ARIZONA DEPARTMENT OF TRANSPORTATION

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GOVERNOR

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DIRECTOR

HOV SPEED COMPLIANCE ACTION PLAN

Prepared by
Arizona Department of Transportation
Multimodal Planning Division

Submitted to
Federal Highway Administration
Arizona Division
May 30, 2025

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ARIZONA DEPARTMENT OF TRANSPORTATION

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May 30, 2025

Anthony Sarhan, Acting Division Administrator
Federal Highway Administration (FHWA), Arizona Division
4000 North Central Avenue, Suite 1500
Phoenix, Arizona 85012-3500

Dear Mr. Sarhan:

In compliance with the agreement between the Arizona Division Office of the Federal Highway Administration (FHWA) and Arizona Department of Transportation (ADOT) addressing the degradation of the High Occupancy Vehicle (HOV) Lanes per 23 USC 166 d (1) D, this action plan was prepared for submission by the established date of June 2025. This action plan identifies any and all segments of the currently operational HOV lanes within the metropolitan area freeway system that are not fully compliant with 23 USC 166 d (2). The action plan also addresses the actions established or planned by ADOT to bring the HOV lanes into compliance with the previously identified requirements. If you require further information or assistance with this matter, please contact Matt Moul, MPD Director at (602) 712-8274.

Sincerely,

Signed by:
Jennifer Toth
B62A62C2C737460...

Jennifer Toth
Director

azdot.gov

ARIZONA DEPARTMENT OF TRANSPORTATION

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May 30, 2025

Anthony Sarhan, Acting Division Administrator
Federal Highway Administration (FHWA), Arizona Division
4000 North Central Avenue, Suite 1500
Phoenix, Arizona 85012-3500

RE: 2025 High Occupancy Vehicle Speed Compliance Update

Mr. Sarhan,

In accordance with FHWA guidance (23 USC 166) on High Occupancy Vehicle (HOV) facility operations, the responsible state agency will limit or discontinue the use of HOV facilities by non-HOV vehicles (low emission and energy efficient vehicles not meeting the occupancy requirement) if the presence of the vehicles contributes to degraded operation of the facility. The performance standard is based upon an agreement between ADOT and FHWA Division, as follows: maintain a 45 mph average speed in each morning and evening peak hour during the 180-day period ending in March of each year.

As requested we have provided an HOV Report Supplement summarizing the HOV lane speed compliance results for 2025.

Please let us know If you have any questions or concerns.

Thank you,

DocuSigned by:
Matt Moul
4277854E018B416...

Matt Moul
Multimodal Planning Division Director

Acronyms

ADOT:	Arizona Department of Transportation
AZDPS:	Arizona Department of Public Safety
AFV:	Alternative Fuel Vehicle
CalTrans:	California Department of Transportation
CDOT:	Colorado Department of Transportation
CVD:	Connected Vehicle Data
DMB:	Dynamic Message Boards
FHWA:	Federal Highways Administration
FIS:	Feature Inventory System
FMS:	Freeway Management System
GIS:	Geographic Information System
HOT:	High Occupancy Toll
HOV:	High Occupancy Vehicle
IDO:	Infrastructure Delivery & Operations
LOS:	Level of Service
LPR:	License Plate Reader
MAG:	Maricopa Association of Governments
MnDOT:	Minnesota Department of Transportation
MPD:	Multimodal Planning Division
MPO:	Metropolitan Planning Organization
MUTCD:	Manual on Uniform Traffic Control Devices
MVD:	Motor Vehicle Division
NDOT:	Nevada Department of Transportation
SHS:	State Highway System
VDOT:	Virginia Department of Transportation

Executive Summary

The Arizona Department of Transportation (ADOT) received a grant from the FHWA to implement High Occupancy Vehicle (HOV) Lanes in the past. This HOV Lane report is required under 23 USC 166 (d)(1)(D)(i), and has been prepared to establish a plan to mitigate the existing degradation of the HOV lanes within the Phoenix metro area. The goal of HOV lanes is to reduce congestion and improve air quality. This report will be the final official report to the Federal Highways Administration (FHWA) as the law expires on September 30, 2025. ADOT has created a mitigation strategy for the remaining Alternative Fuel Vehicles (AFV) on the highway network and to ensure there is continued analysis performed and communication with stakeholders. At the time of expiration, ADOT is required to disallow single-occupant-vehicles from the HOV lanes with the exception of public transit vehicles, blood-transport vehicles, and motorcycles that have permitted public authority certification.

The HOV lane report timeline details the steps and responsible parties of the annual report. The report is provided to the FHWA every June 1st and includes 6-months worth of data (October through March). Analysis is performed to identify areas of congestion on the network. Compliance is defined for segments as speeds of 45 mph or faster for 90% of the time over a 180-day period during the weekdays rush hours (excluding holidays) which start from 6 am to 9 am and from 3 pm to 7 pm. For the 2025 collection cycle, there are ten segments that are out of compliance.

The data analysis illustrates an increase in HOV lane degradation from 18% in 2024 to 26% in 2025. Much of this is due to increases in traffic volume, construction projects and traffic incidents that affect the flow of traffic. Extensive outreach has been performed with stakeholders including AZDPS, MAG and the public to ensure a robust communication plan. This report details new hot spot analysis for citations and crashes to support in making informed decisions. Methods continue to be updated in ADOT's processes to improve compliance on the roadway network. Reporting requirements include updates to mitigation strategies per countermeasures to show continuous improvement in travel time reliability.

HOV Lane Facilities

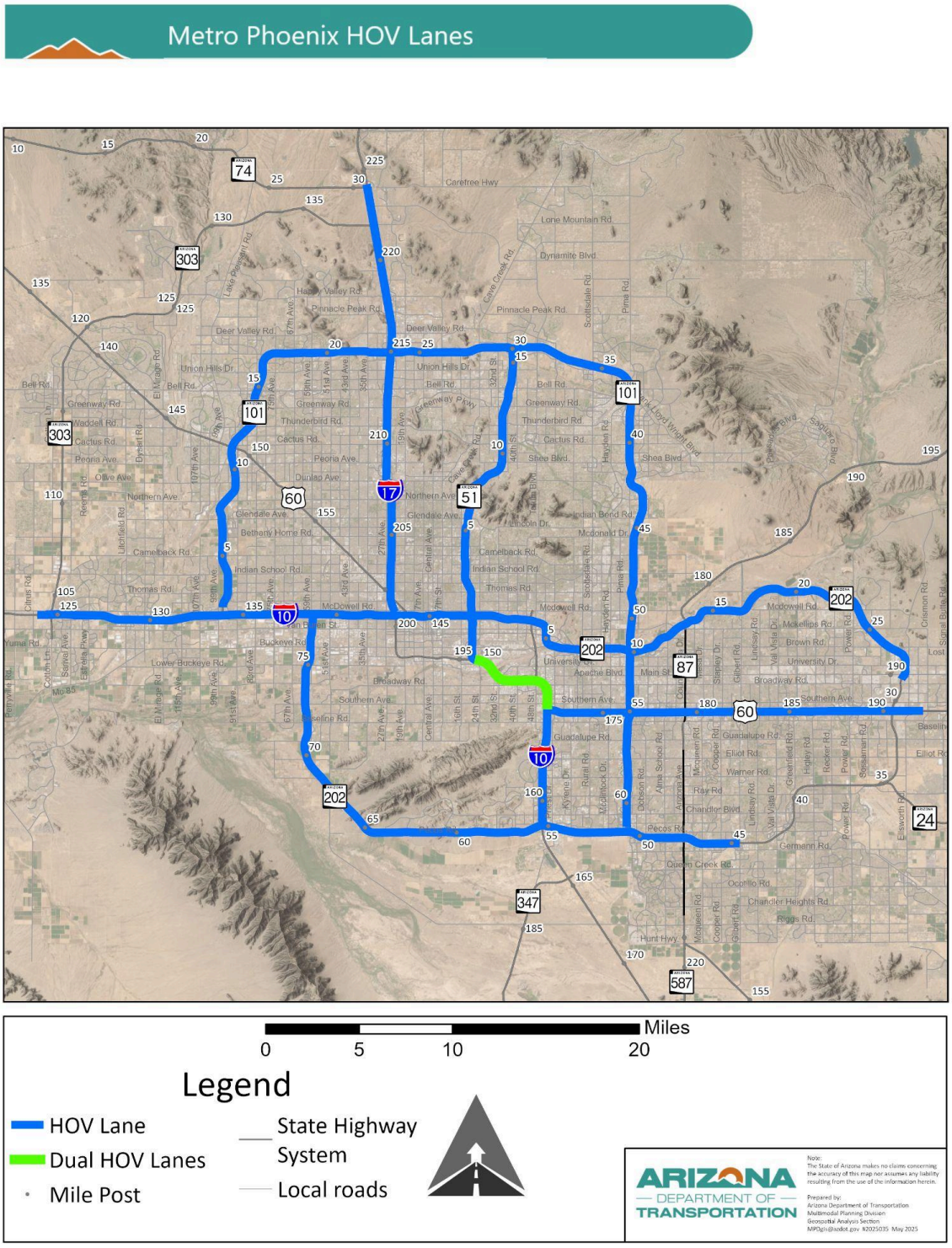


Figure 1. Overview map of HOV Lanes

As of calendar year 2025, there are 446 lane miles of High Occupancy Vehicle (HOV) lanes in the state of Arizona, all of which reside within the Phoenix metropolitan area (see Figure 1 below). Most of the HOV lanes are 1-lane HOV lanes. There are plans to add over 10 additional lane miles of 2-lane HOV lanes on Interstate 10 via the Broadway Curve project that will be completed in 2025. The 2-lane HOV lanes on Interstate 10 will help to support planned increase in traffic volumes in the future as well as allow for transit via express bus services.

The primary purpose of an HOV lane is to increase the total number of people moved through a congested corridor by offering two kinds of incentives: a savings in travel time and a reliable and predictable travel time (FHWA, 2016). The predominant freeway striping that separates the HOV lane from the general purpose lane is a wide solid single white lane line (shown below in Figure 2B). A wide solid white line is appropriate to discourage, but not prohibit, crossing between the two lane types. Other types of preferential lanes also use solid wide lines, so drivers are accustomed to this treatment. Current striping allows for entering/exiting where there are available gaps between vehicles and no additional signage is needed.

There is a combination of overhead signing and ground mounted signing throughout the Phoenix-metro freeways showing the designated HOV preferential lane that would be easily recognizable to any visitors unfamiliar with the area. Violating the HOV lane restrictions in Arizona results in a fine of $400.

Currently, ADOT does not have any congestion pricing on any of the freeways in the state. If there is a time when this would be implemented, changing the striping at that time might be appropriate. There would be a significant change to the usage of the preferential lane and a change to the striping would make the public aware of this. Implementing this now would require significant stripe obliteration, which would result in significant costs. Please see countermeasure #7 for more details.

(Source: FHWA, 14 Sep. 2022)

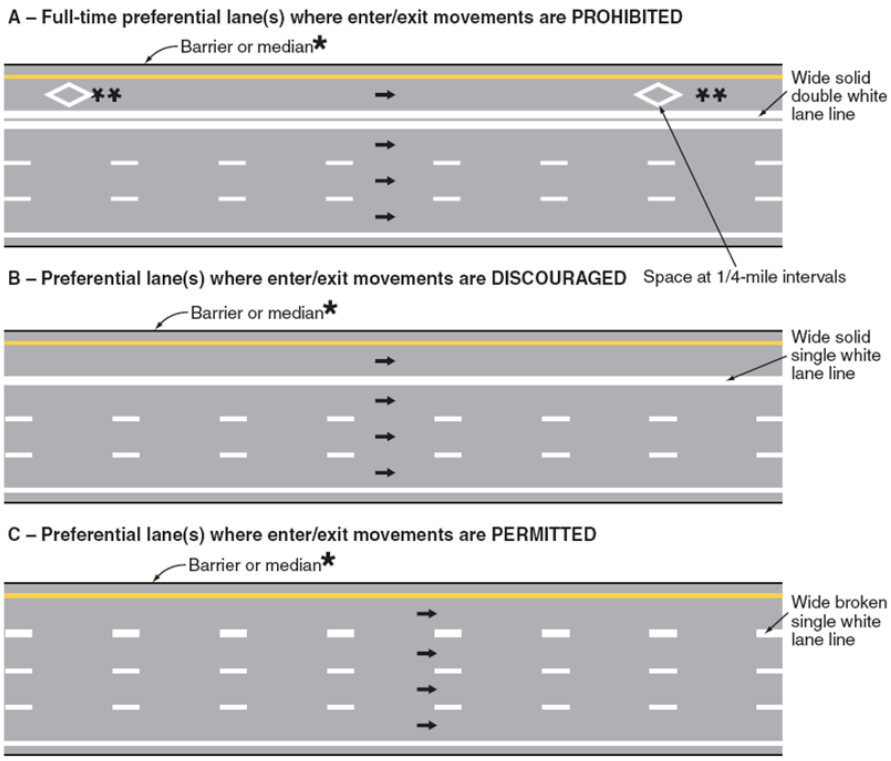


Figure 2. HOV Lane Striping

There are numerous stakeholders for the HOV lane report including Federal Highways Administration (FHWA), ADOT divisions, Arizona Department of Public Safety (AZDPS) and the public at large, see Figure 3 for details. Their roles & responsibilities vary from data owners, data analysis, enforcement and roadway users.

