.

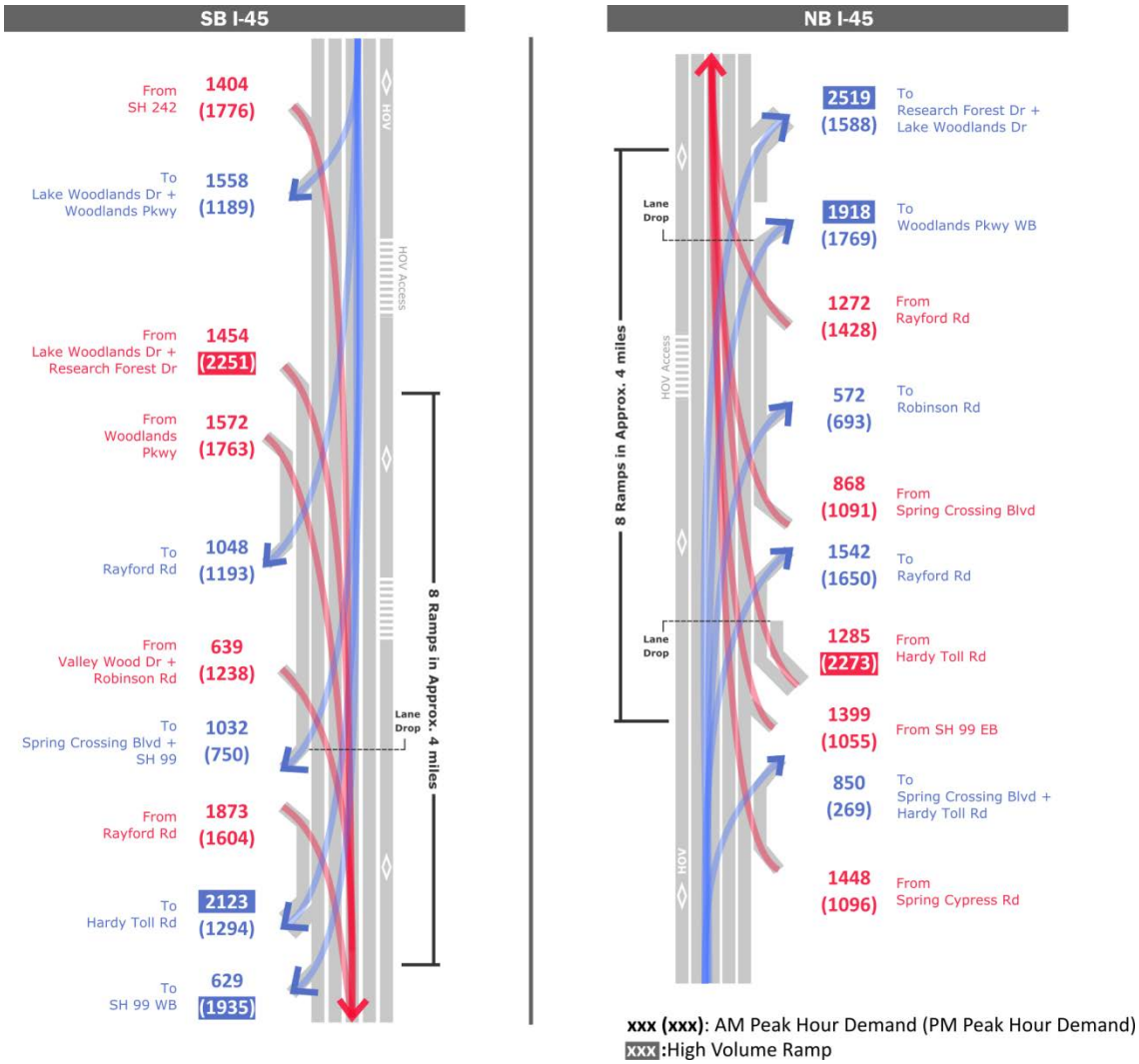


Figure 3. I-45N Volumes near SH 99, Hardy Toll Rd, and Woodlands Parkway

2.1.5. Travel Time Reliability

Reliability describes the variability of travel time along a highway facility such as I-45N. For example, if a person has a typical home-to-work commute of 20 minutes with little day-to-day variance, 20 minutes would be considered a reliable travel time. The travel time would be unreliable if this trip that typically takes 20 minutes often takes significantly longer or shorter. Crashes, weather, work zones, traffic, special events, bottlenecks, and traffic control are all factors that can negatively affect the reliability of a trip.

2.1.6. Methodology

Existing travel time reliability for I-45N was measured using speed data from the NPMRDS provided by the FHWA for years 2016 and 2017. The NPMRDS contains five minute travel times along approximately one mile segments of highway on the National Highway System. These NPMRDS segments were aggregated into larger segments to reflect the longer distance trips that typically occur on freeways. Year 2017 NPMRDS speed data was also aggregated up to 15 minutes for calibrating FREEVAL.

Travel time reliability was quantified using Planning Time Index (PTI). PTI represents the travel time needed to ensure on time arrival 95% of the time. PTI is calculated by taking the 95th percentile travel time for a given time period and dividing by the free-flow travel time at posted speed. For example, on a PM peak commute that would take 20 minutes driving at posted speed, a PTI of 2.0 means that someone would need to plan for 40 minutes if they want to be on time 95% of the time. This equates to arriving late about once per month. PTI values were classified based on a scale adapted from the FHWA "Guide to Incorporating Reliability Performance Measures into the Transportation Planning and Programming Processes":

- **Reliable**: PTI of 1.0 – 1.3
- **Moderately reliable**: PTI of 1.3 – 2.0
- **Unreliable**: PTI 2.0 or greater

2.1.7. Existing Year 2017 Travel Time Reliability

I-45N has generally unreliable travel times throughout the corridor during both the AM and PM peaks in both directions. As a result, motorists regularly need to plan for extra time in their commute to account for traffic, crashes, and other sources of congestion that cause significant day-to-day variation in travel times. The study corridor was divided into four segments for quantifying travel time reliability using PTI. The PTI for each segment was calculated based on actual Monday through Friday travel times for 2016 and 2017.

Year 2016 PTI results are shown in **Figure 4**, and range from 1.4 to 4.7 depending on the freeway segment and peak period. Year 2017 PTI results are shown in **Figure 5** and range from 1.3 to 2.9. The reason for the difference in PTI between 2016 and 2017 may be due to completion of the HOV lanes or general year-to-year variability in traffic operations.

The northern sections of the corridor have better overall reliability than the southern sections. In some sections that would typically take about five to seven minutes to drive, travel time during congested conditions could take 15 or more minutes.

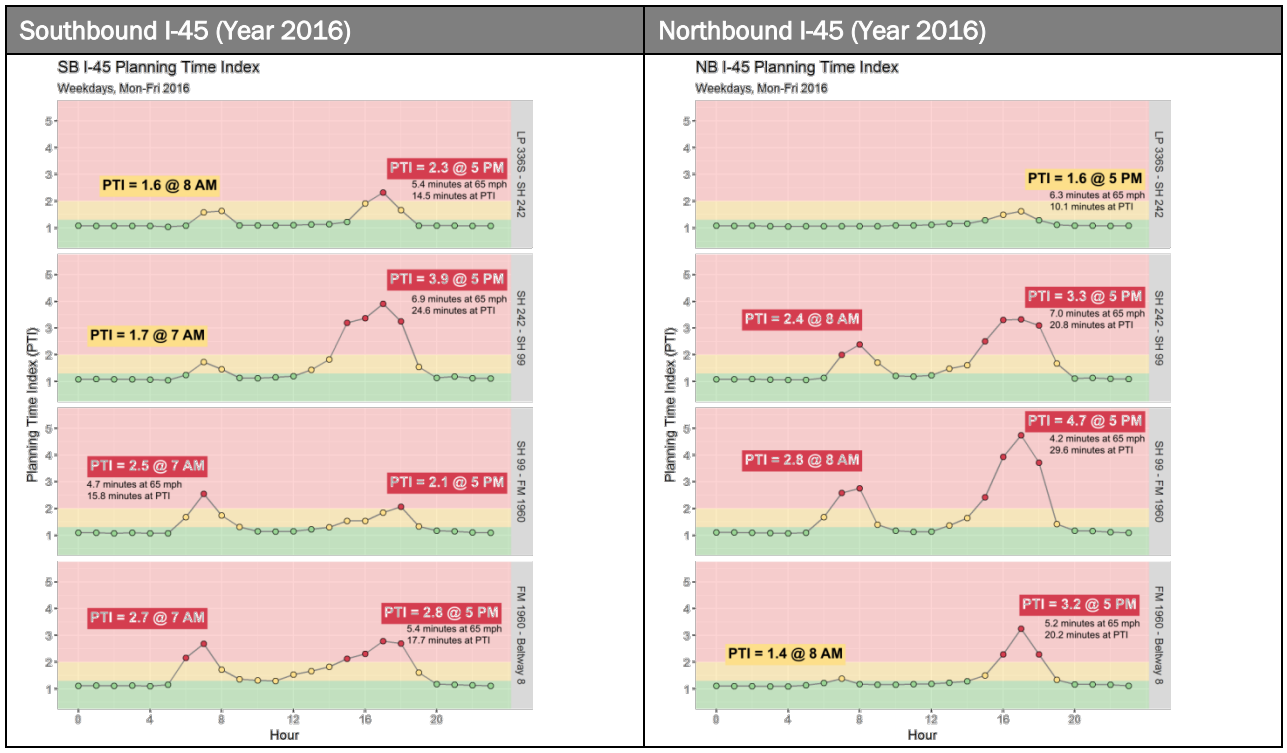


Figure 4. Field Observed Planning Time Index (Year 2016 NPMRDS Data)

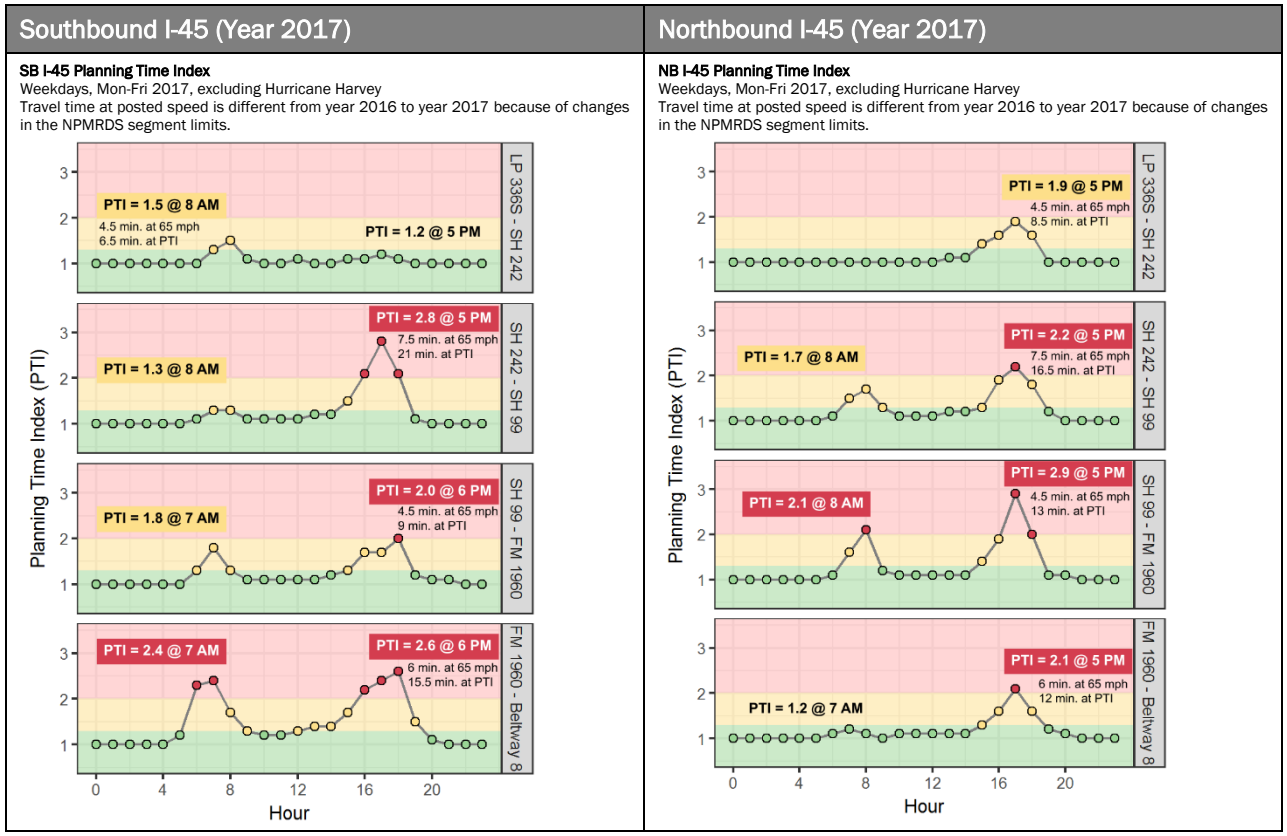


Figure 5. Field Observed Planning Time Index (Year 2017 NPMRDS Data)

FREEVAL reliability modeling uses the scenario developed for the LOS analysis as a seed, or baseline, to generate additional scenarios that vary in traffic volume, crashes, and weather. The variance in traffic travel time reliability in a given year can be estimated from these scenarios. Although work zones can be included in reliability modeling, they were excluded from this analysis because construction impacts are not a primary focus of the I-45N study. In total, 240 scenarios were modeled to represent the approximately 20 weekdays that occur in each of the 12 months. Each scenario may or may not include crash or weather events based on their probability of occurrence derived from the following data input into the reliability analysis:

- **Crash Frequency** – Corridor-wide mainlane crash frequency by peak-period, direction, and month were obtained for year 2017 based on the TxDOT Crash Records Information System (CRIS) database. **Figure 6** shows that crashes range from 11 to 40 crashes per month in each peak period and direction. This means that about one crash could be expected to occur in each direction, in each peak period, on every weekday. Crashes occurring in the HOV lane could not be directly identified from the CRIS database and were not included in the reliability scenario generation. The probability of crash occurrence in any given scenario and segment is based on the modeled vehicle miles traveled in the segment as well as the corridor-wide crash frequency.

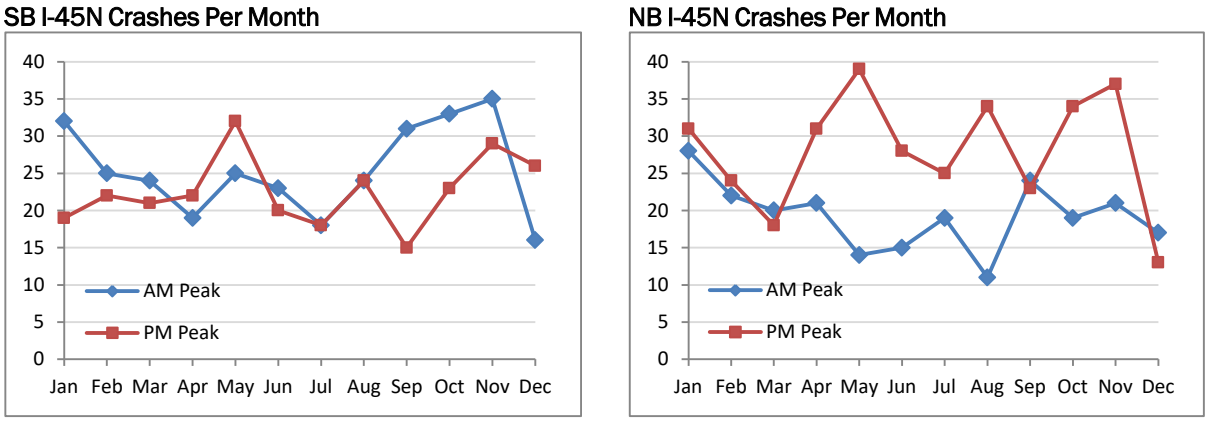


Figure 6. I-45N Crashes per Month (Weekday Peak Periods, Year 2017)

- **Seasonal changes in daily traffic** – Volumes in each scenario were derived by multiplying the seed scenario volumes by seasonal factors. Seasonal factors were developed from the permanent traffic counter on I-45N between Hollow Tree Lane and Cypresswood Drive (Counter ID A316) for the latest available year 2016 in the TxDOT Traffic Count Database System (TCDS). Seasonal factors ranged from about 80% to 118% of the seed scenario volumes depending on travel direction, weekday, and month.
- **Weather** – Inclement weather affects traffic operations and decreases reliability of the transportation system. Long term weather statistics are included in the FREEVAL software for major cities including Houston, Texas. These statistics estimate the probability of rain and snow and limited visibility scenarios to include in the reliability analysis scenarios.

In addition to PTI, FREEVAL reliability analysis also outputs a Travel Time Index (TTI) distribution to demonstrate the expected variability of traffic operations. TTI is a ratio between actual travel time and free-flow travel time at posted speed. This formula is the generalized version of the PTI formula, meaning that PTI is equivalent to a TTI using the 95th percentile actual travel time. Standard FREEVAL output includes TTI reported at the 50th, 80th, and 95th percentiles.

Existing peak-period TTI from the year 2017 NPMRDS data matching the FREEVAL analysis limits is shown in **Table 2**. Existing field-observed TTI versus modeled TTI results are shown in **Appendix A**. Field data is emphasized

because the modeled results were only used to estimate the *change* in reliability between existing and future scenarios.

Existing PTI for each travel direction and period is classified as moderately reliable at the corridor level. FREEVAL output only reports TTI aggregated for the entire analysis limits. TTI reported for longer segments is best suited for high-level reporting, but may mask the detailed operational issues highlighted in **Figure 4** and **Figure 5**.

Table 2. 2017 Travel Time Index

	AM Peak TTI 6-9 AM		PM Peak TTI 4-7 PM	
Percentile	SB	NB	SB	NB
95th (PTI)	1.5	1.3	1.8	1.8
80th	1.2	1.1	1.4	1.4
50th	1.1	1.0	1.2	1.2

Existing Year - 2017 NPMRDS Data; Highlighted by TTI (yellow: 1.3 - 2.0 moderately unreliable)

2.2. Future Year 2045 No-Build

2.2.1. Future No-Build Traffic Volumes & Growth Rates

The future year 2045 no-build scenario represents a "status quo" scenario where population, employment, and transportation trends experienced today would be expected to continue in the future. Analysis for this scenario used forecasted daily traffic growth rates as described in the I-45N Traffic Projection Methodology Memorandum (February 2018). These growth rates were obtained from the Houston-Galveston Area Council (H-GAC) Regional Travel Demand Model (TDM). The interchange at I-45 and SH 99 will be constructed by year 2045 so it was considered as part of the no-build scenario. Traffic volume projections and analysis results for this interchange are documented in **Appendix C**.

Freeway mainlane growth rates from the forecast range from about 0.8% to 1.6% compounded annually, with lower growth occurring in the existing highly-developed areas in the southern part of the study corridor. Future year mainlane daily traffic volumes for all corridor sections are summarized in **Table 3**. These volumes represent the maximum total roadway volume of all segments in each section. Details for all segments are included in **Exhibit 4**.

Table 3. Daily Traffic Volume Summary – Existing and Future Year

Section	Total Roadway (NB + SB) Daily Traffic (vpd)	
	Existing Year 2017	Future Year No-Build 2045
North of LP 336 S	137,860	203,060
FM 1488 – LP 336 S	170,060	251,440
SH 242 – FM 1488	184,100	278,900
Research Forest Dr – SH 242	164,140	251,020
Woodlands Pkwy – Research Forest Dr	202,270	315,300
Rayford Rd – Woodlands Pkwy	245,100	366,870
Hardy Toll Rd – Rayford Rd	253,660	372,970
SH 99 – Hardy Toll Rd	220,240	299,460
Spring Cypress Rd – SH 99	202,870	276,720
Cypresswood Dr – Spring Cypress Rd	202,460	306,110
FM 1960 – Cypresswood Dr	235,490	326,420
Rankin Rd – FM 1960	263,210	352,960
BW 8N – Rankin Rd	262,050	344,190
South of BW 8N	261,850	324,280

The following process was used to develop future year no-build peak hour traffic volumes for LOS analysis:

- **Apply mainlane growth rates to existing mainlane daily traffic volumes** – Total roadway growth rates between each interchange were obtained from the TDM and applied to the existing balanced daily traffic volumes.
- **Apply crossroad growth rates to existing ramp daily traffic volumes** – Traffic at ramps is typically controlled by the traffic of arterial street connections. Growth rates applied to the existing balanced ramp traffic volumes was dependent on the origin or destination of the ramp. For off-ramps, the downstream destination crossroad growth rate was applied. For on-ramps, the upstream origin crossroad growth rate was applied. Growth rates were constrained to an expected range of 0.5% to 3.0%.
- **Balance mainlane and ramp daily volumes** – Because the growth rates were not uniform throughout the corridor, forecasted volumes were initially unbalanced. A balancing adjustment process similar to that performed for the existing year was used for the future year in order to minimize the difference between the unbalanced input and output balanced volumes. After balancing, ramp and mainlane growth rates typically stayed within the 0.5% to 3.0% range, with few exceptions ranging from 0% to 3.6% growth. Final growth rates are shown in **Exhibit 4**.
- **Develop a sub-hourly traffic profile** – The existing year sub-hourly traffic profile described in Section 2.1.1 was applied to the balanced future year daily volumes. This resulted in traffic volumes for all 15-minute periods in the day.
- **Apply peak spreading** – Applying the existing year sub-hourly traffic profile resulted in some mainlane and ramp locations exceeding expected capacity. As daily traffic volumes increase, peak characteristics tend to decrease. This phenomenon is described in more detail in Section 2.2.2. Traffic volumes derived after peak spreading were used for LOS analyses.

2.2.2. Peak Spreading

As a result of peak period congestion, travelers tend to adjust departure time, route, or travel mode, a phenomenon known as "peak spreading." Forecasted traffic growth from the TDM accounts for traffic shifts in routes and modes at the daily level, but may not fully reflect spreading in time at the sub-hourly level needed for LOS analysis. Peak spreading for the sub-hourly volumes was applied based on the National Cooperative Highway Research Program Report 765 methodology. This methodology iteratively shifts volume from over-capacity time periods to adjacent under-capacity time periods until all time periods are constrained to the assumed capacity.

Accounting for peak spreading in this manner helps prevent overstating no-build traffic operations by constraining demand in the peak hours. If future alternative scenario analyses consider supply or demand management, the no-build traffic volumes can be unconstrained to help prevent overestimating benefits from alternatives. Peak spreading also demonstrates that future congestion may extend along the corridor in both time and location.

Figure 7 shows two examples of peak spreading at freeway ramps. Both the amount of peak spreading, and capacity can vary by location, amount of congestion, vehicle mix (cars and trucks), and time. The applied peak spreading assumed a capacity of 2,400 vehicles per hour per lane (veh/hr/ln), based on HCM 6, as an approximation to capture the effect of peak spreading for this high-level analysis. Further precision would require modeling techniques beyond the scope of this analysis.

SB On-Ramp from Spring Crossing Blvd **SB On-Ramp from BW 8**

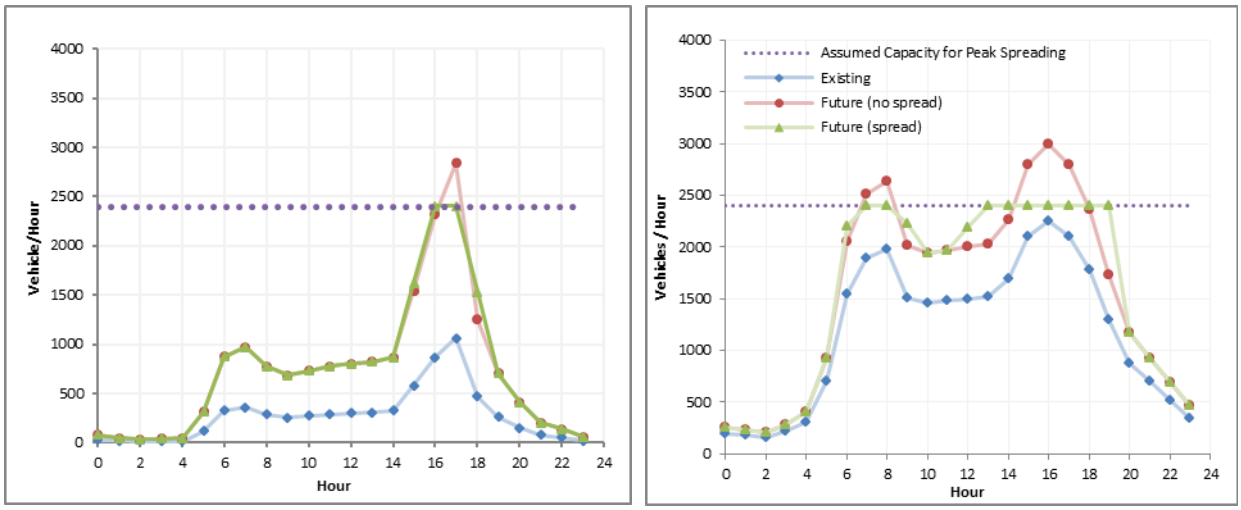


Figure 7. Examples of Peak Spreading at Ramps

Some ramp locations had forecasted growth rates that would result in traffic volumes at capacity for nearly the entire day. The assumed 2,400 veh/hr/ln constraint for peak spreading was incrementally increased based on engineering judgement in order to provide more realistic daily and peak hour traffic profiles for the following ramps:

- **Louetta Road Exits/Entrances** – The exits/entrances to Louetta Road carry traffic for adjacent crossroads (either Spring Cypress Road or Cypresswood Drive). Forecasted daily ramp volumes for year 2045 are 32,000 to 53,000 vpd for the single-lane ramps. This reflects the growth expected for all crossroads carried by the ramps.

Other single-lane ramps showed high-volume forecasts but did not require increased assumed capacity to account for peak spreading. These ramps may experience extended periods of congestion. **Exhibit 1** highlights

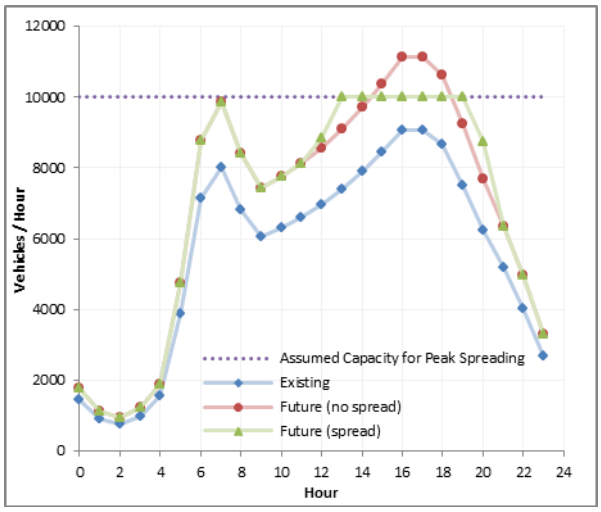
all high-volume single-lane ramps carrying greater than 25,000 vpd in the future year 2045 no-build forecast. The following ramps have projected volumes more than 35,000 vpd:

- SB I-45N
  - On-ramp from SH 242 (39,520 vpd)
  - Off-ramp to Louetta Road and Cypresswood Drive (52,640 vpd)
  - On-ramp from FM 1960 (45,030 vpd)
  - Off-ramp to Richey Road (35,580 vpd)
  - Direct connector to Beltway 8 WB (44,380 vpd)
  - Direct connector from Beltway 8 EB (37,710 vpd)

- NB I-45N
  - Off-ramp to SH 242 (38,110 vpd)
  - On-ramp from Cypresswood Drive and Louetta Road (40,430 vpd)
  - Off-ramp to Louetta Road and Spring Cypress Road (43,640 vpd)

Figure 8 shows peak spreading applied to mainlane traffic volumes at the start of the corridor in each direction. Future year mainlane volumes for NB I-45N at the beginning of the analysis limits were forecasted to exceed capacity. Existing bottlenecks south of Beltway 8N would constrain volume to capacity and limit the flow of traffic entering the NB I-45N analysis limits. Using 2,400 veh/hr/ln for peak spreading resulted in volumes less than existing observed traffic volumes on some downstream mainlane segments. Peak spreading was adjusted to use 2500 veh/hr/ln to keep the future traffic greater than existing. The SB I-45N forecasted volumes did not exceed capacity and no peak spreading adjustments were required.

NB I-45N, South of BW 8



SB I-45N, North of LP 336

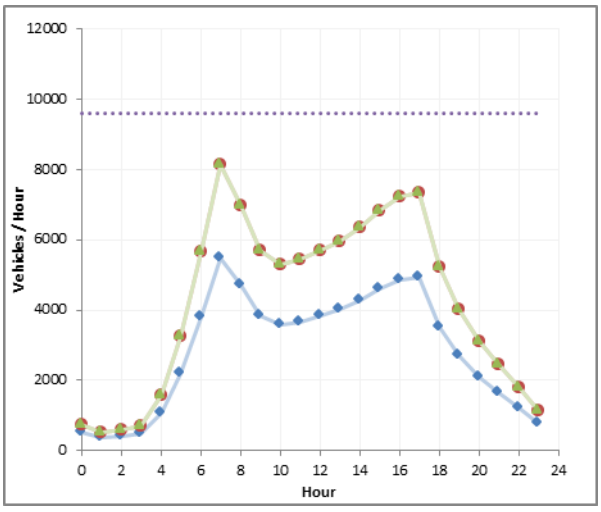


Figure 8. Mainlane Peak Spreading

2.2.3. Future Year 2045 No-Build LOS

Table 4 summarizes LOS for the future year 2045 no-build scenario. Detailed results are shown in **Exhibit 5**. Traffic operations are expected to degrade with increasing traffic volumes. The no-build traffic forecasts would result in LOS F for most sections along I-45N, including locations that operate at LOS D or better today. Where there are existing bottlenecks, queue spillback is projected to worsen, impacting adjacent segments. Hidden bottleneck locations may also exist due to traffic demand being held upstream, making downstream operations appear better than they would if the upstream bottleneck did not exist. The percentage of freeway mainlanes that will operate at LOS F increases to the range between 60% and 97% depending on the peak and direction.

HOV lanes also showed degraded performance in the future year 2045 no-build model. High demand and friction between the HOV and general purpose lanes is projected to result in degraded LOS in HOV lanes, including barrier separated sections. Peak congestion in the HOV lane may extend beyond the weaving access sections for HOV lanes. Future year HOV lane traffic demand and operations may also depend on management strategies, either price or occupancy qualifications, but congestion in the general purpose lanes may still negatively impact HOV lanes.

Table 4. Worst Future Year No-Build 2045 LOS in Each Section of I-45N

	General Purpose Lanes				◊ HOV Lanes			
	AM Peak		PM Peak		AM Peak		PM Peak	
Section	SB	NB	SB	NB	SB	NB	SB	NB
North of LP 336 S	F	C	F	D	C	C	C	C
SH 242 - LP 336 S	F	C	E	F	F	C	D	D
Woodlands Pkwy - SH 242	F	D	F	F	F	C	F	D
Hardy Toll Rd - Woodlands Pkwy	F	F	F	F	F	F	F	F
SH 99 - Hardy Toll Rd	E	F	E	F	C	C	E	C
FM 1960 - SH 99	F	F	F	F	F	F	F	F
Rankin Rd - FM 1960	F	F	F	F	D	Closed NB	Closed SB	F
BW 8N Rankin Rd	F	F	F	F	D			F
South of BW 8N	E	F	F	F	D			F

Notes:
Buffer separated HOV lanes LOS C indicates a LOS C or better, but may be better or worse than shown with daily variance in congestion.
LOS in segments near BW 8N may be worse than shown due to spillback from bottlenecks outside the analysis limits south of BW 8N.

2.2.4. Future Year 2045 No-Build Speeds and Bottlenecks

FREEVAL results include estimated future year 2045 no-build speeds along I-45N as shown in **Figure 9**. The FREEVAL 3-hour peak hour models were expanded to 24 hours based on the future daily traffic volumes and flow profile described in Section 2.2.1. Expanding the model in time allowed better estimation of the extent of congestion. Estimated typical future year speeds from the model were found to be similar to the slowest speeds observed today. The worst days observed today are therefore indicative of what future typical traffic operations will be if trends in population, employment, and transportation continue.

Existing bottlenecks are projected to worsen in both duration of occurrence and and length of queues in the future no-build scenario. Existing congestion that is typically confined to 3-hour peak periods may extend from 6AM to 10PM in the future, especially near the Beltway 8N and SH 99 to Woodlands Parkway sections. Similar all-day congestion is experienced today south of Beltway 8N. Bottlenecks outside of the FREEVAL model limits may result in conditions in the study corridor that are worse than shown in **Figure 9**.

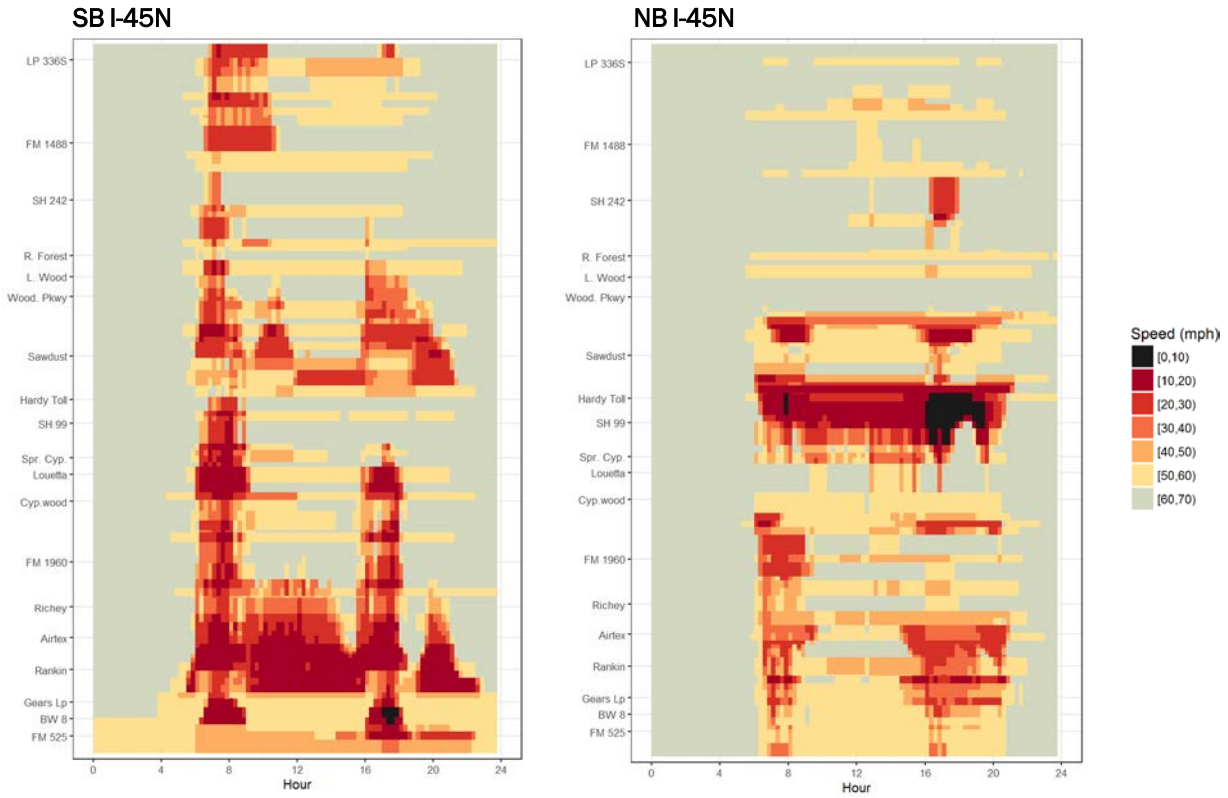


Figure 9. Year 2045 No-Build Estimated Speeds – FREEVAL 24-Hour Model

2.2.5. Travel Time Reliability

Travel time reliability is projected to decrease in the future year 2045 no-build scenario due to increased susceptibility to congestion from crashes, weather, and increased traffic volumes. **Table 5** quantifies the future year reliability results based on existing field-observed data and the estimated change in reliability from FREEVAL modeling. In all peak periods, PTI for the corridor increases, meaning that travelers would need to plan for extra time to arrive at their destinations on time. For example, future year northbound travel time during the PM peak may be over three times longer than traveling at the posted speed.

FREEVAL also projects an increase for the entire travel time distribution of about 15% to 65%, depending on direction and peak. Typical future congestion (50th percentile) values are near to or exceed the 95th percentile (PTI) values seen today (e.g. SB PM peak existing 95th percentile = 1.56, future 50th percentile = 1.51). This further demonstrates that the worst days seen today may become more prevalent in the future.

Table 6 shows the information from **Table 5** expressed as the estimated travel time for the corridor. Assuming posted speed, it takes 22 minutes to traverse the 25-mile study corridor. Travel times could take as much as 55 minutes in the future, depending on the peak period and direction of travel.

Table 5. Existing and Estimated Future Year 2045 No-Build Travel Time Index

Percentile	Travel Time Index (TTI) Existing **(Future)**							
	AM Peak 6-9 AM				PM Peak 4-7 PM			
	SB		NB		SB		NB	
95th (PTI)	1.5	**(2.3)**	1.3	**(1.9)**	1.8	**(2.2)**	1.8	**(2.5)**
80th	1.2	**(1.9)**	1.1	**(1.6)**	1.4	**(1.8)**	1.4	**(2.2)**
50th	1.1	**(1.8)**	1.0	**(1.5)**	1.2	**(1.6)**	1.2	**(1.9)**

Highlighted by TTI (yellow: 1.3 - 2.0 moderately unreliable, red: ≥2.0 unreliable)

Table 6. Existing and Estimated Future Year 2045 No-Build I-45N Corridor Travel Times

Percentile	Travel Time in Minutes Existing **(Future)**							
	AM Peak 6-9 AM				PM Peak 4-7 PM			
	SB		NB		SB		NB	
95th (PTI)	33	**(51)**	29	**(42)**	40	**(48)**	40	**(55)**
80th	26	**(42)**	24	**(35)**	31	**(40)**	31	**(48)**
50th	24	**(40)**	22	**(33)**	26	**(35)**	26	**(42)**

3. Intersection Traffic Operations

Intersections were analyzed at 17 cross street locations within the Study limits where I-45N frontage roads provide controlled access to the freeway. Cross streets with free-flow frontage road intersections were not analyzed because the Highway Capacity Manual does not define performance measures for these situations. These include the intersections at I-45N and FM 1488, I-45N and Woodlands Parkway, and I-45N and Lake Woodlands Drive.

Analyzed intersections typically included one-way frontage roads with signalized control and Texas Transportation Institute (TTI) phasing. TTI phasing allows each approach to proceed through the interchange without stopping at the next downstream signal.

Intersections were analyzed using Trafficware Synchro software and the standard Synchro output (percentile delay method) that is compatible with HCM methodology, but is more flexible in analyzing TTI signal phasing. Performance measures output from Synchro include:

- **LOS** – Provides a qualitative performance measure based on the average delay experienced by drivers. The HCM defines six levels of service, ranging from LOS A to LOS F as shown in **Table 7**.
- **Volume to Capacity (v/c) Ratio** – estimates the level of saturation for traffic movements at the intersection (over or under capacity). Higher v/c ratios indicate little room to absorb increases in traffic volumes.
- **50th Percentile Queue Length** – Estimates typical (50th percentile) queues on each approach. Longer or shorter queues can occur with changes in traffic volumes.

Table 7. Highway Capacity Manual Intersection Level of Service Scale

LOS	Description	Delay (seconds/vehicle)	
		Signalized	Unsignalized
A	Very low average control delay, free flow	0-10	0-10
B	Average control delay, still relatively free flow	>10-20	>10-15
C	Fair control delay, some stoppage	>20-35	>15-25
D	Delays expected, possible unfavorable progression	>35-55	>25-35
E	Large delays expected, poor progression	>55-80	>35-50
F	Unacceptable delay, poor progression and stoppage	>80	>50

Scenarios analyzed in Synchro included:

- Existing Year 2017 AM & PM peak hours
- Future Year 2045 No-Build AM & PM peak hours

3.1. Existing Year 2017

The existing year 2017 Synchro model network was developed using field collected data, including lane configuration, traffic control at intersections, signal timing data, and speed limits. The peak hour traffic volumes collected as part of this project were balanced and entered as inputs to evaluate traffic operations at study intersections.

3.1.1. Existing Year 2017 Intersection LOS

LOS, v/c ratio, and queue length performance measures for each intersection are shown in **Exhibit 6** for the AM and PM peak hours. Under the existing conditions, the interchanges shown in **Table 8** would have at least one intersection operating at LOS E or F during both AM and PM peak hours.

Table 8. Existing Year 2017 – Interchanges Operating at LOS E/F

Location
I-45 at FM 1960
I-45 at Springwoods Village Parkway
I-45 at Sawdust Road/Rayford Road
I-45 at Research Forest Drive/Tamina Road
I-45 at SH 242/College Park Drive
I-45 at Loop 336
I-45 at Cypresswood Drive (PM peak only)
I-45 at FM 2920/Spring Cypress Road (PM peak only)

LOS E or LOS F indicates poor traffic operations where long delays and queues can be expected due to high traffic volumes. These conditions generally indicate that the intersection is operating at or near capacity, where the intersection cannot accommodate even slight increases in traffic volumes. Drivers may have to wait for more than one signal cycle to travel through the intersection.

3.2. Future Year 2045 No-Build

3.2.1. Traffic Projection

The existing year 2017 traffic volumes at the study intersections along I-45N between Beltway 8N and Loop 336S were projected to future year 2045 condition based on the growth factors developed by utilizing the 2045 H-GAC travel demand model. The traffic projection methodology involved utilizing annual growth rate to develop future year 2045 no-build traffic volumes for the I-45N freeway and cross streets as described in the I-45N Traffic Projection Methodology Memo (Feb 2018).

3.2.2. Future Year 2045 No-Build LOS

The AM and PM peak period LOS for study intersections were calculated utilizing traffic volumes developed for the future year 2045 no-build scenario. The interchanges shown in **Table 9** were estimated to have at least one intersection operating at LOS F in at least one peak period in the future year 2045 no-build scenario. **Bold and underlined** locations were not listed in **Table 8** of as having LOS E or LOS F in the existing year 2017. Degraded LOS for these intersections is a result of traffic volumes increased beyond intersection capacity.