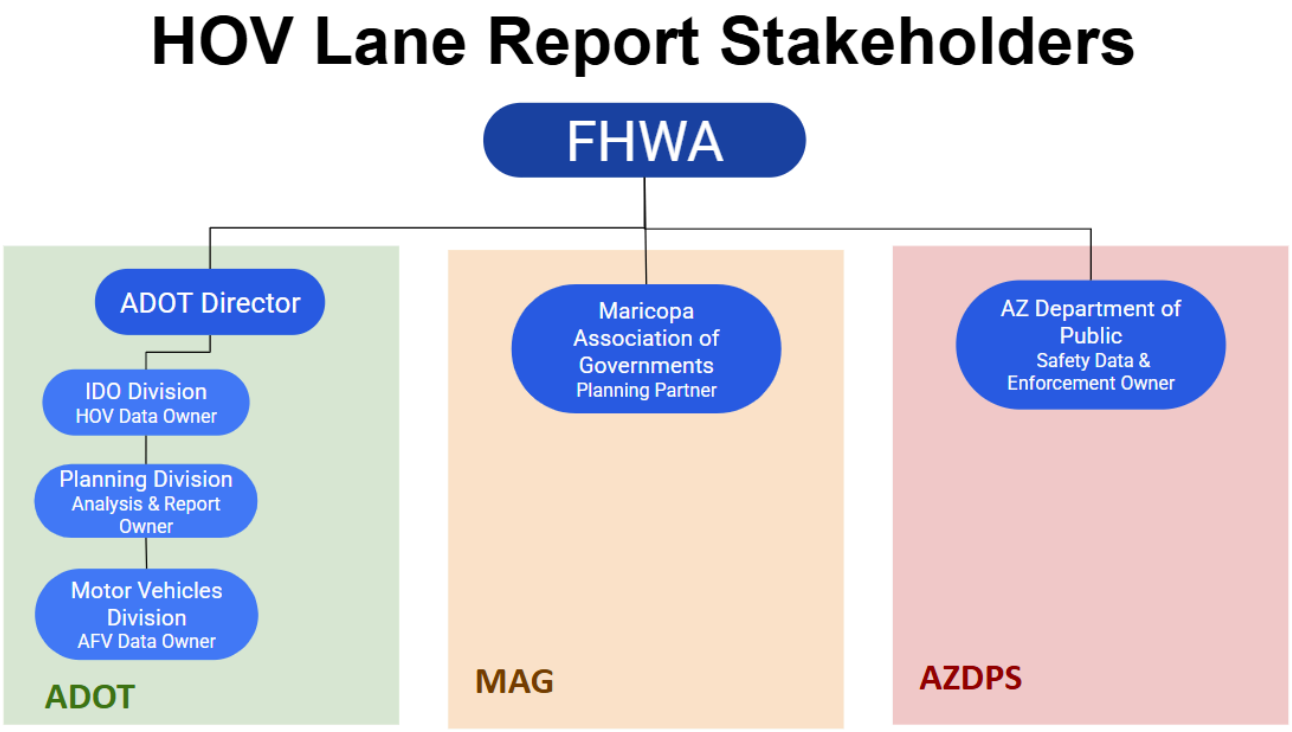


Figure 3. Stakeholders with Roles & Responsibilities

Calculating Degradation

The calculation for a good or poor performing highway segment is expressed as a percentage. Morning peak period is from 6 am to 9 am and evening peak period is from 3 pm to 7 pm. For the purposes of speed performance monitoring, a segment is in compliance if the average speed is 45 mph or faster for 90% of the time over the 180 day period (October through March). FHWA does not specify the speed data sources, only the analysis of the speed data. This is primarily because each state has different characteristics, and each agency responsible for operations has different resources to collect and analyze data.

Data Collection

The first step in the HOV lane degradation analysis is the collection of data. A detailed HOV lane report timeline reviews the steps and responsible parties of the annual report. The speed data used in the analysis is collected via Freeway Management System (FMS) detectors by direction on the metropolitan freeway system in an automated fashion. The speed data is gathered in 20-second intervals and is averaged into 5-minute intervals. The selected reporting period reduces the seasonality issues observed from some segments. However, ADOT monitors the monthly performance of

the segments during the reporting period for possible compliance issues. Table 1 illustrates the performance of all the segments during the 180-day period.

Table 1. HOV Corridor Speed Segments

FHWA Speed Compliance (for 180 day period ending March 31st of the Evaluation Year)				
Segment	**HOV Segment**	**2023**	**2024**	**2025**
1	I-10_EB_L101_to_I-17	80	77	77
2	I-10_EB_I-17_to_SR_51	97	100	85
3	I-10_EB_SR_51_to_I-17	100	100	No Data
4	I-10_EB_I-17_to_US_60	93	No Data	No Data
5	I-10_EB_US_60_to_L202	99	No Data	No Data
6	I-10_WB_L101_to_I-17	84	76	63
7	I-10_WB_I-17_to_SR_51	88	92	No Data
8	I-10_WB_SR_51_to_I-17	88	100	No Data
9	I-10_WB_I-17_to_US_60	95	No Data	No Data
10	I-10_WB_US_60_to_L202	100	No Data	No Data
11	I-17_NB_I-10_to_L101	90	89	93
12	I-17_SB_I-10_to_L101	88	85	81
13	L101_Pima_NB_SR_51_to_L202	98	93	89
14	L101_Pima_SB_SR_51_to_L202	92	86	84
15	L101_Price_NB_L202_Red_Mt_to_US_60	100	75	98
16	L101_Price_NB_US_60_to_L202_San_Tan	97	99	99
17	L101_Price_SB_L202_Red_Mt_to_US_60	89	76	81
18	L101_Price_SB_US_60_to_L202_San_Tan	100	100	98
19	L202_Red_Mt_EB_SR_51_to_L101_Pima	96	91	95
20	L202_Red_Mt_WB_SR_51_to_L101_Pima	93	92	96
21	SR_51_NB_L202_to_L101	99	99	97
22	SR_51_SB_L202_to_L101	97	95	91
23	US_60_EB_I-10_to_L101	100	99	97
24	US_60_EB_L101_to_SR_87	100	99	96
25	US_60_EB_SR_87_to_L202	99	95	96
26	US_60_WB_I-10_to_L101	100	100	79
27	US_60_WB_L101_to_SR_87	100	100	100
28	US_60_WB_SR_87_to_L202	97	93	97
29	L101_SB_BEARDSLEY_TO_THOMAS	93	94	92
30	L101_NB_THOMAS_TO_INDIAN_SCHOOL	100	100	100
31	L101_EB_75TH_AVE_TO_27TH_AVE	98	98	83
32	L101_WB_27TH_AVE_TO_67TH_AVE	93	91	76
33	L202_South_Mnt_WB_I-10_to_Bend	100	100	100
34	L202_South_Mnt_NB_Bend_to_Elliot	100	100	100
35	L202_South_Mnt_NB_Dobbins_to_I-10	100	100	No Data
36	L202_South_Mnt_EB_Bend_to_40th_St	100	100	100
37	L202_South_Mnt_SB_Elliot_to_Bend	100	100	100
38	L202_South_Mnt_SB_I-10_to_Dobbins	100	100	100

Notes: *HOV Segments highlighted in red are out of compliance for the evaluation period.*
CFR Compliance Guidance: HOV lane speeds that fail to maintain 45 mph for 90 percent of the time over a 180 day period are non-compliant

Research studies indicate that improvements in roadway infrastructure elements such as lane width, road width, horizontal and vertical geometry, traffic flow conditions, and roadside environment impact travel speed considerably. ADOT is continuously evaluating the health of the detector stations and has resources in place for updating detector stations.

It can be observed from the data in Table 2 the following:

- 16% of the total HOV segments are out of compliance in 2023
- 18% of the total HOV segments are out of compliance in 2024
- 26% of the total HOV segments are out of compliance in 2025

Chart 1 visualizes the trends for the seven segments that are out of compliance over the past 3 years. The chart shows a trend of either improvement or degradation over time.

Chart 1. HOV Lane Compliance

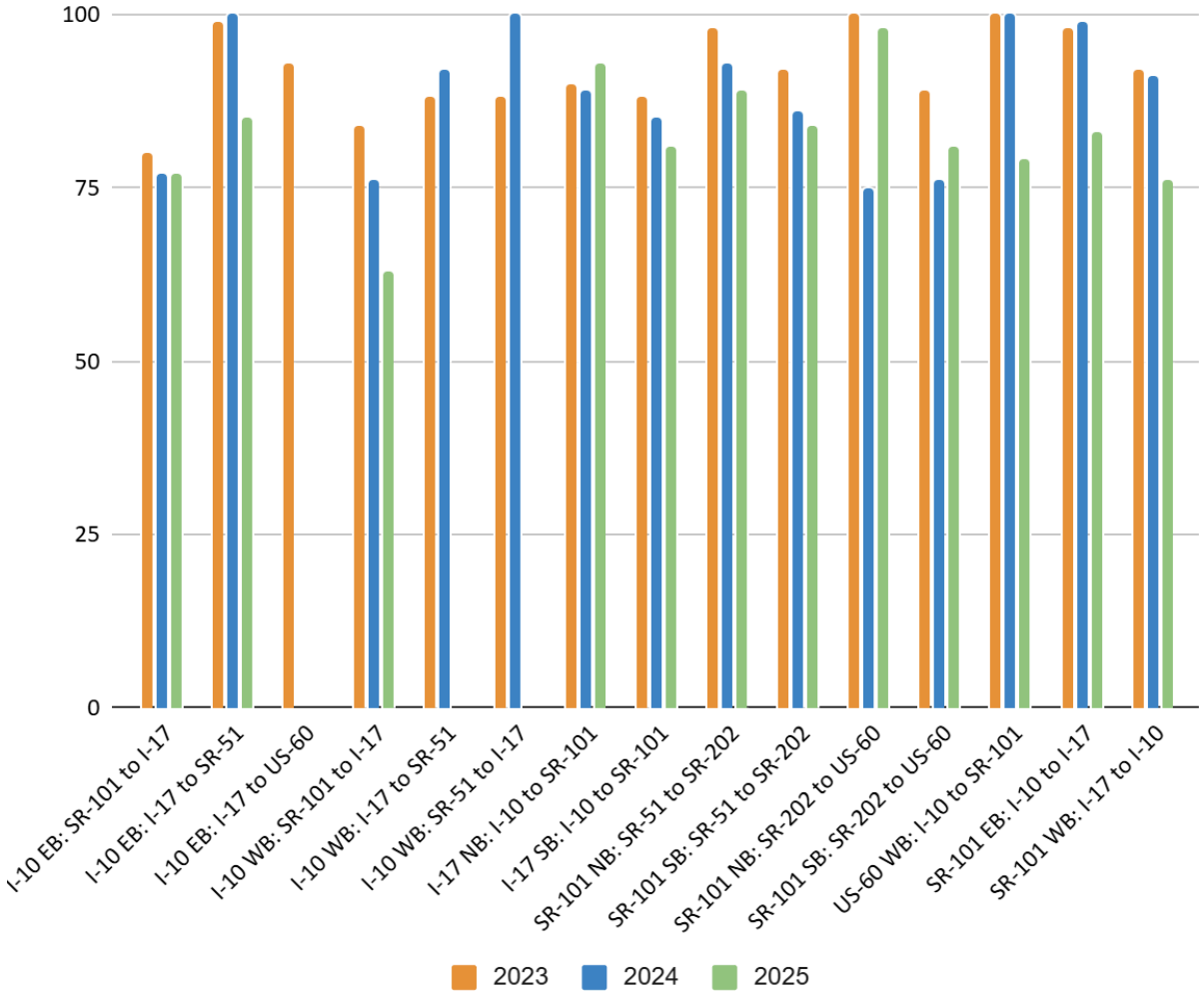
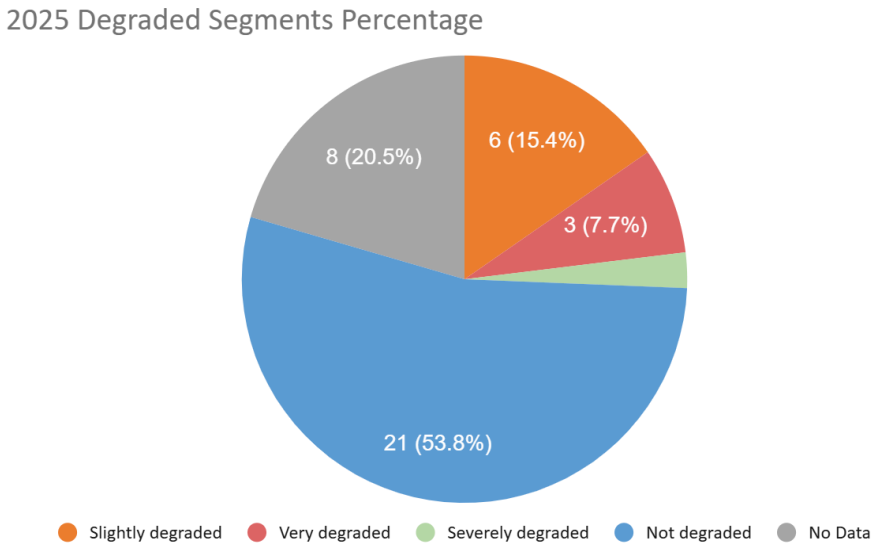
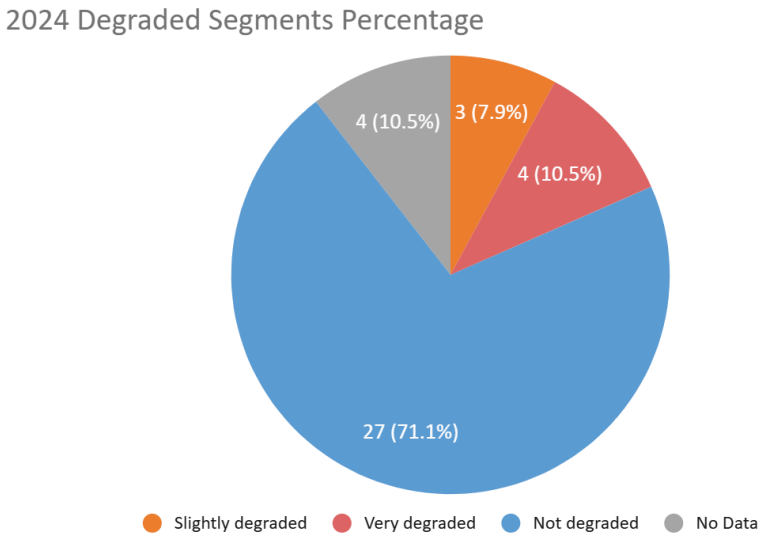


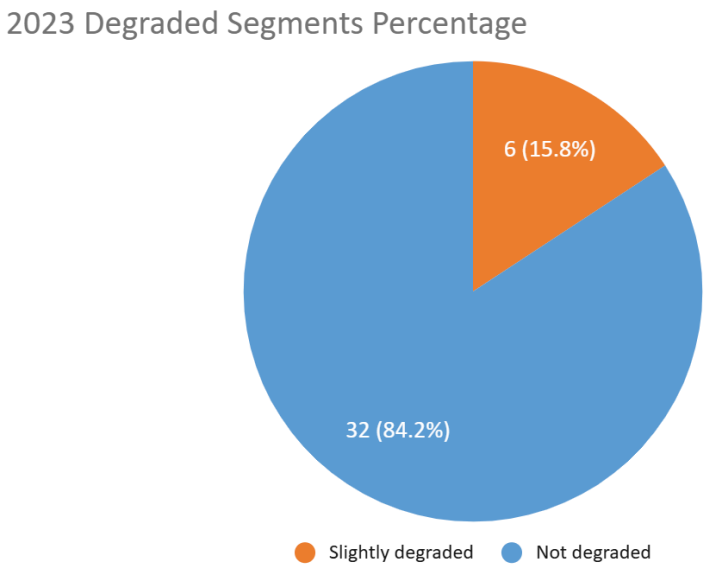
Chart 2 visualizes the percentage of the 38 segments and whether they are in or out of compliance over the past 3 years. The pie chart shows a trend of either improvement or degradation over time. Degradation is best visualized in a qualitative way.

- Slightly Degraded: Refers to speed criteria between 89-80%
- Very Degraded: Refers to speed criteria between 79-70%
- Extremely Degraded: Refers to speed criteria between 69% and under

Chart 2. HOV Lane Percentage







The compliance data can be further analyzed by HOV lane corridor by date and time. The degraded segments calendar map visualizes the dates and times when segments were either degraded or within compliance. This granularity is helpful to see trends in the data.

Phoenix Metro Degradation Summary

The data in Table 2 represents the percentage of time for each segment that is out of compliance and shows the real segment performance changes over the past 3 years.

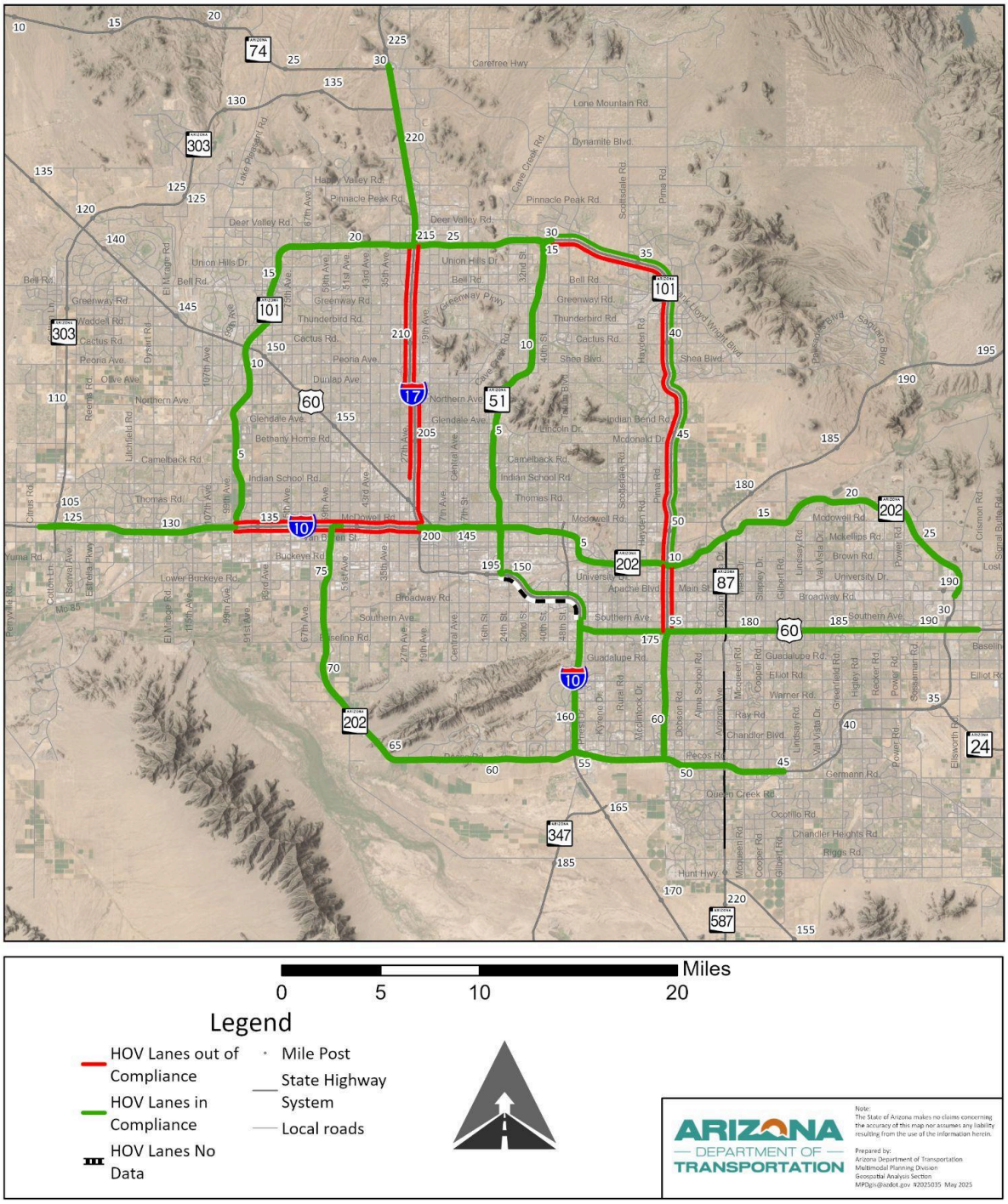
Table 2. HOV Corridor of Degraded Segments

		Evaluation Year		
Segment Order	**HOV Segment**	**2023**	**2024**	**2025**
1	I-10 EB: SR-101 to I-17	80	77	77
2	I-10 EB: I-17 to SR-51	100	100	85
4	I-10 EB: I-17 to US-60	93	No Data	No Data
6	I-10 WB: SR-101 to I-17	84	76	63
7	I-10 WB: I-17 to SR-51	88	92	No Data

8	I-10 WB: SR-51 to I-17	88	100	No Data
11	I-17 NB: I-10 to SR-101	90	89	93
12	I-17 SB: I-10 to SR-101	88	85	81
13	SR-101 NB: SR-51 to SR-202	98	93	89
14	SR-101 SB: SR-51 to SR-202	92	86	84
15	SR-101 NB: SR-202 to US-60	100	75	98
17	SR-101 SB: SR-202 to US-60	89	76	81
26	US-60 WB: I-10 to SR-101	100	100	79
31	SR-101 EB: I-10 to I-17	98	98	83
32	SR-101 WB: I-17 to I-10	93	91	76
Total number of segments out of compliance		**6**	**7**	**10**

The maps in Figure 4, illustrate the HOV segments in compliance (in green) and the HOV segments out of compliance (in red) for the years 2024 and 2025. There are more HOV segments in compliance in 2024 than there are in 2025. There are 2 segments that improved from 2024 to 2025 and 5 new degraded segments.