Table 9. Future Year 2045 No-Build – Interchanges Operating at LOS F

Location
I-45 at Loop 336
I-45 at Crighton Road
I-45 at SH 242/College Park Drive
I-45 at Research Forest Drive/Tamina Road
I-45 at Sawdust/Rayford Road
I-45 at Springwoods Village Parkway
I-45 at SH 99
I-45 at Spring Stuebner
I-45 at FM 2920/Spring Cypress Road
I-45 at Cypresswood Drive
I-45 at FM 1960
I-45 at Richey Road
I-45 at Airtex Drive
I-45 at Rankin Road
I-45 at Greens Road
Cypresswood Road & Holzwarth Road
I-45 at Beltway 8N

Bold and underlined locations were not listed in **Table 8** of as having LOS E or LOS F in the existing year 2017

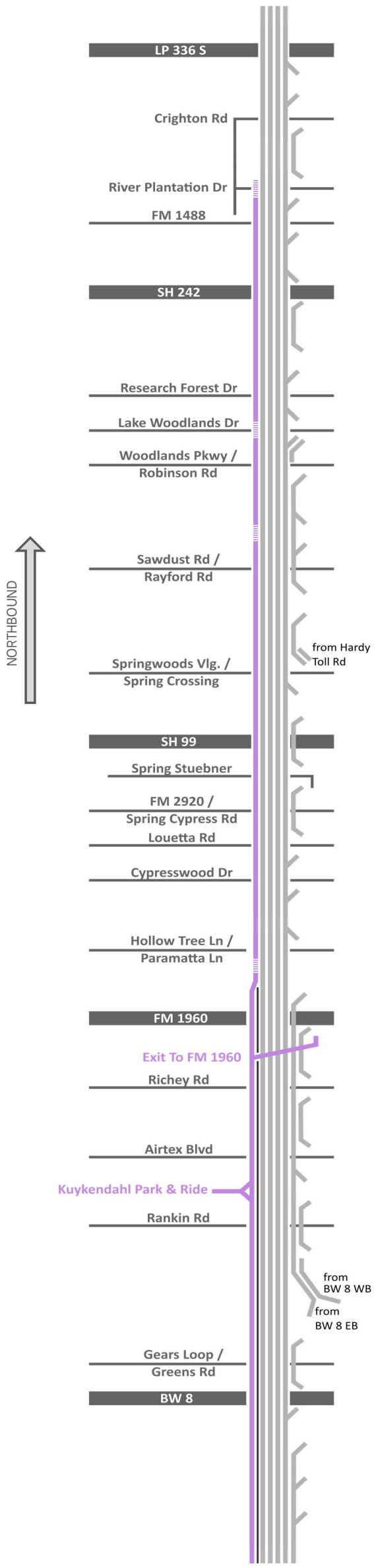
The results of the traffic analysis for the future year 2045 no-build scenario indicate that intersection traffic operations will significantly deteriorate based on the projected traffic volumes. All interchanges would have at least one intersection operating at LOS F in the future. Intersections already operating at LOS E or LOS F today would continue operating poorly with long delays and queues expected.

4. Conclusion

Based on the traffic operation analysis conducted for the I-45N study corridor, traffic congestion, which already exists today for many segments during AM and PM peak hours, will be severely deteriorated in both time and distance due to the rapid growth in population and employment in the Houston Metropolitan area over the next several decades. Without addressing the growing transportation demand, low operating speeds and long traffic queues are expected in 2045 on I-45N mainlanes, ramps, interchanges, frontage roads and intersections, which will lead to poor travel time reliability along the corridor.

In order to address future traffic congestion, the next step in the study is to identify and evaluate the Universe of Alternatives consolidated from different sources including previous plans and studies, Project Ambassador Committee (PAC) meetings, stakeholder and agency meetings and workshops, public meetings, and the I-45N PEL Study team. The Universe of Alternatives will be evaluated and screened based on the study purpose and needs, and other factors such as Right-of-Way (ROW) requirement, environmental and community impacts, and cost-benefit ratio. The conceptual alternative(s) that best meets the mobility, accessibility and safety needs of the corridor will be recommended for the next phase of project development.

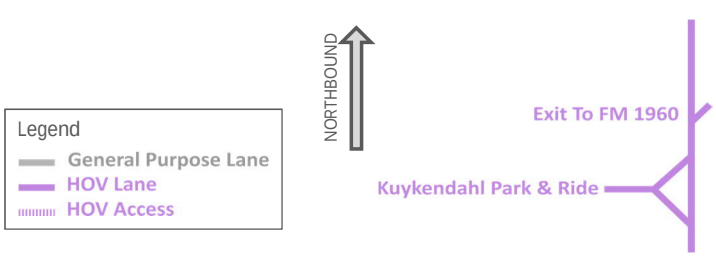
Exhibits



General Purpose Lanes

NORTHBOUND

Location	Ramp	Daily Traffic (ADT) Existing	Peak Hour Demands AM	PM
LP 336 S		69,340	4734	6776
from River Plantation Dr + Crighton Rd	on	4,000	425	322
		65,340	4309	6454
to Loop 336 S	off	17,110	1160	1510
		82,450	5469	7964
to Crighton Rd	off	3,160	195	306
		85,610	5664	8270
from FM 1488	on	11,170	926	1048
		74,440	4738	7222
to River Plantation Dr	off	2,220	47	209
		76,660	4785	7431
to FM 1488	off	13,740	625	1317
		90,400	5410	8748
from SH 242	on	12,720	746	1072
SH 242		77,680	4664	7676
DC to SH 242 WB	off	4,050	328	489
		81,730	4992	8165
from Research Forest Dr	on	11,260	451	1384
		70,470	4541	6781
to SH 242	off	21,260	1709	1548
		91,730	6250	8329
from Robinson Rd + Lake Woodlands Dr	on	16,310	967	1538
		75,420	5283	6791
to Lake Woodlands Dr + Research Forest Dr	off	23,860	2519	1588
		99,280	7802	8379
DC to Woodlands Pkwy WB	off	23,740	1918	1769
		123,020	9720	10148
from Rayford Rd	on	20,240	1272	1428
		102,780	8448	8720
to Robinson Rd	off	5,770	572	693
		108,550	9020	9413
from Spring Crossing Blvd	on	9,540	868	1091
		99,010	8152	8322
to Rayford Rd	off	25,010	1542	1650
		124,020	9694	9972
DC from Hardy Toll Rd	on	17,460	1285	2273
		106,560	8409	7699
DC from SH 99 EB	on	13,560	1399	1055
		93,000	7010	6644
to Hardy Toll Rd + Spring Crossing Blvd	off	4,560	850	269
SH 99		97,560	7860	6913
from Spring Cypress Rd	on	16,330	1448	1096
		81,230	6412	5817
to Spring Stuebner Rd + SH 99	off	14,720	949	1465
		95,950	7361	7282
from Cypresswood Dr + Louetta Rd	on	17,910	1482	1237
		78,040	5879	6045
to Louetta Rd + Spring Cypress Rd	off	27,700	1572	2514
		105,740	7451	8559
to Cypresswood Dr	off	13,670	661	948
		119,410	8112	9507
from FM 1960 + Hollow Tree Ln	on	23,980	1789	1792
		95,430	6323	7715
Ramp from I-45 HOV NB to I-45 NB	on	2,760	Closed	646
		92,670	6323	7069
to Hollow Tree Ln	off	7,610	365	1008
FM 1960		100,280	6688	8077
to FM 1960	off	23,860	1300	1590
		124,140	7988	9667
from Richey Rd	on	8,510	459	718
		115,630	7529	8949
to Richey Rd	off	18,650	926	1226
		134,280	8455	10175
from Airtex Blvd	on	8,910	576	745
		125,370	7879	9430
from Rankin Rd	on	11,630	981	867
		113,740	6898	8563
to Airtex Blvd	off	19,650	1142	1478
		133,390	8040	10041
from Greens Rd	on	9,710	507	1044
		123,680	7533	8997
DC from BW 8 (EB + WB)	on	40,710	2285	2554
BW 8 WB		21,940	1318	1432
BW 8 EB		18,770	967	1122
		82,970	5248	6443
to Rankin Rd	off	15,430	762	1109
		98,400	6010	7552
from BW 8 FR	on	10,620	634	1147
BW 8		87,780	5376	6405
to Greens Rd	off	8,890	526	582
		96,670	5902	6987
DC to BW 8 EB	off	12,630	677	597
		109,300	6579	7584
DC to BW 8 WB	off	18,660	913	1304
		127,960	7492	8888
to BW 8 FR	off	5,750	531	278
South of BW 8		133,710	8023	9166

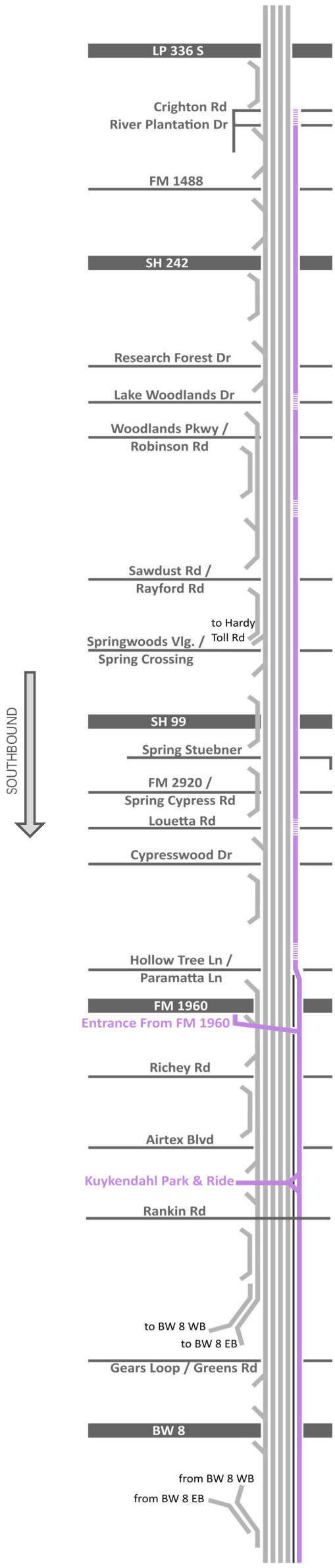


HOV Barrier Separated Lanes

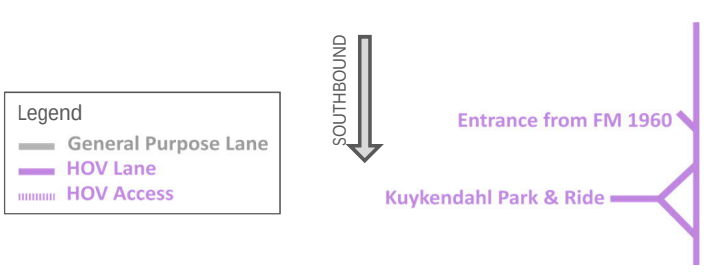
NORTHBOUND

Location	Ramp	Daily Traffic (ADT) Existing	Peak Hour Demands AM	PM
at Barrier Separated Exit		2,760	Closed NB AM	646
to FM 1960	off	576		129
		3,336		775
from Kuykendahl P&R	on	789		225
		2,547		550
to Kuykendahl P&R	off	135		65
South of BW 8		2,682		615

Exhibit 1: Mainlane Traffic Volumes - Existing Year 2017
1 of 2: NB I-45

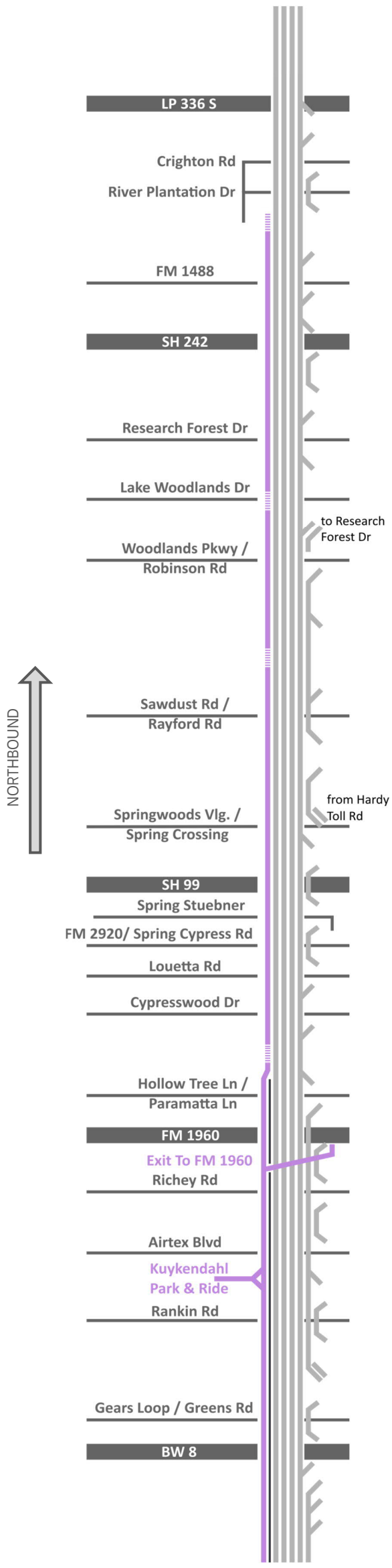


General Purpose Lanes				
SOUTHBOUND		Daily Traffic (ADT)	Peak Hour Demands	
Location	Ramp	Existing	AM	PM
LP 336 S		68,520	5473	5191
from Loop 336 S	on	20,250	2023	1416
		88,770	7496	6607
to Crighton Rd + River Plantation Dr	off	4,320	231	437
		84,450	7265	6170
from Crighton Rd + River Plantation Dr	on	5,100	552	222
		89,550	7817	6392
to FM 1488	off	12,310	882	1178
		77,240	6935	5214
from FM 1488	on	16,460	1660	1067
		93,700	8595	6281
to SH 242	off	17,520	1361	1295
SH 242		76,180	7234	4986
DC from SH 242 WB	on	6,230	784	425
		82,410	8018	5411
to Research Forest Dr	off	10,260	1222	657
		72,150	6796	4754
from SH 242	on	22,020	1404	1776
		94,170	8200	6530
to Lake Woodlands Dr + Woodlands Pkwy	off	17,520	1558	1189
		76,650	6642	5341
from Research Forest Dr + Lake Woodlands Dr	on	26,340	1454	2251
		102,990	8096	7592
DC from Woodlands Pkwy EB	on	19,090	1572	1763
		122,080	9668	9355
to Rayford Rd	off	18,110	1048	1193
		103,970	8620	8162
from Robinson Rd + Valley Wood Dr	on	9,100	639	1238
		113,070	9259	9400
to Spring Crossing Blvd + SH 99	off	9,120	1032	750
		103,950	8227	8650
from Rayford Rd	on	25,690	1873	1604
		129,640	10100	10254
DC to Hardy Toll Rd	off	15,960	2123	1294
		113,680	7977	8960
DC to SH 99 WB	off	14,860	629	1935
		98,820	7348	7025
from Spring Crossing Blvd	on	6,490	363	1068
SH 99		105,310	7711	8093
to Spring Stuebner Rd + Spring Cypress Rd	off	14,430	744	1255
		90,880	6967	6838
from SH 99 + Spring Stuebner Rd	on	15,630	1690	935
		106,510	8657	7773
to Louetta Rd + Cypresswood Dr	off	24,170	1827	1317
		82,340	6830	6456
from Spring Cypress Rd + Louetta Rd	on	20,060	1200	1034
		102,400	8030	7490
from Cypresswood Dr	on	13,680	1169	693
		116,080	9199	8183
to Hollow Tree Ln + FM 1960	off	24,150	1751	1535
		91,930	7448	6648
Ramp from I-45 SB to I-45 HOV SB	off	2,420	383	Closed
		89,510	7065	6648
from Hollow Tree Ln	on	7,400	718	428
FM 1960		96,910	7783	7076
from FM 1960	on	35,930	2064	2321
		132,840	9847	9397
to Richey Rd	off	20,410	1953	1567
		112,430	7894	7830
from Richey Rd	on	16,500	1237	1039
		128,930	9131	8869
to Airtex Blvd	off	8,760	741	509
		120,170	8390	8360
to Rankin Rd	off	11,680	1023	881
		108,490	7367	7479
from Airtex Blvd	on	11,700	894	797
		120,190	8261	8276
from Rankin Rd	on	18,180	1292	942
		138,370	9553	9218
to Greens Rd	off	4,670	500	278
		133,700	9053	8940
DC to BW 8 (EB+WB)	off	55,450	3519	3,250
BW 8 WB		31,900	2434	1908
BW 8 EB		23,550	1085	1342
		78,250	5534	5690
to BW 8 FR	off	6,860	719	517
		71,390	4815	5173
from Greens Rd	on	9,620	760	688
BW 8		81,010	5575	5861
from BW 8 FR	on	6,250	392	539
		87,260	5967	6400
BW 8 WB		12,540	730	710
BW 8 EB		28,340	1892	2205
DC from BW 8 (EB + WB)	on	28,340	2622	2915
South of BW 8		128,140	8589	9315



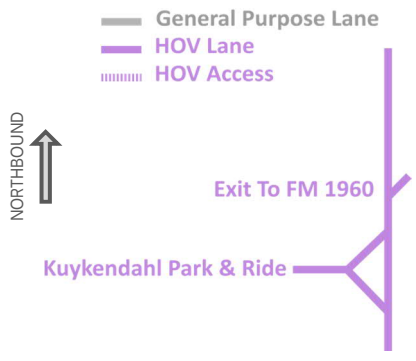
HOV Barrier Separated Lanes				
SOUTHBOUND		Daily Traffic (ADT)	Peak Hour Demands	
Location	Ramp	Existing	AM	PM
at Barrier Separated Exit		2,420	383	Closed SB PM
from FM 1960	on	630	194	
		3,050	577	
to Kuykendahl P&R	off	120	55	
		2,930	522	
from Kuykendahl P&R	on	869	254	
South of BW 8		3,799	776	

Exhibit 1: Mainlane Traffic Volumes - Existing Year 2017
2 of 2: SB I-45



General Purpose Lanes					
NORTHBOUND		AM		PM	
Segment Name	HCM Segment Type	Density	LOS	Density	LOS
from River Plantation Dr + Crighton Rd	Merge	21.1	C	29.9	D
	Basic	17.8	B	26.1	D
to Loop 336 S	Diverge	22.5	C	34.8	D
	Basic	22.5	C	34.8	D
to Crighton Rd from FM 1488	Weave	19.3	C	34.7	D
	ML Access	17.6	B	26.8	D
	Basic	17.7	B	28.3	D
to River Plantation Dr	Diverge	17.8	B	29.4	D
	Basic	17.8	B	29.4	D
to FM 1488	Diverge	20.2	C	38.5	E
from SH 242	Merge	21.8	C	38.6	E
	Basic	17.2	B	30.9	D
DC to SH 242 WB from Research Forest Dr	Weave	14.7	B	30.4	D
	Basic	17.1	B	26.1	D
to SH 242	Diverge	23.8	C	35.2	E
	Overlap	25.9	C	36.8	E
from Robinson Rd + Lake Woodlands Dr	Merge	25.9	C	36.8	E
	Basic	20.4	C	27.4	D
	ML Access	19.8	C	26.3	D
	Basic	19.8	C	26.4	D
to Lake Woodlands Dr + Research Forest Dr	Diverge	23.2	C	25.7	C
	Basic	29.9	D	35.0	D
DC to Woodlands Pkwy WB	Diverge	43.9	E	45.0	E
	Overlap	67.2	F	45.0	E
from Rayford Rd	Merge	67.2	F	45.0	E
	Basic	80.7	F	31.0	D
	ML Access	86.6	F	27.4	D
	Basic	49.2	F	29.7	D
to Robinson Rd	Diverge	37.4	E	33.2	D
	Basic	43.3	E	33.2	D
from Spring Crossing Blvd	Merge	46.7	F	33.2	D
	Basic	42.8	E	33.3	D
to Rayford Rd	Diverge	44.9	E	42.4	E
	Basic	80.7	F	85.7	F
DC from Hardy Toll Rd	Merge	99.4	F	104.2	F
DC from SH 99 EB	Merge	73.6	F	96.4	F
	Basic	55.5	F	108.9	F
to Hardy Toll Rd + Spring Crossing Blvd from Spring Cypress Rd	Weave	40.7	E	93.1	F
	Basic	26.1	D	22.7	C
to Spring Stuebner Rd + SH 99 from Cypresswood Dr + Louetta Rd	Weave	28.4	D	25.0	C
	Basic	23.2	C	23.3	C
to Louetta Rd + Spring Cypress Rd	Diverge	35.6	E	43.2	E
	Basic	35.6	E	43.2	E
to Cypresswood Dr	Diverge	33.1	D	57.8	F
	ML Access	26.4	D	78.4	F
from FM 1960 + Hollow Tree Ln	Merge	36.6	E	59.1	F
	Basic	27.2	D	32.0	D
to Hollow Tree Ln	Diverge	24.7	C	35.1	E
	Basic	22.6	C	29.3	D
to FM 1960 from Richey Rd	Weave	24.3	C	34.8	D
	Basic	26.7	D	35.2	E
to Richey Rd from Airtex Blvd	Weave	26.6	D	39.3	E
	Basic	28.3	D	39.4	E
from Rankin Rd	Merge	28.6	D	39.4	E
	Basic	23.8	C	32.3	D
to Airtex Blvd from Greens Rd	Weave	23.6	C	34.3	D
	Basic	26.7	D	35.4	E
DC from BW 8 (EB + WB)	Merge	21.6	C	27.4	D
	Basic	23.8	C	28.3	D
to Rankin Rd from BW 8 FR	Weave	21.9	C	30.8	D
	Basic	24.5	C	28.3	D
to Greens Rd	Diverge	26.4	D	31.2	D
DC to BW 8 EB	Diverge	23.7	C	26.6	D
DC to BW 8 WB	Diverge	26.9	D	32.0	D
to BW 8 FR	Diverge	28.5	D	33.4	D

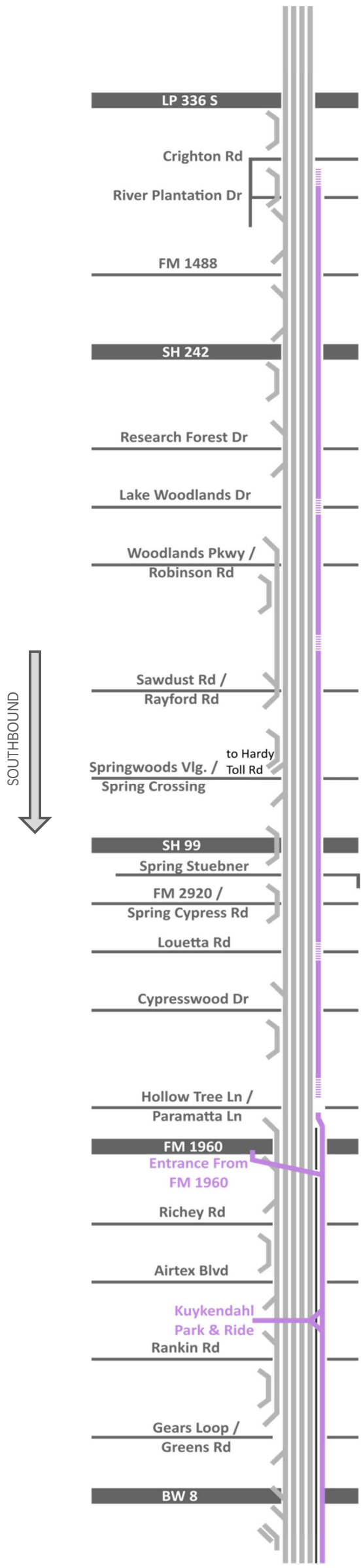
General Purpose Lane
HOV Lane
HOV Access



LOS	Density (pc/mi/ln)
A	0 - 11
B	11 - 18
C	18 - 26
D	26 - 35
E	35 - 45
F	> 45

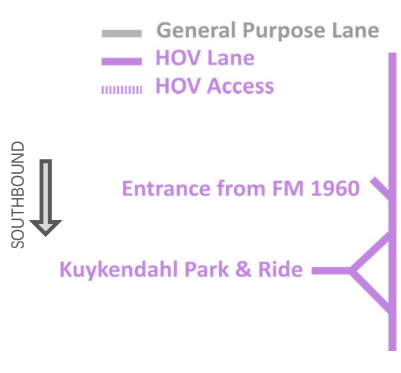
HOV Barrier Separated Lanes					
NORTHBOUND		AM		PM	
Segment Name	HCM Segment Type	Density	LOS	Density	LOS*
	Basic	Closed NB AM		12.3	B
to FM 1960	Diverge			18.7	C
	Basic			15.3	B
from Kuykendahl P&R	Merge			7.2	A
	Basic			11.7	B
to Kuykendahl P&R	Diverge			5.8	A
	Basic			12.2	B

Density (pc/mi/ln): reflects the total density of all lanes in a segment. Merge/Diverge influence area density may be higher or lower than shown.
*Existing 2017 HOV LOS is expected to be LOS C or better.



General Purpose Lanes					
SOUTHBOUND		AM		PM	
Segment Name	HCM Segment Type	Density	LOS	Density	LOS
	Basic	23.6	C	22.0	C
from Loop 336 S to Crighton Rd + River Plantaion Dr	Weave	32.6	D	24.9	C
	Basic	33.7	D	26.4	D
	ML Access	29.1	D	23.7	C
	Basic	32.1	D	25.5	C
from Crighton Rd + River Plantation Dr	Merge	36.4	E	28.6	D
	Basic	36.1	E	26.6	D
to FM 1488	Diverge	36.1	E	26.6	D
	Basic	29.5	D	21.4	C
from FM 1488	Merge	42.7	E	28.3	D
	Basic	42.3	E	26.1	D
to SH 242	Diverge	42.3	E	26.1	D
	Basic	31.6	D	20.4	C
DC from SH 242 WB to Research Forest Dr	Weave	34.7	D	18.1	C
	Basic	29.4	D	19.4	C
from SH 242	Merge	39.9	E	30.2	D
	Overlap	39.9	E	30.2	D
to Lake Woodlands Dr + Woodlands Pkwy	Diverge	39.3	E	27.3	D
	Basic	28.9	D	21.8	C
	ML Access	26.2	D	21.2	C
	Basic	28.7	D	19.9	C
from Research Forest Dr + Lake Woodlands Dr	Merge	27.7	D	34.3	D
	Basic	27.7	D	37.8	E
DC from Woodlands Pkwy EB to Rayford Rd	Weave	33.3	D	54.8	F
	Basic	30.3	D	59.0	F
	ML Access	28.4	D	62.9	F
	Basic	30.1	D	77.9	F
from Robinson Rd + Valley Wood Dr	Merge	34.5	D	57.6	F
to Spring Crossing Blvd + SH 99	Diverge	33.6	D	63.7	F
	Basic	41.0	E	67.5	F
from Rayford Rd DC to Hardy Toll Rd	Weave	45.0	E	68.4	F
	Basic	42.7	E	42.5	E
DC to SH 99 WB	Diverge	42.7	E	42.5	E
	Basic	31.2	D	22.2	C
from Spring Crossing Blvd to Spring Stuebner Rd + Spring Cypress Rd	Weave	30.5	D	21.5	C
	Basic	29.0	D	20.6	C
from SH 99 + Spring Stuebner Rd to Louetta Rd + Cypresswood Dr	Weave	32.1	D	21.0	C
	Basic	28.4	D	19.7	C
	ML Access	26.2	D	23.6	C
	Basic	28.2	D	22.3	C
from Spring Cypress Rd + Louetta Rd	Merge	37.1	E	29.3	D
	Basic	36.0	E	26.9	D
from Cypresswood Dr to Hollow Tree Ln + FM 1960	Weave	36.0	E	24.4	C
	Basic	32.6	D	23.6	C
	ML Access	29.3	D	25.0	C
	Basic	32.5	D	26.2	D
from Hollow Tree Ln	Merge	30.1	D	22.0	C
	Basic	32.0	D	22.0	C
from FM 1960	Merge	53.3	F	33.7	D
	Overlap	53.3	F	33.7	D
to Richey Rd	Diverge	43.9	E	30.3	D
	Basic	39.3	E	24.3	C
from Richey Rd to Airtex Blvd	Weave	62.0	F	25.2	C
	Basic	60.1	F	26.4	D
to Rankin Rd	Diverge	63.4	F	26.4	D
	Basic	83.6	F	23.3	C
from Airtex Blvd	Merge	91.2	F	34.0	D
	Basic	92.4	F	52.0	F
from Rankin Rd to Greens Rd	Weave	77.4	F	79.6	F
DC to BW 8 (EB + WB)	Diverge	41.4	E	43.6	E
	Basic	22.2	C	31.6	D
to BW 8 FR	Diverge	22.2	C	43.6	E
	Basic	19.9	C	129.6	F
from Greens Rd	Merge	24.7	C	118.0	F
from BW 8 FR	Merge	26.9	D	108.7	F
DC from BW 8 (EB + WB)	Merge	38.7	E	93.7	F

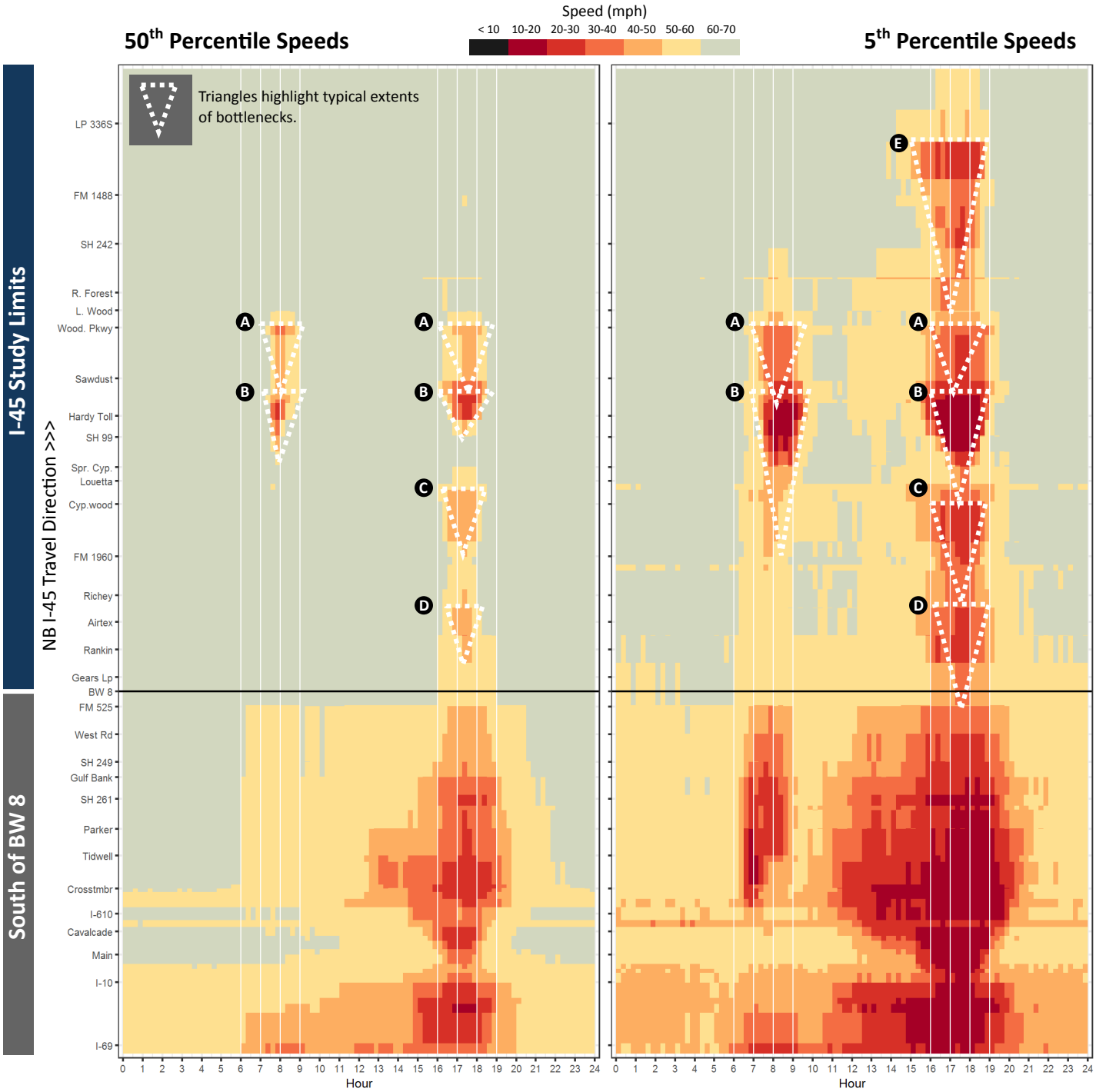
LOS	Density (pc/mi/ln)
A	0 - 11
B	11 - 18
C	18 - 26
D	26 - 35
E	35 - 45
F	> 45



HOV Barrier Separated Lanes					
SOUTHBOUND		AM		PM	
Segment Name	HCM Segment Type	Density	LOS*	Density	LOS
	Basic	13.0	B	Closed SB PM	
from FM 1960	Merge	15.8	B		
	Basic	15.9	B		
to Kuykendahl P&R	Diverge	7.4	A		
	Basic	15.5	B		
from Kuykendahl P&R	Merge	8.9	A		
	Basic	20.2	C		

Density (pc/mi/ln): reflects the total density of all lanes in a segment. Merge/Diverge influence area density may be higher or lower than shown.
*Existing 2017 HOV LOS is expected to be LOS C or better.

Exhibit 2: Mainlane Level of Service - Existing Year 2017
2 of 2: SB I-45



Bottlenecks within I-45 Study Limits

Primary, Recurring Bottlenecks
(50th percentile speeds < 40 mph)

A Woodlands Pkwy Diverge
AM & PM peak, typically extends to Hardy Toll Rd bottleneck.

B Hardy Toll Road Merge
AM & PM peak, typically extends to Spring Cypress Rd, can extend to Cypresswood Dr.

Secondary Bottlenecks
(50th percentile speeds < 50 mph)

C Louetta Rd Diverge
Typically PM peak, extending back to FM 1960.

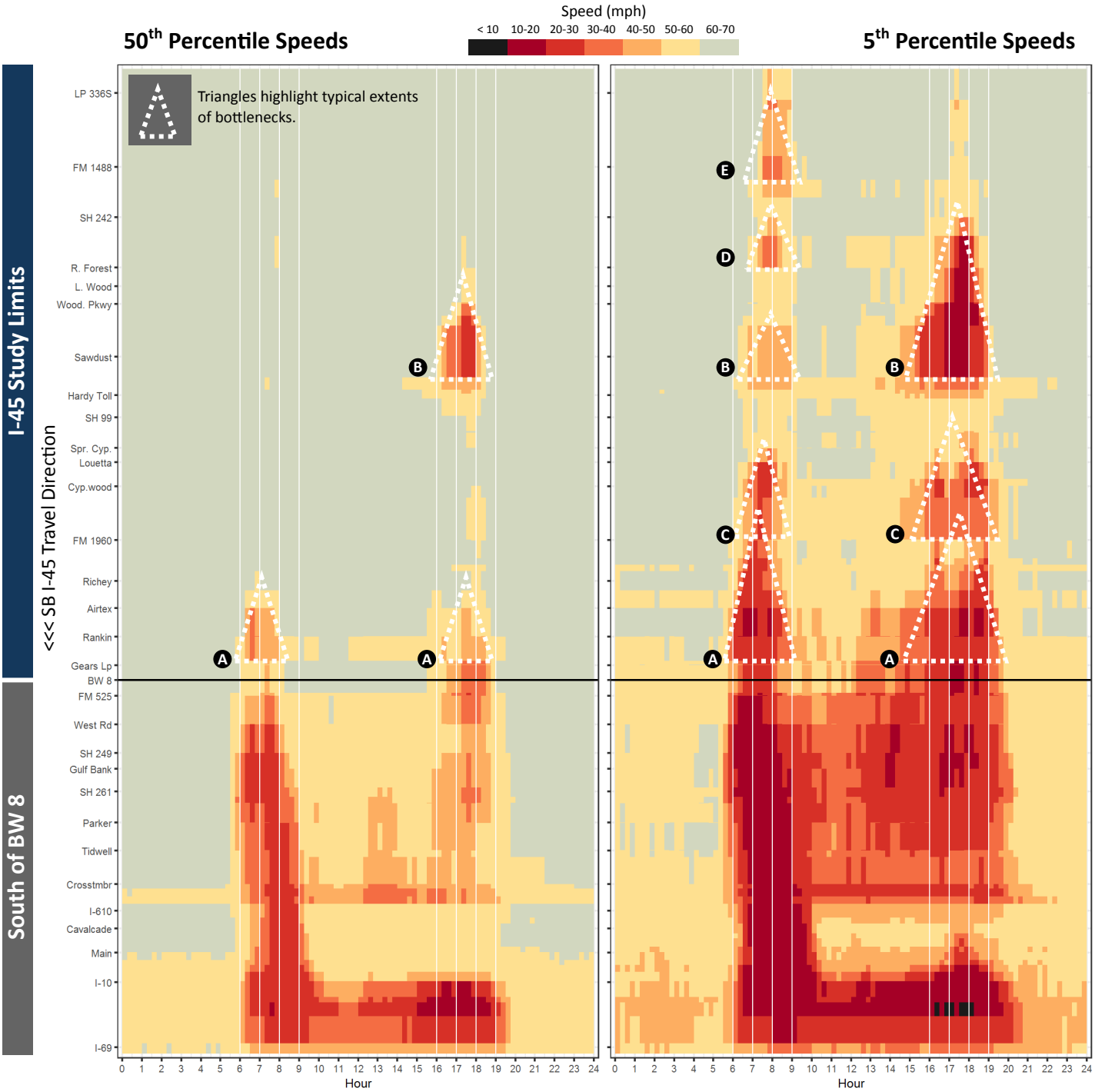
D Airtex Dr Diverge
Typically PM peak, extending back to Rankin Rd

Intermittent Bottlenecks
(5th Percentile Speeds < 40 mph)

E LP 336 S / End of HOV Lane
Occasionally occurs in PM peak, can extend past FM 1488

Texas Department of Transportation

Exhibit 3: Existing Mainlane Bottlenecks
1 of 2: NB I-45



Bottlenecks within I-45 Study Limits

Primary, Recurring Bottlenecks
(50th percentile speeds < 40 mph)

A Beltway 8 Diverge
AM & PM peak, typically extends to Richey Rd. Congestion south of BW 8 can intensify this bottleneck.

B SH 99, Hardy Toll Road Diverges
Typically PM peak, extending to Lake Woodlands Dr. Can extend to SH 242.

Secondary Bottlenecks
(50th percentile speeds < 50 mph)

No secondary bottlenecks observed.

Intermittent Bottlenecks
(5th Percentile Speeds < 40 mph)

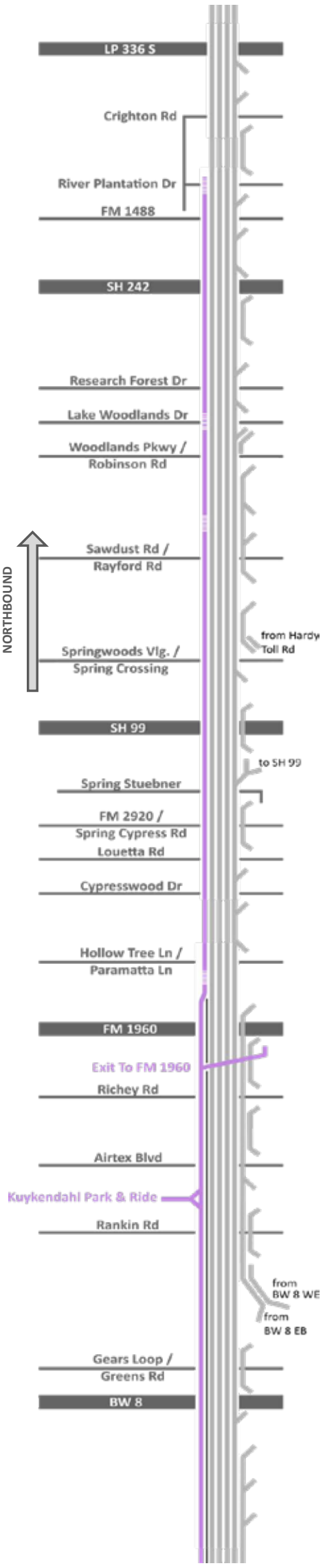
C Spring Stuebner / Louetta Weave
Occasionally occurs in AM & PM, can extend to SH 99. Decreases downstream speeds to FM 1960.

D SH 242 Merge / Lake Woodlands Diverge
Occasionally occurs in AM peak, extends to SH 242.

E FM 1488 Merge / SH 242 Diverge
Occasionally occurs in AM peak, can extend to LP 336 S.