HOV Segments



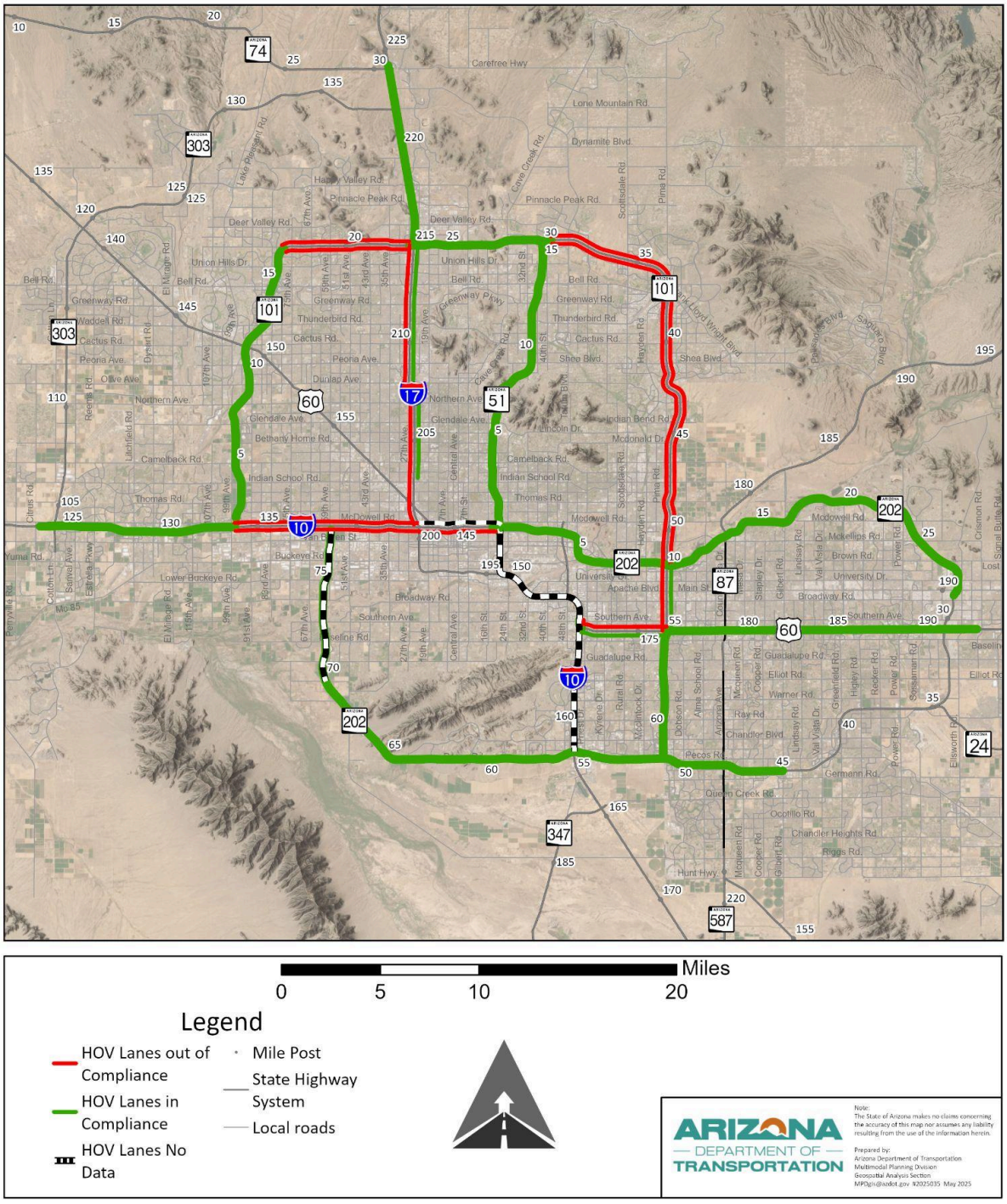


Figure 4. Overview maps of HOV Segments

There are a number of contributing factors for the increased degradation on the HOV lane network.

1. Maricopa County's population grew 5.6% from the year 2020 to 2024 (Arizona Commerce Authority, 2025). With the population of the state increasing, the state highway system Level of Service (LOS) will be affected with increased travel times.
2. Maricopa County experienced a 10% increase in employment from January 2020 to January 2024 (Arizona Commerce Authority, 2025).
3. Construction projects play a significant role in the reliability of the HOV lanes. For the 2024-2025 data collection cycle, ADOT found issues with several locations including:
    a. Construction along the I-10 corridor between I-17 and SR-202 in both East and Westbound. Both corridors lack data due to the Broadway Curve construction project. In the past, these segments have stayed within compliance.
    b. Construction along the US-60 corridor from pavement rehabilitation and the Broadway Curve construction project. In the past, these segments have stayed within compliance.
    c. Construction along the SR-101 corridor (Pima Freeway) aligned with degraded segments in the east valley.
    d. Construction along the SR-101 corridor (Agua Fria Freeway) aligned with degraded segments in the west valley. In the past, these segments have stayed within compliance.
4. In 2025, there are an additional 4 segments with No Data. In the past, these segments have stayed within compliance. This is due to issues with the power and controllers of the counters. Contractors have been hired by ADOT to work on these issues. Efforts to fill in these data gaps via 3rd party data sources are detailed in countermeasure #2.
5. The number of serious crashes have increased over the years in the Phoenix metropolitan area. While a crash may not occur in the HOV lane, it will still disrupt the flow of traffic as accidents are pushed into the median. Mitigation strategies for crashes can be found in countermeasure #2 & #8 (2023 Arizona Crash Facts).

Countermeasures

The countermeasures listed below are used to track progress with ADOT's compliance with 23 USC 166. Some of these countermeasures are works in progress and will take multiple years of data collection and analysis to complete. Several operational

strategies are being considered to improve HOV lanes performance. These high level categories will be discussed in detail in the below countermeasure section.

Countermeasure #1: **End Low Emission Efficient Vehicle (Hybrid) Program**

Per 23 USC 166(b)(5)(B), earlier versions of hybrid vehicle technologies (non-plug-in-type) were to be removed from the occupancy requirements exemptions effective September 30, 2019.

Changes: Continue to track data and perform analysis.
Progress: ADOT implemented this countermeasure by issuing a letter dated December 23, 2019 and made the actions effective March 2, 2020. The letter informed Blue Sky hybrid plate holders of the Federal law ending the program for their specific vehicles. Blue Sky Hybrid Plates are being phased out through sales and attrition of the vehicles.

Currently, ADOT allows qualified alternative fuel vehicles (AFV) with an AFV license plate to use HOV lanes, regardless of the number of occupants. Qualified AFVs include vehicles powered exclusively by electricity, propane, natural gas, hydrogen, or a blend of hydrogen with propane or natural gas. This exemption expires September 30, 2025. After that date, ADOT will discontinue allowing the use of AFV in HOV lanes unless such vehicle has the required number of occupants. For more information about vehicle eligibility and HOV access, visit the ADOT AFV website. This will help to reduce the number of vehicles in the HOV lane and will lead to greater travel time reliability.

ADOT's mitigation plan for after September 30, 2025 deadline will be multifaceted and will include the following actions:

- Congestion Mitigation: Seek to reduce congestion on the HOV lanes by disallowing single-occupant-vehicles from the HOV lanes with exception of public transit vehicles, blood-transport vehicles, and motorcycles that have permitted public authority certification.
- Communication Plan: Develop a robust communication plan to perform outreach with the public on changes to the law. This will include updating ADOT public facing websites and outreach with affected stakeholders. The goal is to lower risk related to public concerns and promote transparency.
- Outreach: Consult with the Maricopa Association of Governments (MAG) as the sole Metropolitan Planning Organization (MPO) in Arizona that has HOV lane facilities to ensure they have a voice in the decision making process.
- Plate Reduction: ADOT's priority is to minimize the disruption to the traveling public. Discussions will occur internally to determine the best path forward.
- If necessary, submit a waiver from sanctions while efforts continue.

Status: Active
Results: As of January of 2025, there are 140,845 active alternative fuel plates and 2,148 hybrid plates remaining on Arizona's roadways. That is a reduction of 405 hybrid plates from 2024. A phased communication plan has been developed by ADOT with the message that Arizona is committed to supporting adoption of AFV to reduce reliance on fossil fuels and reduce carbon emissions. Communication to public stakeholders started in January of 2025. Updates were made to the HOV lane home page on the ADOT website. An ADOT website was developed with additional resources and FAQs for public review. A news release was sent out on March 27th that details the end of the law. Follow up communication will occur in June.

Social media will be leveraged and will include regular posts from ADOT and its partners that will point the public to dedicated websites for more information. The ADOT public information officer will develop messaging for constituent calls to explain the upcoming change and point to the Federal Code and the ADOT website.

Communication was sent out on March 27th to registered AFV owners with key information from the news release explaining what's happening and promoting the website. The ADOT MVD registration website will be updated with language regarding impending expiration of the law. Outreach occurred on March 27th via email to AFV dealerships, state offices and authorized third parties included memos that detail the expiration of the law for customers. Affected plate holders will have letters sent in the mail detailing changes to the law. Lastly, law enforcement engagement with AZDPS will occur to explain pending expiration.

Furthermore, outreach occurred with MAG in January of 2025 and was greatly beneficial. MAG was able to share findings from past studies and ADOT provided context and plans for the future use of HOV lanes. Details can be found in countermeasure #2. Outreach occurred with AZDPS in March of 2025 and was enlightening. More details can be found in countermeasure #4.

After discussions internally, ADOT does not have the authority to remove the remaining AFV plates. Instead, the plan will allow for the natural cycle of customer renewals to dwindle down over time. As the plates are non-transferable and they have been declining by ~400 each year, this is a viable option that is less disruptive to the public. Once the 2025 report has been approved by FHWA, it will also be posted to the website.

Responsible Parties: ADOT MVD

Countermeasure #2: Traffic Congestion Analysis

Analysis was performed from October through March, per the analysis, there are ten segments identified that do not comply with the minimum speed requirements. These particular segments will be analyzed to determine factors that may be affecting upstream and downstream HOV lane volume and speed reductions.

Changes: Conduct analysis on out of compliance segments.
Progress: The analysis of the detector level data in the non-compliant segments is underway. There were several segments without data due to the construction on the Broadway curve. These segments will likely continue to be in compliance due to the additional HOV lane once the construction is completed. Coordination with the Infrastructure Delivery & Operations (IDO) division continues to ensure proper maintenance of the traffic loop detectors, which is the mechanism for getting the speed data. Improvements in process continue to be identified and implemented.

Categorizing the different types of congestion will help to target specific countermeasures. There are several congestion root causes included in the following list (FHWA, 2020).

- Physical Bottlenecks
- Traffic Incidents
- Work Zones
- Weather
- Traffic Control Devices
- Special Events
- Fluctuations in Normal Traffic

For the HOV lanes, the culprit is typically physical bottlenecks, work zones and traffic incidents. In the MAG 2024 System Performance Report, it details the bottlenecks in the region. It is no surprise that the bottlenecks mapped on page 23 of the document align with the HOV lane segments that are degraded. This stems from congestion during the peak hours (MAG SPR, 2024). This means the network is at or exceeds its capacity and car crashes compound the issues during peak hours. More research will be performed to support the improvement of travel time reliability. The goal is to define the issue, assemble data, pin-point root causes (i.e. weather, road geometry or volumes), find solutions (either network wide or by specific corridor), create actionable activities and monitor and evaluate the solution. Table 3 details the 2025 segments that are out of compliance and contributing factors to the degradation.

Table 3. HOV Lane Traffic Congestion Segment Analysis

HOV Segment	Severity Level	Contributing Factors
I-10 EB: SR-101 to I-17	Very degraded	This segment has been degraded for over 3-years and is due to a 30% increase in traffic volume over the years and lack of alternative corridors. There is a strong correlation between crashes and degradation in this corridor.
I-10 EB: I-17 to SR-51	Slightly degraded	Newly degraded segment due to the increase in traffic volumes in the deck park tunnel area of downtown. Likely due to a 34% increase in traffic into the downtown corridor. There is a strong correlation between crashes and degradation in this corridor.
I-10 WB: SR-101 to I-17	Extremely degraded	This segment has been degraded for over 3-years and is due to a 30% increase in traffic volume over the years and lack of alternative corridors. There is a strong correlation between crashes and degradation in this corridor.
I-17 SB: I-10 to SR-101	Slightly degraded	This segment has been degraded for over 3-years and is due to a 12% increase in traffic volume over the years. There is a strong correlation between crashes and degradation in this corridor.
SR-101 NB: SR-51 to SR-202	Slightly degraded	Newly degraded segment due to a 21% increase in traffic volume over the years. Construction continues along this corridor and is likely contributing to the degradation. There is not a strong correlation between crashes and degradation in this corridor.
SR-101 SB: SR-51 to SR-202	Slightly degraded	This segment has been degraded for over 2-years and is due to a 21% increase in traffic volume over the years. Construction continues along this corridor and is likely contributing to the degradation. There is not a strong correlation between crashes and degradation in this corridor.
SR-101 SB: SR-202 to US-60	Slightly degraded	This segment has been degraded for over 3-years and is due to a 32% increase in traffic volume over the years. There is a strong correlation between crashes and degradation in this corridor.
US-60 WB: I-10 to SR-101	Very degraded	Newly degraded segment due to a 27% increase in traffic volumes due to construction on the Broadway curve. Pavement rehabilitation along this corridor was completed in November of 2024 and is likely contributing to the degradation. There is not a strong correlation between crashes and degradation in this corridor.
SR-101 EB: I-10 to I-17	Slightly degraded	Newly degraded segment due to a 27% increase in

		traffic volumes. Construction continues along this corridor and is likely contributing to the degradation. There is a strong correlation between crashes and degradation in this corridor.
SR-101 WB: I-17 to I-10	Very degraded	Newly degraded segment due to a 27% increase in traffic volumes. Construction continues along this corridor and is likely contributing to the degradation. There is a strong correlation between crashes and degradation in this corridor.