Texas Department of Transportation

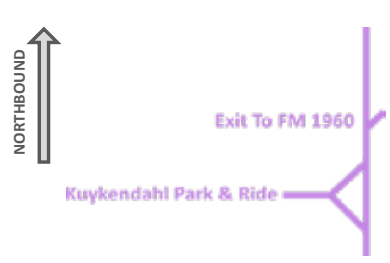
Exhibit 3: Existing Mainlane Bottlenecks 2 of 2: SB I-45



General Purpose Lanes

NORTHBOUND I-45

Location	Ramp	Daily Traffic (ADT) Existing	CAGR	Future	Peak Hour Demands Existing Year 2017 AM	PM	CAGR AM	CAGR PM	Future Year 2045 AM	PM
LP 336 S		69,340	1.4%	101,260	4734	6776	1.4%	1.6%	7027	10565
from River Plantation Dr + Crighton Rd	on	4,000	2.8%	8,730	425	322	2.8%	2.8%	927	703
		65,340	1.3%	92,530	4309	6454	1.2%	1.5%	6100	9862
to Loop 336 S	off	17,110	1.5%	25,760	1160	1510	1.5%	1.5%	1746	2273
		82,450	1.3%	118,290	5469	7964	1.3%	1.5%	7846	12135
to Crighton Rd	off	3,160	3.4%	8,020	195	306	3.4%	3.4%	496	777
		85,610	1.4%	126,310	5664	8270	1.4%	1.6%	8342	12912
from FM 1488	on	11,170	0.2%	11,880	926	1048	0.2%	0.2%	984	1114
		74,440	1.5%	114,430	4738	7222	1.6%	1.8%	7358	11798
to River Plantation Dr	off	2,220	2.9%	4,950	47	209	2.9%	2.9%	104	466
		76,660	1.6%	119,380	4785	7431	1.6%	1.8%	7462	12264
to FM 1488	off	13,740	0.8%	17,360	625	1317	0.8%	0.8%	789	1664
		90,400	1.5%	136,740	5410	8748	1.5%	1.7%	8251	13928
from SH 242	on	12,720	1.9%	21,830	746	1072	1.9%	1.9%	1281	1840
SH 242		77,680	1.4%	114,910	4664	7676	1.4%	1.6%	6970	12088
DC to SH 242 WB	off	4,050	3.1%	9,450	328	489	3.1%	3.1%	765	1140
		81,730	1.5%	124,360	4992	8165	1.6%	1.7%	7735	13228
from Research Forest Dr	on	11,260	1.4%	16,520	451	1384	1.4%	1.4%	662	2031
		70,470	1.5%	107,840	4541	6781	1.6%	1.8%	7073	11197
to SH 242	off	21,260	2.1%	38,110	1709	1548	1.2%	1.6%	2401	2401
		91,730	1.7%	145,950	6250	8329	1.5%	1.8%	9474	13598
from Robinson Rd + Lake Woodlands Dr	on	16,310	1.0%	21,380	967	1538	1.0%	1.0%	1268	2016
		75,420	1.8%	124,570	5283	6791	1.6%	1.9%	8206	11582
to Lake Woodlands Dr + Research Forest Dr	off	23,860	1.1%	32,340	2519	1588	1.1%	1.1%	3414	2152
		99,280	1.6%	156,910	7802	8379	1.4%	1.8%	11620	13734
DC to Woodlands Pkwy WB	off	23,740	0.7%	28,470	1918	1769	0.7%	0.7%	2300	2121
		123,020	1.5%	185,380	9720	10148	1.3%	1.6%	13920	15855
from Rayford Rd	on	20,240	1.2%	27,890	1272	1428	1.2%	1.2%	1752	1967
		102,780	1.5%	157,490	8448	8720	1.3%	1.7%	12168	13888
to Robinson Rd	off	5,770	0.4%	6,460	572	693	0.4%	0.4%	640	776
		108,550	1.5%	163,950	9020	9413	1.3%	1.6%	12808	14664
from Spring Crossing Blvd	on	9,540	0.8%	11,910	868	1091	3.1%	2.9%	2034	2401
		99,010	1.5%	152,040	8152	8322	1.0%	1.4%	10774	12263
to Rayford Rd	off	25,010	0.9%	32,530	1542	1650	0.9%	0.9%	2006	2147
		124,020	1.4%	184,570	9694	9972	1.0%	1.3%	12780	14410
DC from Hardy Toll Rd	on	17,460	2.9%	38,820	1285	2273	2.9%	2.7%	2857	4801
		106,560	1.1%	145,750	8409	7699	0.6%	0.8%	9923	9609
DC from SH 99 (EB + WB)	on	13,560	2.5%	27,400	1399	1055	1.9%	2.5%	2400	2132
		93,000	0.9%	118,350	7010	6644	0.3%	0.4%	7523	7477
to Hardy Toll Rd + Spring Crossing Blvd	off	4,560	3.6%	12,330	850	269	3.6%	3.6%	2299	728
SH 99		97,560	1.0%	130,680	7860	6913	0.8%	0.6%	9822	8205
from Spring Cypress Rd	on	16,330	1.8%	26,730	1448	1096	1.8%	1.8%	2371	1794
		81,230	0.9%	103,950	6412	5817	0.5%	0.3%	7451	6411
to SH 99 (EB + WB) DC	off	-	-	25,000	-	-	-	-	1631	1760
		-	-	128,950	-	-	-	-	9082	8171
to Spring Stuebner Rd + SH 99	off	14,720	0.5%	16,950	949	1465	0.5%	0.5%	1092	1687
		95,950	1.5%	145,900	7361	7282	1.2%	1.1%	10174	9858
from Cypresswood Dr + Louetta Rd	on	17,910	3.0%	40,430	1482	1237	1.7%	2.4%	2401	2401
		78,040	1.1%	105,470	5879	6045	1.0%	0.8%	7773	7457
to Louetta Rd + Spring Cypress Rd	off	27,700	1.6%	43,640	1572	2514	1.5%	1.3%	2400	3600
		105,740	1.2%	149,110	7451	8559	1.1%	0.9%	10173	11057
to Cypresswood Dr	off	13,670	1.0%	18,160	661	948	1.0%	1.0%	879	1259
		119,410	1.2%	167,270	8112	9507	1.1%	0.9%	11052	12316
from FM 1960 + Hollow Tree Ln	on	23,980	1.3%	34,130	1789	1792	1.1%	1.1%	2401	2401
		95,430	1.2%	133,140	6323	7715	1.1%	0.9%	8651	9915
Ramp from I-45 HOV NB to I-45 NB	on	2,760	3.4%	7,040	Closed	646	Closed	3.4%	Closed	1647
		92,670	1.1%	126,100	6323	7069	1.1%	0.6%	8651	8268
to Hollow Tree Ln	off	7,610	2.6%	15,680	365	1008	2.6%	2.6%	753	2077
FM 1960		100,280	1.2%	141,780	6688	8077	1.2%	0.9%	9404	10345
to FM 1960	off	23,860	0.5%	27,100	1300	1590	0.5%	0.5%	1477	1806
		124,140	1.1%	168,880	7988	9667	1.1%	0.8%	10881	12151
from Richey Rd	on	8,510	2.3%	16,260	459	718	2.3%	2.3%	878	1372
		115,630	1.0%	152,620	7529	8949	1.0%	0.7%	10003	10779
to Richey Rd	off	18,650	1.6%	29,340	926	1226	1.6%	1.6%	1457	1929
		134,280	1.1%	181,960	8455	10175	1.1%	0.8%	11460	12708
from Airtex Blvd	on	8,910	2.1%	15,750	576	745	2.1%	2.1%	1019	1317
		125,370	1.0%	166,210	7879	9430	1.0%	0.7%	10441	11391
from Rankin Rd	on	11,630	1.3%	16,590	981	867	1.3%	1.3%	1399	1236
		113,740	1.0%	149,620	6898	8563	1.0%	0.6%	9042	10155
to Airtex Blvd	off	19,650	1.5%	29,680	1142	1478	1.5%	1.5%	1724	2233
		133,390	1.1%	179,300	8040	10041	1.0%	0.8%	10766	12388
from Greens Rd	on	9,710	2.1%	17,340	507	1044	2.1%	2.1%	906	1864
		123,680	1.0%	161,960	7533	8997	1.0%	0.6%	9860	10524
DC from BW 8 (EB + WB)	on	40,710	1.4%	59,640	2285	2554	1.4%	1.4%	3349	3741
BW 8 WB		21,940	1.4%	32,270	1318	1432	1.4%	1.4%	1939	2106
BW 8 EB		18,770	1.4%	27,370	967	1122	1.4%	1.4%	1410	1635
		82,970	0.8%	102,320	5248	6443	0.8%	0.2%	6511	6783
to Rankin Rd	off	15,430	0.9%	19,750	762	1109	0.9%	0.9%	975	1420
		98,400	0.8%	122,070	6010	7552	0.8%	0.3%	7486	8203
from BW 8 FR	on	10,620	1.5%	15,980	634	1147	1.5%	1.5%	953	1726
BW 8		87,780	0.7%	106,090	5376	6405	0.7%	0.0%	6533	6477
to Greens Rd	off	8,890	1.5%	13,500	526	582	1.5%	1.5%	799	884
		96,670	0.8%	119,590	5902	6987	0.8%	0.2%	7332	7361
DC to BW 8 EB	off	12,630	0.8%	15,720	677	597	0.8%	0.8%	842	743
		109,300	0.8%	135,310	6579	7584	0.8%	0.2%	8174	8104
DC to BW 8 WB	off	18,660	0.7%	22,870	913	1304	0.7%	0.7%	1119	1598
		127,960	0.8%	158,180	7492	8888	0.8%	0.3%	9293	9702
to BW 8 FR	off	5,750	0.2%	6,160	531	278	0.2%	0.2%	568	298
South of BW 8		133,710	0.7%	164,340	8023	9166	0.7%	0.3%	9861	10000



HOV Barrier Separated Lanes

NORTHBOUND

Location	Ramp	Daily Traffic (ADT) Existing	CAGR	Future	Peak Hour Demands Existing Year 2017 AM	PM	CAGR AM	CAGR PM	Future Year 2045 AM	PM
at Barrier Separated Exit		2,760	3.4%	7,040	Closed NB AM	646	Closed NB AM	3.4%	Closed NB AM	1647
to FM 1960	off	576	3.4%	1,469		129		3.4%		329
		3,336	3.4%	8,509		775		3.4%		1976
from Kuykendahl P&R	on	789	3.4%	2,011		225		3.4%		573
		2,547	3.4%	6,498		550		3.4%		1403
to Kuykendahl P&R	off	135	3.4%	344		65		3.4%		167
South of BW 8		2,682	3.4%	6,842		615		3.4%		1570

Notes:

General Purpose Lane
HOV Lane
HOV Access

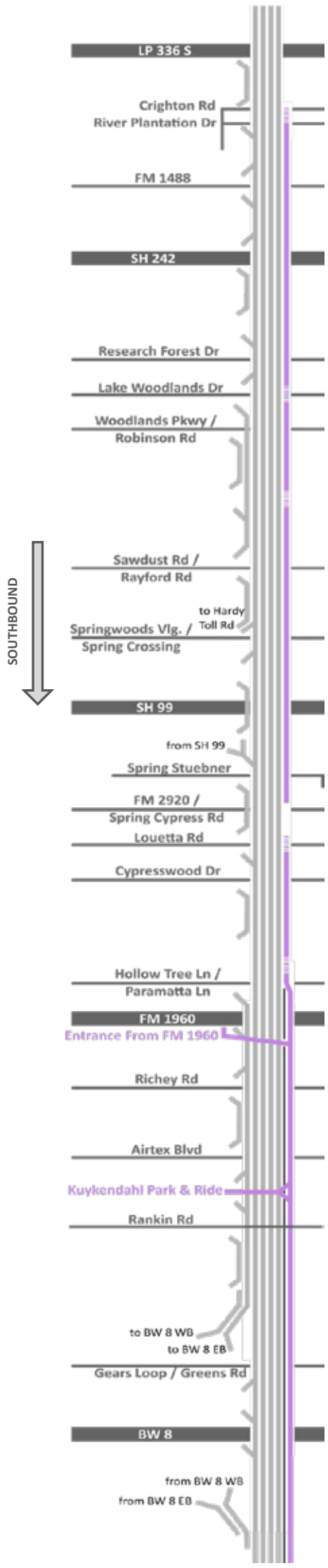
CAGR is the Compound Annual Growth Rate

$$CAGR = \left(\frac{V_{FY}}{V_{EY}}\right)^{\frac{1}{FY-EY}} - 1$$

V is the traffic volume,
EY is the existing year (2017), and
FY is the future year (2045).

For 1-lane ramps:
XXX ADT = 25,000 - 35,000 vehicle/day
XXX ADT ≥ 35,000 vehicle/day

Exhibit 4: Mainlane Traffic Volumes - Existing Year 2017 and Future Year 2045 No-Build
1 of 2: NB I-45



General Purpose Lanes

SOUTHBOUND I-45

Location	Ramp	Daily Traffic (ADT) Existing	CAGR	Future	Peak Hour Demands Existing Year 2017 AM	PM	CAGR AM	CAGR PM	Future Year 2045 AM	PM
LP 336 S		68,520	1.4%	101,800	5473	5191	1.4%	1.4%	8131	7712
from Loop 336 S	on	20,250	1.6%	31,840	2023	1416	0.6%	1.6%	2401	2226
		88,770	1.5%	133,640	7496	6607	1.2%	1.5%	10532	9938
to Crighton Rd + River Plantation Dr	off	4,320	2.5%	8,510	231	437	2.5%	2.5%	456	861
		84,450	1.4%	125,130	7265	6170	1.2%	1.4%	10076	9077
from Crighton Rd + River Plantation Dr	on	5,100	2.0%	8,960	552	222	2.0%	2.0%	970	389
		89,550	1.5%	134,090	7817	6392	1.2%	1.4%	11046	9466
to FM 1488	off	12,310	0.1%	12,530	882	1178	0.1%	0.1%	898	1199
		77,240	1.6%	121,560	6935	5214	1.4%	1.7%	10148	8267
from FM 1488	on	16,460	0.8%	20,600	1660	1067	0.8%	0.8%	2077	1335
		93,700	1.5%	142,160	8595	6281	1.3%	1.5%	12225	9602
to SH 242	off	17,520	1.8%	29,000	1361	1295	1.8%	1.8%	2252	2144
SH 242		76,180	1.4%	113,160	7234	4986	1.2%	1.4%	9973	7458
DC from SH 242 WB	on	6,230	2.8%	13,500	784	425	2.8%	2.8%	1700	922
		82,410	1.5%	126,660	8018	5411	1.4%	1.6%	11673	8380
to Research Forest Dr	off	10,260	1.3%	14,530	1222	657	1.2%	1.3%	1730	931
		72,150	1.6%	112,130	6796	4754	1.4%	1.6%	9943	7449
from SH 242	on	22,020	2.1%	39,520	1404	1776	1.9%	1.1%	2400	2400
		94,170	1.7%	151,650	8200	6530	1.5%	1.5%	12343	9849
to Lake Woodlands Dr + Woodlands Pkwy	off	17,520	0.9%	22,280	1558	1189	0.9%	0.9%	1982	1512
		76,650	1.9%	129,370	6642	5341	1.6%	1.6%	10361	8337
from Research Forest Dr + Lake Woodlands Dr	on	26,340	0.3%	29,020	1454	2251	0.3%	0.2%	1602	2401
		102,990	1.5%	158,390	8096	7592	1.4%	1.2%	11963	10738
DC from Woodlands Pkwy EB	on	19,090	0.7%	23,100	1572	1763	0.7%	0.7%	1902	2133
		122,080	1.4%	181,490	9668	9355	1.3%	1.1%	13865	12871
to Rayford Rd	off	18,110	1.2%	25,150	1048	1193	1.2%	1.2%	1455	1656
		103,970	1.5%	156,340	8620	8162	1.3%	1.1%	12410	11215
from Robinson Rd + Valley Wood Dr	on	9,100	1.6%	14,230	639	1238	1.6%	1.6%	1000	1937
		113,070	1.5%	170,570	9259	9400	1.3%	1.2%	13410	13152
to Spring Crossing Blvd + SH 99	off	9,120	1.9%	15,320	1032	750	1.9%	1.9%	1733	1259
		103,950	1.4%	155,250	8227	8650	1.3%	1.1%	11677	11893
from Rayford Rd	on	25,690	0.9%	33,150	1873	1604	0.9%	0.9%	2387	2069
		129,640	1.3%	188,400	10100	10254	1.2%	1.1%	14064	13962
DC to Hardy Toll Rd	off	15,960	2.8%	34,690	2123	1294	2.8%	2.8%	4614	2812
		113,680	1.1%	153,710	7977	8960	0.6%	0.8%	9450	11150
DC to SH 99 EB + WB	off	14,860	1.9%	25,000	629	1935	1.9%	0.8%	1058	2400
		98,820	0.9%	128,710	7348	7025	0.5%	0.8%	8392	8750
from Spring Crossing Blvd	on	6,490	3.6%	17,330	363	1068	3.6%	2.9%	969	2401
SH 99		105,310	1.2%	146,040	7711	8093	0.7%	1.2%	9361	11151
to Spring Stuebner Rd + Spring Cypress Rd	off	14,430	2.3%	27,200	744	1255	2.3%	2.3%	1402	2369
		90,880	1.0%	118,840	6967	6838	0.5%	0.9%	7959	8782
DC from SH 99 (EB + WB) to I-45 SB	on	-	-	23,400	-	-	-	-	2400	1400
		-	-	142,240	-	-	-	-	10359	10182
from SH 99 + Spring Stuebner Rd	on	15,630	0.5%	17,970	1690	935	0.5%	0.5%	1943	1075
		106,510	1.5%	160,210	8657	7773	1.3%	1.3%	12302	11257
to Louetta Rd + Cypresswood Dr	off	24,170	2.8%	52,640	1827	1317	1.5%	2.7%	2800	2800
		82,340	1.0%	107,570	6830	6456	1.2%	1.0%	9502	8457
from Spring Cypress Rd + Louetta Rd	on	20,060	1.7%	32,350	1200	1034	1.7%	1.7%	1935	1667
		102,400	1.1%	139,920	8030	7490	1.3%	1.1%	11437	10124
from Cypresswood Dr	on	13,680	1.2%	19,230	1169	693	1.2%	1.2%	1643	974
		116,080	1.1%	159,150	9199	8183	1.3%	1.1%	13080	11098
to Hollow Tree Ln + FM 1960	off	24,150	0.8%	29,870	1751	1535	0.8%	0.8%	2166	1898
		91,930	1.2%	129,280	7448	6648	1.4%	1.2%	10914	9200
Ramp from I-45 SB to I-45 HOV SB	off	2,420	1.2%	3,380	383	Closed	1.2%	Closed	535	Closed
		89,510	1.2%	125,900	7065	6648	1.4%	1.2%	10379	9200
from Hollow Tree Ln	on	7,400	0.4%	8,290	718	428	0.4%	0.4%	804	480
FM 1960		96,910	1.2%	134,190	7783	7076	1.3%	1.1%	11183	9680
from FM 1960	on	35,930	0.8%	45,030	2064	2321	0.5%	0.1%	2400	2400
		132,840	1.1%	179,220	9847	9397	1.2%	0.9%	13583	12080
to Richey Rd	off	20,410	2.0%	35,580	1953	1567	0.7%	1.5%	2400	2400
		112,430	0.9%	143,640	7894	7830	1.3%	0.8%	11183	9680
from Richey Rd	on	16,500	1.8%	27,360	1237	1039	1.8%	1.8%	2051	1723
		128,930	1.0%	171,000	9131	8869	1.3%	0.9%	13234	11403
to Airtex Blvd	off	8,760	1.8%	14,630	741	509	1.8%	1.9%	1238	851
		120,170	0.9%	156,370	8390	8360	1.3%	0.8%	11996	10552
to Rankin Rd	off	11,680	1.2%	16,100	1023	881	1.2%	1.2%	1410	1214
		108,490	0.9%	140,270	7367	7479	1.3%	0.8%	10586	9338
from Airtex Blvd	on	11,700	1.6%	18,470	894	797	1.6%	1.6%	1411	1259
		120,190	1.0%	158,740	8261	8276	1.3%	0.9%	11997	10597
from Rankin Rd	on	18,180	0.9%	23,490	1292	942	0.9%	0.9%	1669	1218
		138,370	1.0%	182,230	9553	9218	1.3%	0.9%	13666	11815
to Greens Rd	off	4,670	2.2%	8,700	500	278	2.2%	2.2%	931	517
		133,700	0.9%	173,530	9053	8940	1.2%	0.8%	12735	11298
DC to BW 8 (EB+WB)	off	55,450	1.2%	77,570	3519	3,250	0.4%	1.0%	3,931	4292
BW 8 WB		31,900	1.2%	44,380	2434	1908	0.0%	0.8%	2401	2401
BW 8 EB		23,550	1.2%	33,190	1085	1342	1.2%	1.2%	1530	1891
		78,250	0.7%	95,960	5534	5690	1.7%	0.7%	8804	7006
to BW 8 FR	off	6,860	1.4%	10,130	719	517	1.4%	1.4%	1062	763
		71,390	0.7%	85,830	4815	5173	1.7%	0.7%	7742	6243
from Greens Rd	on	9,620	0.9%	12,450	760	688	0.9%	0.9%	984	891
BW 8		81,010	0.7%	98,280	5575	5861	1.6%	0.7%	8726	7134
from BW 8 FR	on	6,250	0.7%	7,650	392	539	0.7%	0.7%	480	660
		87,260	0.7%	105,930	5967	6400	1.6%	0.7%	9206	7794
BW 8 WB		12,540	0.9%	16,300	730	710	0.9%	0.9%	949	923
BW 8 EB		28,340	1.0%	37,710	1892	2205	0.9%	0.3%	2401	2401
DC from BW 8 (EB + WB)	on	28,340	2.3%	54,010	2622	2915	0.9%	0.5%	3350	3324
South of BW 8		128,140	0.8%	159,940	8589	9315	1.4%	0.6%	12556	11118

HOV Barrier Separated Lanes

SOUTHBOUND

Location	Ramp	Daily Traffic (ADT) Existing	CAGR	Future	Peak Hour Demands Existing Year 2017 AM	PM	CAGR AM	CAGR PM	Future Year 2045 AM	PM
at Barrier Separated Exit		2420	1.2%	3380	383	Closed SB PM	1.2%	Closed SB PM	535	Closed SB PM
from FM 1960	on	630	1.2%	882	194		1.2%		272	
		3050	1.2%	4262	577		1.2%		807	
to Kuykendahl P&R	off	120	1.2%	169	55		1.2%		77	
		2930	1.2%	4093	522		1.2%		730	
from Kuykendahl P&R	on	869	1.2%	1217	254		1.2%		355	
South of BW 8		3799	1.2%	5310	776		1.2%		1085	

Notes:

General Purpose Lane
HOV Lane
HOV Access

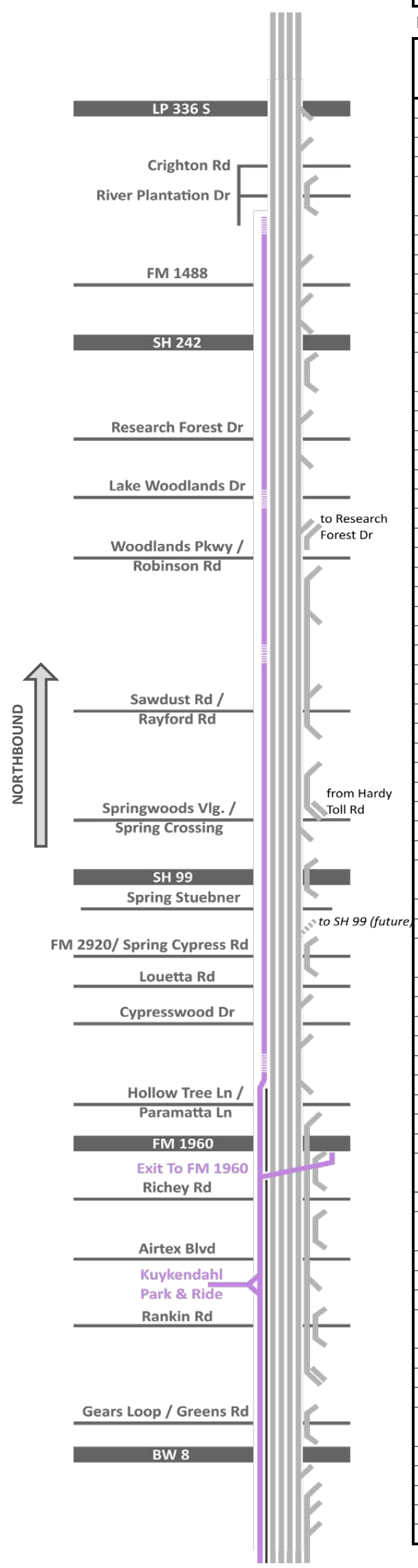
CAGR is the Compound Annual Growth Rate

$$CAGR = \left(\frac{V_{FY}}{V_{EY}}\right)^{\frac{1}{FY-EY}} - 1$$

V is the traffic volume,
EY is the existing year (2017), and
FY is the future year (2045).

For 1-lane ramps:
XXX ADT = 25,000 - 35,000 vehicle/day
XXX ADT ≥ 35,000 vehicle/day

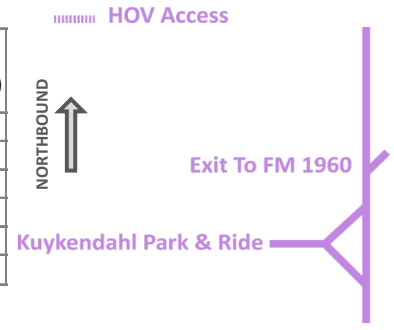
Exhibit 4: Mainlane Traffic Volumes - Existing Year 2017 and Future Year 2045 No-Build
2 of 2: SB I-45



General Purpose Lanes		2017 Existing				2045 No-Build			
NORTHBOUND		AM		PM		AM		PM	
Segment Name	HCM Segment Type	Density	LOS	Density	LOS	Density	LOS	Density	LOS
from River Plantation Dr + Crighton Rd	Merge	21.1	C	29.9	D	24.8	C	31.9	D
	Basic	17.8	B	26.1	D	19.3	C	26.8	D
to Loop 336 S	Diverge	22.5	C	34.8	D	25.5	C	35.8	E
	Basic	22.5	C	34.8	D	25.5	C	35.8	E
to Crighton Rd from FM 1488	Weave	19.3	C	34.7	D	24.0	C	37.7	E
	ML Access	17.6	B	26.8	D	22.4	C	30.5	D
	Basic	17.7	B	28.3	D	20.6	C	29.6	D
to River Plantation Dr	Diverge	17.8	B	29.4	D	20.9	C	31.1	D
	Basic	17.8	B	29.4	D	20.9	C	31.1	D
to FM 1488	Diverge	20.2	C	38.5	E	23.6	C	38.9	E
from SH 242	Merge	21.8	C	38.6	E	25.7	C	40.1	E
	Basic	17.2	B	30.9	D	19.2	C	75.0	F
DC to SH 242 WB from Research Forest Dr	Weave	14.7	B	30.4	D	16.9	B	64.7	F
	Basic	17.1	B	26.1	D	19.2	C	28.8	D
to SH 242	Diverge	23.8	C	35.2	E	28.4	D	40.9	E
	Overlap	25.9	C	36.8	E	30.7	D	43.6	E
from Robinson Rd + Lake Woodlands Dr	Merge	25.9	C	36.8	E	30.7	D	43.6	E
	Basic	20.4	C	27.4	D	26.1	D	28.8	D
	ML Access	19.8	C	26.3	D	25.2	C	30.3	D
	Basic	19.8	C	26.4	D	25.0	C	26.5	D
to Lake Woodlands Dr + Research Forest Dr	Diverge	23.2	C	25.7	C	24.3	C	24.9	C
	Basic	29.9	D	35.0	D	32.4	D	33.5	D
DC to Woodlands Pkwy WB	Diverge	43.9	E	45.0	E	36.9	E	40.3	E
	Overlap	67.2	F	45.0	E	69.0	F	40.3	E
from Rayford Rd	Merge	67.2	F	45.0	E	69.0	F	40.3	E
	Basic	80.7	F	31.0	D	84.2	F	71.8	F
	ML Access	86.6	F	27.4	D	93.4	F	84.6	F
	Basic	49.2	F	29.7	D	73.2	F	75.0	F
to Robinson Rd	Diverge	37.4	E	33.2	D	63.5	F	65.8	F
	Basic	43.3	E	33.2	D	58.2	F	59.2	F
from Spring Crossing Blvd	Merge	46.7	F	33.2	D	69.0	F	57.0	F
	Basic	42.8	E	33.3	D	49.2	F	33.3	D
to Rayford Rd	Diverge	44.9	E	42.4	E	54.0	F	37.4	E
	Basic	80.7	F	85.7	F	64.2	F	42.8	E
DC from Hardy Toll Rd	Merge	99.4	F	104.2	F	105.6	F	105.0	F
DC from SH 99 EB	Merge	73.6	F	96.4	F	115.2	F	131.4	F
	Basic	55.5	F	108.9	F	132.8	F	141.8	F
to Hardy Toll Rd + Spring Crossing Blvd from Spring Cypress Rd	Weave	40.7	E	93.1	F	89.6	F	131.1	F
	Basic	26.1	D	22.7	C	57.9	F	89.6	F
to SH 99 DC (future)	*Diverge*					35.1	E	33.4	D
to Spring Stuebner Rd + SH 99 from Cypresswood Dr + Louetta Rd	Weave	28.4	D	25.0	C	35.7	E	27.0	D
	Basic	23.2	C	23.3	C	24.3	C	20.3	C
to Louetta Rd + Spring Cypress Rd	Diverge	35.6	E	43.2	E	37.9	E	37.9	E
	Basic	35.6	E	43.2	E	37.9	E	37.9	E
to Cypresswood Dr	Diverge	33.1	D	57.8	F	66.2	F	57.9	F
	ML Access	26.4	D	78.4	F	90.9	F	74.4	F
from FM 1960 + Hollow Tree Ln	Merge	36.6	E	59.1	F	57.7	F	56.8	F
	Basic	27.2	D	32.0	D	74.2	F	29.9	D
to Hollow Tree Ln	Diverge	24.7	C	35.1	E	60.4	F	38.1	E
	Basic	22.6	C	29.3	D	73.9	F	30.9	D
to FM 1960 from Richey Rd	Weave	24.3	C	34.8	D	48.8	F	35.9	E
	Basic	26.7	D	35.2	E	45.7	F	31.5	D
to Richey Rd from Airtex Blvd	Weave	26.6	D	39.3	E	48.5	F	36.9	E
	Basic	28.3	D	39.4	E	63.1	F	61.0	F
from Rankin Rd	Merge	28.6	D	39.4	E	60.9	F	60.9	F
	Basic	23.8	C	32.3	D	73.4	F	76.0	F
to Airtex Blvd from Greens Rd	Weave	23.6	C	34.3	D	71.0	F	61.5	F
	Basic	26.7	D	35.4	E	67.7	F	58.8	F
DC from BW 8 (EB + WB)	Merge	21.6	C	27.4	D	94.6	F	83.5	F
	Basic	23.8	C	28.3	D	67.8	F	49.9	F
to Rankin Rd from BW 8 FR	Weave	21.9	C	30.8	D	63.1	F	57.3	F
	Basic	24.5	C	28.3	D	50.9	F	57.0	F
to Greens Rd	Diverge	26.4	D	31.2	D	48.9	F	41.6	E
DC to BW 8 EB	Diverge	23.7	C	26.6	D	47.9	F	52.0	F
DC to BW 8 WB	Diverge	26.9	D	32.0	D	44.4	E	39.3	E
to BW 8 FR	Diverge	28.5	D	33.4	D	46.6	F	38.0	E

General Purpose Lane
HOV Lane
HOV Access

LOS	Density (pc/mi/ln)
A	0 - 11
B	11 - 18
C	18 - 26
D	26 - 35
E	35 - 45
F	> 45

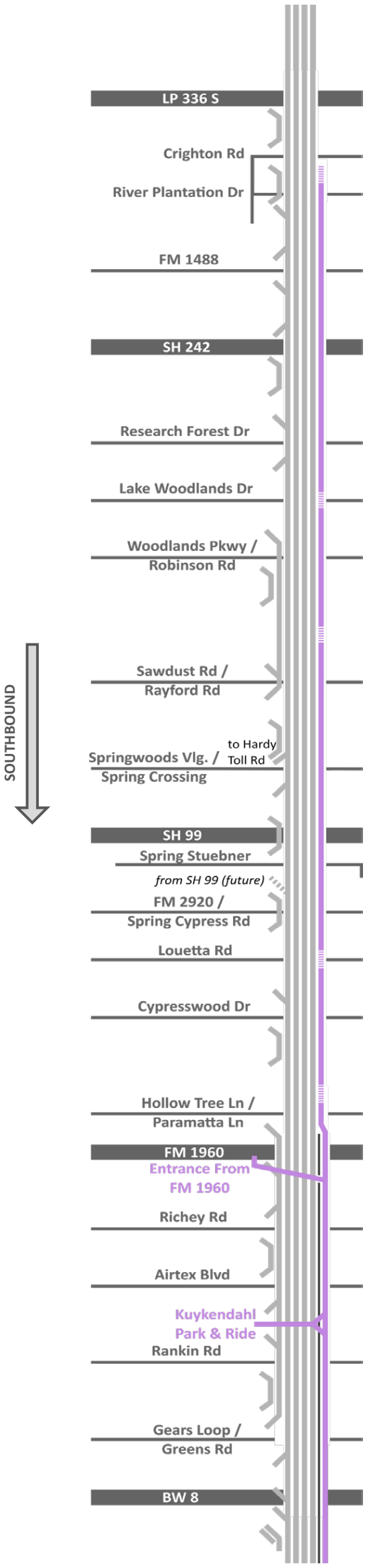


HOV Barrier Separated Lanes		2017 Existing				2045 No-Build			
NORTHBOUND		AM		PM		AM		PM	
Segment Name	HCM Segment Type	Density	LOS	Density	LOS*	Density	LOS	Density	LOS
	Basic	Closed NB AM		12.3	B	Closed NB AM		98.1	F
to FM 1960	Diverge			18.7	C			59.9	F
	Basic			15.3	B			62.5	F
from Kuykendahl P&R	Merge			7.2	A			150.2	F
	Basic			11.7	B			124.2	F
to Kuykendahl P&R	Diverge			5.8	A			157.9	F
	Basic			12.2	B			128.4	F

Density (pc/mi/ln): reflects the total density of all lanes in a segment. Merge/Diverge influence area density may be higher or lower than shown.
*Existing 2017 HOV LOS is expected to be LOS C or better.

Texas Department of Transportation

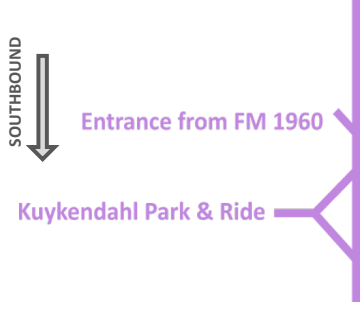
Exhibit 5: Mainlane Level of Service - Existing Year 2017 and Future Year 2045 No-Build
1 of 2: NB I-45



General Purpose Lanes		2017 Existing				2045 No-Build			
SOUTHBOUND		AM		PM		AM		PM	
Segment Name	HCM Segment Type	Density	LOS	Density	LOS	Density	LOS	Density	LOS
	Basic	23.6	C	22.0	C	83.4	F	72.1	F
from Loop 336 S to Crighton Rd + River Plantaion Dr	Weave	32.6	D	24.9	C	60.0	F	45.0	E
	Basic	33.7	D	26.4	D	58.3	F	37.7	E
	ML Access	29.1	D	23.7	C	89.1	F	32.1	D
	Basic	32.1	D	25.5	C	84.2	F	35.9	E
from Crighton Rd + River Plantation Dr	Merge	36.4	E	28.6	D	68.1	F	39.0	E
	Basic	36.1	E	26.6	D	66.8	F	39.0	E
to FM 1488	Diverge	36.1	E	26.6	D	67.7	F	39.0	E
	Basic	29.5	D	21.4	C	77.2	F	30.8	D
from FM 1488	Merge	42.7	E	28.3	D	50.8	F	41.2	E
	Basic	42.3	E	26.1	D	44.3	E	41.2	E
to SH 242	Diverge	42.3	E	26.1	D	44.3	E	41.2	E
	Basic	31.6	D	20.4	C	48.1	F	27.6	D
DC from SH 242 WB to Research Forest Dr	Weave	34.7	D	18.1	C	48.1	F	29.8	D
	Basic	29.4	D	19.4	C	76.3	F	28.0	D
from SH 242	Merge	39.9	E	30.2	D	58.2	F	45.5	F
	Overlap	39.9	E	30.2	D	58.2	F	45.5	F
to Lake Woodlands Dr + Woodlands Pkwy	Diverge	39.3	E	27.3	D	40.3	E	43.6	E
	Basic	28.9	D	21.8	C	34.9	D	32.3	D
	ML Access	26.2	D	21.2	C	65.7	F	34.8	D
	Basic	28.7	D	19.9	C	47.2	F	52.3	F
from Research Forest Dr + Lake Woodlands Dr	Merge	27.7	D	34.3	D	58.6	F	52.8	F
	Basic	27.7	D	37.8	E	72.5	F	51.6	F
DC from Woodlands Pkwy EB to Rayford Rd	Weave	33.3	D	54.8	F	58.0	F	62.0	F
	Basic	30.3	D	59.0	F	64.0	F	54.8	F
	ML Access	28.4	D	62.9	F	96.6	F	70.5	F
	Basic	30.1	D	77.9	F	86.8	F	73.1	F
from Robinson Rd + Valley Wood Dr	Merge	34.5	D	57.6	F	79.4	F	39.2	E
to Spring Crossing Blvd + SH 99	Diverge	33.6	D	63.7	F	79.6	F	44.1	E
	Basic	41.0	E	67.5	F	38.9	E	53.5	F
from Rayford Rd DC to Hardy Toll Rd	Weave	45.0	E	68.4	F	45.0	E	67.4	F
	Basic	42.7	E	42.5	E	43.3	E	39.1	E
DC to SH 99 WB	Diverge	42.7	E	42.5	E	43.3	E	39.1	E
	Basic	31.2	D	22.2	C	29.3	D	20.3	C
from Spring Crossing Blvd to Spring Stuebner Rd + Spring Cypress Rd	Weave	30.5	D	21.5	C	30.9	D	26.5	D
	Basic	29.0	D	20.6	C	42.1	E	21.7	C
from SH 99 DC (future)	*Merge*					81.0	F	22.5	C
from SH 99 + Spring Stuebner Rd to Louetta Rd + Cypresswood Dr	Weave	32.1	D	21.0	C	69.8	F	33.5	D
	Basic	28.4	D	19.7	C	71.7	F	22.7	C
	ML Access	26.2	D	23.6	C	92.4	F	39.3	E
	Basic	28.2	D	22.3	C	95.3	F	66.8	F
from Spring Cypress Rd + Louetta Rd	Merge	37.1	E	29.3	D	79.4	F	58.5	F
	Basic	36.0	E	26.9	D	75.4	F	47.6	F
from Cypresswood Dr to Hollow Tree Ln + FM 1960	Weave	36.0	E	24.4	C	84.8	F	49.5	F
	Basic	32.6	D	23.6	C	67.2	F	68.3	F
	ML Access	29.3	D	25.0	C	72.1	F	81.8	F
	Basic	32.5	D	26.2	D	55.9	F	42.9	E
from Hollow Tree Ln	Merge	30.1	D	22.0	C	52.6	F	46.8	F
	Basic	32.0	D	22.0	C	54.0	F	56.8	F
from FM 1960	Merge	53.3	F	33.7	D	73.6	F	56.7	F
	Overlap	53.3	F	33.7	D	73.6	F	56.7	F
to Richey Rd	Diverge	43.9	E	30.3	D	60.0	F	46.2	F
	Basic	39.3	E	24.3	C	60.4	F	43.8	E
from Richey Rd to Airtex Blvd	Weave	62.0	F	25.2	C	72.3	F	68.4	F
	Basic	60.1	F	26.4	D	73.2	F	79.0	F
to Rankin Rd	Diverge	63.4	F	26.4	D	81.1	F	84.3	F
	Basic	83.6	F	23.3	C	94.3	F	91.8	F
from Airtex Blvd	Merge	91.2	F	34.0	D	91.4	F	88.2	F
	Basic	92.4	F	52.0	F	93.1	F	88.4	F
from Rankin Rd to Greens Rd	Weave	77.4	F	79.6	F	77.7	F	76.1	F
DC to BW 8 (EB + WB)	Diverge	41.4	E	43.6	E	37.0	E	37.0	E
	Basic	22.2	C	31.6	D	25.0	C	22.5	C
to BW 8 FR	Diverge	22.2	C	43.6	E	25.0	C	22.5	C
	Basic	19.9	C	129.6	F	22.5	C	107.7	F
from Greens Rd	Merge	24.7	C	118.0	F	30.0	D	120.1	F
from BW 8 FR	Merge	26.9	D	108.7	F	32.5	D	108.2	F
DC from BW 8 (EB + WB)	Merge	38.7	E	93.7	F	45.0	E	93.7	F

General Purpose Lane
HOV Lane
HOV Access

LOS	Density (pc/mi/ln)
A	0 - 11
B	11 - 18
C	18 - 26
D	26 - 35
E	35 - 45
F	> 45



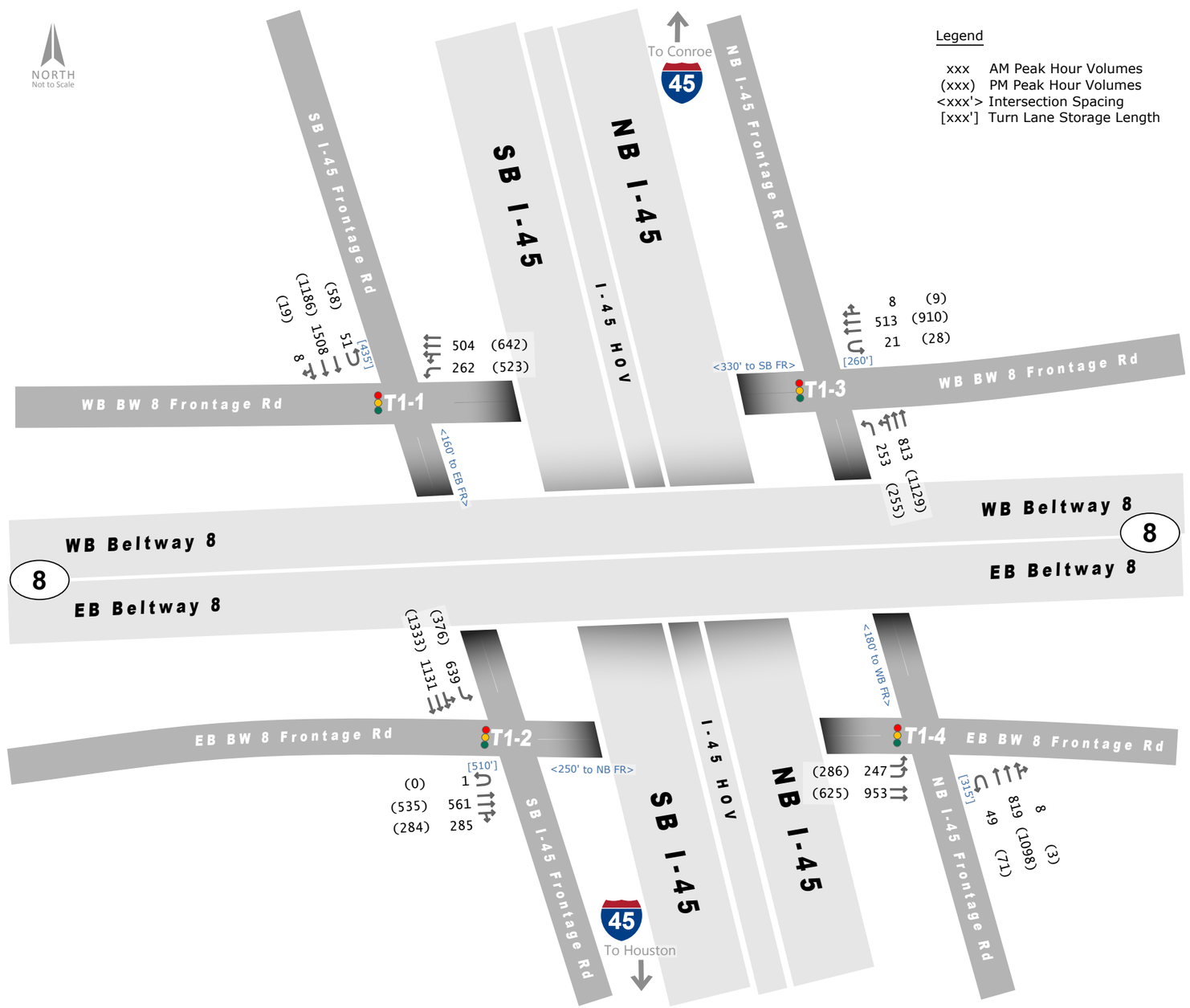
HOV Barrier Separated Lanes		2017 Existing				2045 No-Build			
SOUTHBOUND		AM		PM		AM		PM	
Segment Name	HCM Segment Type	Density	LOS*	Density	LOS	Density	LOS	Density	LOS
	Basic	13.0	B	Closed SB PM		55.9	F	Closed SB PM	
from FM 1960	Merge	15.8	B			94.8	F		
	Basic	15.9	B			81.1	F		
to Kuykendahl P&R	Diverge	7.4	A			98.6	F		
	Basic	15.5	B			94.3	F		
from Kuykendahl P&R	Merge	8.9	A			94.0	F		
	Basic	20.2	C			93.1	F		

Density (pc/mi/ln): reflects the total density of all lanes in a segment. Merge/Diverge influence areadensity may be higher or lower than shown.
*Existing 2017 HOV LOS is expected to be LOS C or better.

Exhibit 5: Mainlane Level of Service - Existing Year 2017 and Future Year 2045 No-Build
2 of 2: SB I-45

Exhibit 6:
Frontage Road Intersection Operational Analysis – Existing Year 2017

Volumes and Lane Assignments



Capacity & Level of Service Analysis

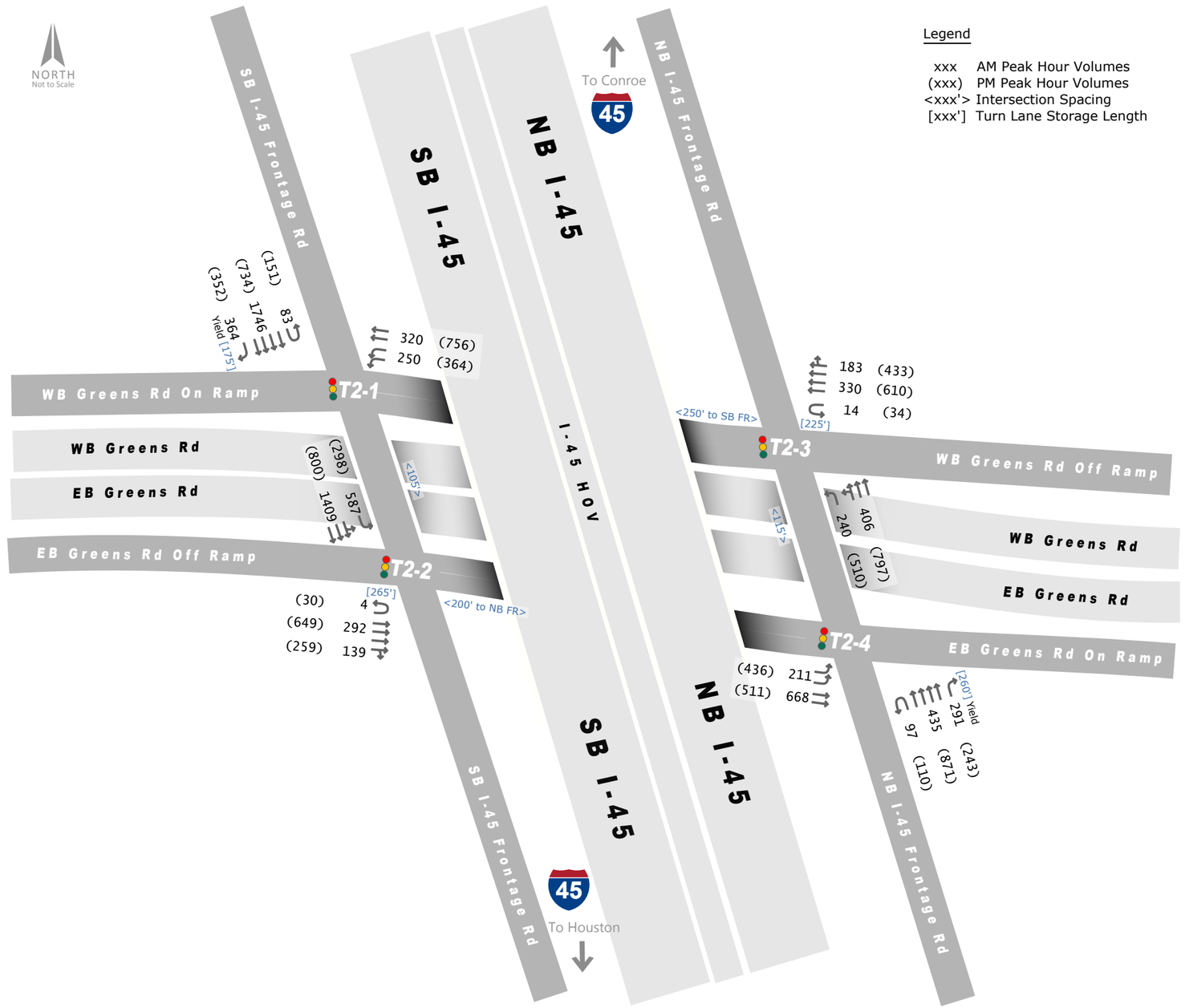
				EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R
				BW 8 WB FR						I-45 SB FR					
T1-1 I-45 SB FR at BW 8 WB FR	AM	LOS	C				A	B						C	
		Delay (s/veh)	23.9				2.9	13.1						23.9	
		50% queue (ft)	-				3	63						254	
		v/c ratio	-				0.27	0.29						0.79	
	PM	LOS	C				A	B						C	
		Delay (s/veh)	23.8				7.9	12.5						23.8	
		50% queue (ft)	-				8	82						198	
		v/c ratio	-				0.38	0.4						0.69	
				BW 8 EB FR						I-45 SB FR					
T1-2 I-45 SB FR at BW 8 EB FR	AM	LOS	B		B								B	A	
		Delay (s/veh)	19.9		19.9								11.8	9.8	
		50% queue (ft)	-		122								0	170	
		v/c ratio	-		0.51								0.55	0.6	
	PM	LOS	B		B								A	B	
		Delay (s/veh)	19.3		19.3								10	13.5	
		50% queue (ft)	-		117								41	262	
		v/c ratio	-		0.48								0.45	0.62	
				BW 8 WB FR						I-45 NB FR					
T1-3 I-45 NB FR at BW 8 WB FR	AM	LOS	C					C		A	A				
		Delay (s/veh)	25.2					25.2		1.9	4				
		50% queue (ft)	-					84		0	32				
		v/c ratio	-					0.42		0.26	0.31				
	PM	LOS	C					C		A	A				
		Delay (s/veh)	30.5					30.5		0.7	5.2				
		50% queue (ft)	-					165		0	35				
		v/c ratio	-					0.74		0.26	0.43				
				BW 8 EB FR						I-45 NB FR					
T1-4 I-45 NB FR at BW 8 EB FR	AM	LOS	C	A	A						C				
		Delay (s/veh)	28.5	8.2	5.3						28.5				
		50% queue (ft)	-	32	58						145				
		v/c ratio	-	0.25	0.37						0.66				
	PM	LOS	D	A	A						D				
		Delay (s/veh)	36.4	7.9	4.7						36.4				
		50% queue (ft)	-	30	30						208				
		v/c ratio	-	0.25	0.26						0.87				

Summary of Operational Issues

T1-4: I-45 NB FR & BW 8 EB FR

- NBT/R PM peak hour 95th% queue reaches 283 feet.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

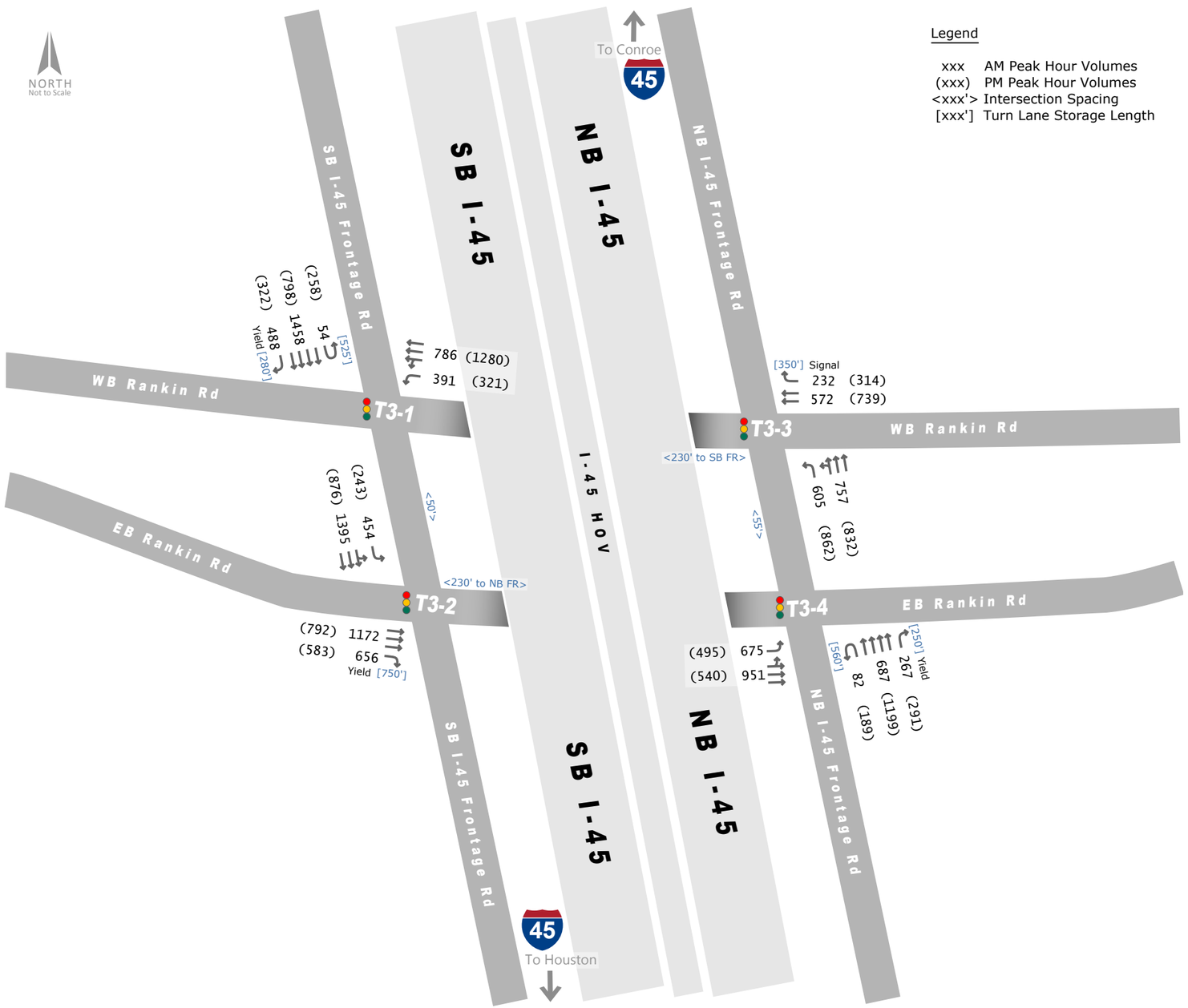
				EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R
				Greens WB						I-45 SB FR					
T2-1 I-45 SB FR at Greens Rd WB	AM	LOS	C				A	A						C	
		Delay (s/veh)	20.1				3.8	7.1						20.1	
		50% queue (ft)	-				0	21						214	
		v/c ratio	-				0.17	0.22						0.68	
	PM	LOS	C				A	A						C	
		Delay (s/veh)	24.6				8.2	7.2						24.6	
		50% queue (ft)	-				84	94						94	
		v/c ratio	-				0.19	0.4						0.44	
				Greens EB						I-45 SB FR					
T2-2 I-45 SB FR at Greens Rd EB	AM	LOS	C		C								B	A	
		Delay (s/veh)	21.5		21.5								13.4	4.9	
		50% queue (ft)	-		49								268	0	
		v/c ratio	-		0.27								0.52	0.57	
	PM	LOS	C		C								B	A	
		Delay (s/veh)	26.2		26.2								14.1	2.8	
		50% queue (ft)	-		113								155	0	
		v/c ratio	-		0.64								0.29	0.3	
				Greens WB						I-45 NB FR					
T2-3 I-45 NB FR at Greens Rd WB	AM	LOS	C					C		A	A				
		Delay (s/veh)	20.8					20.8		8.4	2.1				
		50% queue (ft)	-					50		89	0				
		v/c ratio	-					0.42		0.16	0.16				
	PM	LOS	C					C		B	A				
		Delay (s/veh)	22.8					22.8		12	4				
		50% queue (ft)	-					122		182	1				
		v/c ratio	-					0.62		0.37	0.38				
				Greens EB						I-45 NB FR					
T2-4 I-45 NB FR at Greens Rd EB	AM	LOS	C	A	A						C				
		Delay (s/veh)	27.1	0.1	4.3						27.1				
		50% queue (ft)	-	0	17						58				
		v/c ratio	-	0.1	0.32						0.34				
	PM	LOS	C	A	A						C				
		Delay (s/veh)	22.7	0.2	5.8						22.7				
		50% queue (ft)	-	0	18						108				
		v/c ratio	-	0.25	0.29						0.46				

Summary of Operational Issues

T2-3: I-45 NB FR & Greens Rd WB

- WBT/R PM peak hour 95th% queue reaches 157 feet, which blocks access to local business driveways.

Volumes and Lane Assignments



Legend

xxx AM Peak Hour Volumes
(xxx) PM Peak Hour Volumes
<xxx'> Intersection Spacing
[xxx'] Turn Lane Storage Length

Capacity & Level of Service Analysis

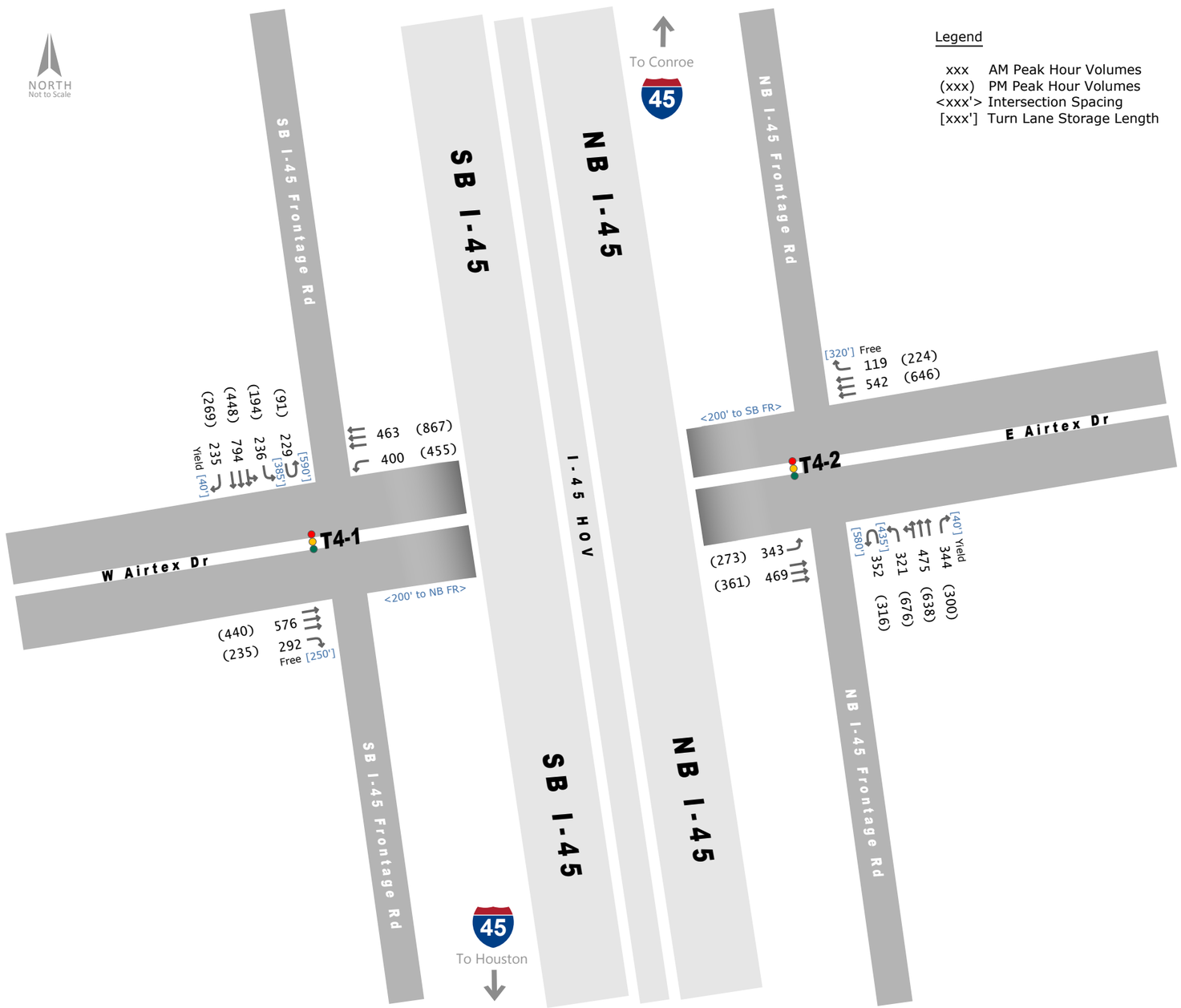
				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Rankin Rd WB						I-45 SB FR					
T3-1 I-45 SB FR at Rankin Rd WB	AM	LOS	C				A	A						C	
		Delay (s/veh)	32.2				3	4.1						32.2	
		50% queue (ft)	-				16	88						204	
		v/c ratio	-				0.34	0.34						0.76	
	PM	LOS	D				A	A						D	
		Delay (s/veh)	38.3				1.7	7.4						38.3	
		50% queue (ft)	-				0	170						143	
		v/c ratio	-				0.26	0.43						0.65	
				Rankin Rd EB						I-45 SB FR					
T3-2 I-45 SB FR at Rankin Rd EB	AM	LOS	C		C								B	A	
		Delay (s/veh)	25.5		25.5								11	7.2	
		50% queue (ft)	-		221								63	72	
		v/c ratio	-		0.66								0.57	0.57	
	PM	LOS	C		C								A	A	
		Delay (s/veh)	28.7		28.7								5.8	5.8	
		50% queue (ft)	-		161								45	63	
		v/c ratio	-		0.5								0.29	0.34	
				Rankin Rd WB						I-45 NB FR					
T3-3 I-45 NB FR at Rankin Rd WB	AM	LOS	C					C	A	B	A				
		Delay (s/veh)	25.9					32.5	9.5	10.7	9.6				
		50% queue (ft)	-					161	19	111	121				
		v/c ratio	-					0.63	0.43	0.39	0.39				
	PM	LOS	D					D	C	B	A				
		Delay (s/veh)	36.6					43.5	20.3	10.9	8.1				
		50% queue (ft)	-					248	85	97	102				
		v/c ratio	-					0.82	0.61	0.47	0.46				
				Rankin Rd EB						I-45 NB FR					
T3-4 I-45 NB FR at Rankin Rd EB	AM	LOS	D	A	A						D				
		Delay (s/veh)	39.0	4.7	8.4						39				
		50% queue (ft)	-	25	103						118				
		v/c ratio	-	0.4	0.39						0.7				
	PM	LOS	D	A	A						D				
		Delay (s/veh)	39.3	3	8.9						39.3				
		50% queue (ft)	-	6	75						222				
		v/c ratio	-	0.27	0.28						0.8				

Summary of Operational Issues

T3-3: I-45 NB FR & Rankin Rd WB

- WBT PM peak hour 95th% queue is 389 feet and blocks access to local business driveways.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

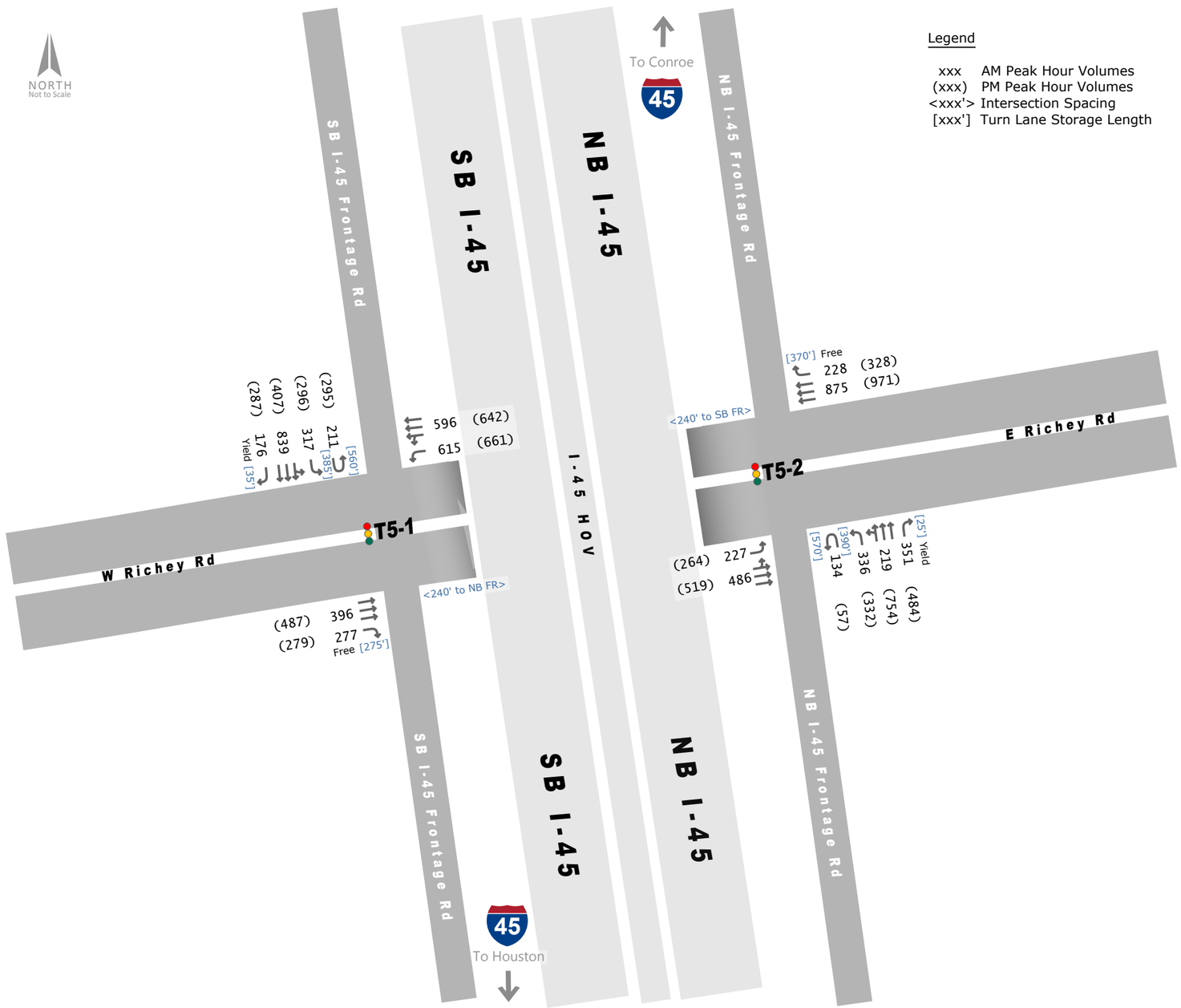
				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Airtex Dr						I-45 SB FR					
T4-1 I-45 SB FR at Airtex Dr	AM	LOS	C		D		C	A					C	C	
		Delay (s/veh)	34.1		39.5		22.3	1.1					32.7	30.6	
		50% queue (ft)	-		134		198	0					140	188	
		v/c ratio	-		0.66		0.79	0.18					0.5	0.61	
	PM	LOS	C		D		D	A					C	C	
		Delay (s/veh)	32.7		36.6		36.2	1.4					32.1	29.2	
		50% queue (ft)	-		95		229	0					100	104	
		v/c ratio	-		0.51		0.8	0.31					0.41	0.41	
				Airtex Dr						I-45 NB FR					
T4-2 I-45 NB FR at Airtex Dr	AM	LOS	C	B	A			D		C	C				
		Delay (s/veh)	34.3	17.3	1.2			39.8		32.7	29.2				
		50% queue (ft)	-	184	0			126		125	131				
		v/c ratio	-	0.63	0.17			0.65		0.48	0.48				
	PM	LOS	D	B	A			D		D	C				
		Delay (s/veh)	38.9	12.7	1.4			41.2		42.9	32.3				
		50% queue (ft)	-	133	0			147		239	225				
		v/c ratio	-	0.56	0.14			0.73		0.77	0.71				

Summary of Operational Issues

T4-2: I-45 NB FR & Airtex Dr

- NBL PM peak hour 95th% queue is 433 feet and blocks access to the U-turn lane.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Richey Rd						I-45 SB FR					
T5-1 I-45 SB FR at Richey Rd	AM	LOS	D		D		B	A					D	D	
		Delay (s/veh)	38.6		40.8		13.5	3.1					42.5	36	
		50% queue (ft)	-		101		11	0					215	224	
		v/c ratio	-		0.46		0.66	0.52					0.66	0.66	
	PM	LOS	D		D		C	A					D	D	
		Delay (s/veh)	40.3		41.9		25.4	3.6					41.5	37.6	
		50% queue (ft)	-		123		17	0					137	140	
		v/c ratio	-		0.52		0.61	0.49					0.51	0.5	
				Richey Rd						I-45 NB FR					
T5-2 I-45 NB FR at Richey Rd	AM	LOS	D	B	A			D		D	D				
		Delay (s/veh)	44.2	12.7	2.7			47.1		42.2	35.8				
		50% queue (ft)	-	9	0			236		131	97				
		v/c ratio	-	0.35	0.27			0.82		0.51	0.38				
	PM	LOS	D	A	A			E		D	D				
		Delay (s/veh)	47.8	9.4	2.9			56.3		44.8	38.3				
		50% queue (ft)	-	9	0			273		210	220				
		v/c ratio	-	0.43	0.34			0.91		0.66	0.66				

Summary of Operational Issues

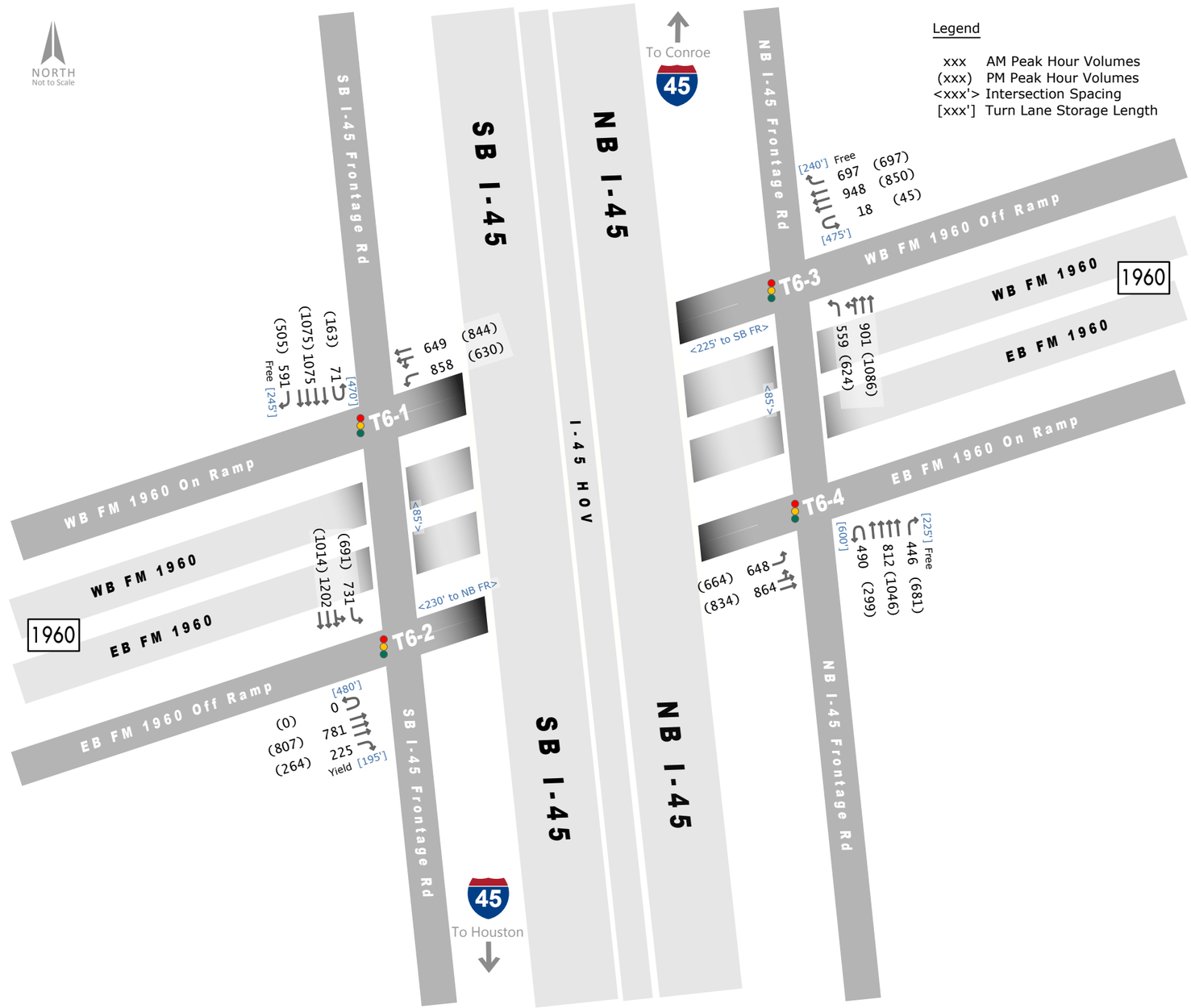
T5-1: I-45 SB FR & Richey Rd

- SBL AM peak hour 95th% queue is 366 feet and blocks access to the U-turn lane.
- SBT 95th% queue is 308 feet in the AM peak hour and 179 feet in the PM peak hour, blocking the right turn lane.

T5-2: I-45 NB FR & Richey Rd

- WBT PM peak hour 95th% queue is 430 feet and blocks the right turn lane.
- NBL PM peak hour 95th% queue is 353 feet and blocks access to the U-turn lane.
- NBT 95th% queue is 138 feet in the AM peak hour and is 298 feet in the PM peak hour, blocking the right turn lane.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R
				Cypress Creek / FM 1960 WB						I-45 SB FR					
T6-1 I-45 SB FR at FM 1960 WB	AM	LOS	D				D	A						D	
		Delay (s/veh)	54.7				44.5	5.6						54.7	
		50% queue (ft)	-				194	87						253	
		v/c ratio	-				0.48	0.48						0.84	
	PM	LOS	F				E	A						F	
		Delay (s/veh)	115.7				65.8	2.8						115.7	
		50th Q (ft)	-				247	51						~316	
		v/c ratio	-				0.44	0.44						1.03	
				Cypress Creek / FM 1960 EB						I-45 SB FR					
T6-2 I-45 SB FR at FM 1960 EB	AM	LOS	F		F								E	A	
		Delay (s/veh)	115.4		115.4								67.5	3.5	
		50% queue (ft)	-		~276								232	63	
		v/c ratio	-		1.11								0.44	0.45	
	PM	LOS	E		E								E	A	
		Delay (s/veh)	72.3		72.3								68.9	2.2	
		50% queue (ft)	-		280								195	19	
		v/c ratio	-		0.93								0.41	0.41	
				Cypress Creek / FM 1960 WB						I-45 NB FR					
T6-3 I-45 NB FR at FM 1960 WB	AM	LOS	D					D		E	A				
		Delay (s/veh)	44.8					44.8		68.1	4.8				
		50% queue (ft)	-					269		172	26				
		v/c ratio	-					0.76		0.39	0.4				
	PM	LOS	D					D		E	A				
		Delay (s/veh)	54.9					54.9		65.9	4.1				
		50% queue (ft)	-					281		211	34				
		v/c ratio	-					0.79		0.43	0.43				
				Cypress Creek / FM 1960 EB						I-45 NB FR					
T6-4 I-45 NB FR at FM 1960 EB	AM	LOS	E	E	A						E				
		Delay (s/veh)	58.4	70.2	2.3						58.4				
		50% queue (ft)	-	252	41						194				
		v/c ratio	-	0.45	0.45						0.83				
	PM	LOS	D	E	A						D				
		Delay (s/veh)	54.0	68.5	4.2						54				
		50% queue (ft)	-	245	63						273				
		v/c ratio	-	0.48	0.48						0.77				

Summary of Operational Issues

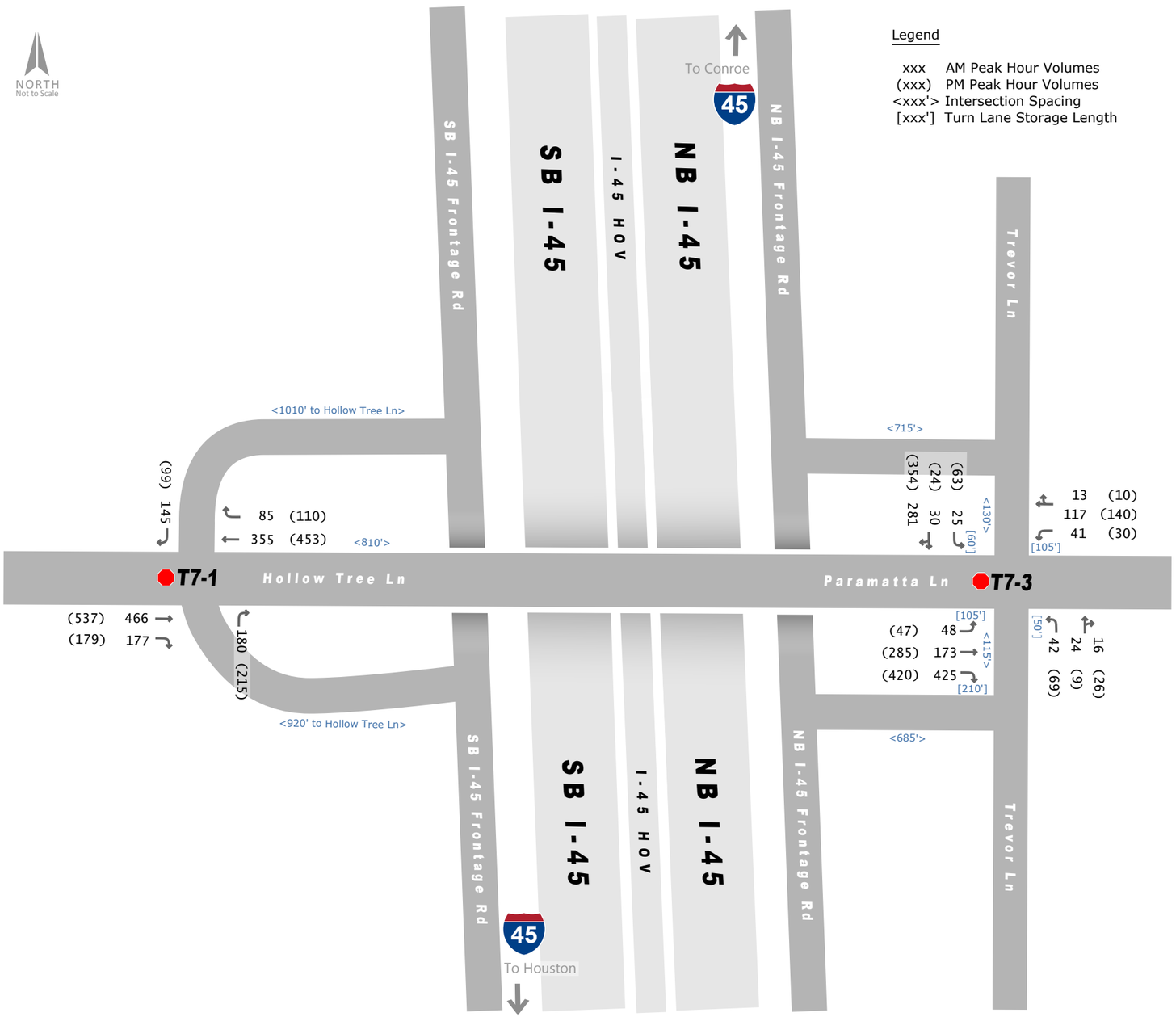
T6-1: I-45 SB FR & FM 1960 WB

- SBT PM peak hour 95th% queue is 392 feet. The movement is over capacity in the PM peak hour.

T6-2: I-45 SB FR & FM 1960 EB

- EBT AM peak hour 95th% queue is 365 feet. PM peak hour 95th% queue is 363 feet. The movement is over capacity in the AM peak hour and near capacity in the PM peak hour.

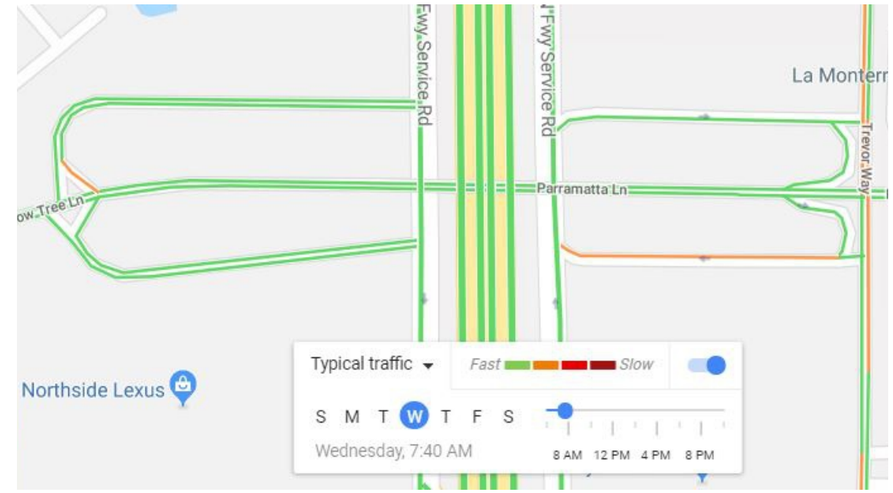
Volumes and Lane Assignments



Capacity & Level of Service Analysis

Google traffic was used to evaluate typical traffic operations at unsignalized intersections.

In the AM peak hour, both intersections have low congestion.



In the PM peak hour, the NB Frontage Road intersection experiences high congestion and the SB Frontage Road intersection experiences moderate congestion.

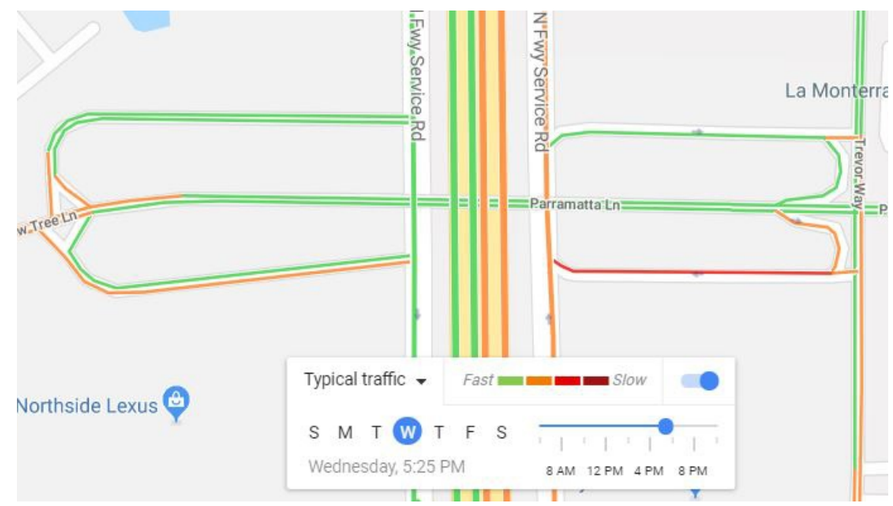
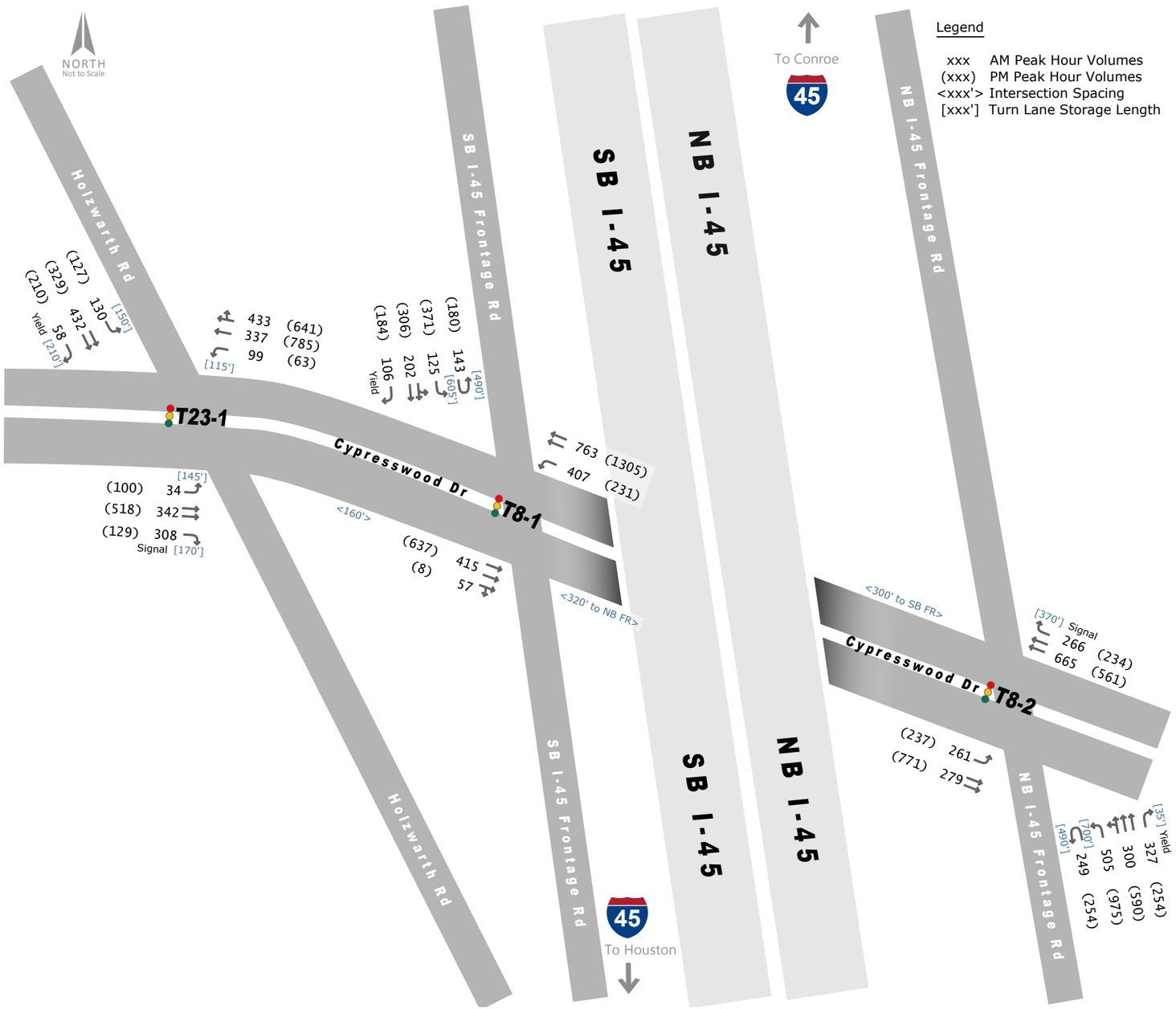


Exhibit 6: Frontage Road Intersection Operational Analysis - Existing Year 2017
7 of 17: I-45 & Hollow Tree Ln

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Cypresswood Dr						I-45 SB FR					
T8-1 I-45 SB FR at Cypresswood Dr	AM	LOS	D		D		E	A					D	D	
		Delay (s/veh)	41.0		39.5		67.3	0.9					43.8	42.2	
		50% queue (ft)	-		157		349	3					87	90	
		v/c ratio	-		0.6		0.62	0.34					0.36	0.36	
	PM	LOS	E		F		A	A					D	D	
		Delay (s/veh)	78.0		116.5		8.5	2					43.1	40.1	
		50% queue (ft)	-		~324		0	7					180	183	
		v/c ratio	-		1.03		0.37	0.64					0.57	0.56	
				Cypresswood Dr						I-45 NB FR					
T8-2 I-45 NB FR at Cypresswood Dr	AM	LOS	C	C	A			D	A	C	C				
		Delay (s/veh)	33.8	29.1	3.9			47.2	6.6	33.6	28.6				
		50% queue (ft)	-	218	41			266	0	193	132				
		v/c ratio	-	0.81	0.16			0.75	0.45	0.48	0.34				
	PM	LOS	D	B	A			E	B	D	C				
		Delay (s/veh)	43.2	12.6	6.6			58.5	14.7	48.9	30.6				
		50% queue (ft)	-	215	148			231	32	450	287				
		v/c ratio	-	0.62	0.48			0.85	0.53	0.86	0.61				
				Cypresswood Dr						Holzwarth Rd					
T23-1 Holzwarth Rd at Cypresswood Dr	AM	LOS	C	E	B	A	F	A					D	E	
		Delay (s/veh)	29.2	66.8	12.7	4.4	82.1	1.6					50.8	59.9	
		50% queue (ft)	-	28	65	22	89	11					100	186	
		v/c ratio	-	0.4	0.18	0.32	0.68	0.39					0.49	0.81	
	PM	LOS	D	E	C	A	C	E					E	E	
		Delay (s/veh)	39.6	77.1	28.2	6.8	30	59.5					62	64.6	
		50% queue (ft)	-	87	158	4	41	349					107	150	
		v/c ratio	-	0.69	0.38	0.19	0.13	0.71					0.6	0.78	

Summary of Operational Issues

T8-1: I-45 SB FR & Cypresswood Dr

- SBL PM peak hour 95th% queue is 254 feet and blocks access to the U-turn lane.
- EBT/R AM peak hour 95th% queue is 247 feet. PM peak hour 95th% queue is 448 feet and the movement is over capacity. Both peak hour queues extend into T23-1 (Holzwarth Rd at Cypresswood Rd).