ADOT's mitigation plan for reducing congestion around HOV lane facilities will be multifaceted and will include the following actions:

- Vehicle Eligibility: Remove the use of AFVs and only allow vehicles that meet occupancy requirements to travel in the HOV lanes.
- Research: Perform research on the effects of congestion with the implementation of HOV 3+ occupancy requirements. Research the purchase of 3rd party data providers to improve data quality. In addition, research the effects of congestion pricing to improve HOV lane reliability.
- Capacity Increase: Perform research on adding additional HOV lanes on the network where congestion is most severe. This can occur either through highway widening or conversion of general purpose lanes.
- Connected Vehicle Data (CVD) Analysis: Coordinate with MAG on the use of 3rd Party data to fill in gaps in the HOV lane network.

Status: Active
Results: Data will continue to be collected by FMS and analyzed for customers on an as needed basis after the September 30th, 2025 deadline. Vehicle eligibility will continue to be exclusive to those that meet the occupancy requirements of 2+ passengers. This will greatly improve the level of service on the HOV lanes. A new bill is being proposed by the Arizona Legislature of the State of Arizona (HB 2863). The bill proposes to restrict vehicles from using the HOV lane while towing a trailer, semitrailer or pole trailer at any time. If passed, it would likely improve speed in the HOV lanes as the towing vehicles tend to impede free flow in the lanes.

Research was performed on the benefits and challenges for congestion pricing with the goal of reducing congestion and improving the level of service. Some of the lessons learned from a FHWA facilitated workshop was the potential for enhanced corridor mobility performance. Challenges were focused on how to best navigate the public and political challenges (FHWA, 2017). ADOT is currently not considering adding congestion pricing. If ADOT were to consider moving forward with congestion pricing, extensive outreach with partners would be needed to achieve awareness and stakeholder approval.

Another consideration to help reduce traffic congestion is research on the HOV 3+ which would increase occupancy requirements from 2 to 3 individuals. The perspective is that by increasing the number of occupants required for HOV lanes that it will improve level of service. For more details, please see Countermeasure #9. Updated signage will be needed and would affect Countermeasure #3. Capacity increases either by adding additional HOV lanes or transitioning general purpose lanes to HOV lanes have several benefits to the traveling public. One possibility is to perform analysis on the I-10 Broadway Curve for before and after the construction of the 2-lane HOV facility. This would give ADOT insights on the benefits of increased capacity.

The University of Utah performed research that found that after an HOV lane extension, the vehicle occupancy increased within the corridor. It was also observed that travel time decreased and vehicle speeds increased for the HOV lanes (Martin, Lahon and Stevanovic, 2005). In the MAG 2012 Vehicle Occupancy Study, a hybrid method includes windshield method and carousel method was used to count vehicle occupants. The findings from the report show of the 82 HOV lane locations, 39 (48%) are seen to carry higher occupancy than the average general purpose lane during the AM and PM peaks (MAG VOS, 2012). The challenge with increasing capacity are the financial and physical in nature due to likely needing to acquire new right of way.

Research was performed to identify 3rd party vendors with speed data to support validating and/or enhancing internal data. The findings are found in Table 4. The key challenge with this data is two fold. First, the CVD is a sample of the overall traffic volumes. Second, several data providers are not able to meet spatial accuracy needs to distinguish between HOV lanes and general purpose lanes. The conclusion is that the internal data source is still the most robust for analysis.

Table 4. 3rd Party Data Matrix

3rd Party Data Matrix							
Vendor	**Speed Data**	**Vehicle Types**	**Data Format**	**Data Range**	**Data Latency**	**Lane Specific**	**Limitations**
AirSage	✔	Passenger	Tabular	Statewide	Real-Time	X	Data Lacks Granularity
GeoTab	✔	Commercial	Geospatial	Statewide	Real-Time	X	No Passenger Data
HERE	✔	Passenger	Geospatial	Statewide	Real-Time	X	Data Sample
INRIX	✔	Passenger	Tabular	Statewide	Real-Time	X	Data Sample
Replica	✔	Passenger	Geospatial	Statewide	Real-Time	X	Data Sample
Street Light	✔	Passenger	Geospatial	Statewide	Real-Time	✔	Data Sample
Teralytics Studio	X	O-D	Geospatial	Statewide	Real-Time	X	No Truck Data
Wejo	✔	Passenger	Geospatial	Statewide	Real-Time	✔	Data Sample

Over the past several years, CVD has emerged as the next frontier in transportation planning. Vehicles equipped with communication capabilities can transmit real-time data about their speed, position, and even sensor readings. The transformative potential of CVD lies in its potential of providing lane-based information. The use of CVD to supplement corridors with no data has produced a reasonable approximation of HOV lane performance.

MAG has partnered with Wejo since 2020 for connected vehicle data and performed analysis comparing the ADOT FMS data. MAG determined that the differences were minimal. This means that the CVD is a viable alternative to the FMS data and will be beneficial for filling in data gaps on the highway network due to construction (i.e. Broadway Curve).

There are 8 No Data segments for the HOV lanes. ADOT collaborated with MAG, who has access to 3rd party data to help fill in data gaps on the HOV lane network. MAG has access to StreetLight data which consists of CVD. The StreetLight data includes speed information in 3-second intervals and is a sample of around 5% of the total traffic. This data can be used to augment the FMS data where there are data gaps. MAG was able to analyze StreetLight data for the 8 No Data segments. The StreetLight data is geospatially enabled and is not specific to the HOV lanes. For the purposes of the analysis, a geofence was used to only analyze data in the HOV lanes and discard the data in the general purpose lanes (See Figure 5).

Figure 5. Connected Vehicle Data Geofencing

Outliers with exceptionally high speeds (i.e. >90 mph) were removed from the analysis. Speed comparison was run between the FMS and CVD and they aligned nicely, this confirms the quality of the CVD. The data was then reviewed and assigned a degradation value depending on the average speed being more or less than 45 mph. In general, CVD based HOV speed data is lower than FMS HOV speed data but is a viable option when no FMS data is available. CVD can also provide valuable insights on where and when incidents or work zones occur and their impacts to traffic flow. ADOT will continue to collaborate with MAG on the uses of the CVD. The findings from the analysis on the 8 No Data segments are found in Table 5.

Table 5. HOV Lane CVD Analysis

HOV Segment	FMS Data	MAG Analysis Results
I-10 EB: SR-51 to I-17	No Data	The results of the analysis show not degraded segment at 100%.
I-10 EB: I-17 to US-60	No Data	The results of the analysis show a degraded segment at 86%. This is not surprising due to construction in the Broadway Curve corridor.
I-10 EB: US-60 to SR-202	No Data	The results of the analysis show not degraded segment at 100%.
I-10 WB: I-17 to SR-51	No Data	The results of the analysis show a degraded segment at 66%. This is not surprising due to being in the urban core.
I-10 WB: SR-51 to I-17	No Data	The results of the analysis show a not degraded segment at 94%.
I-10 WB: I-17 to US-60	No Data	The results of the analysis show a not degraded segment at 92%.
I-10 WB: US-60 To SR-202	No Data	The results of the analysis show a not degraded segment at 99%.
SR-202 NB: Dobbins to I-10	No Data	The results of the analysis show a not degraded segment at 98%.

Since this data is only a sample of the overall vehicle volume, ADOT decided not to leverage it in the official analysis. This report and its methodologies serve as a proof of concept for future applications of CVD.

Responsible Parties: ADOT MPD

Countermeasure #3: Increased Signage

Proper signage along the HOV corridor is essential to communicating to the traveling public. The successful operation of HOV lanes hinges on the ability of transportation agencies to effectively communicate the rules and regulations governing their use to the driving public. Signage serves as the principal means of conveying this critical information, including occupancy requirements (such as 2+ or 3+ persons per vehicle), the types of vehicles permitted (e.g., carpools, buses, motorcycles), the specific hours of operation (if not 24/7), and the potential penalties for non-compliance. Clear and understandable signage is therefore fundamental to ensuring that drivers are aware of who can use the lanes and under what conditions, which is a prerequisite for achieving high levels of compliance and realizing the intended benefits of HOV lanes. Conversely, if the signage is confusing, inconsistent, or inadequate, it can lead to driver uncertainty, unintentional violations of HOV lane restrictions, underutilization by eligible vehicles due to a lack of awareness, or even congestion within the HOV lane itself as a result of misuse by unauthorized vehicles.

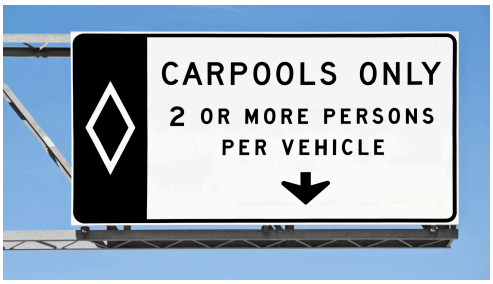
Research suggests that while most drivers understand the basic concept of HOV lanes, confusion can arise from inconsistent regulations or frequent changes. Clear and concise signage explicitly stating restrictions is crucial for improving driver comprehension and reducing violations. Overhead signage tends to be more effective than side-mounted signs due to better visibility. Factors influencing compliance include high visibility (reflective materials), clarity in messaging (standard symbols and concise language), and consistency in design and placement. Advance warning signs and informational signage also contribute to compliance by providing timely notification and context. Conversely, confusing or inadequate signage, especially at entry and exit points or regarding part-time operations, can lead to violations. The effectiveness of increased signage depends on strategic placement, clarity, and consistency, alongside driver familiarity and perceived enforcement.

Other state DOTs use signage in different capacities than ADOT. The California Department of Transportation (Caltrans), for example, utilizes overhead signage above the HOV lane with a large image of the HOV diamond symbol covering the entire vertical length of the sign. The Virginia Department of Transportation (VDOT) uses electronic overhead signage indicating the status of the HOV lanes (VDOT, 2024).

The reason for the differences in the signage as seen in the pictures from ADOT, Caltrans, and VDOT below is because of the *Manual on Uniform Traffic Control Devices (MUTCD)*. For example, the overhead sign for Caltrans has a large HOV diamond symbol, but does not use the word message “HOV” (Candelieri, 2023). As seen in the

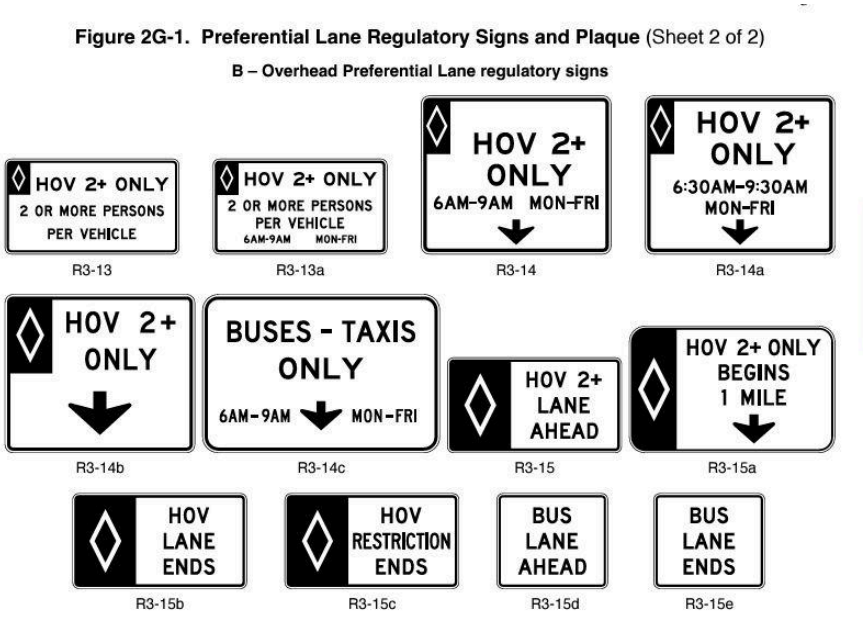
MUTCD Figure 2G-1, there is a variety of overhead HOV sign designs that range from a diamond spanning the full sign, like in the Caltrans sign, or a diamond covering half of the sign, like in the ADOT and VDOT signs (FHWA, 2023). Additionally, Dynamic Message Boards (DMB) may replace static signs according to Section 2G.03 of the *MUTCD,* which can be seen in the VDOT image below (FHWA, 2023).