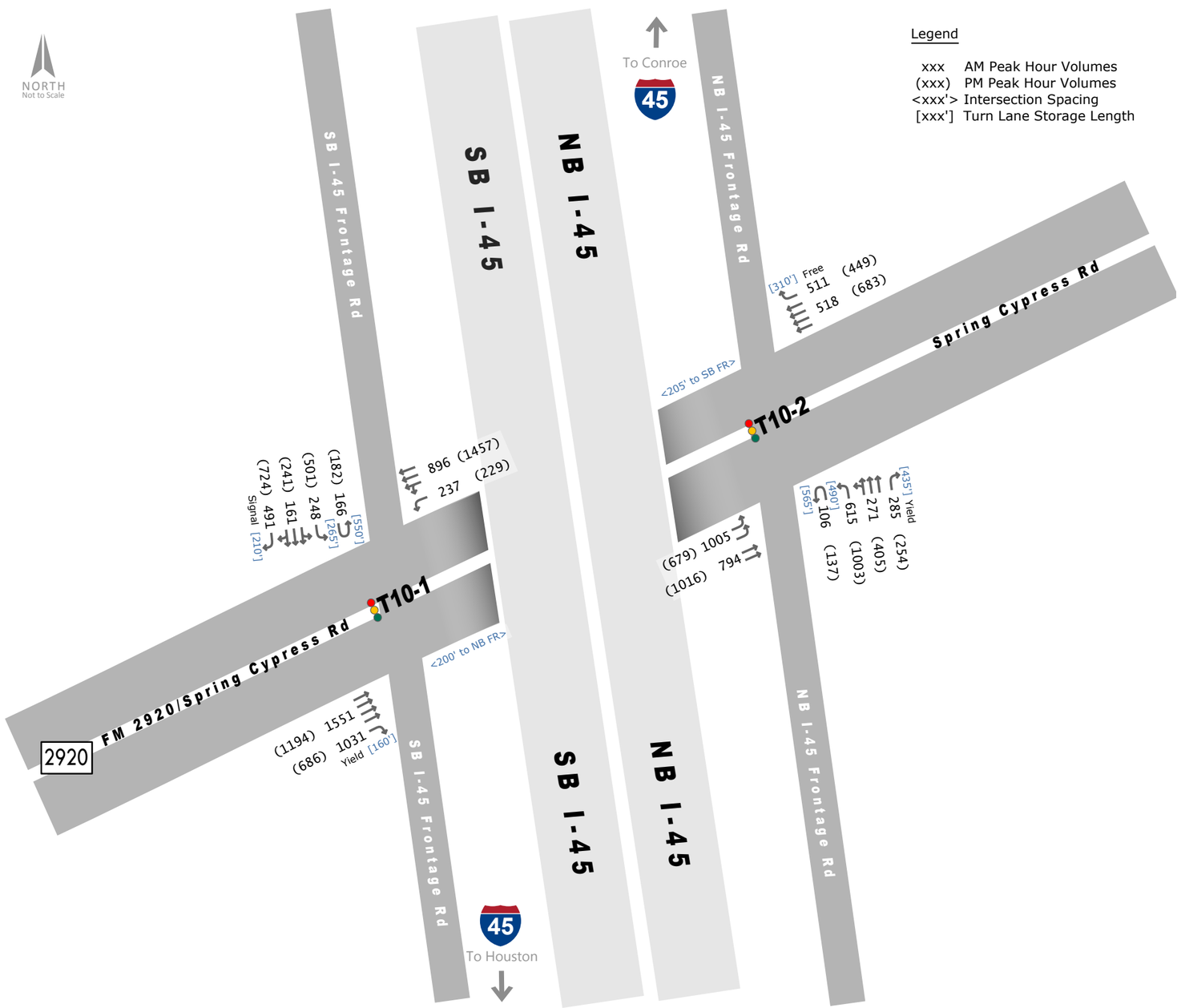
T8-2: I-45 NB FR & Cypresswood Dr

- WBT AM peak hour 95th% queue is 393 feet. PM peak hour 95th% queue is 352 feet. Both queues block access to the right turn lane.
- NBL PM peak hour 95th% queue is 703 feet and blocks access to the U-turn lane.

T23-1: Holzwarth Rd & Cypresswood Dr

- WBT/R PM peak hour 95th% queue is 547 feet and extends into T8-1 (SB FR at Cypresswood Dr).

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				FM 2920 / Spring Cypress Rd						I-45 SB FR					
T10-1 I-45 SB FR at FM 2920 / Spring Cypress Rd	AM	LOS	D		E		B	A					D	C	B
		Delay (s/veh)	52.5		67.6		16.8	3.9					45.6	29	16
		50% queue (ft)	-		402		19	0					144	100	48
		v/c ratio	-		0.93		0.46	0.43					0.52	0.48	0.57
	PM	LOS	E		E		B	A					F	E	E
		Delay (s/veh)	65.6		56		14.3	4.2					91.5	68.5	62.4
		50% queue (ft)	-		345		38	250					350	332	282
		v/c ratio	-		0.78		0.37	0.61					0.93	1.08	0.93
				Spring Cypress Rd						I-45 NB FR					
T10-2 I-45 NB FR at Spring Cypress Rd	AM	LOS	D	E	A			D		D	D				
		Delay (s/veh)	47.2	60.7	7.7			47.5		51.4	36.9				
		50% queue (ft)	-	415	1			117		277	156				
		v/c ratio	-	0.81	0.41			0.54		0.75	0.46				
	PM	LOS	F	B	B			E		F	D				
		Delay (s/veh)	96.6	14.9	10.3			66.2		136.9	48.2				
		50% queue (ft)	-	79	400			201		734	329				
		v/c ratio	-	0.53	0.51			0.71		1.15	1.05				

Summary of Operational Issues

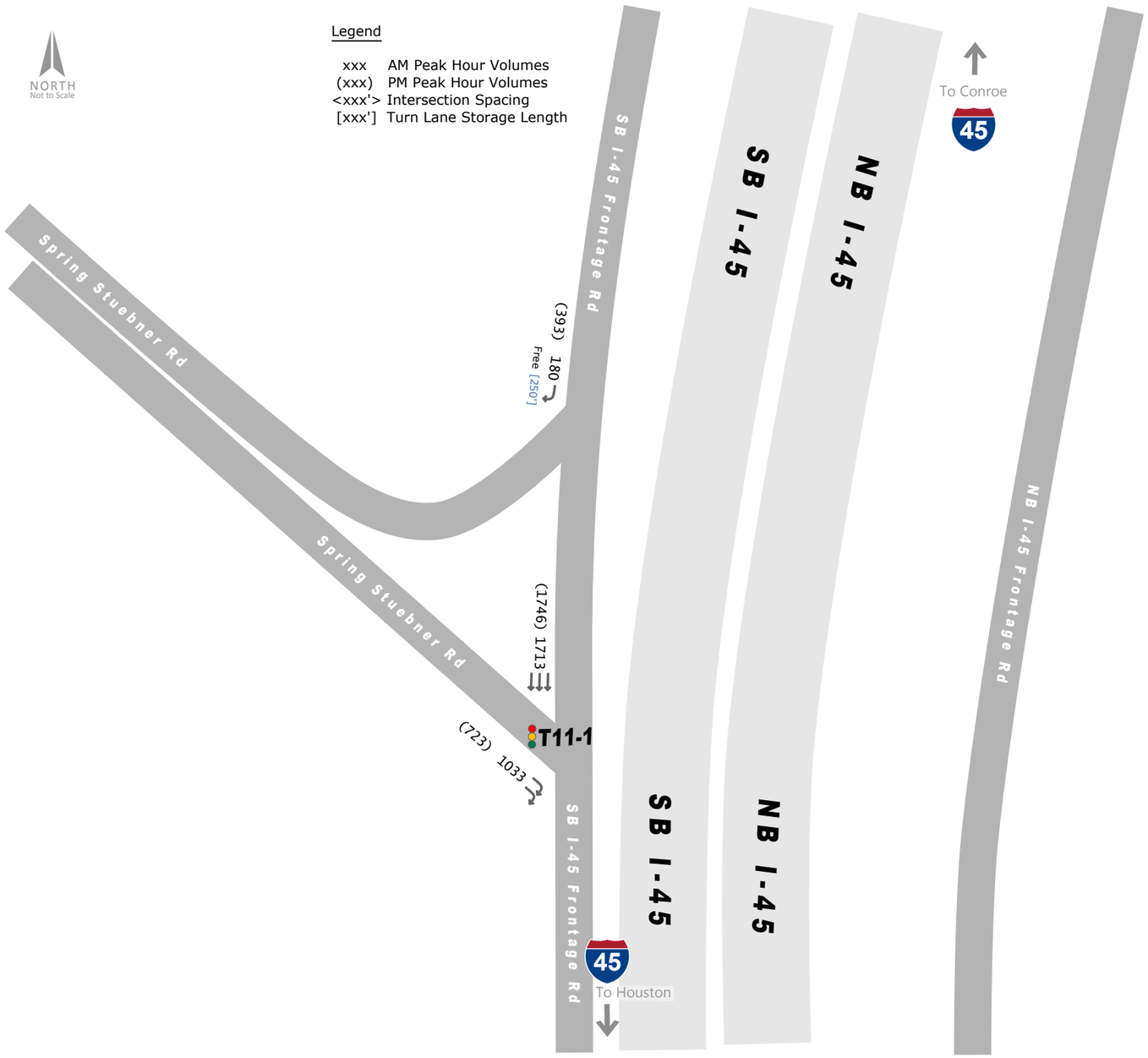
T10-1: I-45 SB FR & FM 2920/Spring Cypress Rd

- EBT AM peak hour 95th% queue is 479 feet. PM peak hour 95th% queue is 389 feet. Both queues block access to local business driveways.
- In the PM peak hour, SBT is over capacity and SBL and SBR are almost at capacity. SB 95th% queues range from 425 to 567 feet, exceeding the storage length and blocking access to local business driveways.

T10-2: I-45 NB FR & Spring Cypress Rd

- NBL PM peak hour 95th% queue is 1005 feet and the movement is over capacity.
- NBT movement is over capacity in the PM peak hour.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

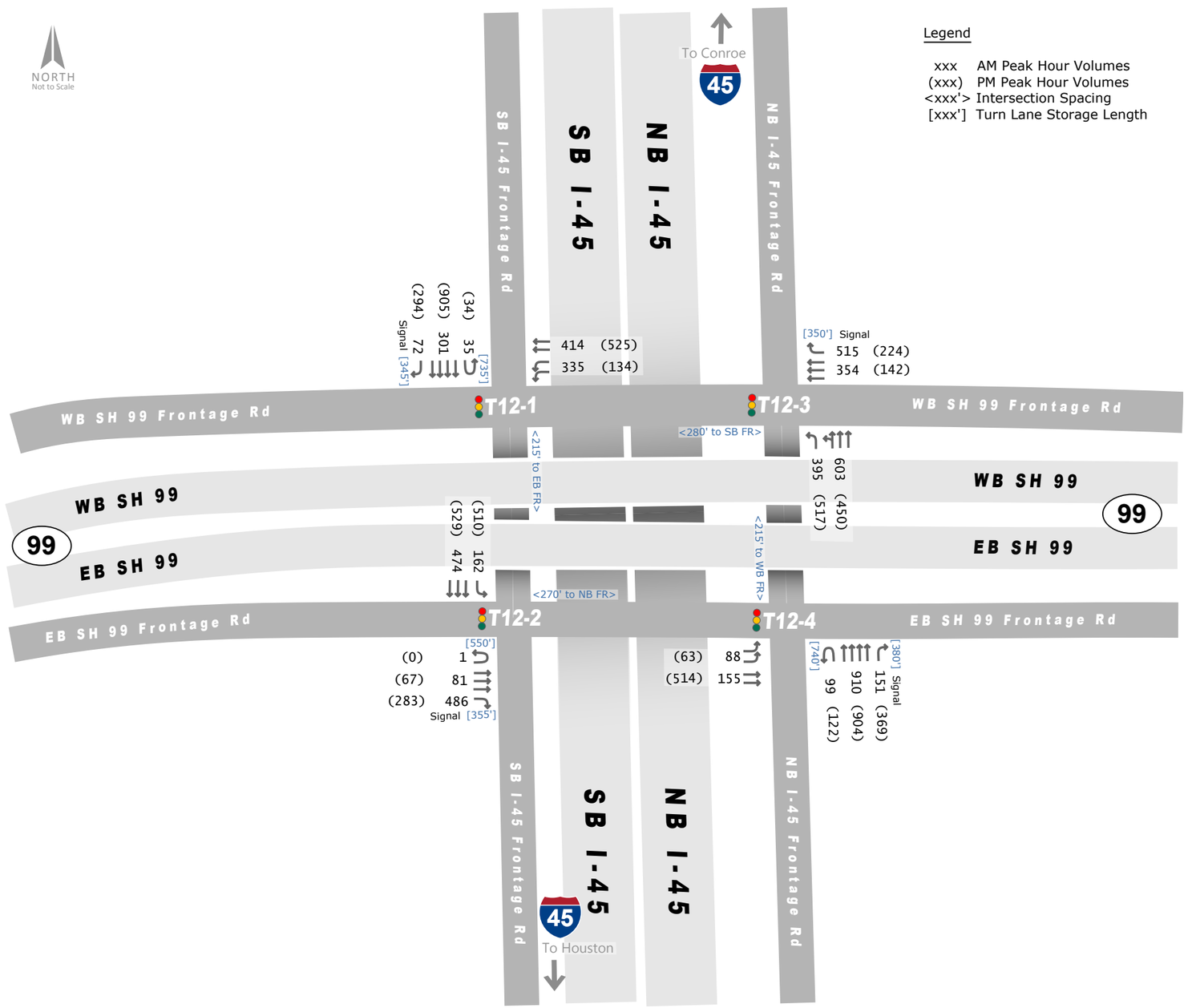
				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Spring Stuebner Rd						I-45 SB FR					
T11-1 I-45 SB FR at Spring Stuebner Rd	AM	LOS	C		D									C	
		Delay (s/veh)	34.5		53.2									23.2	
		50% queue (ft)	-		330									300	
		v/c ratio	-		1.0									0.8	
	PM	LOS	C		C									B	
		Delay (s/veh)	22.2		31.1									18.5	
		50% queue (ft)	-		192									256	
		v/c ratio	-		0.82									0.74	

Summary of Operational Issues

T11-1: I-45 SB FR & Spring Stuebner Rd

- EBR AM peak hour 95th% queue is 494 feet and is at capacity.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

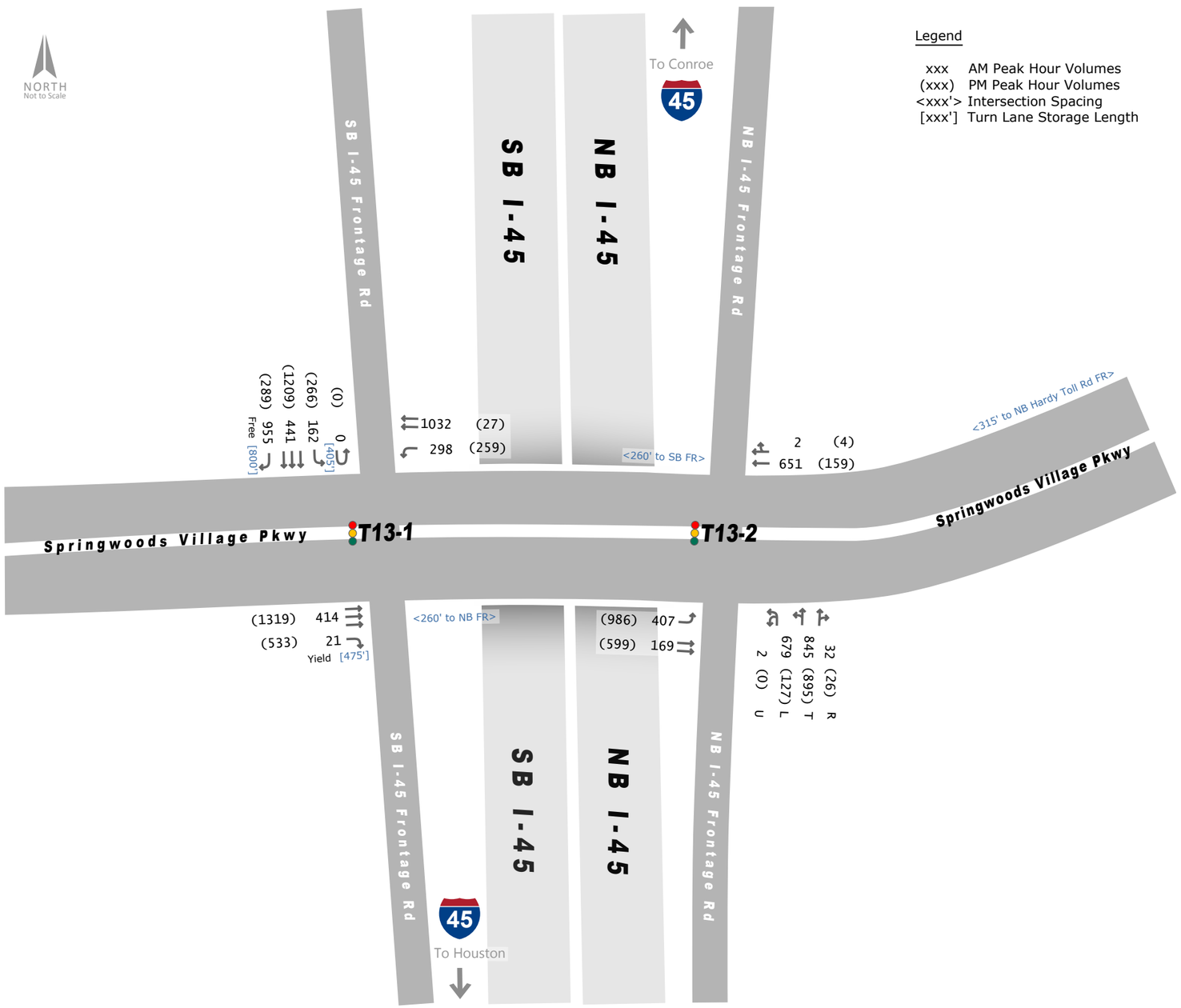
				EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R
				SH 99 WB FR						I-45 SB FR					
T12-1 I-45 SB FR at SH 99 WB FR	AM	LOS	C				A	A						C	A
		Delay (s/veh)	27.2				1	1.2						33.5	1.1
		50% queue (ft)	-				0	7						47	0
		v/c ratio	-				0.15	0.18						0.35	0.19
	PM	LOS	C				A	A						D	A
		Delay (s/veh)	32.6				0.4	1.8						40.4	8.6
		50% queue (ft)	-				0	12						153	0
		v/c ratio	-				0.06	0.25						0.82	0.57
				SH 99 EB FR						I-45 SB FR					
T12-2 I-45 SB FR at SH 99 EB FR	AM	LOS	C		C	C							A	A	
		Delay (s/veh)	27.2		30.7	26.6							0.2	0.1	
		50% queue (ft)	-		14	58							0	0	
		v/c ratio	-		0.11	0.88							0.14	0.15	
	PM	LOS	B		C	A							C	A	
		Delay (s/veh)	13.8		31.2	9.7							27.8	0.1	
		50% queue (ft)	-		12	0							134	0	
		v/c ratio	-		0.09	0.61							0.4	0.16	
				SH 99 WB FR						I-45 NB FR					
T12-3 I-45 NB FR at SH 99 WB FR	AM	LOS	D					C	E	A	A				
		Delay (s/veh)	47.8					32.2	58.5	4.2	0.3				
		50% queue (ft)	-					68	~177	11	0				
		v/c ratio	-					0.39	1.01	0.26	0.26				
	PM	LOS	B					C	A	A	A				
		Delay (s/veh)	18.0					31.8	9.2	5.5	0.2				
		50% queue (ft)	-					26	0	22	0				
		v/c ratio	-					0.19	0.53	0.25	0.23				
				SH 99 EB FR						I-45 NB FR					
T12-4 I-45 NB FR at SH 99 EB FR	AM	LOS	C	A	B						D	A			
		Delay (s/veh)	35.5	0.3	12.5						40.6	5.1			
		50% queue (ft)	-	0	29						152	0			
		v/c ratio	-	0.04	0.07						0.83	0.36			
	PM	LOS	C	A	A						C	B			
		Delay (s/veh)	31.9	0.2	4.5						40.4	11			
		50% queue (ft)	-	0	22						153	12			
		v/c ratio	-	0.03	0.24						0.81	0.67			

Summary of Operational Issues

T12-3: I-45 NB FR & SH 99 WB FR

- WBR AM peak hour 95th% queue is 391 feet and the movement is over capacity. The AM queue exceeds the available right turn lane storage length.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Springwoods Village Pkwy						I-45 SB FR					
T13-1 I-45 SB FR at Springwoods Village Pkwy	AM	LOS	C		D		B	A					C	C	
		Delay (s/veh)	34.9		38.9		17.2	1.4					33.9	31.6	
		50% queue (ft)	-		92		64	0					95	94	
		v/c ratio	-		0.49		0.46	0.5					0.4	0.38	
	PM	LOS	F		F		B	A					C	C	
		Delay (s/veh)	127.1		231.8		12.8	0.2					30.6	34	
		50% queue (ft)	-		461		122	0					147	276	
		v/c ratio	-		1.43		0.53	0.01					0.49	0.77	
				Springwoods Village Pkwy						I-45 NB FR					
T13-2 I-45 NB FR at Springwoods Village Pkwy	AM	LOS	E	C	A			E		E	E				
		Delay (s/veh)	65.5	30.5	0.2			71.6		69.4	57.6				
		50% queue (ft)	-	244	0			240		379	398				
		v/c ratio	-	0.87	0.1			0.99		0.99	0.99				
	PM	LOS	D	F	A			D		C	D				
		Delay (s/veh)	42.0	260.7	1.4			45.3		26.3	43.7				
		50% queue (ft)	-	1013	0			56		62	338				
		v/c ratio	-	1.53	0.33			0.45		0.23	0.89				

Summary of Operational Issues

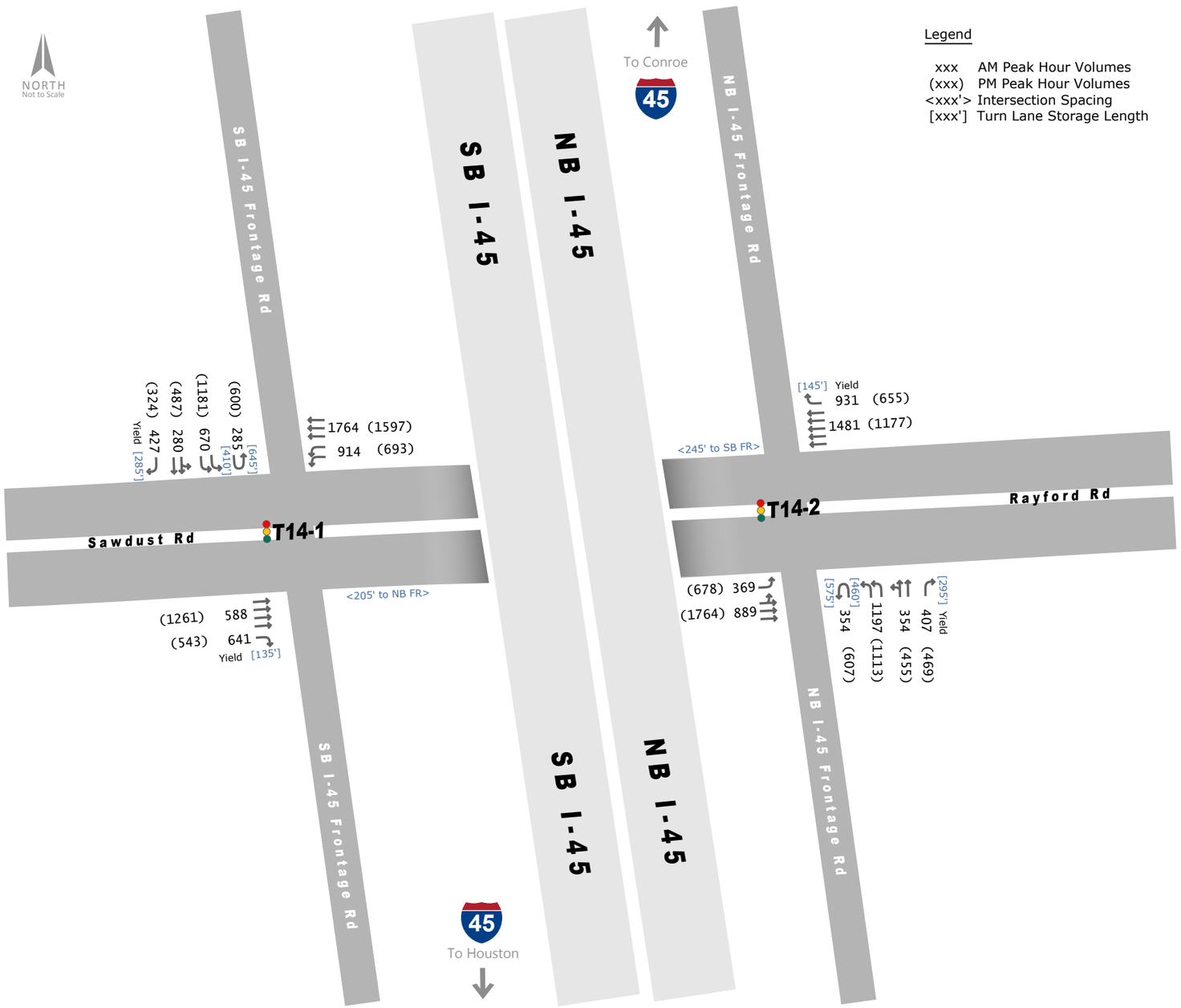
T13-1: I-45 SB FR & Springwoods Village Pkwy

- EBT PM peak hour 95th% queue is 584 feet and blocks access to the right turn lane. This movement significantly exceeds capacity.

T13-2: I-45 NB FR & Springwoods Village Pkwy

- WBT/R AM peak hour 95th% queue is 421 feet and backs up into the Hardy Toll Road NB Frontage Road intersection. This movement is at capacity.
- In the AM peak hour, NB movements are at capacity. 95th% queues range from 650 to 715 feet, blocking access to the Hardy Toll Road SB Frontage Road.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Sawdust Rd						I-45 SB FR					
T14-1 I-45 SB FR at Sawdust Rd	AM	LOS	D		D		E	B					D	D	
		Delay (s/veh)	42.8		45.3		60.9	15.3					41.3	41	
		50% queue (ft)	-		130		310	323					196	201	
		v/c ratio	-		0.52		0.76	0.61					0.61	0.61	
	PM	LOS	F		F		D	D					E	E	
		Delay (s/veh)	80.1		111		46.3	35.6					57.2	55.5	
		50% queue (ft)	-		348		246	306					437	443	
		v/c ratio	-		0.96		0.7	0.59					0.91	0.89	
				Rayford Rd						I-45 NB FR					
T14-2 I-45 NB FR at Rayford Rd	AM	LOS	F	B	A			F		E	D				
		Delay (s/veh)	84.3	17.4	3.2			116.8		55.1	47.2				
		50% queue (ft)	-	23	0			390		377	340				
		v/c ratio	-	0.62	0.53			1.14		0.92	0.83				
	PM	LOS	F	E	E			F		E	E				
		Delay (s/veh)	108.5	75.1	57.1			150.3		76.6	78.7				
		50% queue (ft)	-	465	417			336		425	444				
		v/c ratio	-	0.95	0.87			1.21		0.99	1				

Summary of Operational Issues

T14-1: SB FR & Sawdust Rd

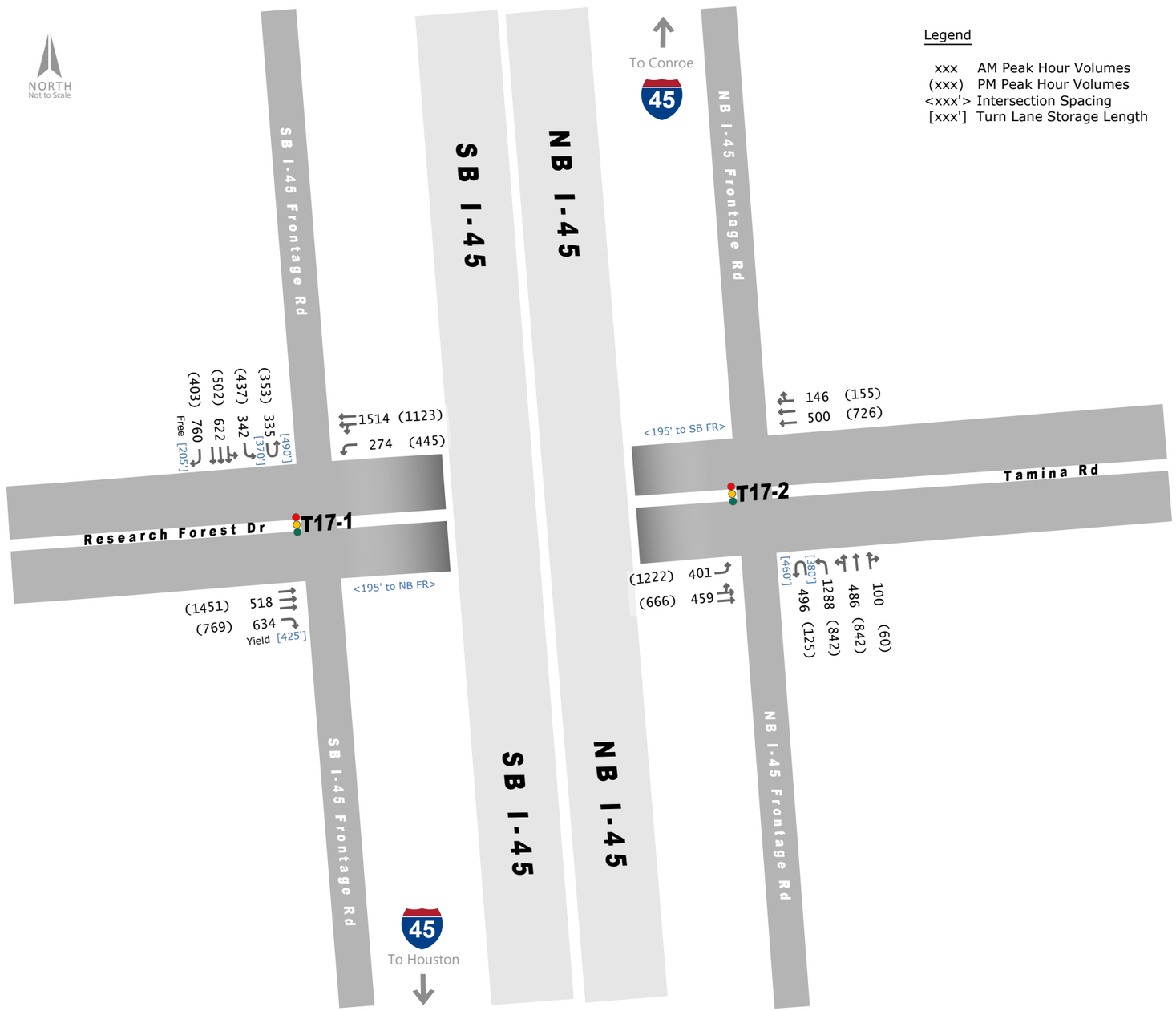
- EBT PM peak hour 95th% queue is 425 feet and blocks access to the right turn lane. This movement is almost at capacity.
- The SB movements are nearing capacity in the PM peak hour. Queues exceed available storage length.

T14-2: NB FR & Sawdust Rd

- In the AM peak hour, WBT is over capacity and all NB movements are nearing capacity.
- In the PM peak hour, all movements are the intersection are near or over capacity.

Exhibit 6: Frontage Road Intersection Operational Analysis - Existing Year 2017
13 of 17: I-45 & Sawdust Rd/Rayford Rd

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Research Forest Dr						I-45 SB FR					
T17-1 I-45 SB FR at Research Forest Dr	AM	LOS	E		E		B	B					E	E	
		Delay (s/veh)	60.4		57.2		13.8	16.4					72.2	56.5	
		50% queue (ft)	-		151		57	195					222	232	
		v/c ratio	-		0.66		0.34	0.89					0.85	0.85	
	PM	LOS	F		E		E	E					F	F	
		Delay (s/veh)	88.1		76.5		75.8	57					118.5	95.1	
		50% queue (ft)	-		488		258	220					266	280	
		v/c ratio	-		0.93		0.73	0.87					1.02	1.03	
				Tamina Rd						I-45 NB FR					
T17-2 I-45 NB FR at Tamina Rd	AM	LOS	F	F	E			E		F	C				
		Delay (s/veh)	80.6	91.4	77.4			62		106.5	31.2				
		50% queue (ft)	-	225	223			175		723	322				
		v/c ratio	-	0.76	0.74			0.74		1.12	1				
	PM	LOS	F	E	E			F		F	F				
		Delay (s/veh)	112.3	78	70			118.2		120.8	98.8				
		50% queue (ft)	-	715	674			306		540	545				
		v/c ratio	-	1.07	1.02			0.99		1.11	1.09				

Summary of Operational Issues

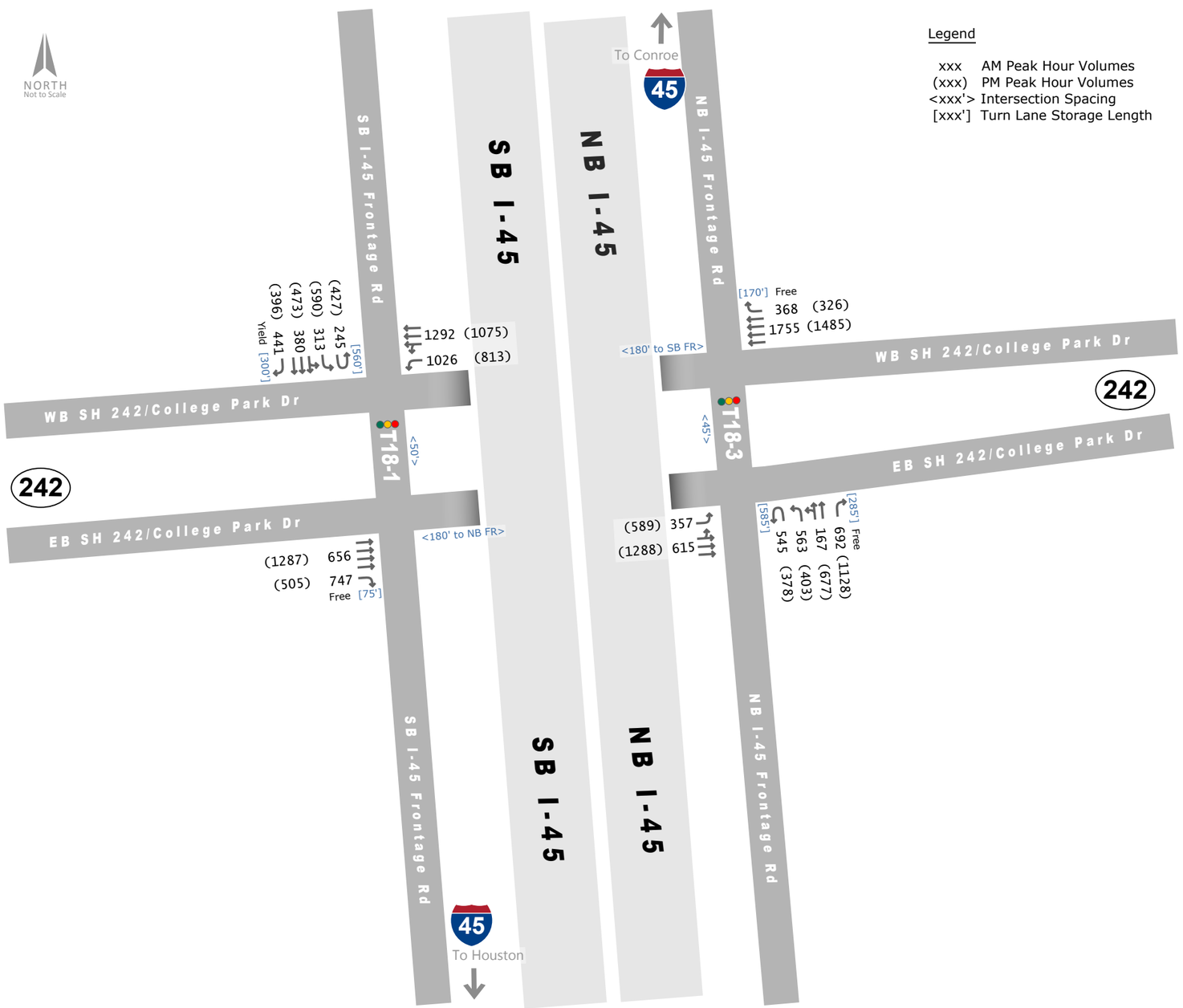
T17-1: I-45 SB FR & Research Forest Dr

- In the PM peak hour, the SB movements exceed capacity and the EBT is nearing capacity.

T17-2: I-45 NB FR & Tamina Rd

- In the AM peak hour, NB movements are over capacity. The NBL 95th% queue is 923 feet.
- In the PM peak hour, all movements are at or over capacity.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				SH 242 / College Park Dr						I-45 SB FR					
T18-1 I-45 SB FR at SH 242 / College Park Dr	AM	LOS	E		E		C	A					E	E	
		Delay (s/veh)	60.9		60.3		34.1	7.5					65.2	58.4	
		50% queue (ft)	-		196		556	550					193	199	
		v/c ratio	-		0.61		0.81	0.73					0.62	0.62	
	PM	LOS	E		E		E	B					F	E	
		Delay (s/veh)	70.3		69.3		74.3	19.4					82.1	58.2	
		50% queue (ft)	-		386		522	494					355	296	
		v/c ratio	-		0.89		0.83	0.7					0.89	0.75	
				SH 242 / College Park Dr						I-45 NB FR					
T18-3 I-45 NB FR at SH 242 / College Park Dr	AM	LOS	E	D	A			E		E	D				
		Delay (s/veh)	57.8	47.4	3.7			57.8		60	49.9				
		50% queue (ft)	-	310	24			510		293	222				
		v/c ratio	-	0.61	0.45			0.89		0.72	0.56				
	PM	LOS	F	E	A			F		F	E				
		Delay (s/veh)	98.9	79.7	8.4			112.5		89	74.9				
		50% queue (ft)	-	597	108			457		406	421				
		v/c ratio	-	0.88	0.74			0.97		0.95	0.94				

Summary of Operational Issues

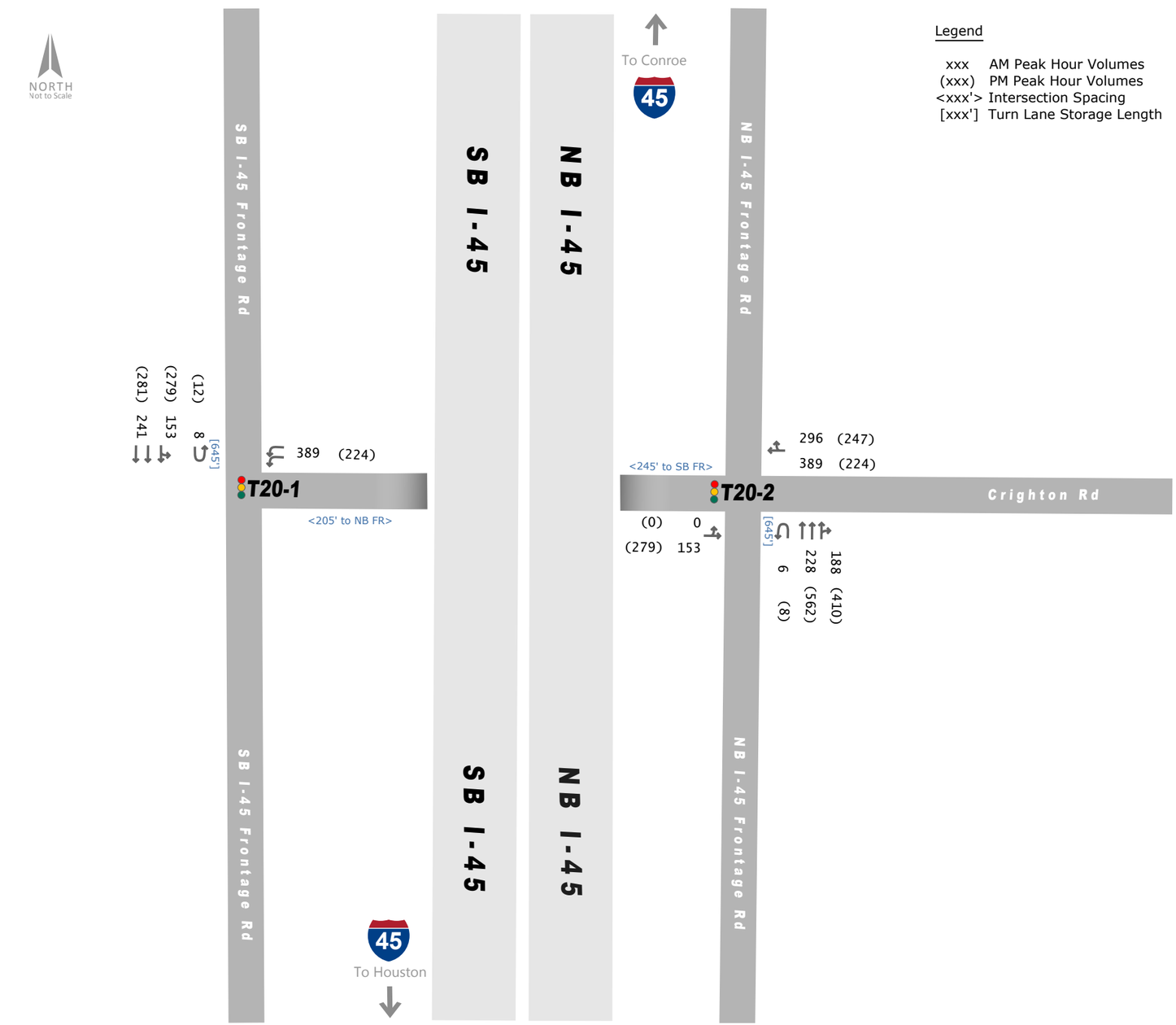
T18-1: I-45 SB FR & SH 242/College Park Dr

- EBT PM peak hour 95th% queue is 434 feet and is nearing capacity.
- SBL PM peak hour 95th% queue is 562 feet, which extends out of the left turn lane and blocks access to the U-turn lane. This movement is nearing capacity.

T18-3: I-45 NB FR & SH 242/College Park Dr

- WBT AM peak hour 95th% queue is 559 feet. PM peak hour 95th% queue is 537 feet. Both queues block access to the right turn lane and local business driveways.
- NBT PM peak hour 95th% queue is 553 feet and access to the right turn lane.
- In the PM peak hour, the NB and WB movements are nearing capacity.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

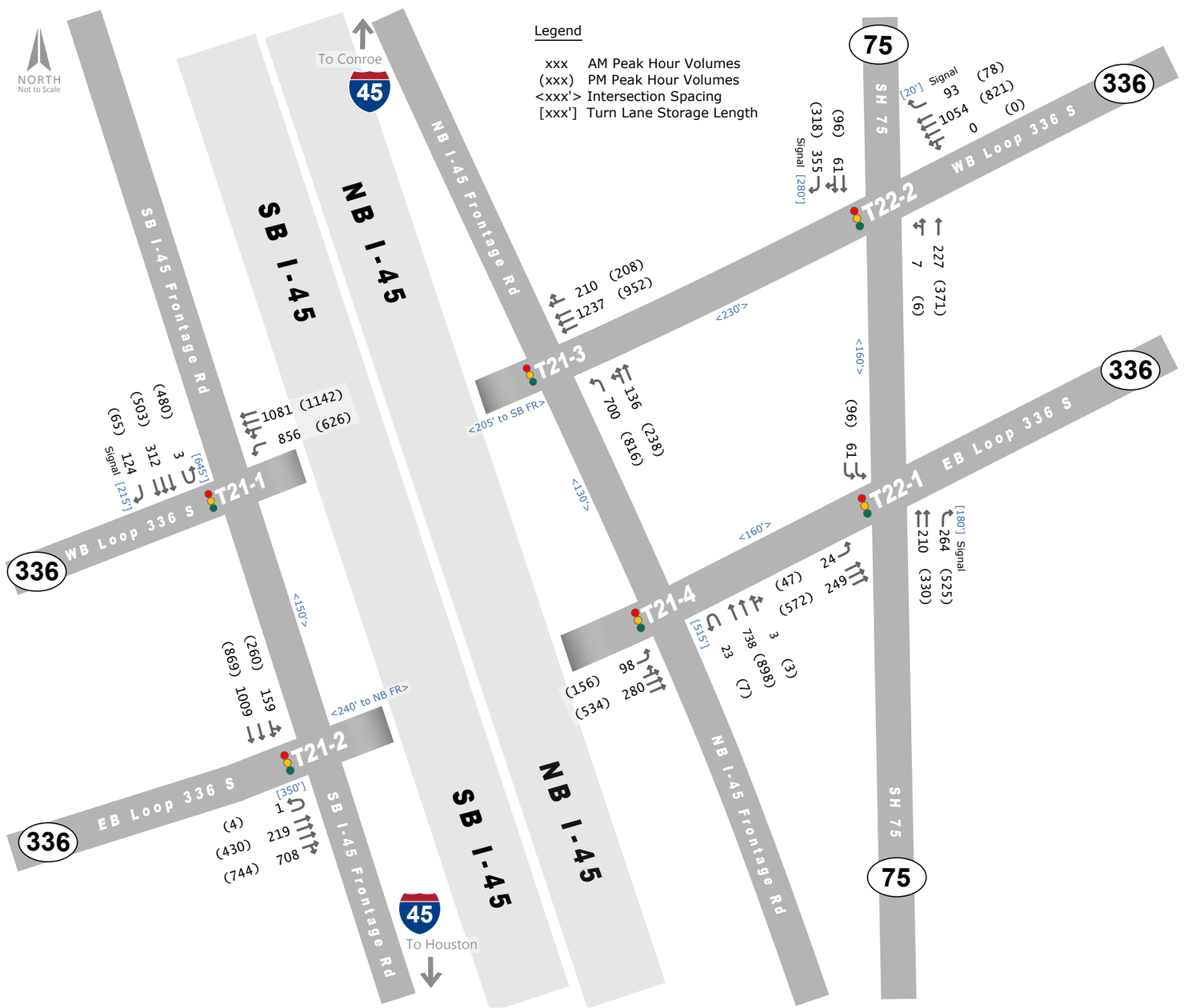
				EB			WB			NB			SB		
				L	T	R	L	T	R	L	T	R	L	T	R
				Crighton Rd						I-45 SB FR					
T20-1 I-45 SB FR at Crighton Rd	AM	LOS	B				A						B		
		Delay (s/veh)	18.2				3						18.2		
		50% queue (ft)	-				8						35		
		v/c ratio	-				0.25						0.43		
	PM	LOS	B				A						B		
		Delay (s/veh)	13.9				3.4						13.9		
		50% queue (ft)	-				5						41		
		v/c ratio	-				0.19						0.41		
				Crighton Rd						I-45 NB FR					
T20-2 I-45 NB FR at Crighton Rd	AM	LOS	B	B				B			B				
		Delay (s/veh)	14.3	12.5				16.6			10.5				
		50% queue (ft)	-	51				118			20				
		v/c ratio	-	0.18				0.81			0.41				
	PM	LOS	B	B				B			B				
		Delay (s/veh)	13.0	19.5				16.2			11.7				
		50% queue (ft)	-	89				81			52				
		v/c ratio	-	0.43				0.72			0.64				

Summary of Operational Issues

T20-1, T20-2

- No operational issues at any intersection.

Volumes and Lane Assignments



Capacity & Level of Service Analysis

				EB L	EB T	EB R	WB L	WB T	WB R	NB L	NB T	NB R	SB L	SB T	SB R
				LP 336 WB						I-45 SB FR					
T21-1 I-45 SB FR at LP 336 WB	AM	LOS	D				D	A						E	A
		Delay (s/veh)	42.5				53.6	3.9						58.3	2.9
		50% queue (ft)	-				94	67						89	0
		v/c ratio	-				0.44	0.44						0.86	0.35
	PM	LOS	D				E	A						D	A
		Delay (s/veh)	47.8				62.6	4.3						53.9	1
		50% queue (ft)	-				113	55						120	0
		v/c ratio	-				0.42	0.43						0.87	0.17
				LP 336 EB						I-45 SB FR					
T21-2 I-45 SB FR at LP 336 EB	AM	LOS	D		D									A	
		Delay (s/veh)	46.9		46.9									4	
		50% queue (ft)	-		145									31	
		v/c ratio	-		2.02dr									0.37	
	PM	LOS	F		F									A	
		Delay (s/veh)	85.8		85.8									3.5	
		50% queue (ft)	-		~215									19	
		v/c ratio	-		1.90dr									0.36	
				LP 336 WB						I-45 NB FR					
T21-3 I-45 NB FR at LP 336 WB	AM	LOS	E					E		E	A				
		Delay (s/veh)	62.0					62		64.3	2.7				
		50% queue (ft)	-					~251		84	2				
		v/c ratio	-					1.01		0.38	0.26				
	PM	LOS	E					E		E	A				
		Delay (s/veh)	71.7					71.7		63	1.9				
		50% queue (ft)	-					~218		93	3				
		v/c ratio	-					1.03		0.41	0.32				
				LP 336 EB						I-45 NB FR					
T21-4 I-45 NB FR at LP 336 EB	AM	LOS	D	A	A						D				
		Delay (s/veh)	50.2	0.1	4.5						50.2				
		50% queue (ft)	-	0	19						165				
		v/c ratio	-	0.09	0.1						0.89				
	PM	LOS	E	A	A						E				
		Delay (s/veh)	77.4	0	4.8						77.4				
		50% queue (ft)	-	0	34						~211				
		v/c ratio	-	0.15	0.19						1.02				
				LP 336 EB						SH 75					
T22-1 SH 75 at LP 336 EB	AM	LOS	B	B	C						C	A	A		
		Delay (s/veh)	13.9	19.3	20						20.9	4.4	3.5		
		50% queue (ft)	-	10	37						47	0	3		
		v/c ratio	-	0.04	0.15						0.18	0.38	0.06		
	PM	LOS	C	C	C						B	C	A		
		Delay (s/veh)	22.5	25.4	29.6						14.4	22.8	5		
		50% queue (ft)	-	17	83						54	161	6		
		v/c ratio	-	0.11	0.48						0.26	0.8	0.11		
				LP 336 WB						SH 75					
T22-2 SH 75 at LP 336 WB	AM	LOS	B				C	A		A				B	B
		Delay (s/veh)	18.2				23.7	0.4		4.9				12.6	11.1
		50% queue (ft)	-				146	0		11				41	49
		v/c ratio	-				0.5	0.14		0.16				0.18	0.26
	PM	LOS	B				C	A		A				A	A
		Delay (s/veh)	16.1				26.4	0.6		4.1				7.8	6
		50% queue (ft)	-				97	0		18				30	27
		v/c ratio	-				0.55	0.15		0.22				0.16	0.21

Summary of Operational Issues

- T21-2: The EBT/R movement is significantly over capacity.
- T21-3: The WBT/R movement is over capacity.
- T21-4: The NBT/R movement is over capacity in the PM peak hour and nearing capacity in the AM peak hour.

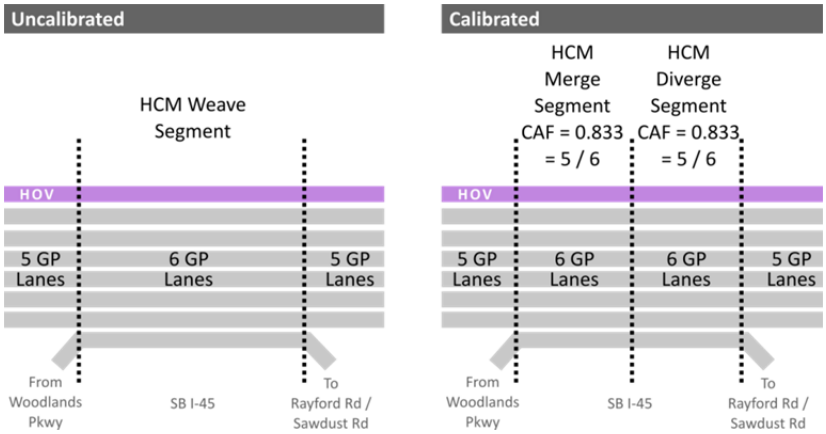
Exhibit 6: Frontage Road Intersection Operational Analysis - Existing Year 2017
17 of 17: I-45 & Loop 336

Appendix A
FREEVAL Calibration

FREEVAL Calibration

Estimating both LOS and reliability required calibrating the Highway Capacity Manual 6 (HCM) methodology in order to reasonably reflect existing conditions. While modeling LOS has been long established, the HCM procedure is segment-based, primarily developed from observations at 2-4 lane facilities, and is not necessarily sensitive to lane-by-lane causes of congestion. I-45 contains several 5 and 6 lane segments, and also experiences congestion in sections with closely-spaced high-volume ramps. The goal of calibration was to make the model reasonably reflect existing trends so that it could be useful for high-level estimation of traffic operations in future or alternative scenarios. Pages 2 through 5 of this Appendix show comparisons of the calibrated model to field data. Calibration was primarily done by two procedural adjustments:

- **Modeling weaves as separate merge/diverge segments** – Using default HCM 6 weaving procedures resulted in severely underestimating capacity along I-45 and showed many bottlenecks where none exist today. The HCM weaving procedure does not provide a way to increase default capacity. To overcome the limitation, all weaves were modeled as separate merge and diverge segments and included a capacity adjustment factor (CAF) to match the capacity of upstream and downstream segments. An example is shown in the figure below where the 6 lane weave is modeled as a 6 lane merge and a 6 lane diverge, each with a CAF of 5 lanes / 6 lanes = 0.833. In the FREEVAL model, CAFs were further lowered if needed to reflect existing bottlenecks. Level of Service (LOS) was reported as the maximum of the merge or diverge.



  Replacing weaves with merges and diverges also appeared reasonable because many weaving sections on I-45 are 2,000 to 3,000 ft between ramps. HCM merge and diverge influence areas are 1500 ft each, or 3,000 ft when combined.

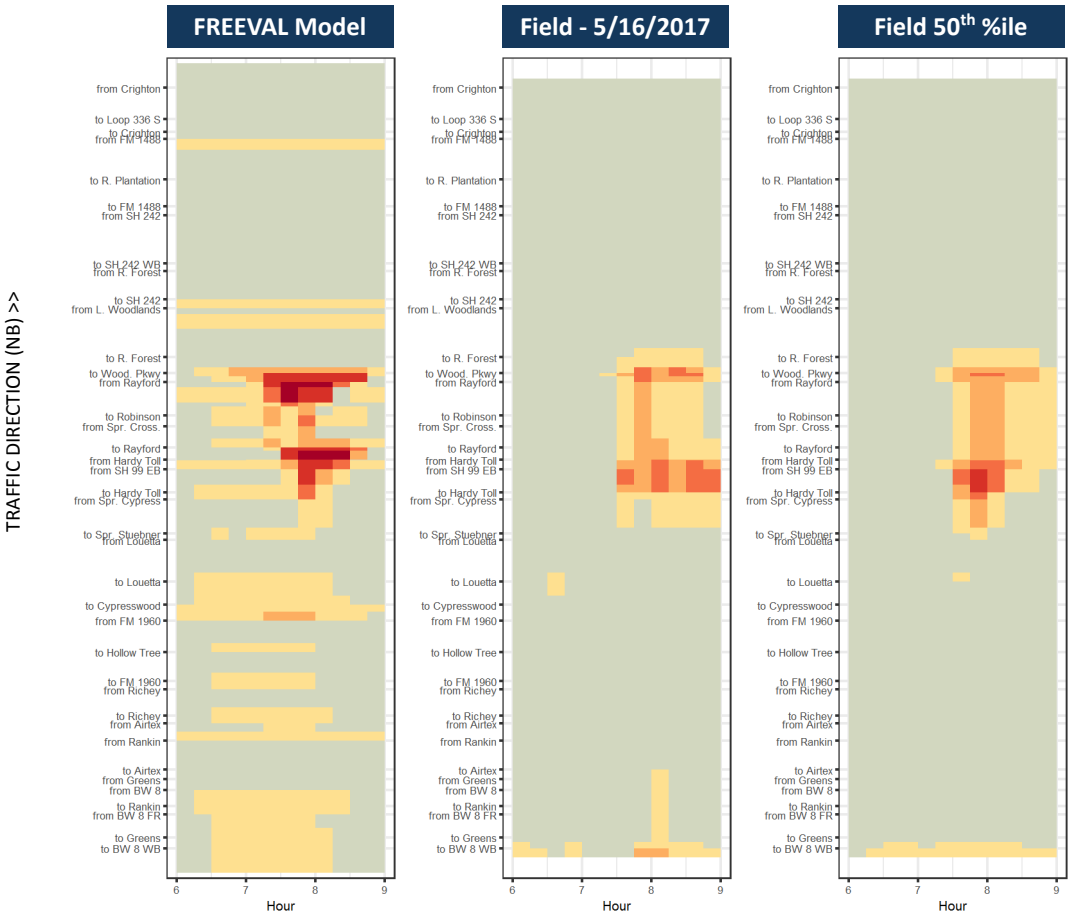
- **Capacity Adjustment Factors (CAF)** – Observed speeds from the NPMRDS were used to assess where bottlenecks occur. CAFs in the bottleneck sections were adjusted based on engineering judgment to reflect typical observed speeds. Adjustments were applied sparingly in order to avoid over-constraining the model and preserve the model's predictive power for estimating reliability and future scenarios. Typical adjustments for bottlenecks were adjusting the CAFs down from 1.0 to 0.8. To replicate congestion from bottlenecks outside of the analysis limits, south of BW 8, a capacity adjustment factor was applied to the last 5 lane segment in the model (required by FREEVAL) with a CAF changing over time from 0.7 down to 0.6 and back to 0.7 during the 6-9 PM peak. SB AM peak used a constant 0.8 CAF. These adjustments helped the model reflect congestion expected south of BW 8 in the typically 4 lane sections. More detailed analysis would require extending the model beyond the scope of the I-45 Study. Longer limits would also strain the abilities of the HCM freeway facilities methodology which works well for freeways of about 20 miles or less.

Speeds

Speed (mph)

- 60-70
- 50-60
- 40-50
- 30-40
- 20-30
- 10-20
- < 10

All field data from the FHWA NPMRDS. 50th percentile data for year 2017.



The FREEVAL model replicates the NB AM peak bottlenecks near Woodlands Parkway and Hardy Toll Road. The modeled back of queue closely matches field conditions on the seed date 5/16/2017 and the 50th percentile speeds. Modeled speeds are slighly slower in the bottlenecks by about 10-20 mph. Speeds, travel time, queue length, and travel time index are reasonable, so this is an acceptable calibration for high-level planning evaluation of I-45.

Travel Time

Travel time in minutes for FREEVAL analysis limits

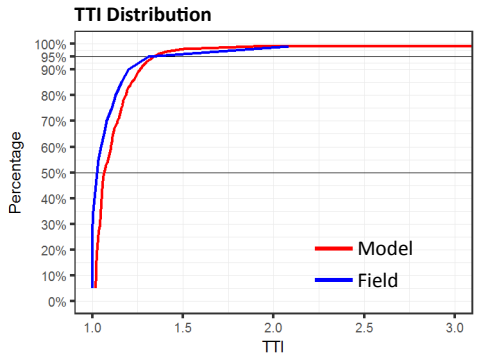
Start Time:	06:00	06:15	06:30	06:45	07:00	07:15	07:30	07:45	08:00	08:15	08:30	08:45	Avg.
Model	23.6	23.9	24.4	24.4	24.6	25.8	27.6	29.0	27.1	25.6	24.3	23.7	25.3
Field	23.1	22.6	23.1	22.9	22.5	23.2	24.2	25.3	25.6	24.9	25.2	24.3	23.9
Diff. (Model - Field)	0.5	1.3	1.3	1.4	2.1	2.6	3.4	3.6	1.5	0.7	-0.9	-0.6	1.4

The FREEVAL model replicates field observed travel times within about 2 minutes on average, and within about 4 minutes in peak 15 minute periods. The model tends to show slightly slower travel times than the NPMRDS field observations.

Reliability

Travel Time Index (TTI) for FREEVAL analysis limits

Percentile	Model	Field
PTI, 95th	1.34	1.31
80th	1.18	1.13
50th	1.06	1.02



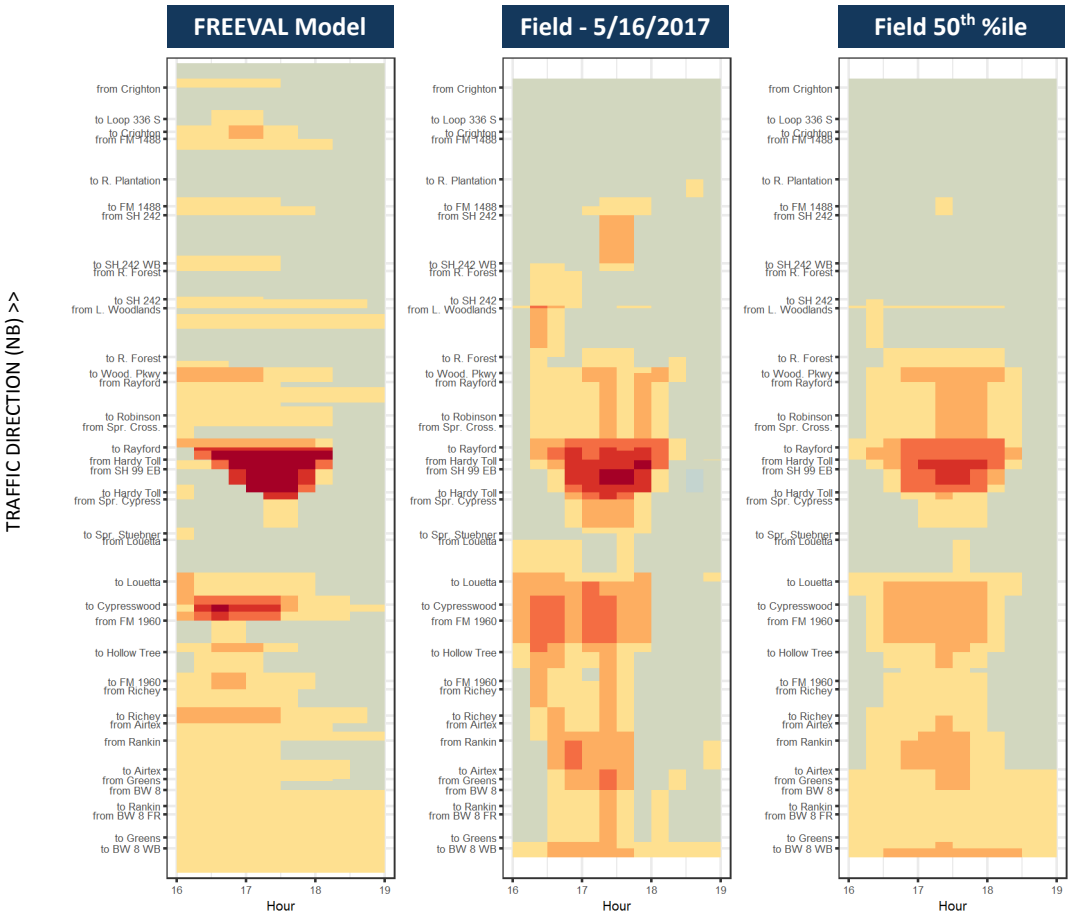
The FREEVAL model closely replicates the travel time index (TTI) distribution obtained from the year 2017 NPMRDS travel time data. Modeled 50th, 80th, and 95th percentile TTI are within 5% of the field observed data, with the model showing higher values.

Speeds

Speed (mph)

- 60-70
- 50-60
- 40-50
- 30-40
- 20-30
- 10-20
- < 10

All field data from the FHWA NPMRDS. 50th percentile data for year 2017.



The FREEVAL model replicates the back of queue from the primary NB PM peak bottlenecks near Woodlands Parkway and Hardy Toll Road. Speeds are within 10 mph of observed 5/16/2017 field conditions. The model shows congestion near Louetta Rd, but field data shows slower speeds over longer distances. The HCM methodology has difficulty replicating these conditions that are near saturation, but not oversaturated. Overall, the calibrated model acceptably reflects the primary bottleneck trends, travel times, and travel time distributions for high-level planning evaluation of I-45.

Travel Time

Travel time in minutes for FREEVAL analysis limits

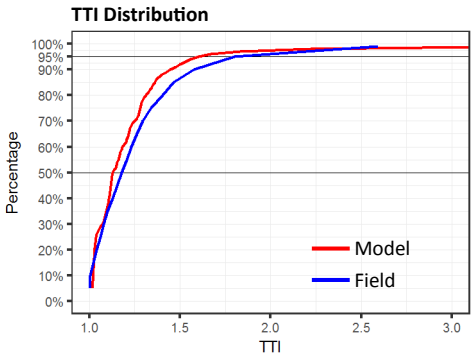
Start Time:	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	Avg.
Model	26.0	26.8	28.2	29.6	31.0	31.5	30.0	27.2	25.2	23.9	23.7	23.6	27.2
Field	24.7	27.2	27.9	29.2	30.0	32.4	30.2	28.0	24.9	23.5	22.9	23.5	27.0
Diff. (Model - Field)	1.3	-0.4	0.3	0.4	1.0	-0.9	-0.2	-0.8	0.3	0.4	0.8	0.1	0.2

The FREEVAL model replicates field observed travel times within about 1 minute on average and during the peak 15 minute periods. The model does not appear to be faster or slower travel times than the NPMRDS field observations.

Reliability

Travel Time Index (TTI) for FREEVAL analysis limits

Percentile	Model	Field
PTI, 95th	1.60	1.80
80th	1.31	1.40
50th	1.13	1.18



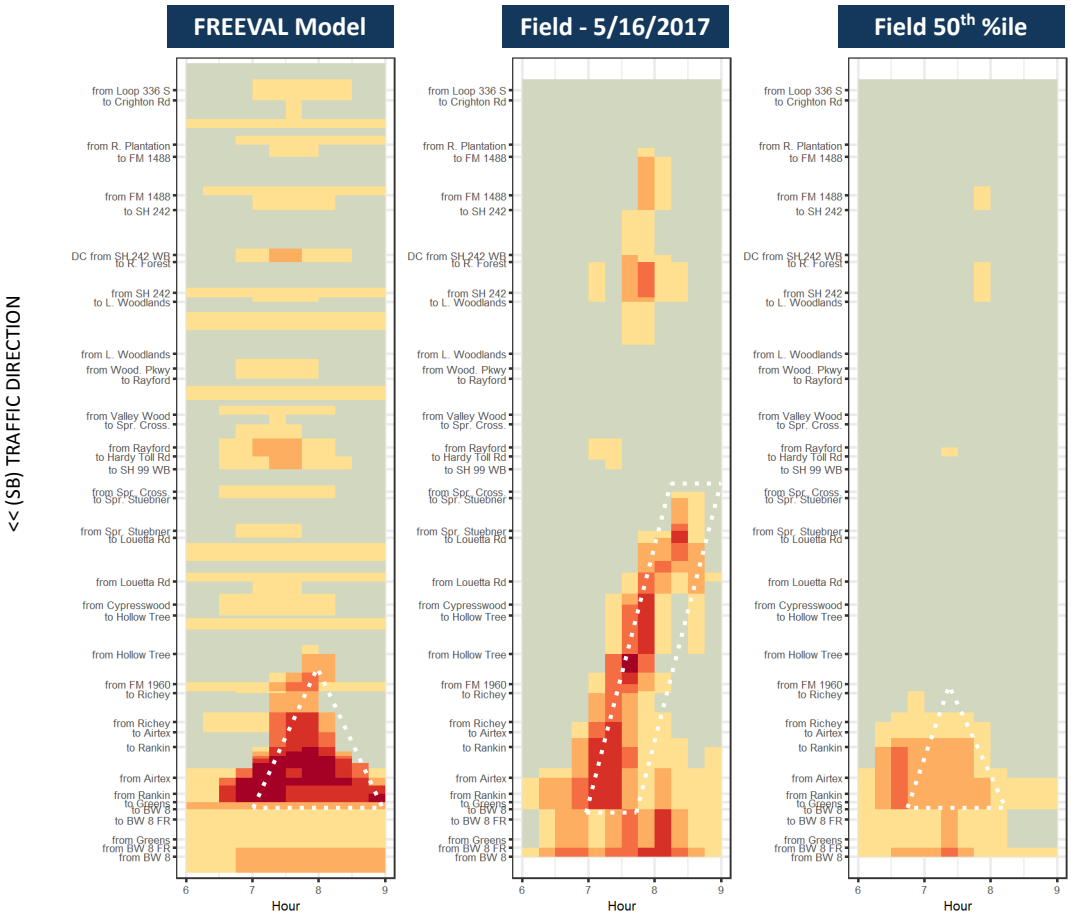
The FREEVAL model acceptably replicates the travel time index (TTI) distribution obtained from the year 2017 NPMRDS travel time data. Modeled 50th, 80th, and 95th percentile TTI are within 11% of the field observed data, with the model showing lower values.

Speeds

Speed (mph)

- 60-70
- 50-60
- 40-50
- 30-40
- 20-30
- 10-20
- < 10

All field data from the FHWA NPMRDS. 50th percentile data for year 2017.



The FREEVAL model replicates the SB AM peak bottleneck near BW 8 with back of queue similar to the Field 50th percentile. Field observed speeds on the 5/16/2017 (seed date) show an unusual "parallagram" shaped pattern on the heatmap, which is atypical of triangular patterns. Modeled speeds are about 10-20 mph slower than the 50th percentile at the bottleneck. Travel time, queue length, and travel time index are reasonably replicated, so this was considered acceptable calibration for high-level planning evaluation of I-45.

Travel Time

Travel time in minutes for FREEVAL analysis limits

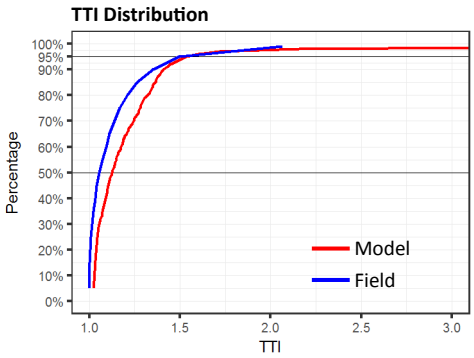
Start Time:	06:00	06:15	06:30	06:45	07:00	07:15	07:30	07:45	08:00	08:15	08:30	08:45	Avg.
Model	23.4	23.6	24.8	26.0	27.8	30.2	30.7	30.4	28.6	26.2	25.0	24.4	26.8
Field	22.2	22.6	23.1	24.8	28.0	29.0	30.0	29.8	27.1	25.5	24.4	23.5	25.8
Diff. (Model - Field)	1.1	1.0	1.7	1.2	-0.2	1.3	0.7	0.7	1.5	0.7	0.6	0.9	0.9

The FREEVAL model replicates field observed travel times within about 1 minute on average, and within about 2 minutes in peak 15 minute periods. The model tends to show slightly slower travel times than the NPMRDS field observations.

Reliability

Travel Time Index (TTI) for FREEVAL analysis limits

Percentile	Model	Field
PTI, 95th	1.53	1.50
80th	1.32	1.21
50th	1.13	1.05



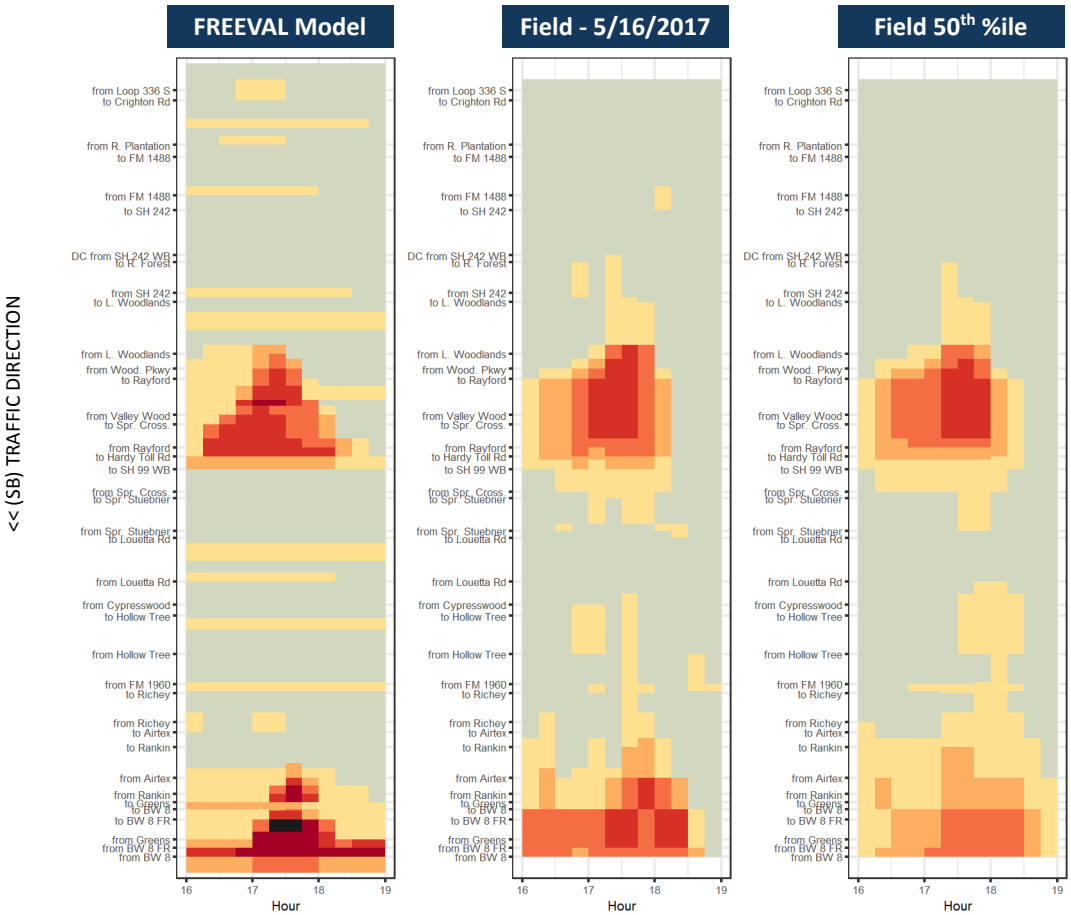
The FREEVAL model closely replicates the travel time index (TTI) distribution obtained from the year 2017 NPMRDS travel time data. Modeled 50th, 80th, and 95th percentile TTI are within 10% of the field observed data, with the model showing higher values.

Speeds

Speed (mph)

- 60-70
- 50-60
- 40-50
- 30-40
- 20-30
- 10-20
- < 10

All field data from the FHWA NPMRDS. 50th percentile data for year 2017.



The FREEVAL model replicates the SB PM peak bottlenecks near Hardy Toll Road, SH 99, and BW 8. The modeled back of queue closely matches field conditions from 5/16/2017 and the 50th percentile speeds. Modeled speeds are slighly slower in the bottleneck near BW 8 by about 10-20 mph. Spillback from downstream bottlnecks south of BW 8 outside of the analysis limits are likely infuencing the field observed speeds. The model includes capacity adjustment factors on the last segment south of BW 8 to help calibrate the back of queue for this bottleneck. Overall, the calibrated model acceptably reflects the primary bottleneck trends, travel times, and travel time distributions for high-level planning evaluation of I-45.

Travel Time

Travel time in minutes for FREEVAL analysis limits

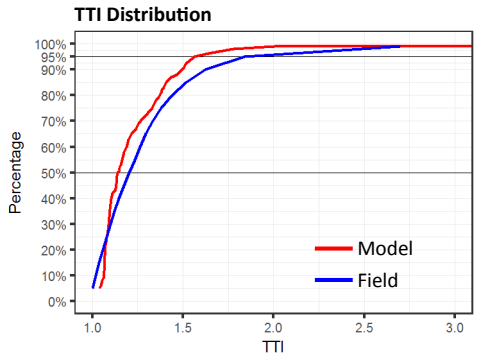
Start Time:	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	Avg.
Model	24.7	25.5	26.1	27.0	30.4	34.3	34.0	30.5	25.9	24.2	24.0	23.9	27.6
Field	24.5	25.6	25.2	26.4	27.3	30.1	32.0	29.6	26.3	25.0	22.9	22.5	26.4
Diff. (Model - Field)	0.2	-0.1	1.0	0.7	3.1	4.2	2.0	0.9	-0.4	-0.8	1.1	1.4	1.1

The FREEVAL model replicates field observed travel times within about 1 minute on average, and within about 4 minutes in peak 15 minute periods. The model tends to show slightly slower travel times than the NPMRDS field observations.

Reliability

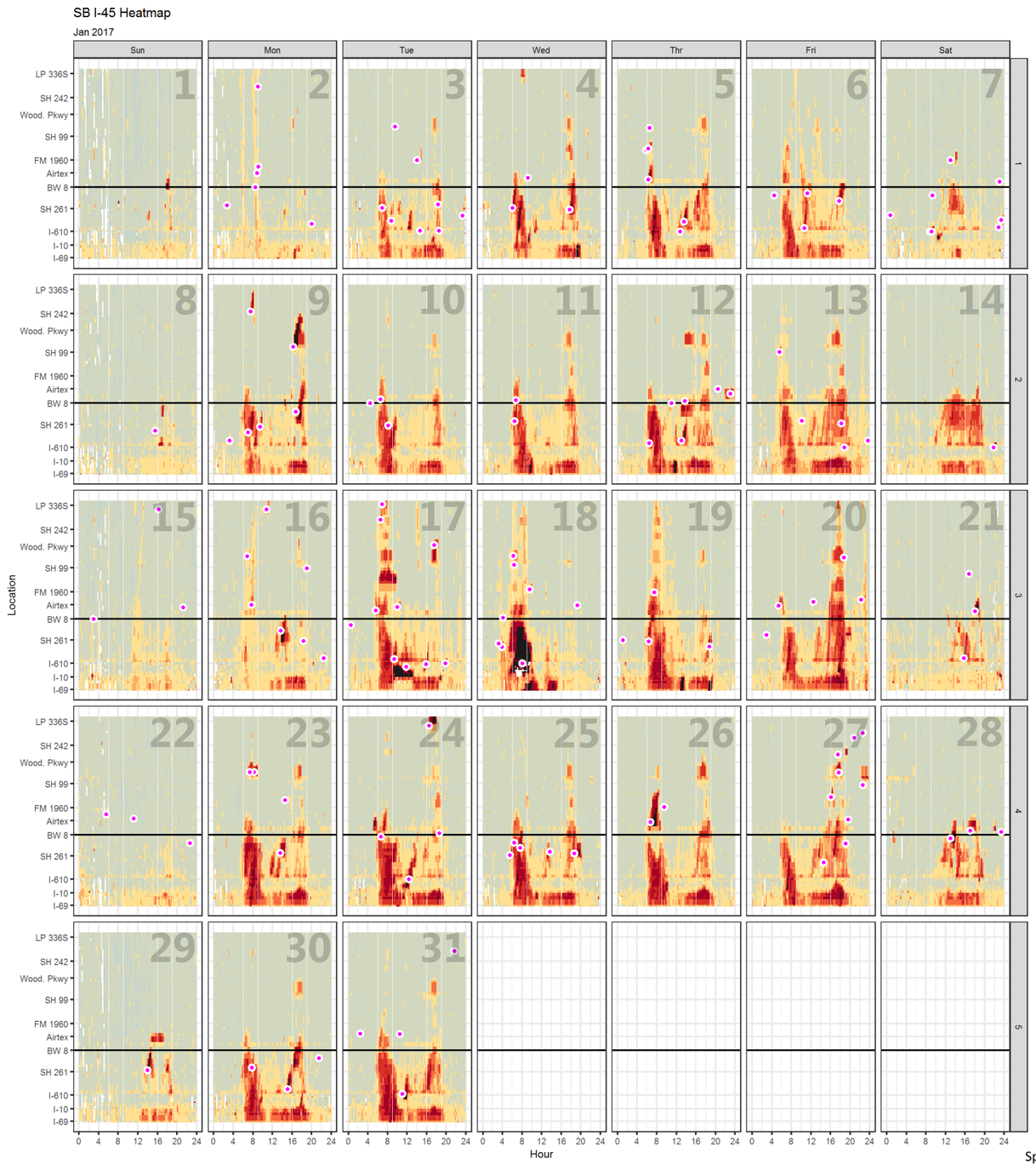
Travel Time Index (TTI) for FREEVAL analysis limits

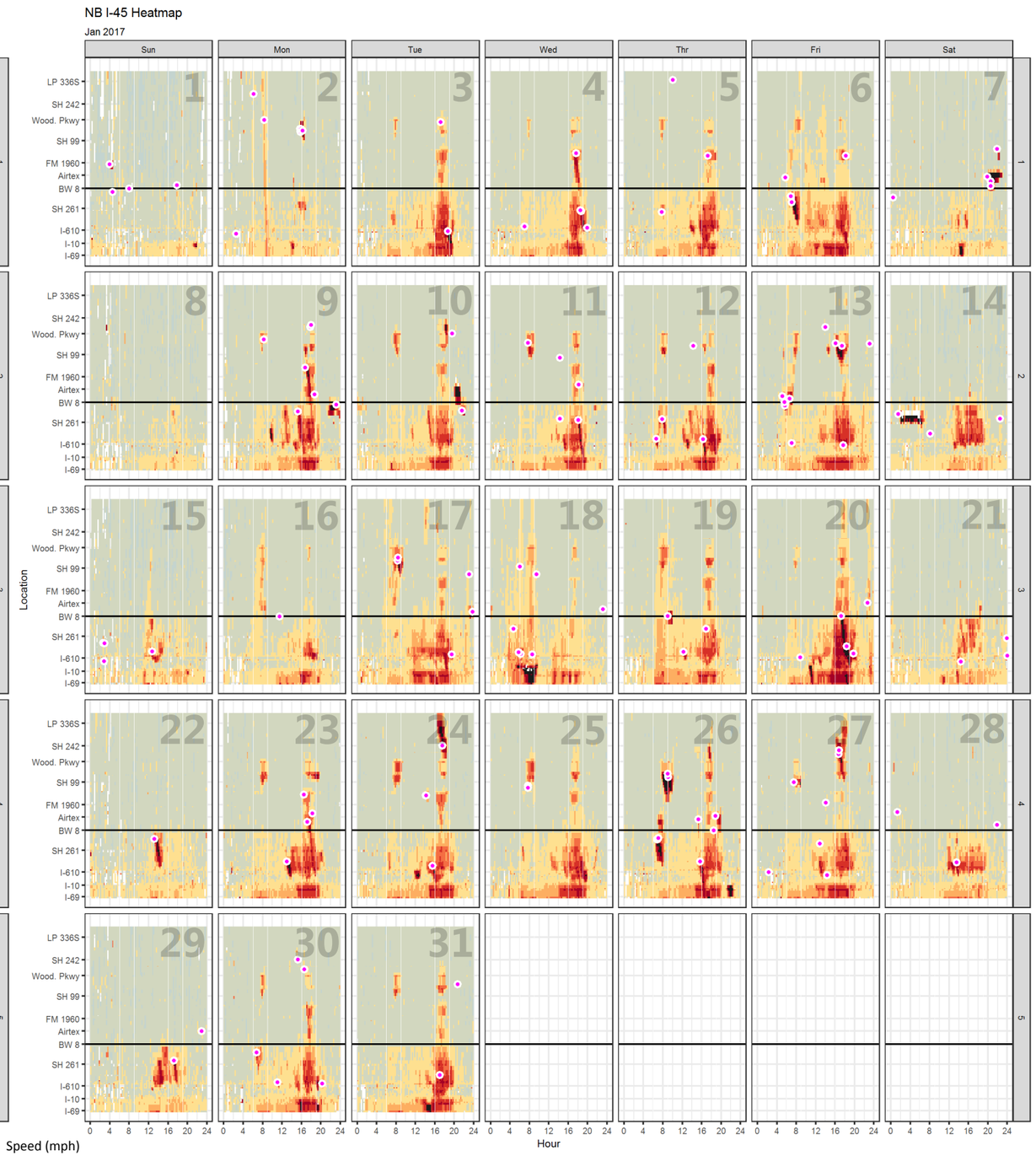
Percentile	Model	Field
PTI, 95th	1.56	1.84
80th	1.37	1.44
50th	1.14	1.20



The FREEVAL model acceptably replicates the travel time index (TTI) distribution obtained from the year 2017 NPMRDS travel time data. Modeled 50th, 80th, and 95th percentile TTI are within 15% of the field observed data, with the model showing lower values.