ADOT I-10



Caltrans

VDOT



MUTCD Overhead Sign Diversity

Signage goes beyond the physical sign and also incorporates messaging that updates in real time. See Figure 6, the DMB allows for updated messaging to the public while traveling on the State Highway System (SHS). ADOT will evaluate if increased signage along the HOV facilities reinforcing the occupancy requirements and penalties for violations may discourage use of the HOV facilities by vehicles that do not meet the occupancy requirements.

(Source: ADOT Flickr, 16 May, 2024)

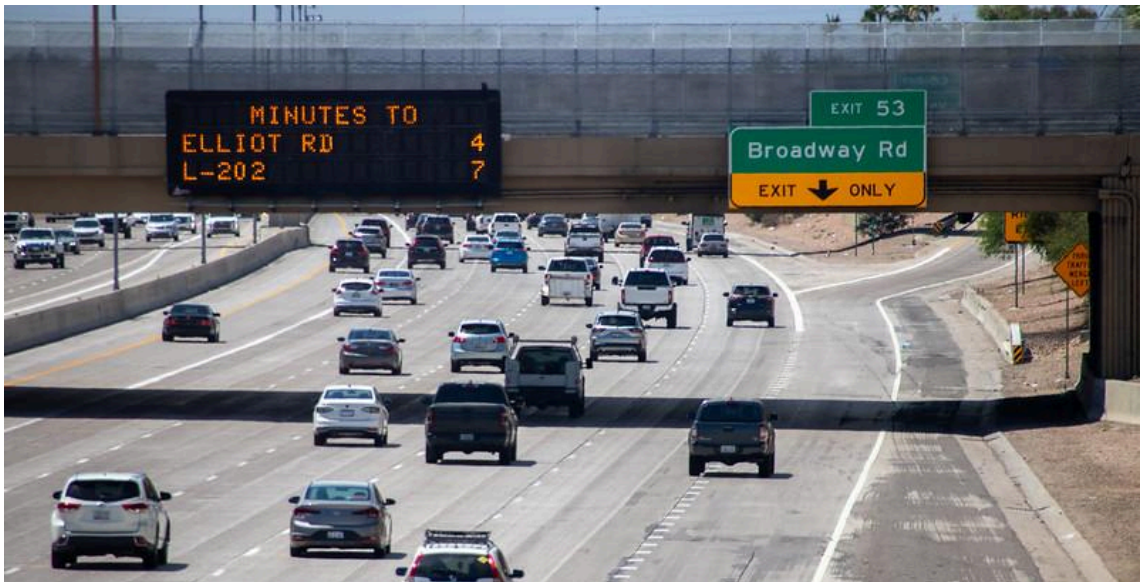


Figure 6. Dynamic Message Boards

Changes: Conduct research on the use of updated signage.
Progress: Planning staff met with internal subject matter experts to understand the current state of HOV signage. ADOT is currently in compliance with MUTCD requirements. As new requirements come from FHWA, ADOT will be sure to make the necessary changes. The feasibility of a Geographic Information System (GIS) analysis was conducted to associate increased signage and citations to see if there is a significant change in driver behavior in these corridors in the future. A thorough evaluation of how improved or increased signage affects traffic would necessitate a comprehensive before-and-after study conducted over several years. With increased signage, enforcement will also need to follow suit.

ADOT's mitigation plan for increased signage will be multifaceted and will include the following actions:

- Research: Research the benefits of adding new signage for HOV lanes.
- Asset Management: Continue performing internal asset management and condition assessment by the IDO division. The will allow for targeted maintenance of the sign inventory.
- Compliance: ADOT will continuously review the MUTCD requirements to ensure compliance.
- Safety Assessment: With the insights from the GIS analysis described above, further work will be done to lower risk to the traveling public.

Status: Active
Results: The use of DMB have tried and true benefits from past use by ADOT and have focused on safety initiatives such as using seat belts to reduce serious injury and fatalities. In addition, DMBs have applications for HOV lanes including real time engagement, cost-effectiveness, versatility, safety awareness and much more. A study from CalTrans found that the use of DMBs have cross cutting benefits in safety and bringing awareness on specific activities in a region (CalTrans, 2009). Per federal regulation, ADOT is only able to leverage the 83 DMB in the Phoenix metropolitan area, for either travel times or safety messaging and would not be used for outreach purposes.

Asset management will continue to be a priority of ADOT, as asset management evolves at ADOT and becomes more data driven, numerous internal efforts related to the modernization of historic systems that consume data are ongoing. The use of GIS technology and spatially enabled data is the future of data driven decision making. A comprehensive sign inventory is essential to improve analysis and targeted maintenance. ADOT is currently within compliance with MUTCD requirements.

A feasibility study commenced by reviewing data from the Feature Inventory System (FIS), it was determined that the GIS sign data necessary to perform the analysis is not currently available. Such an analysis requires specific details about any modifications ADOT makes to roadway signage. Currently, this level of detail is not available in FIS. The signs data lacks a distinct start and end date, making it difficult to establish clear timelines for before-and-after comparisons. Moving forward, ADOT will explore incorporating timestamps with sign inventory changes. This would enable a GIS-based analysis of HOV lane performance and allow for potential correlations with signage changes to be inferred. While the data necessary to complete the analysis isn't available, extensive research was performed and confirmed that the use of clear signage and enforcement does have an effect on reducing unauthorized vehicles from using the HOV lanes. There are several emerging technologies for digital signage that show promise that are detailed in countermeasure #6.

Responsible Parties: ADOT IDO

Countermeasure #4: Increased Enforcement

Enforcement is critical to the successful operation of an HOV facility. The role of an HOV enforcement program is to protect the integrity of the facility by deterring possible violators and promote the safe and efficient use of the HOV lanes (FHWA, 2018). ADOT's coordination with AZDPS is ongoing and seeks to increase enforcement activity of HOV lanes in sections where the data determines that the lanes are degraded. The

challenge with enforcement of the HOV lanes is the safety of the officer and the public. Since the HOV lanes are closest to the highway median, stopping a member of the public to provide a citation can pose a safety risk. AZDPS does an exceptional job balancing the need for safety and improving the level of service for the highways.

Changes: Additional discussions with AZDPS will need to occur to help determine where enforcement efforts should focus on areas of noncompliance with HOV lane usage.
Progress: A new baseline was established for the number of citations issued and where those citations occur on the state highway system. Over the last 7 years, there have been HOV lane citations given within the Phoenix metro area that are detailed in Table 6.

Table 6. HOV Lane Citations

Year	Citations
2018	7,525
2019	6,689
2020	3,225
2021	4,177
2022	4,816
2023	5,232
2024	4,929
2025: Year to Date	2,444

AZDPS provided ADOT with a database of over 27,000 citations issued to drivers in single occupancy vehicles utilizing the HOV lane during rush hour traffic, which is a violation of Arizona Revised Statutes, Title 28-737A. The data is from January 2018, through April 2025.

With this baseline data, more informed metrics and decisions can be made to improve highway reliability and safety. ADOT's mitigation plan for increased enforcement will be multifaceted and will include the following actions:

- Enforcement: Coordinate with AZDPS to understand their HOV lane enforcement plan, along with a performance-monitoring program for future analysis.

- Research: Review emerging technologies to improve enforcement. There are automated enforcement technologies that can assist AZDPS with citing vehicles that use the HOV lane inappropriately.
- Outreach: ADOT will continue to collaborate with AZDPS on increasing citations within the HOV lanes. This will be vital especially after the September 30th, 2025 deadline.
- Analysis: ADOT will perform analysis on hot spots for enforcement and create maps for AZDPS review. ADOT will share these findings to allow AZDPS insights on areas where more enforcement is needed.

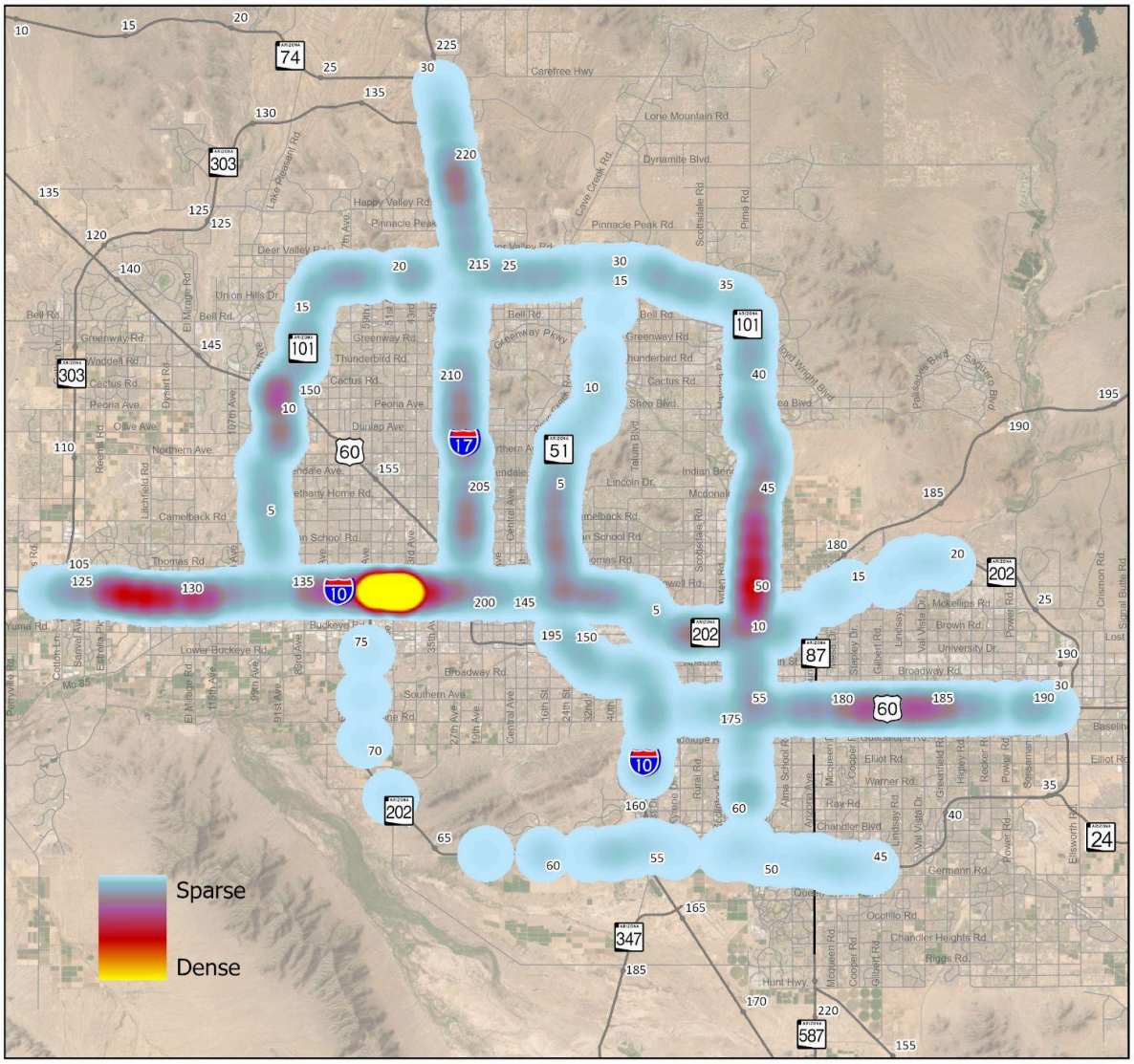
Status: Active
Results: ADOT understands the importance of partnerships and outreach for public safety. Research found that technologies exist that help to monitor vehicle occupancy. This will be important after the September 30th expiration. More research findings on emerging technologies for enforcement can be found in countermeasure #6.

ADOT met with AZDPS staff in March of 2025 to review the degradation report and discuss HOV lane enforcement. The meeting was insightful as ADOT learned about enforcement best practices and safety concerns for their troopers as it relates to the citation analysis found below. The biggest challenge for HOV lane vehicle occupancy enforcement is related to a lack of safe areas for the officers to place their vehicles. This is due to roadway geometry and line of sight challenges.

ADOT inquired on AZDPSs use of technology for improved enforcement, AZDPS is prohibited by Arizona state statute on the use of emerging technologies such as photo enforcement and License Plate Readers (LPR). AZDPS will be given the ADOT communication plan ahead of time to review and comment. AZDPS has plans to perform outreach with the public on the change in enforcement via their social media page, the goal is to educate the public of the change in law.

A hot spot analysis was conducted to find areas of high ticketing. Baseline results will be used in determining areas of high violation and where additional enforcement is needed. Analysis was performed using citation data from AZDPS for a 6-month window (October 2024 - March 2025) of data to determine hot spots for enforcement as well as areas where enhanced enforcement is needed. The deliverable from this analysis is shown in the maps above (Figure 7).

HOV Lane Citations - AM Peak



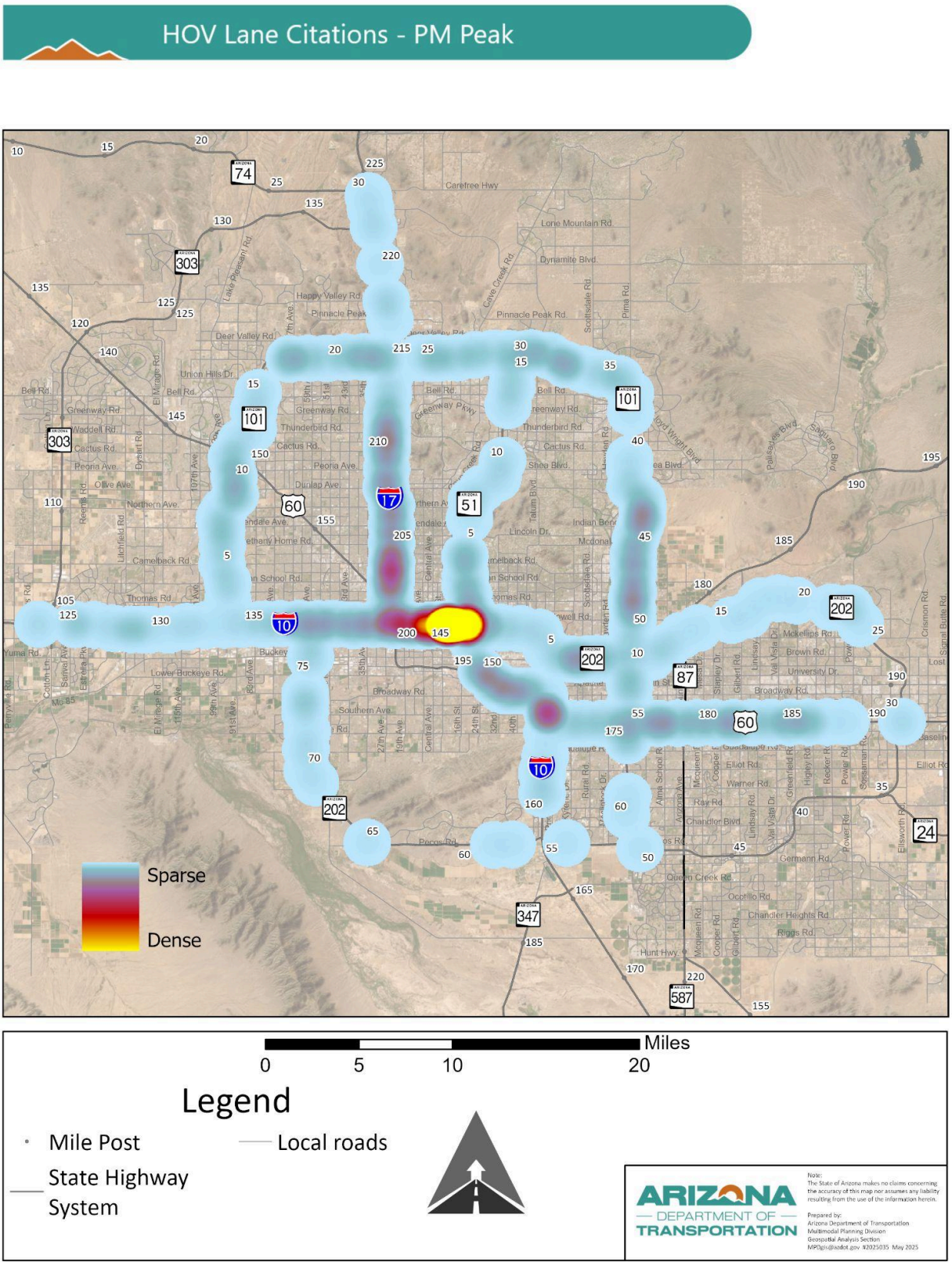


Figure 7. Citation Volume Distribution

For the morning commute, the I-10 in the west valley, I-17 north of downtown, SR-51 north of downtown, US-60 in the east valley and SR-101 corridor in the east valley were identified as highways of greatest citation density. This aligns with past years data and observations from AZDPS. For the afternoon commute, the I-10 downtown corridor had the highest citations due to commuters leaving the downtown area. The I-17 and I-10 Broadway Curve corridors also continue to expand with more citations. This aligns with past years data and analysis. The maps can also be used to visualize where additional enforcement can be done such as the US-60 or SR-202. An interactive map was produced to allow for more detailed review of data.

Responsible Parties: AZDPS

Countermeasure #5: Hours of Operation

The current hours of operation are from 6:00am - 9:00am and 3:00pm - 7:00pm. Due to the current AM peak and PM peak travel demand, extending the operation hours may relieve surges in HOV lanes.

Change: ADOT performed analysis using historical congestion data and changed the peak period from 3:00pm - 7:00pm to 2:00pm - 7:00pm. This update did not have an impact on the compliance results. As population within the Phoenix Metropolitan area increases the hours of operation will be reevaluated to improve level of service. Areas facing extreme congestion on highways such as Southern California have enforced 24/7 HOV lane enforcement (Caltrans). The benefits include encouraging carpooling. However, the costs include high enforcement costs or increased noncompliance. Making a drastic change to 24/7 HOV would require more studies on population increase and traffic volume.
Progress: Evaluation of modified PM peak period. Hours of operation analysis will be performed in the future to determine any trends. ADOT's mitigation plan for updates to the hours of operation will be multifaceted and will include the following actions:

- Research: Continue to research the benefits and challenges of adjusting hours of operations for HOV Lane facilities.
- Analysis: As needed, continue to reevaluate and analyze updates to the peak period and its effect on congestion.

Status: Inactive
Results: ADOT staff performed additional research in regards to benefits of updating the hours of operation for HOV lanes. In California, HOV lanes operate differently based on north and south parts of the state, meaning that some regions in the state have HOV lanes that function on a 24-hour cycle or only during peak periods. This is due to differences in vehicle traffic patterns and traffic volumes. The challenge with

implementing something similar in Arizona is that the HOV lanes are all within a single region. States such as Nevada have reduced the hours of operation and possibly eliminate the HOV lanes altogether (NDOT, 2023).

If a 24-hour cycle was desirable, more analysis would be needed. The goal of the analysis and considerations of adjusting hours of operation is to ensure that as demand increases, the level of service won't decrease. Analysis will be done as needed to reevaluate the hours of operations. This will be vital as population increases in the Phoenix metropolitan area. The catalyst for this review will be the reduced level of service of the HOV lanes.

This successful implementation of updated hours of operation is greatly dependent on the effectiveness of countermeasure #1. The removal of single-occupant vehicles with blue-sky license plates will have significant impacts to freeway operation in terms of reducing congestion during peak hours and HOV lane efficiency will likely improve. There are no plans to make adjustments to hours of operation at this time.

Responsible Parties: ADOT IDO

Countermeasure #6: **Technology and Use Cases in other States**

In 2008, Arizona Department of Transportation (ADOT) paired with Redflex Traffic Systems, an Australian based company, to install 42 mobile units and 36 stationary cameras in Phoenix. However, the cameras were taken down within 2 years due to the public's reaction and claims that the placement of such cameras was a violation of constitutional rights (Sakal, 2010). Currently, ADOT has no HOV lane photo enforcement radars on its highway system. FHWA published a number of state use cases for exempt vehicles, Arizona was one of the showcased states. The website has a wealth of information that will help ADOT plan for the future.

Technology is used by other state DOTs in various ways. Tags such as E-ZPass are used in HOV lanes converted to toll lanes in states like Minnesota (MnDOT) and Virginia. Detectors on the roads read the tag which can be turned to an HOV mode as drivers enter the HOV lanes (MnDOT, 2021; E-ZPass Virginia Service Center, 2024). While there are no toll roads within Arizona currently, this technology has some interesting use cases for HOV lane enforcement.

Technology can help to prevent HOV lane violations. Xerox, for example, created the Vehicle Passenger Detection System which employs cameras that require manual inspection (Xerox, 2015). MnDOT has implemented remote sensing technology to detect vehicle occupancy with good results (MnDOT, 2017). However, the usage of cameras raises questions about privacy. While the efficacy of new technology is tested

through pilot programs, there is potential for more research opportunities for how technology can assist in HOV lane compliance.

Changes: Continued research.
Progress: As technology continues to evolve, further research will be necessary. Partnerships with other state agencies will help to improve Arizona's level of service. ADOT's mitigation plan for technology use cases will be multifaceted and will include the following actions:

- Research: Perform research in the use of emerging technologies and implementation.
- Outreach: Coordination with other states on their respective best practices will help ADOT learn lessons that can be implemented in Arizona.

Status: Active
Results: The research performed on emerging technologies found that there are numerous upcoming technologies that have promising results including:

- LED Signs for HOV lanes that provide visual cues needed to properly enforce HOV lane occupancy requirements. CalTrans implemented similar technology by TransCore in 2022. The project was a success not only for lane monitoring but also for improved enforcement (Signal-Tech, 2022).
- Camera technology such as license plate readers has shown promise in other states such as Utah. The technology is currently used for collecting fees on High Occupancy Toll (HOT) roads. Other technology includes the use of cameras to support enforcement by identifying vehicle occupancy. There are privacy challenges with these cameras similar to what was seen in the past with photo radar on highways. To alleviate these concerns a plan for policy development and communication to the public would be vital for public support. The implementation of camera technology for monitoring vehicle occupancy is currently not an option.

Outreach was performed for the 23 states that have HOV lanes. The goal is to understand the types of HOV lanes in the state, their challenges, benefits and any innovative methods for the degradation report or the management of the HOV lanes. Detailed findings of the outreach can be found in Table 7. The map of states with HOV lanes can be found in Figure 8.