Appendix B
Speed Heatmaps
(Year 2017 NPMRDS Data)



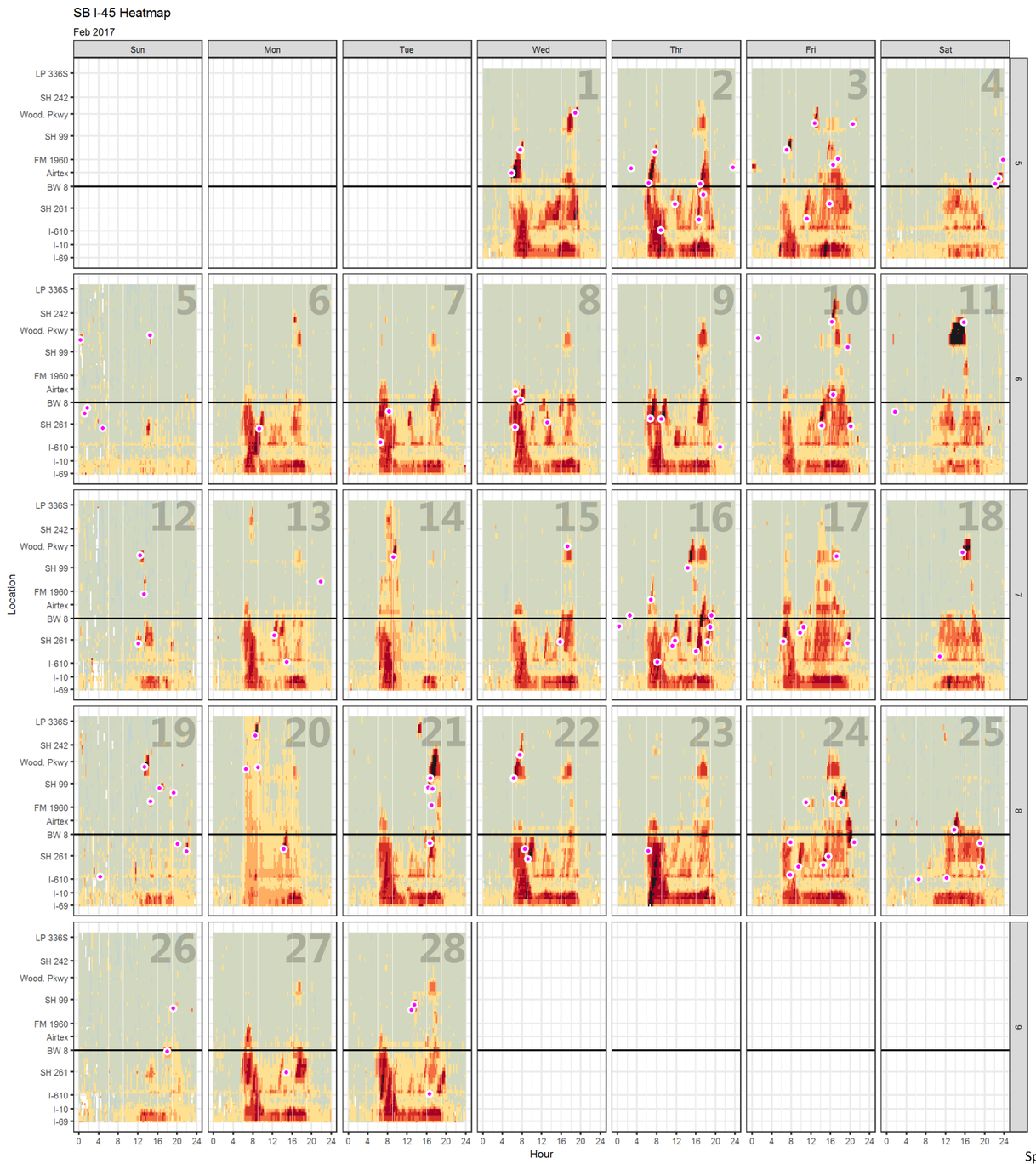


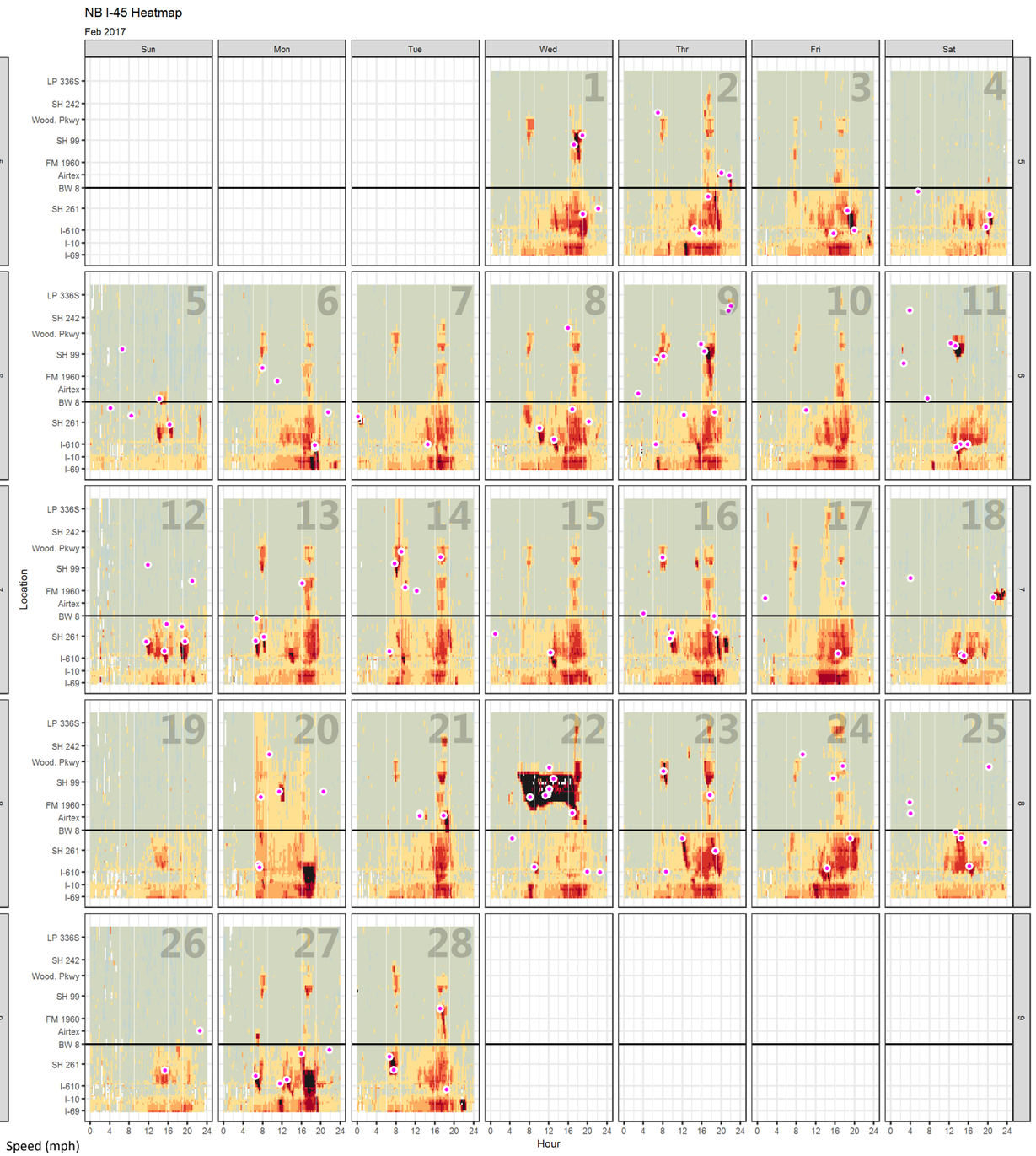
Speed (mph)

Speed data from the FHWA NPMRDS.
Speeds shown for every 15 minutes of year 2017.

< 10 | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | 60-70

Pink dot indicates time & location of a crash in the TxDOT Crash Records Information System (CRIS)



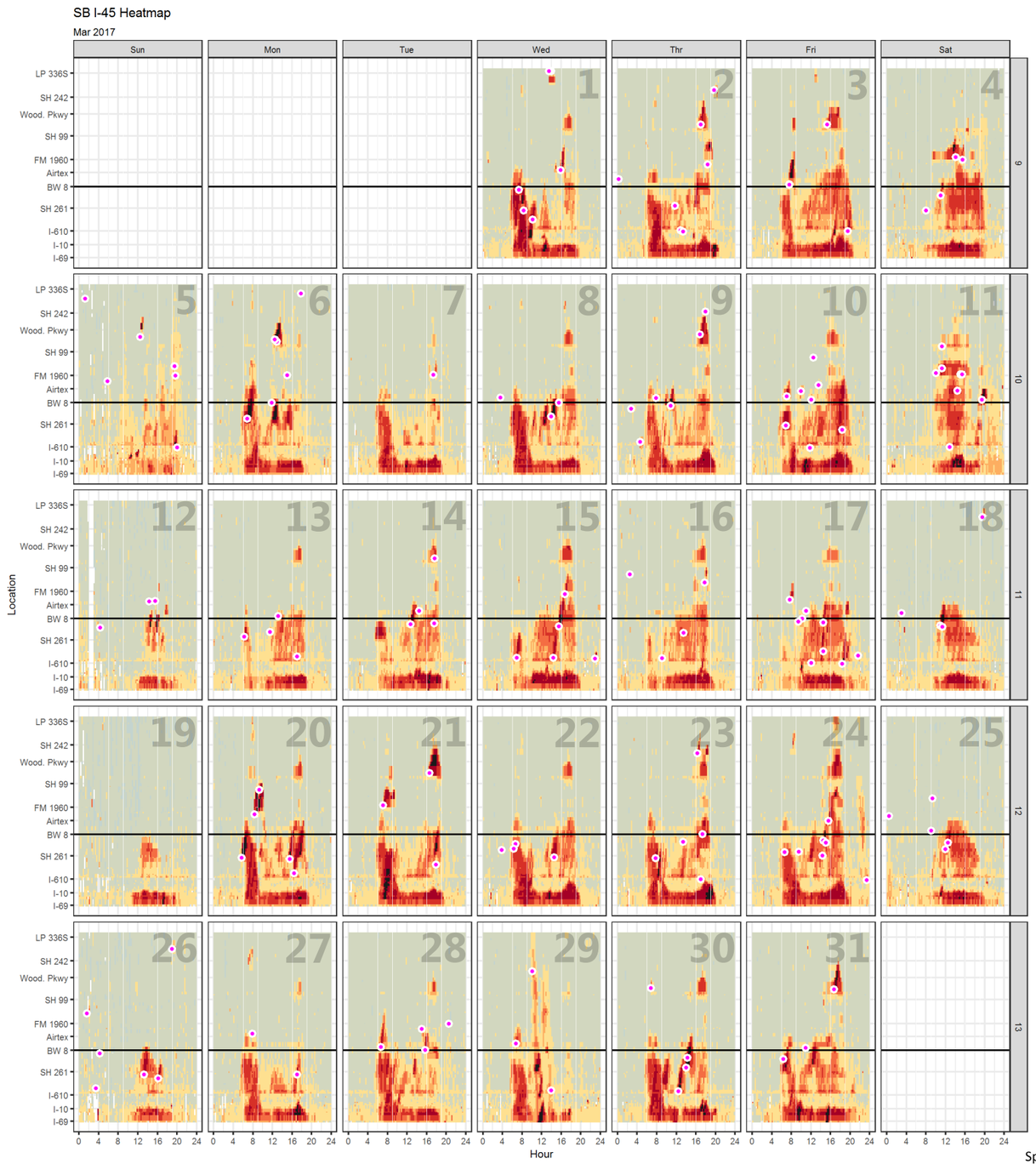


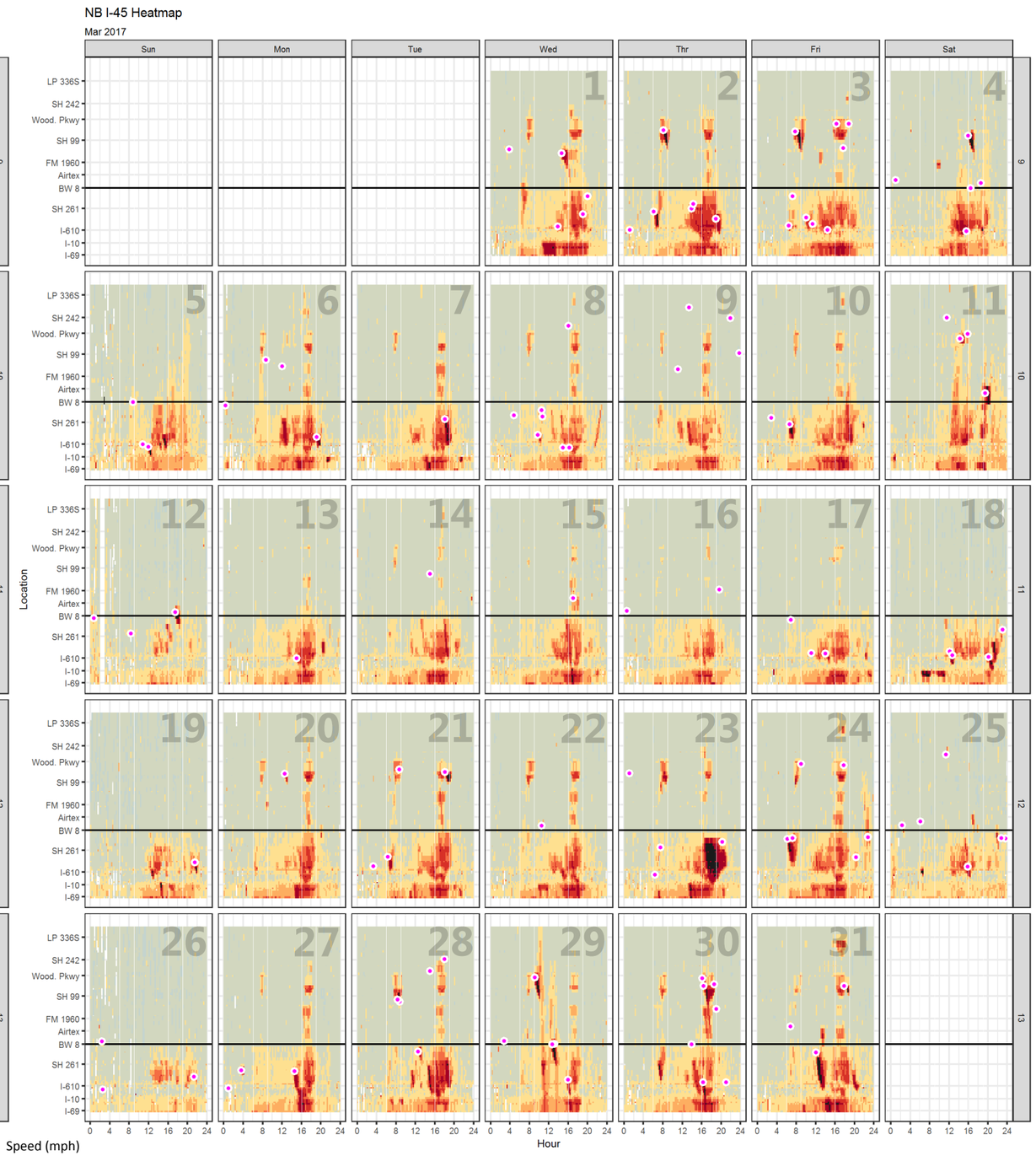
Speed (mph)

Speed data from the FHWA NPMRDS.
Speeds shown for every 15 minutes of year 2017.

< 10 | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | 60-70

Pink dot indicates time & location of a crash in the TxDOT Crash Records Information System (CRIS)





Speed (mph)

Speed data from the FHWA NPMRDS.
Speeds shown for every 15 minutes of year 2017.

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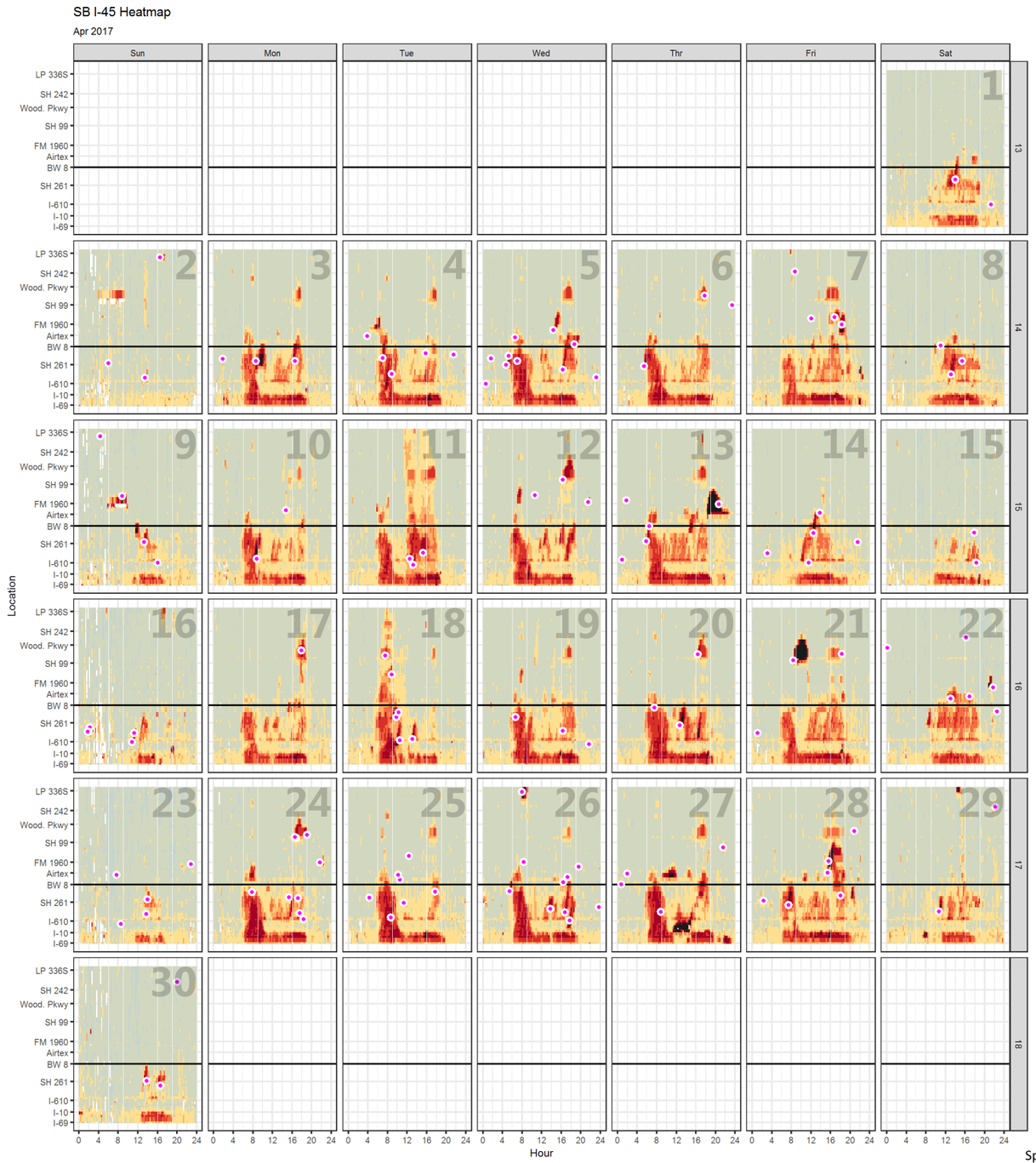

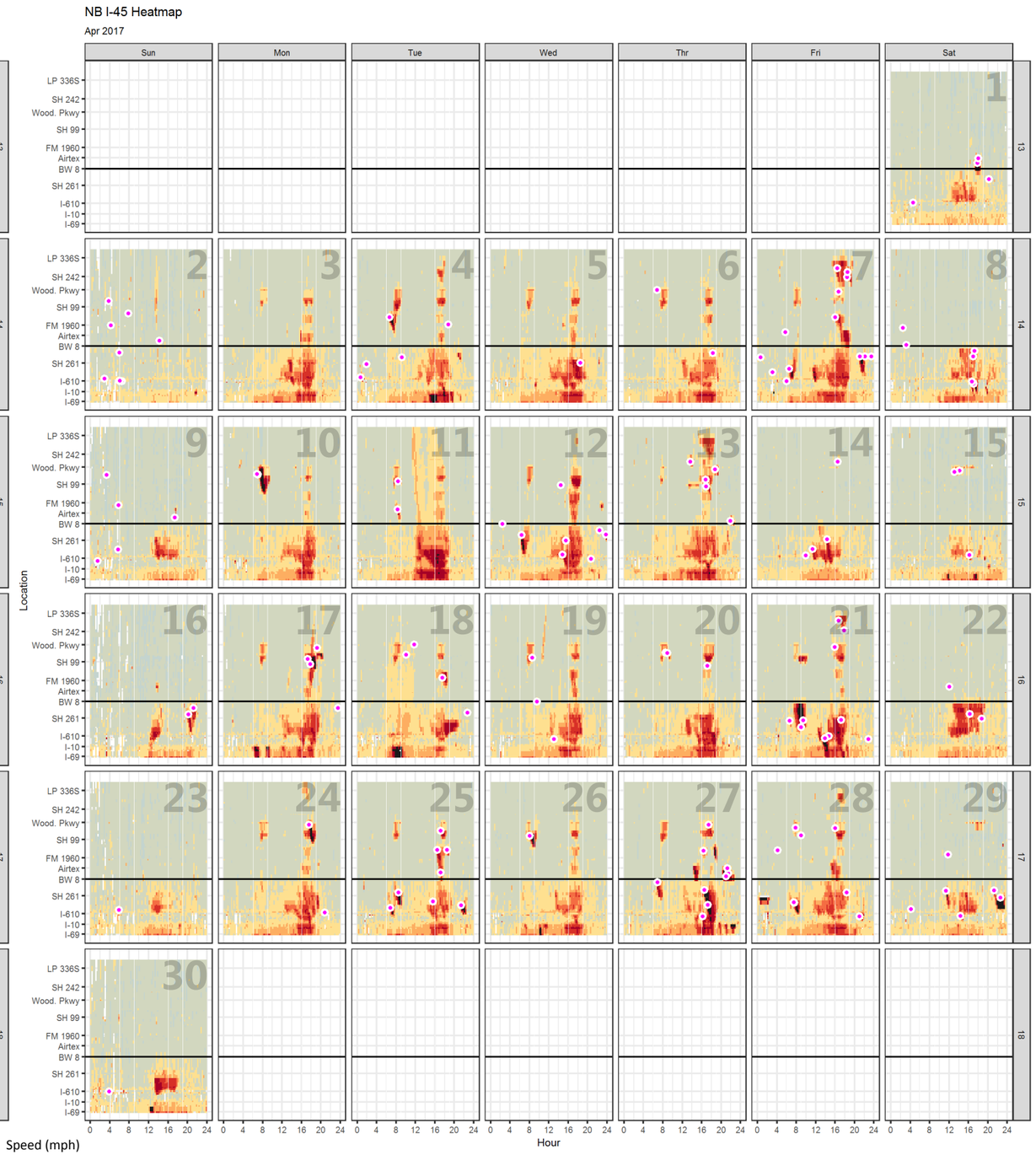

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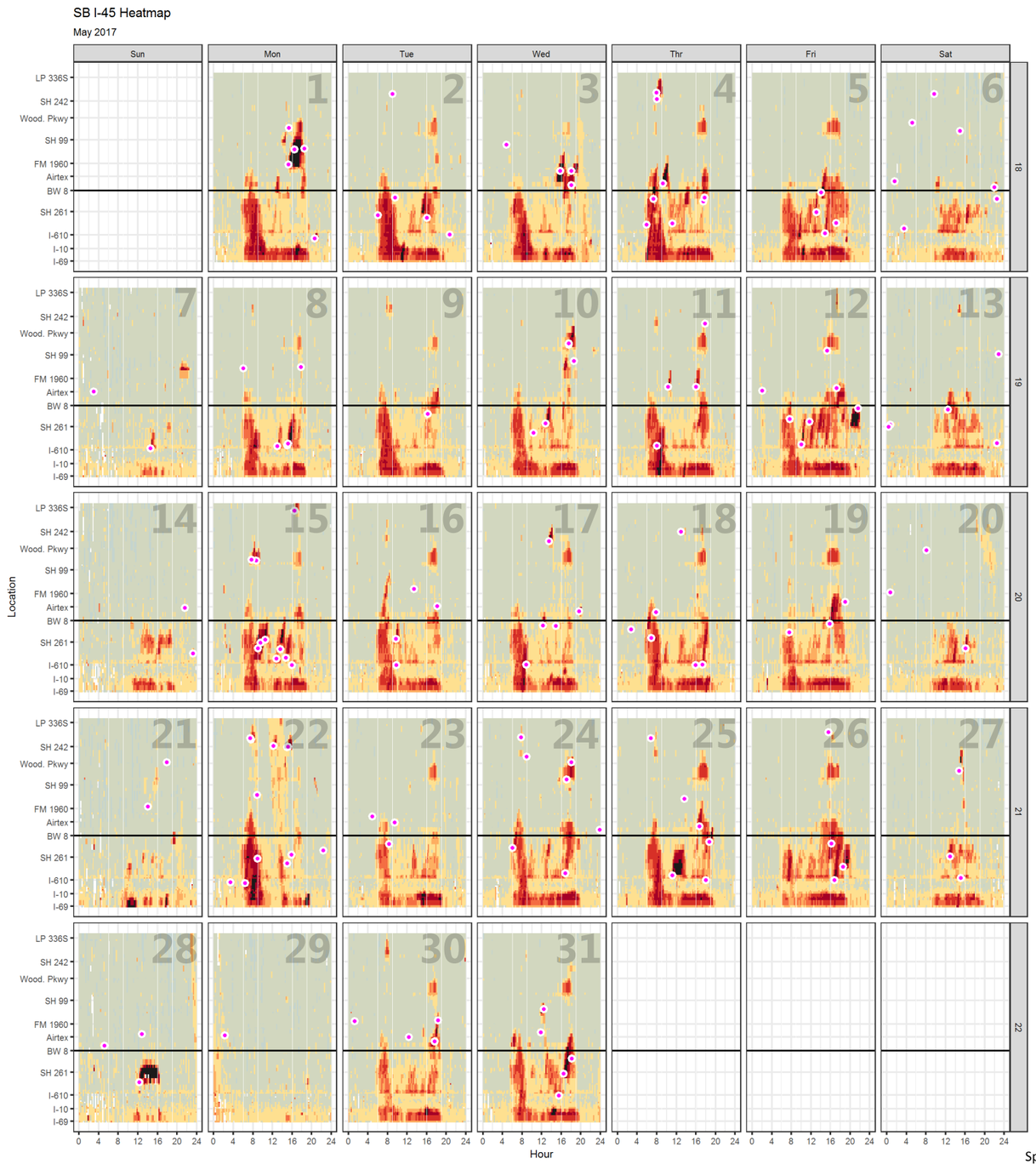

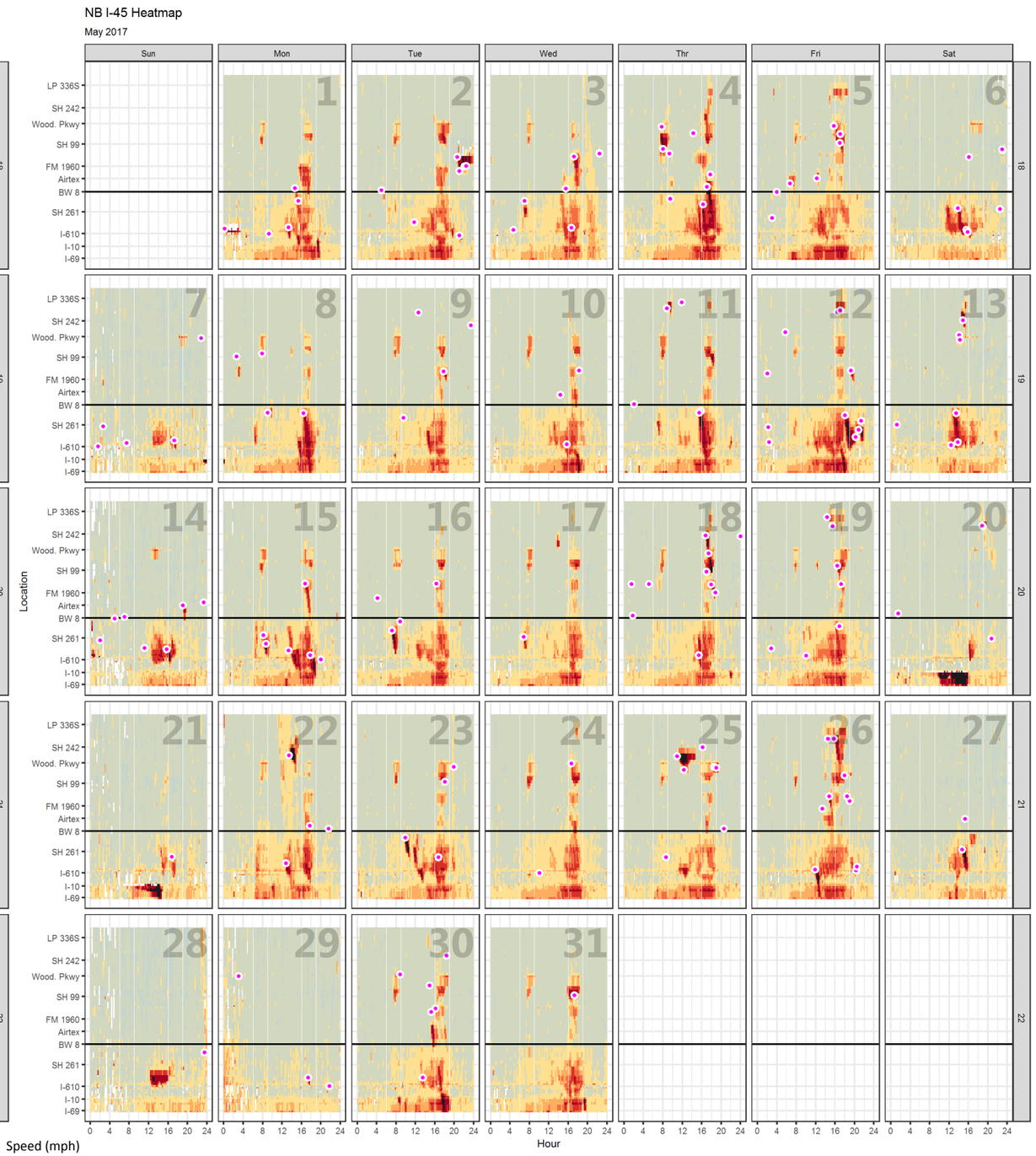

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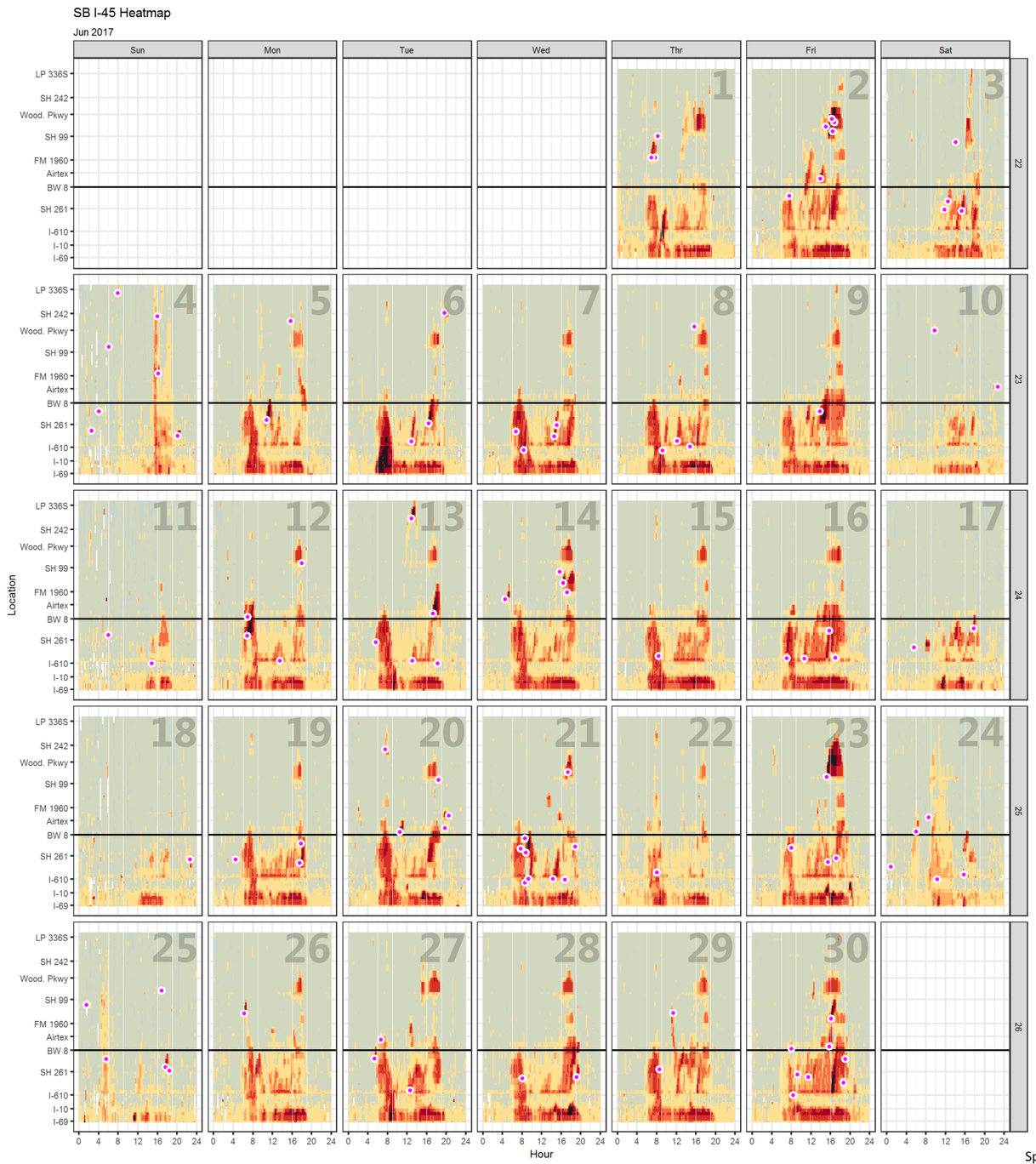

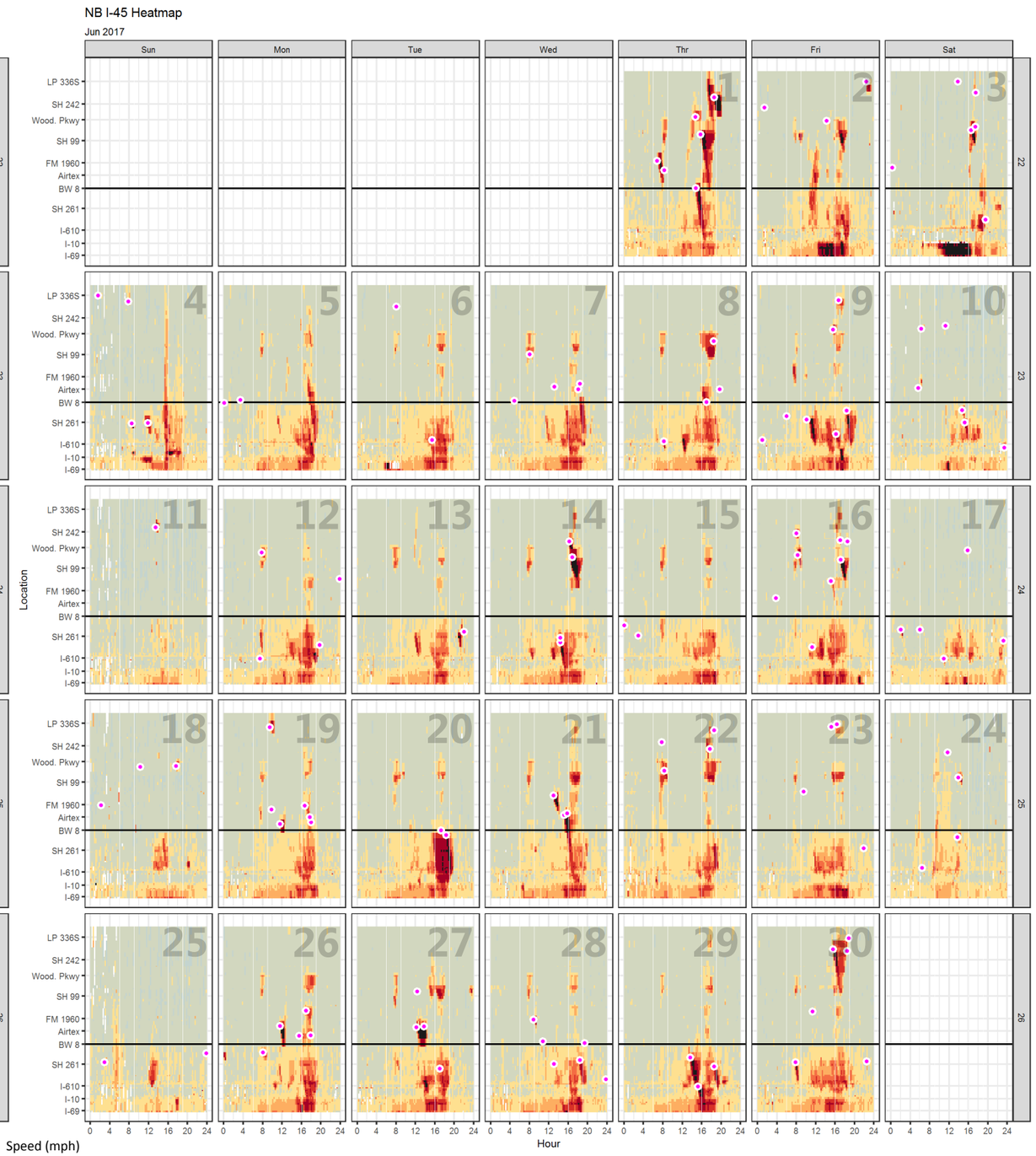

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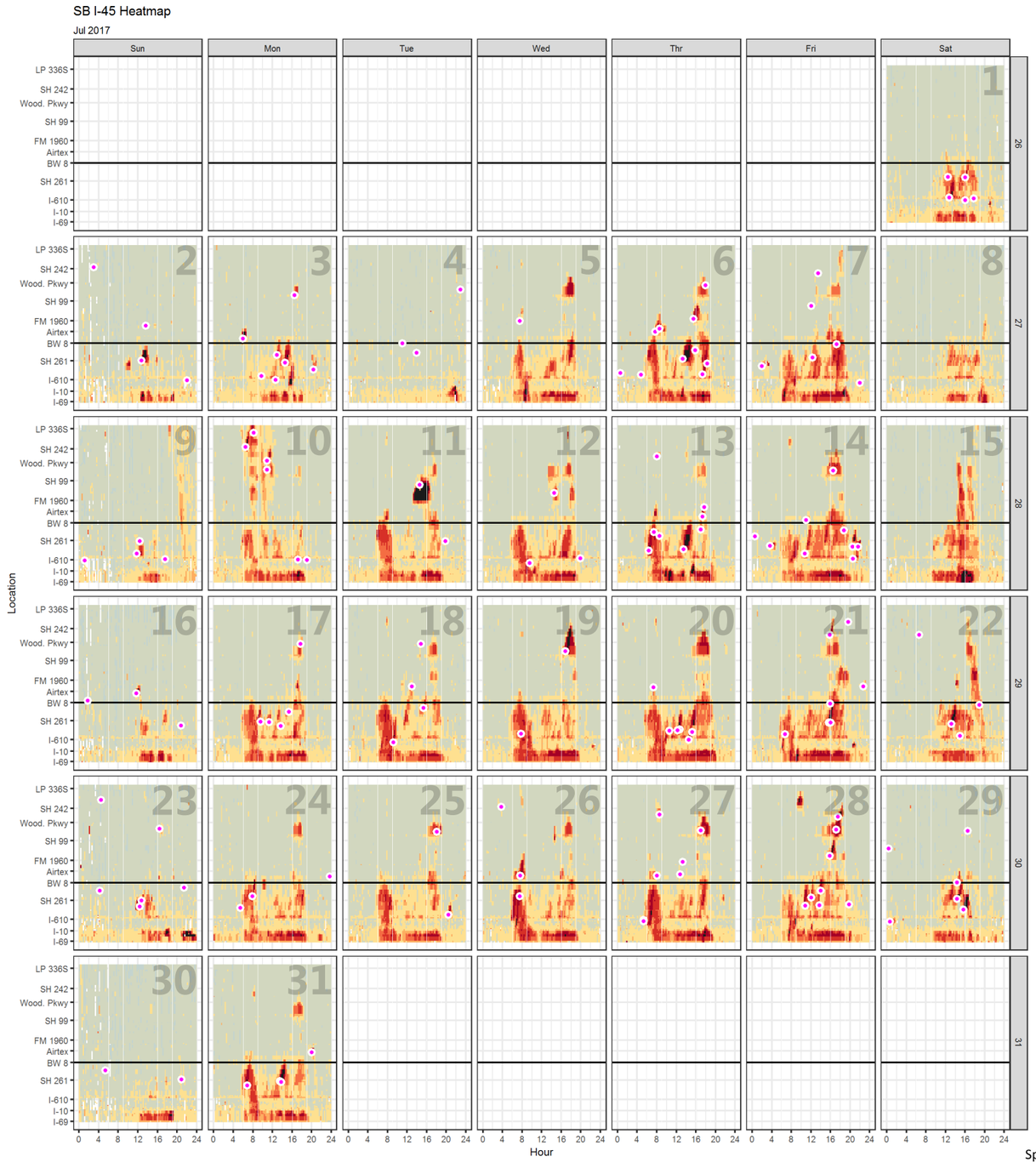

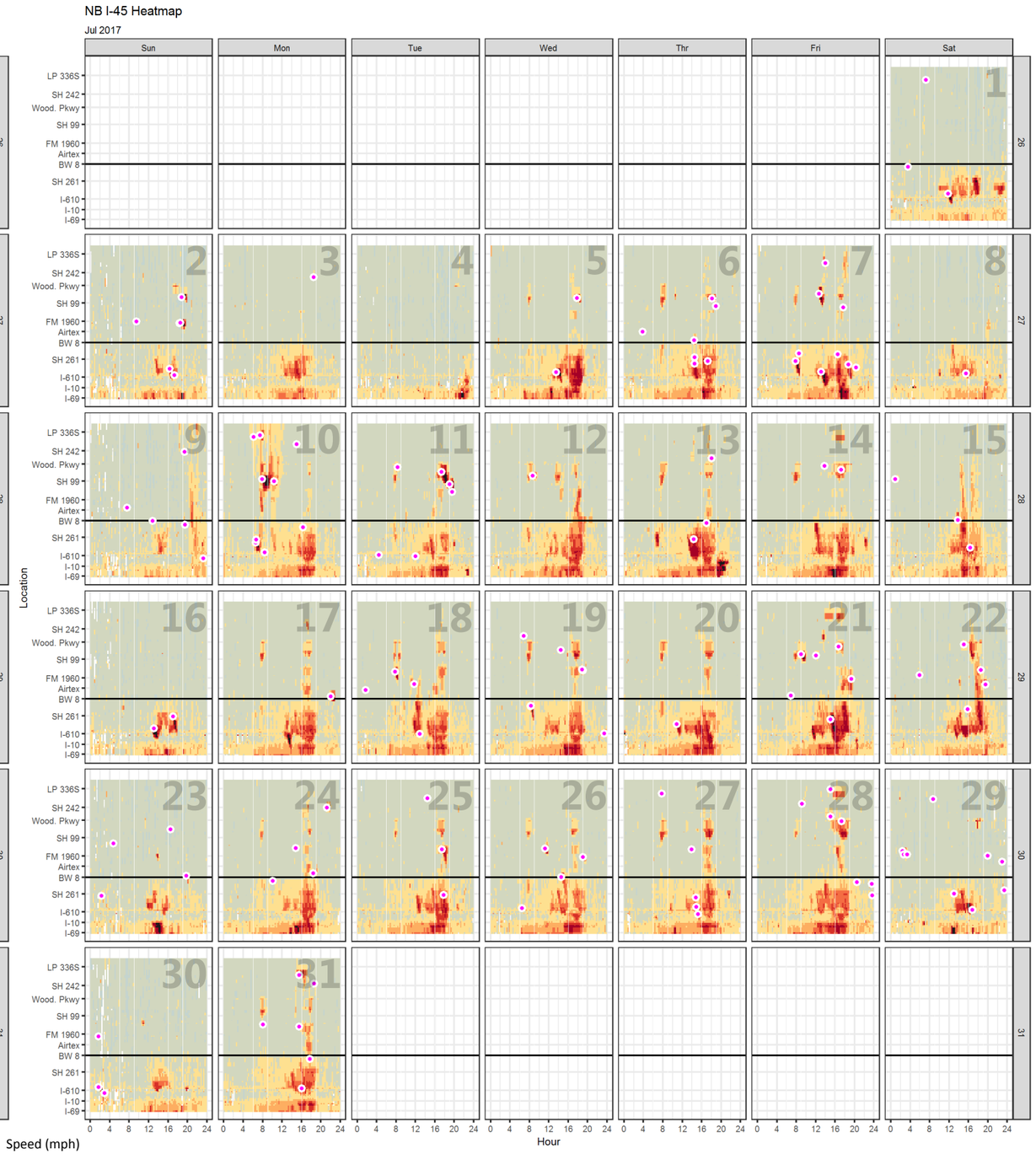

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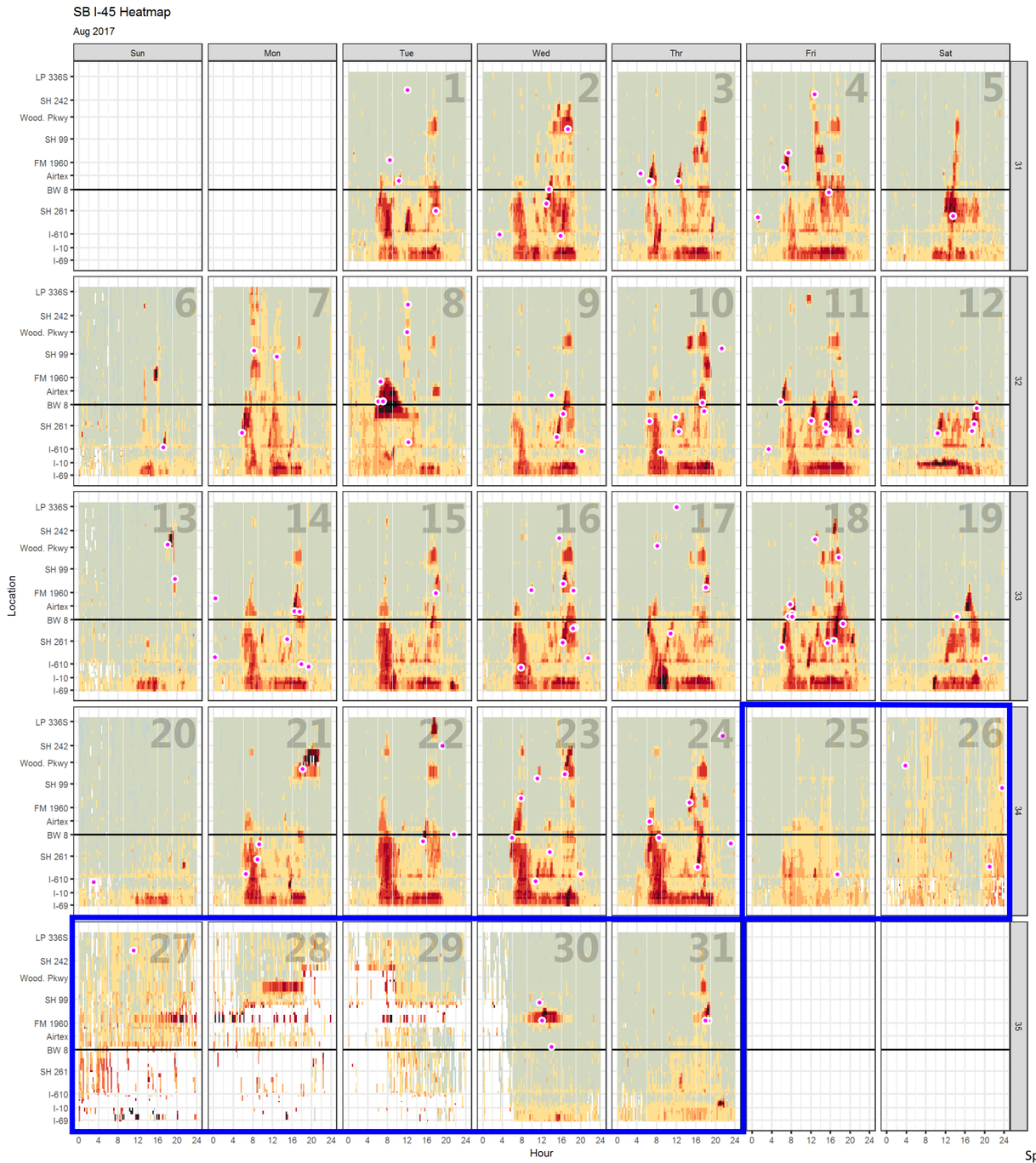

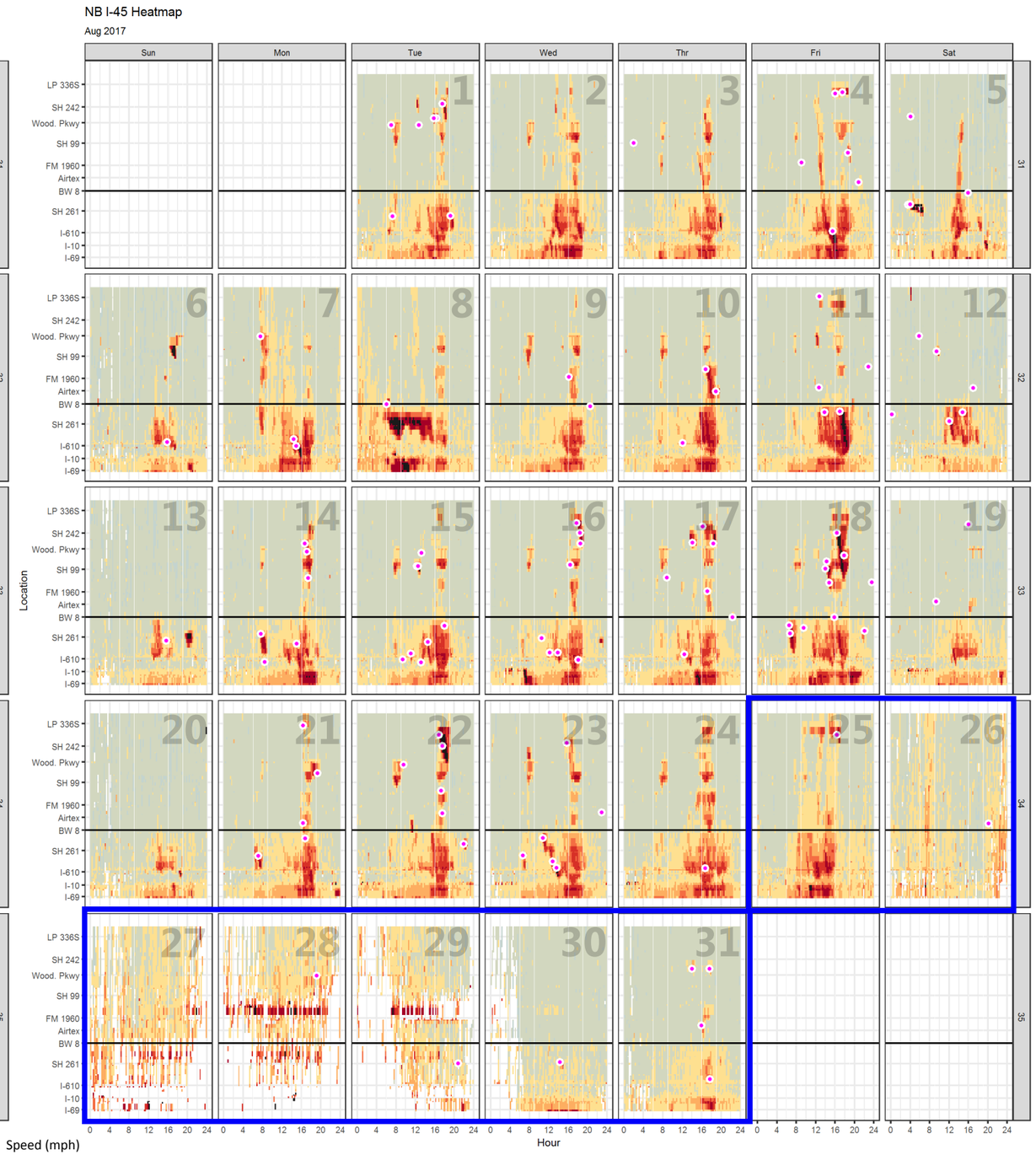

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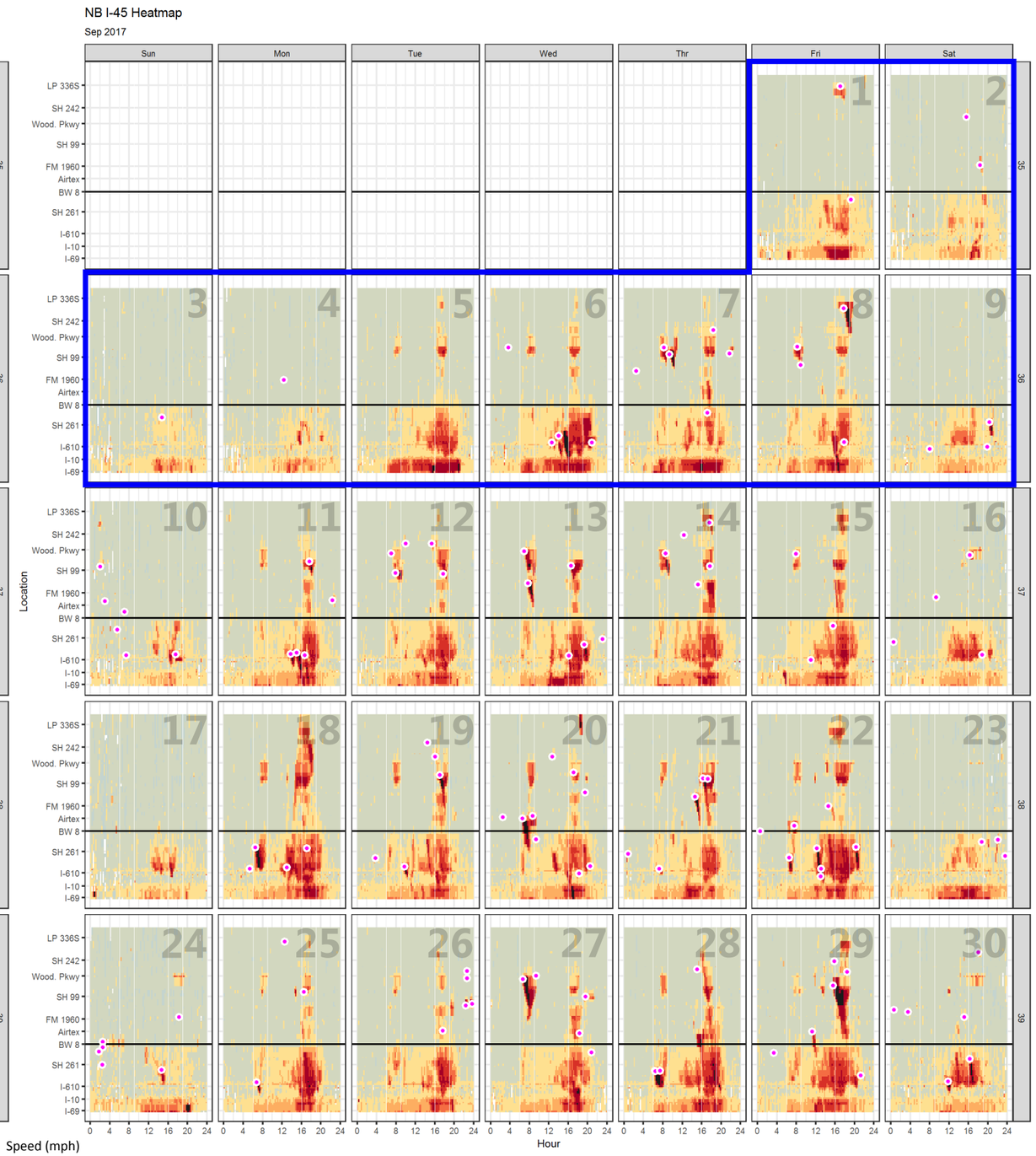
Data affected by hurricane Harvey (Aug 25 - Sep 9)



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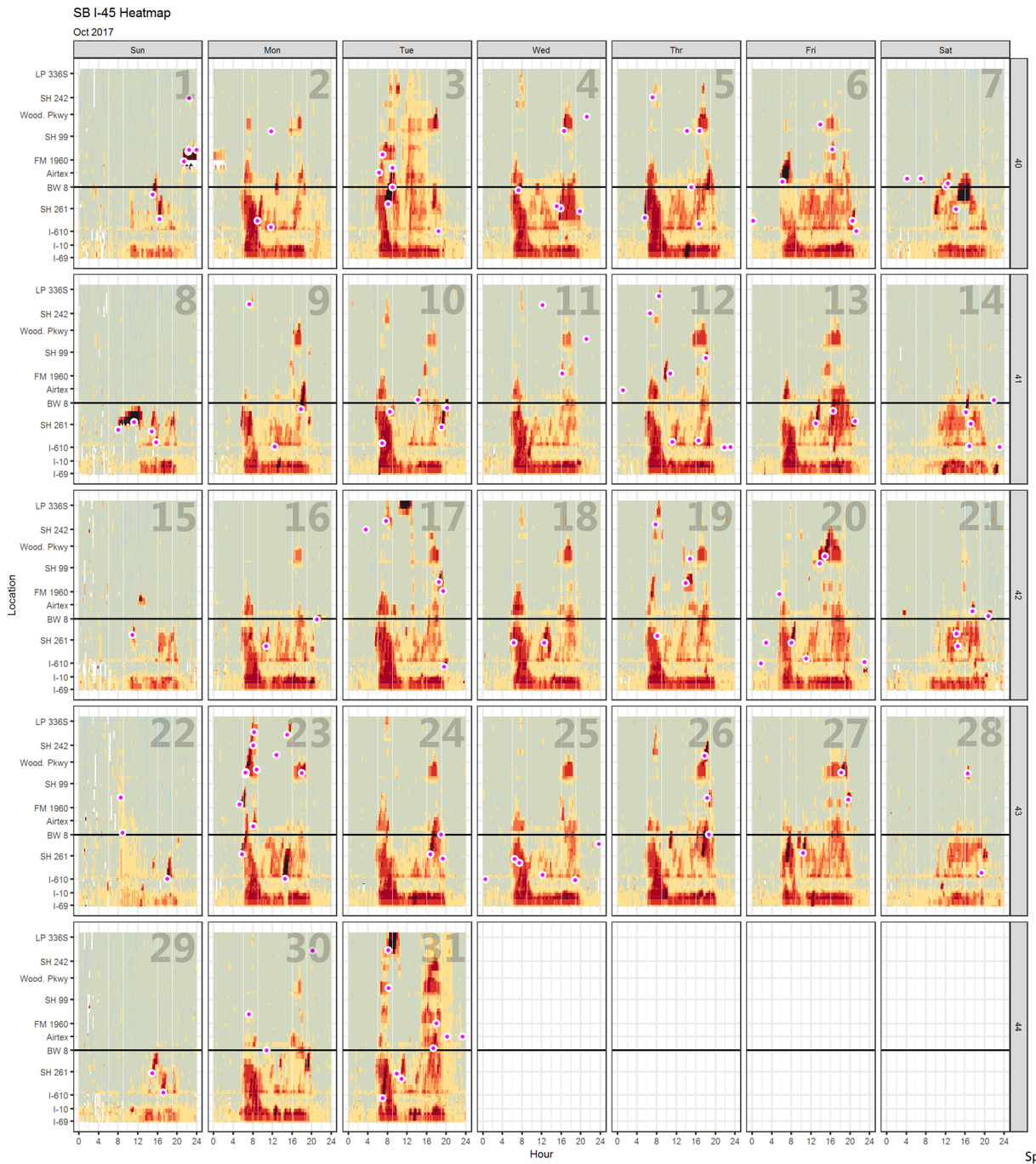

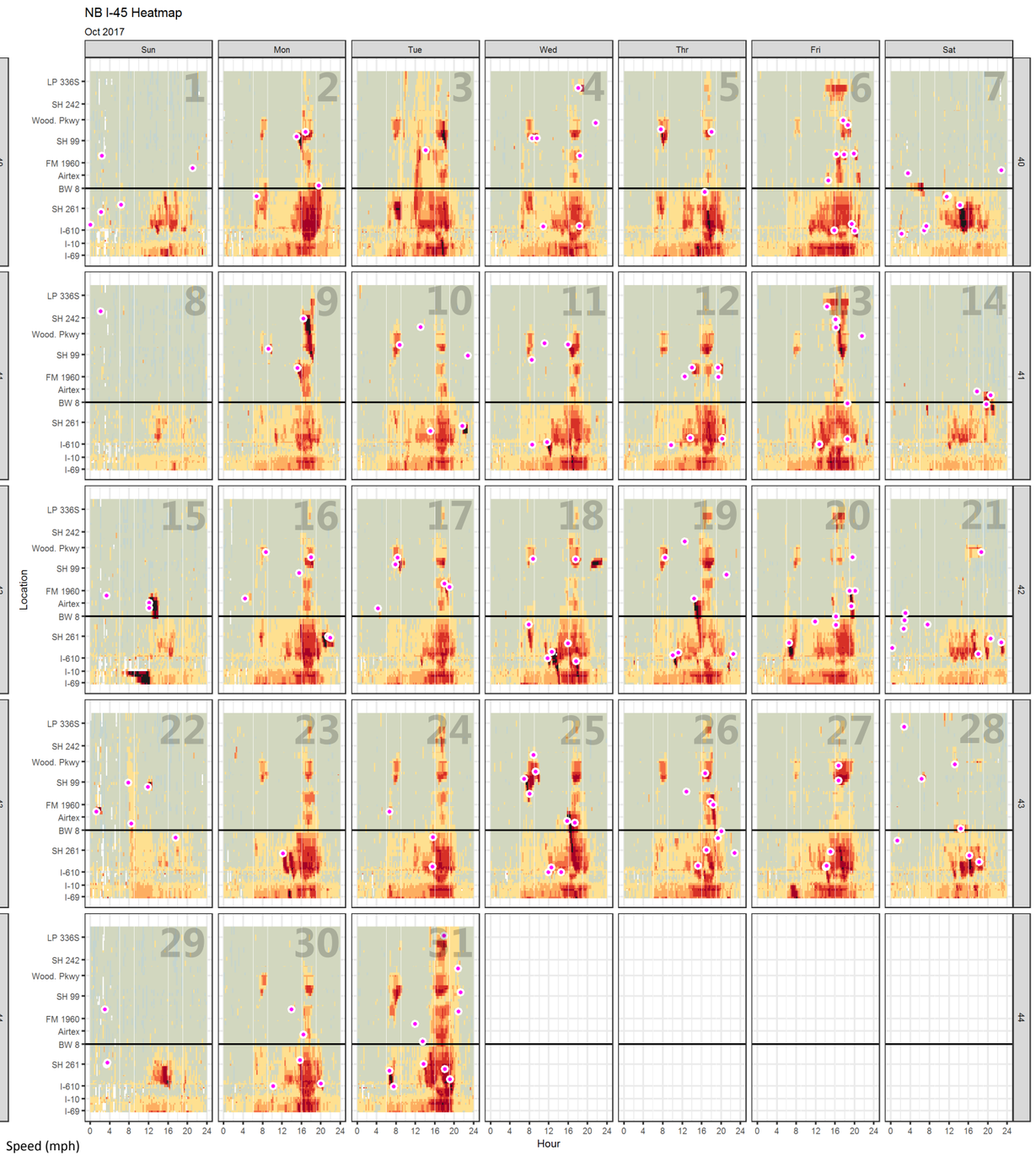

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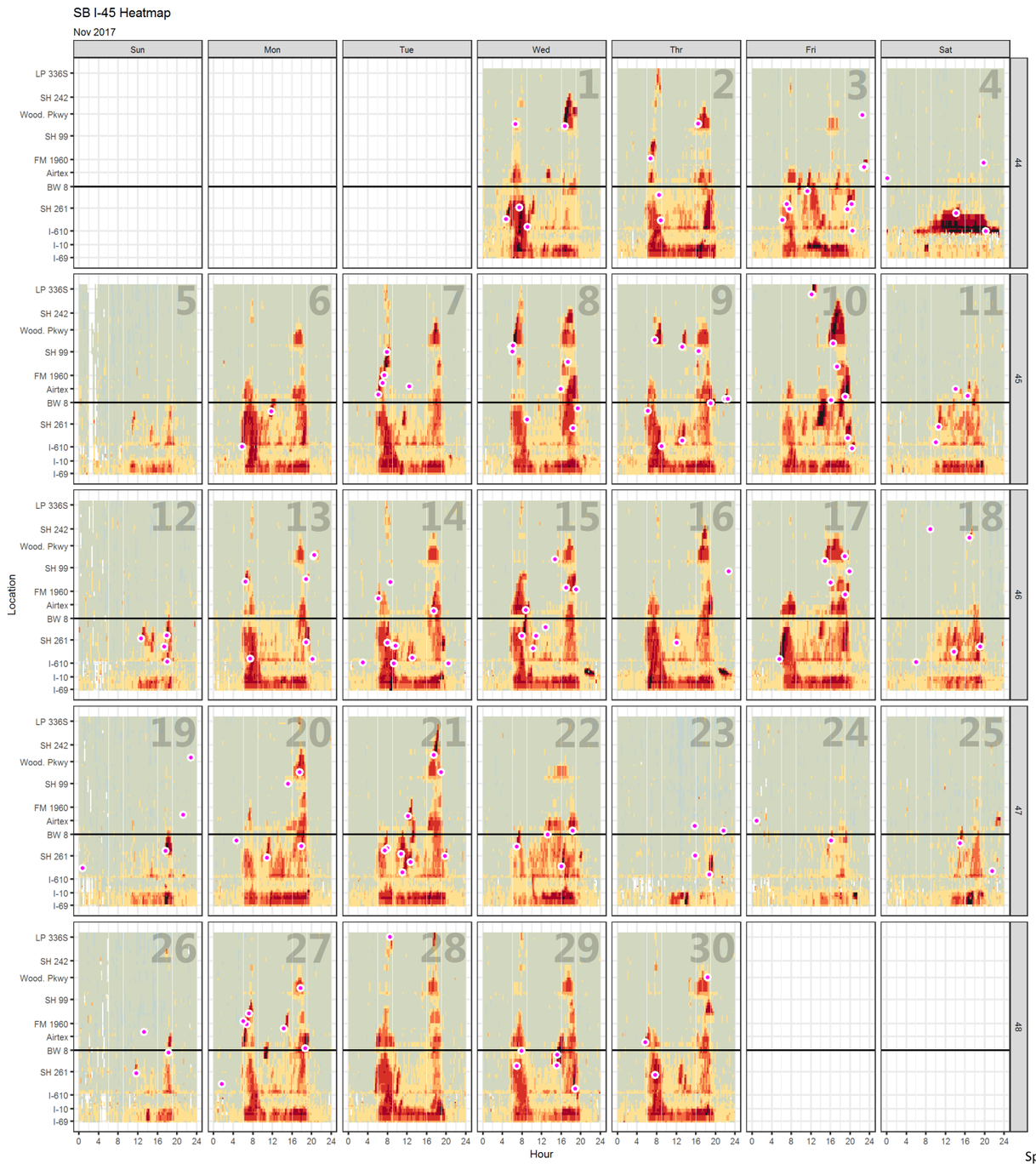

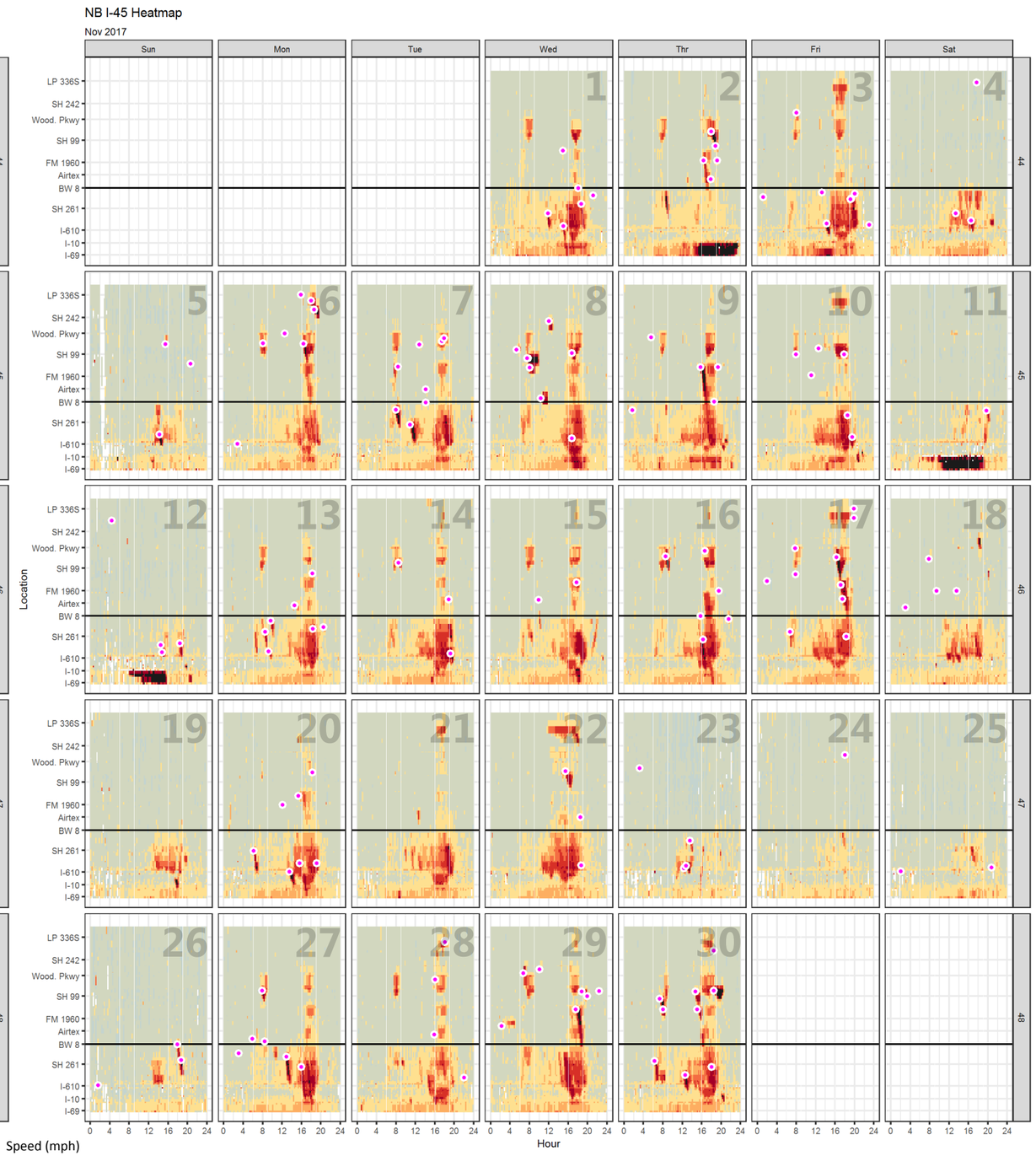

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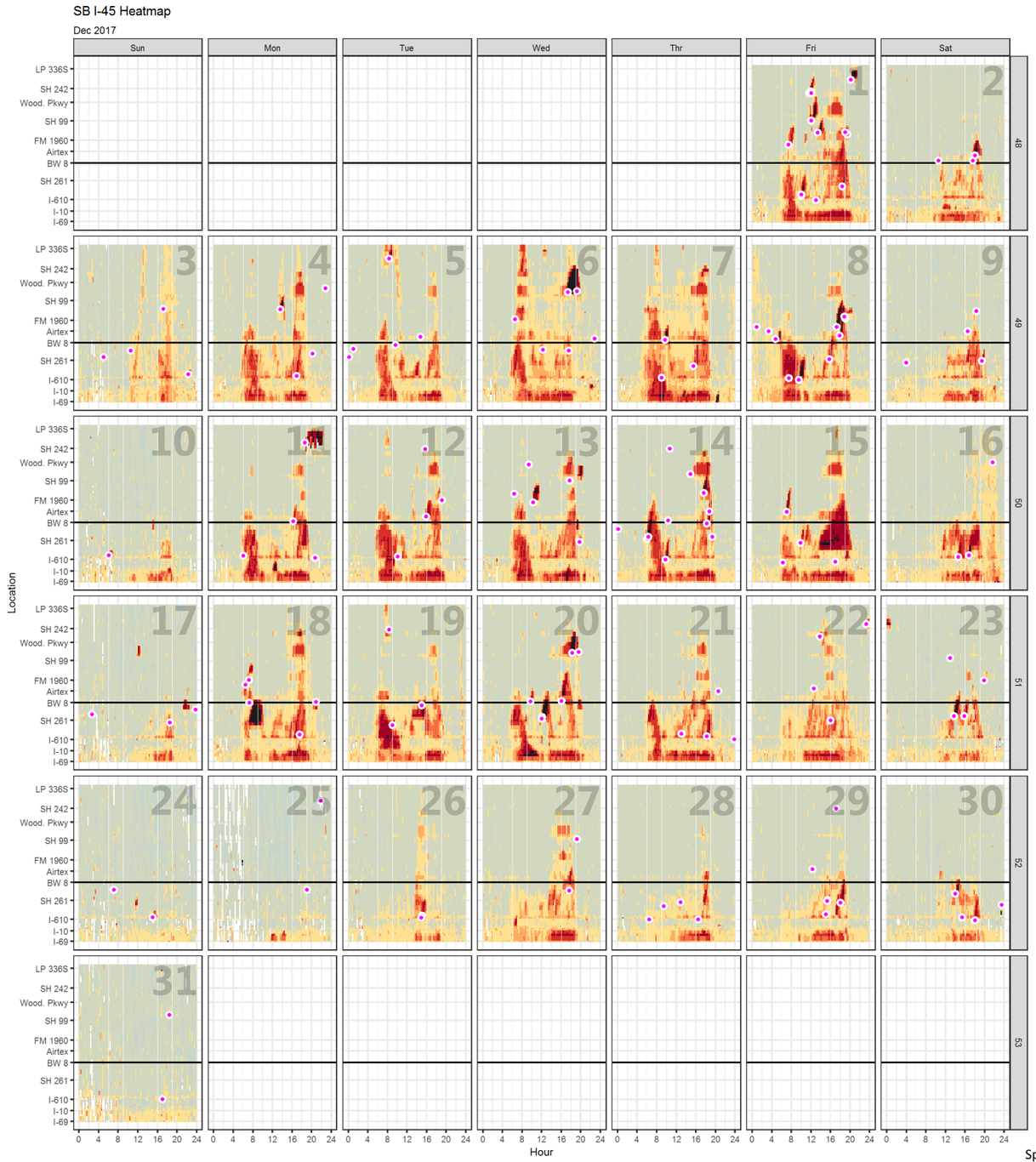

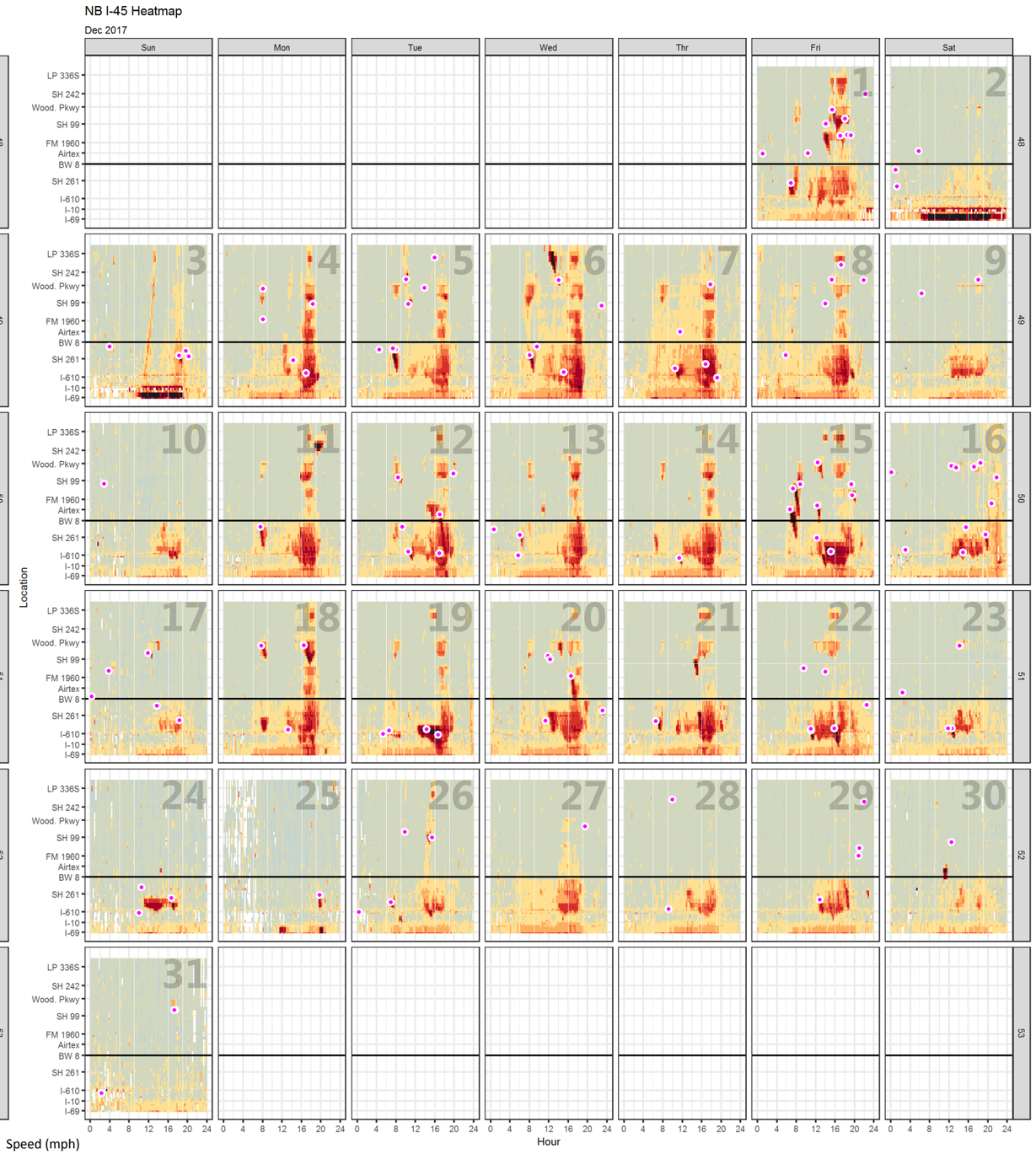

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Appendix C
Traffic Projection at the Interchange of I-45 and SH 99

Traffic Projection at the Interchange of I-45 and SH 99

The fully directional interchange at I-45 and SH 99 will be constructed by year 2045. Currently, there are only two direct connectors (DCs) including the I-45 southbound (SB) to SH 99 westbound (WB) DC and the SH 99 eastbound (EB) to I-45 northbound (NB) DC. The remaining six DCs will be constructed by 2045. The traffic forecasts for the future no-build scenario for the I-45N PEL Study corridor will therefore include the projected volumes for all eight DCs at the interchange. The following sections include a summary of the projection methodology and the analysis results.

1. Freeway Mainlane Volume Projection and Assumptions at I-45 and SH 99

Traffic volumes on the I-45 and SH 99 mainlanes, located just upstream or downstream of the DC connection locations, will be used as the base volume for forecasting future DC traffic volumes in Step 2 and Step 3. The I-45 mainlane base volumes located downstream of the existing DC were derived from multiple sources of traffic projections including TxDOT Transportation Planning and Programming Division (TPP), Houston-Galveston Area Council (H-GAC) and AECOM, the I-45N PEL Study consultant, as summarized in **Table 1.1**. The Recommended Base Volume for I-45 mainlanes considered all three sources and applied volume adjustments to the previous AECOM projection to align with the general volume projections for the entire study corridor. Mainlane base volumes on SH 99 were estimated based on the traffic counts collected in 2017 and the growth rates calculated from H-GAC demographic projections which is summarized in **Table 1.2** and **Table 1.3**.

Table 1.1. I-45 Mainlane Base 2045 ADT Volumes

Location	TPP	H-GAC 2045 TDM	AECOM	Recommended Base Volume
I-45 NB - S of SH 99	167,400	165,800	103,950	131,000
I-45 SB - N of I-45	162,100	135,200	147,060	128,710*

*The base volume at this location is the mainlane volume after adjusting the exiting DC volume (ADT: 18,350).

Table 1.2. Growth Rates for SH 99 Mainlanes

Location	2010 Household Population	2040 Household Population	Linear Annual Growth% (2017-2045)
SH 99 E of I-45	166,653	382,377	4.3%
SH 99 W of I-45	311,370	824,699	5.5%

Source: H-GAC demographic data

Table 1.3 SH 99 Mainlane Base 2045 ADT Volume

Location	2017 Volume	2045 Projected Volume	H-GAC Regional Travel Demand Model (TDM) Linear Annual Percent Growth (2017-2045)
SH 99 WB - E of I-45	19,260	42,450	4.3%
SH 99 EB - W of I-45	14,253	46,200	5.5%

2. Interchange Volume Percentage Estimation

In order to estimate the interchange DC traffic volumes, the following volume percentages were calculated and analyzed:

- Percentage of exiting traffic volume from mainlane to DCs (Exit%), and
- Traffic volume split between DCs (Split%)

Three different data sources were used in this analysis including TPP, H-GAC TDMs and StreetLight origin-destination data. **Table 2.1** provides a summary of the interchange volume percentages. The recommendations for the Exit% and Split% at the interchange were based on the three available data sources and considered the average and weighted average of the results from these data sources.

Table 2.1 Summary of the Interchange Volume Percentages or Splits

Highway	Location	Direction	DC Volume Percentage					
			TDM	TPP	StreetLight	Average	Weighted Ave.*	Recommendation
I-45 NB	S of SH 99	Exit to DC	18.9%	12.1%	10.2%	13.7%	15.0%	16%
		NB to EB	52.4%	28.6%	25.3%	35.4%	39.7%	40%
		NB to WB	47.6%	71.4%	74.7%	64.6%	60.3%	60%
I-45 SB	N of SH 99	Exit to DC	10.4%	16.3%	22.2%	16.3%	14.8%	16%
		SB to EB	35.0%	39.0%	27.5%	33.8%	34.1%	35%
		SB to WB	65.0%	61.0%	72.5%	66.2%	65.9%	65%
SH 99 EB	W of I-45	Exit to DC	71.6%	-	52.5%	62.0%	65.2%	64%
		EB to NB	63.5%	61.0%	75.5%	66.7%	65.9%	63%
		EB to SB	36.5%	39.0%	24.5%	33.3%	34.1%	37%
SH 99 WB	E of I-45	Exit to DC	42.7%	-	33.4%	38.0%	39.6%	50%
		WB to NB	8.9%	72.7%	74.5%	52.0%	41.2%	41%
		WB to SB	91.1%	27.3%	25.5%	48.0%	58.8%	59%

*Weighted average is calculated using the weight 2:1:1 for TDM, TPP and StreetLight.

3. Interchange Volume Calculations

The traffic volumes exiting the mainlanes to enter the direct connectors at four locations (Exit to DC Volumes) were calculated by multiplying the mainlane base volumes (**Table 1.1**) by the Exit Volume Percentage (Exit%). The individual direct connector traffic volumes for eight locations were calculated by multiplying the Exit to DC Volumes by the Volume Split (Split%) between DCs. An example equation is below:

$$Exit\ to\ DC\ on\ I-45\ NB = 131{,}000 * \frac{.16}{1-.16} = 25{,}000\ vehicles\ per\ day$$

To determine the volume on each direct connector, the recommended percentage or split from Table 2.1 was applied to the Exit to DC Volumes. For instance, from the I-45 northbound movement, 40% of the traffic volume goes eastbound and 60% of the traffic volume goes westbound which is equal to 10,000 vehicles per day (vph) and 15,000 vph, respectively. Table 3.1 lists the projected volumes at the SH 99 and I-45 interchange.

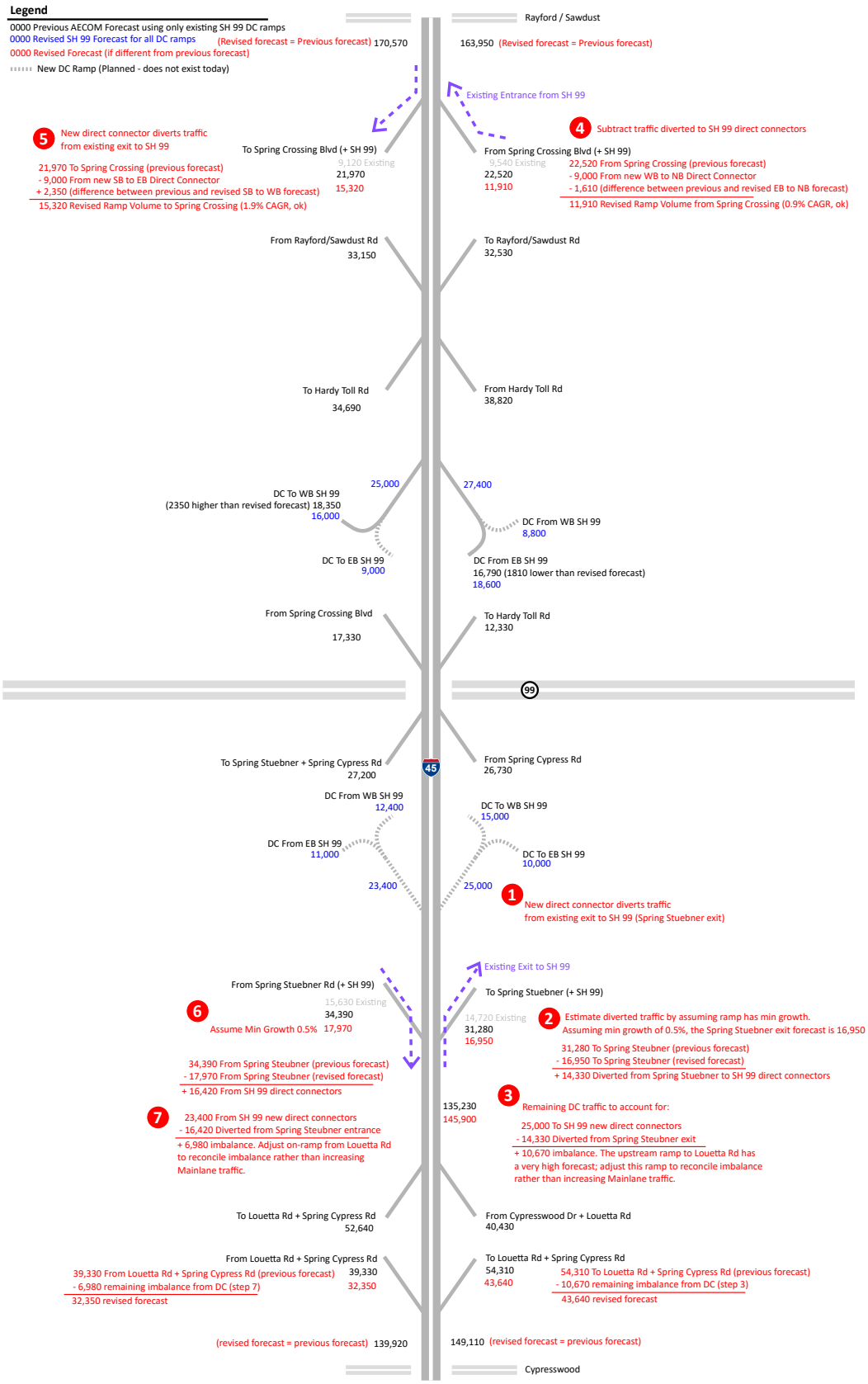
Table 3.1 Summary of the Projected SH 99 at I-45 Interchange Volumes

Highway	Location	Direction of Travel	Projected ADT
I-45 NB	S of SH 99	Exit to DC	25,000
		NB to EB	10,000
		NB to WB	15,000
I-45 SB	N of SH 99	Exit to DC	25,000
		SB to EB	9,000
		SB to WB	16,000
SH 99 EB	W of I-45	Exit to DC	29,600
		EB to NB	18,600
		EB to SB	11,000
SH 99 WB	E of I-45	Exit to DC	21,200
		WB to NB	8,800
		WB to SB	12,400

4. I-45N Corridor No-Build ADT Projection Updates

By accounting for the additional DCs at the I-45 and SH 99 interchange, future traffic volumes will be diverted from ramps in close vicinity to the interchange. For instance, the vehicles traveling along I-45 NB that need to access SH 99 either EB or WB will likely use the new DCs from I-45 NB to SH 99 EB or WB instead of using the existing exit ramp to the I-45 frontage road followed by a left or right turn to access SH 99. **Figure 1** illustrates the no-build ADT projection update considering the impact from the direct connectors associated with the fully directional interchange at I-45 and SH 99.

Figure 1. I-45N & SH 99 2045 No-Build ADT Forecast Update



Texas Department of Transportation

Appendix C: Traffic Projection at the Interchange of I-45 and SH 99