Table 7. HOV Lane Outreach by State

State	Comments	Information Link
Arizona	HOV-2 lanes with designated hours of operation.	LINK
California	HOV-2 and HOV-3 lanes. Combination of designated hours of operation and 24-hour operation based on regional needs.	LINK
Colorado	Express lanes open 24-hours. Include use of HOV-3 and transponder for usage.	LINK
Connecticut	Research on impacts of crashes and new HOV lanes.	LINK
Florida	Managed lanes program that requires vehicle decal.	LINK
Georgia	HOV-2 lanes in the Atlanta region.	LINK
Hawaii	HOV-2 lanes during designated hours of operation.	LINK
Kansas	Express lanes that function as tolls with varying pricing.	LINK
Maryland	HOV-2 lanes with designated hours of operation.	LINK
Massachusetts	HOV-2 lanes with designated hours of operation.	LINK
Minnesota	HOV lane E-Z Pass program with tag that functions as a toll	LINK
Michigan	HOV-2 lanes with designated hours of operation.	LINK
Nevada	HOV-2 lanes with designated hours of operation.	LINK
New Jersey	HOV-2 lanes with designated hours of operation.	LINK
New York	HOV-2 & HOV-3 lanes with designated hours of operation. Clean pass for single occupants.	LINK
North Carolina	HOV-3 lanes with designated hours of operation and transponder for usage.	LINK
Ohio	HOV-2 lanes with designated hours of operation.	LINK
Pennsylvania	HOV-2 lanes with designated hours of operation.	LINK
Tennessee	HOV-2 lanes with designated hours of operation.	LINK

Texas	HOV-2 & HOT lanes with designated hours of operation.	LINK
Utah	HOV-2 & HOT lanes with designated hours of operation.	LINK
Virginia	HOV-2 & HOV-3 lanes with designated hours of operation.	LINK
Washington	HOV-2 & HOV-3 & HOT lanes with designated hours of operation.	LINK

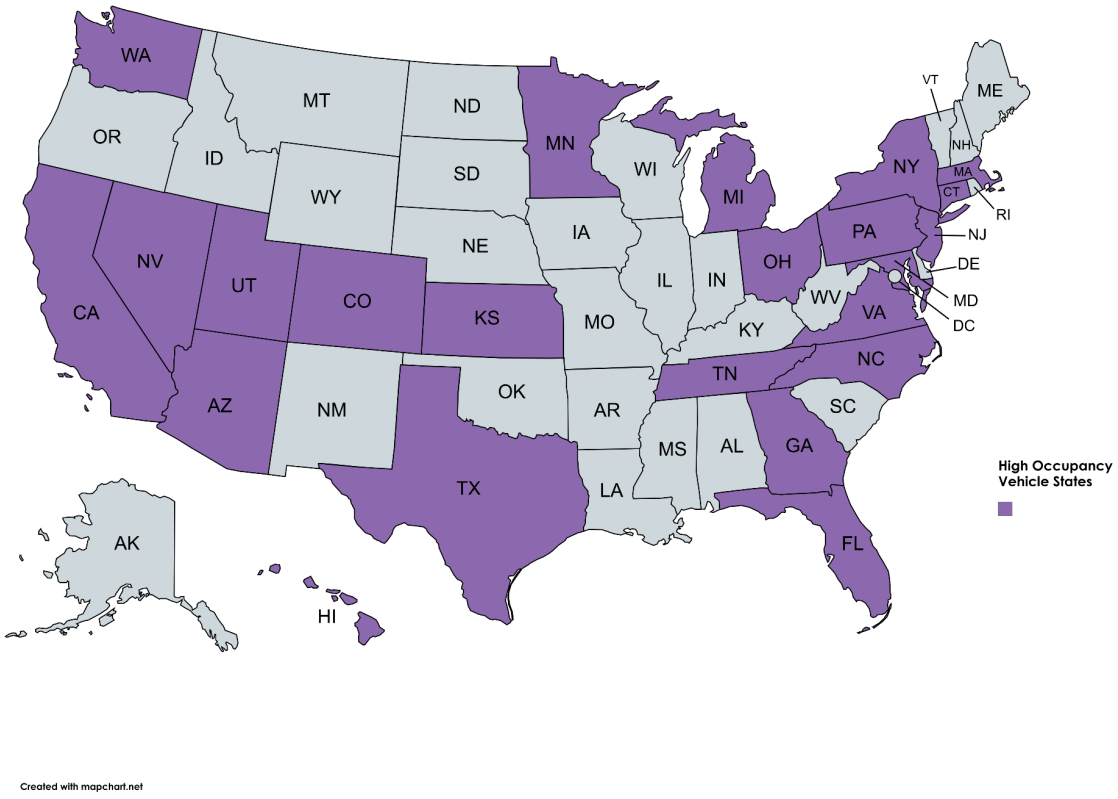


Figure 8. HOV Lane State Distribution

Responsible Parties: ADOT MPD

Countermeasure #7: HOV Lane Access Restrictions

The current configuration of HOV lanes allow ingress and egress at any point along the lane. The reasoning behind this style of striping is to limit land weaving between traffic

interchanges. Limiting the points of ingress and egress may limit traffic volumes in the HOV lanes within certain segments, particularly those currently degraded.

Changes: No major changes at this time.
Progress: Planning staff meet with subject matter experts on the topic. An analysis was done previously to update lane striping. It was determined that the cost outweighs the benefits. The designated ingress/egress locations would not affect congestion as desired. No lane restrictions are being considered by ADOT at this time.

ADOT's mitigation plan for improving HOV lane access restrictions will be multifaceted and will include the following actions:

- Research: ADOT will research the safety benefits of updated striping and ingress/egress locations for HOV lanes.

Status: Inactive
Results: Currently, ADOTs standard for HOV lane striping won't allow for the change. According to an FHWA research publication, the research found that with greater striping separation between the HOV lanes and general purpose lanes, the safer the corridor is. If the policy were to change, updated striping could help ADOT continue to consider actionable safety options in the design of highways (FHWA, 2015). The cost for restriping the roads as seen in Figure 2 is a challenge as it would likely require taking width from general purpose lanes.
Responsible Parties: ADOT IDO

Countermeasure #8: Human Factors Study

Examine and understand why commuters, despite the availability of other commute options, continue to drive unsafely and with single occupants. In addition, safety analysis is needed to understand how crashes affect the level of service for the HOV lanes.

Change: Additional research is needed to understand human behavior and how to change this behavior that benefits the mobility of the HOV lane.
Progress: MPD staff met with ADOT safety teams to understand the use of human factor studies. A recent study from MAG has looked at Interstate 10 and 17 corridors and different alternatives including capacity increases and implementation of HOT lanes (MAG, 2018). At this time, the conversion of HOV to HOT lanes isn't an option due to Arizona state statute in place that won't allow for toll roads.

ADOT's mitigation plan for improving human factors will be multifaceted and will include the following actions:

- Traveler Behavior Research: ADOT will perform research on understanding driver behavior as it relates to the use of HOV lanes.
- Hot Spot Analysis: ADOT will perform spatial analysis on the number of crashes that occur in the HOV lanes.

Status: Active
Results: Research was performed to better understand driver behavior as it relates to the use of HOV lanes. Driver behavior was broken up into two categories, by drivers that violate the law and those that choose to rideshare for their commute. For the driver that violates HOV rules, there are a number of reasons behind the behavior including desire to take risks, disregard for rules, emergency situations and a lack of awareness. Via research performed, violators feel the risk is minimal when driving in the HOV lanes without meeting occupancy requirements. Changing this behavior is incredibly challenging and must come with targeting communication and enforcement.

For the driver that leverages ridesharing, understanding why commuters chose to ride share is important for long term sustainability. There are several motivations including faster travel times, cost savings and air quality benefits. This option is especially attractive to commuters within the urban core for work and for families that travel together. Incentives need to be understood and clearly communicated to the travel public to encourage good behavior.

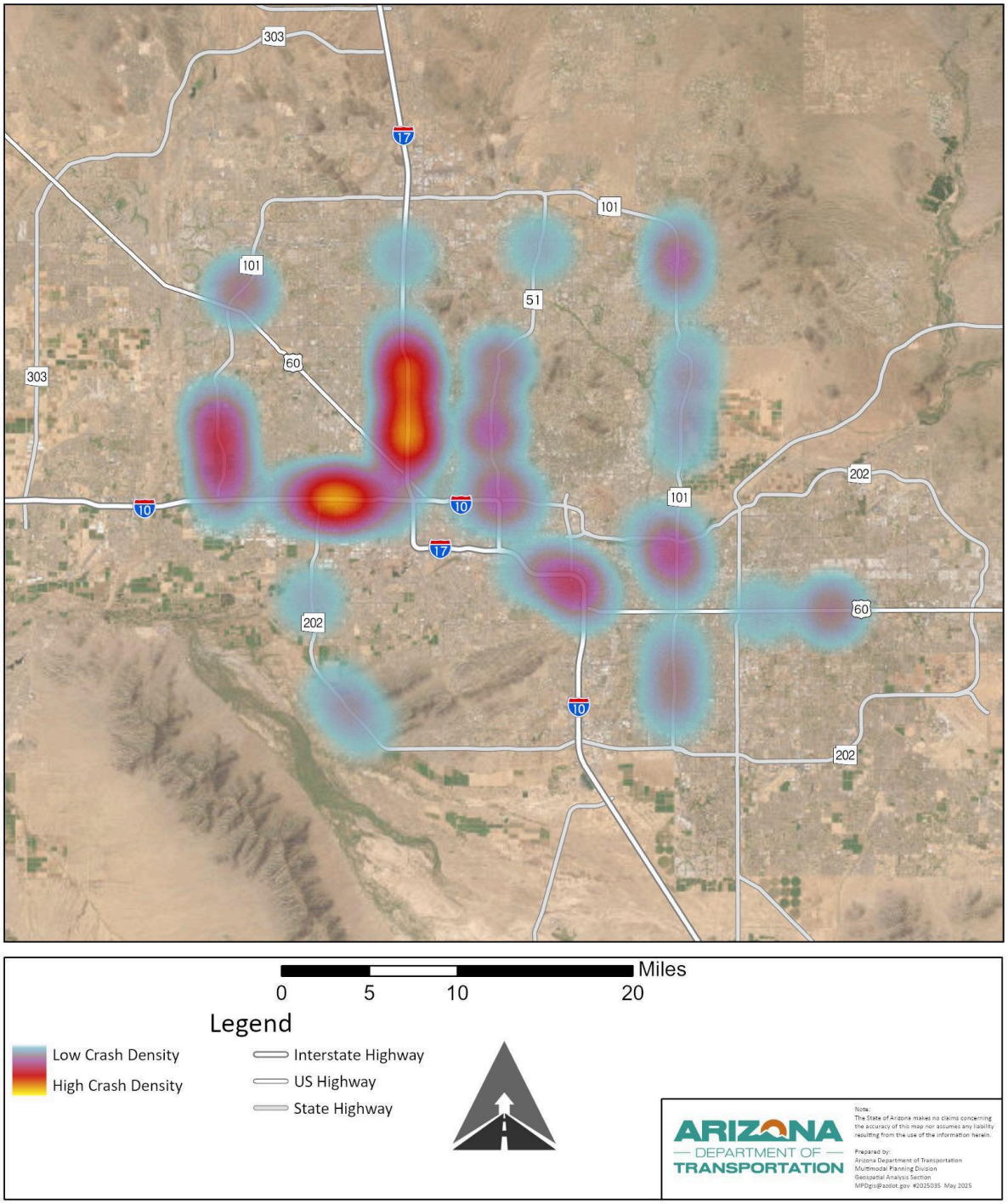
Other considerations include socio-economic and demographic variables. Starting with socio-economic data, which refers to race, income and gender. For example, if traveling using an AFV and the mean price, according to Kelley Blue book, is almost $50,000. It can be inferred due to the cost of AFVs that the drivers come from more affluent backgrounds. This information is important as it helps to market HOV lanes to a specific audience.

Understanding who is carpooling and who isn't via demographic information can provide insights on communities to perform outreach with. Demographic refers to age, income, education. While demographics of the riders in the HOV lanes are challenging to quantify, it provides insights into who is carpooling and who isn't. A travel survey would be helpful as it would collect this information for analysis.

The GIS team collaborated with the traffic safety team to share crash data specific to HOV lanes and performed analysis to identify HOV lane crashes hot spots. The crash data was collected for October through December of 2024 so it would align with the analysis period for the report. The crash hot spot analysis illustrates areas with the highest crash densities are near the Phoenix downtown, along I-10 between SR-101 and I-17 corridors. More crashes occurred during the PM peak, and the injuries involved

in these PM crashes were more severe than those reported during the AM peak. The AM period did not include any fatalities or suspected serious injuries, while the PM period included 4 fatalities and 1 serious injury. These findings are expected given the condensed time period in which the evening commuters head home right when they are finished with the workday, whereas the morning commute time period is more spread out. The more congested PM period creates the potential for collisions with stop and go conditions. Many of these hot spots align with the degraded corridors. The results from the crash analysis can be found in Figure 9. The goal of the analysis is to understand where crashes are occurring to allow for mitigation strategies to be implemented on specific corridors.

HOV Crashes Heatmap - AM Peak



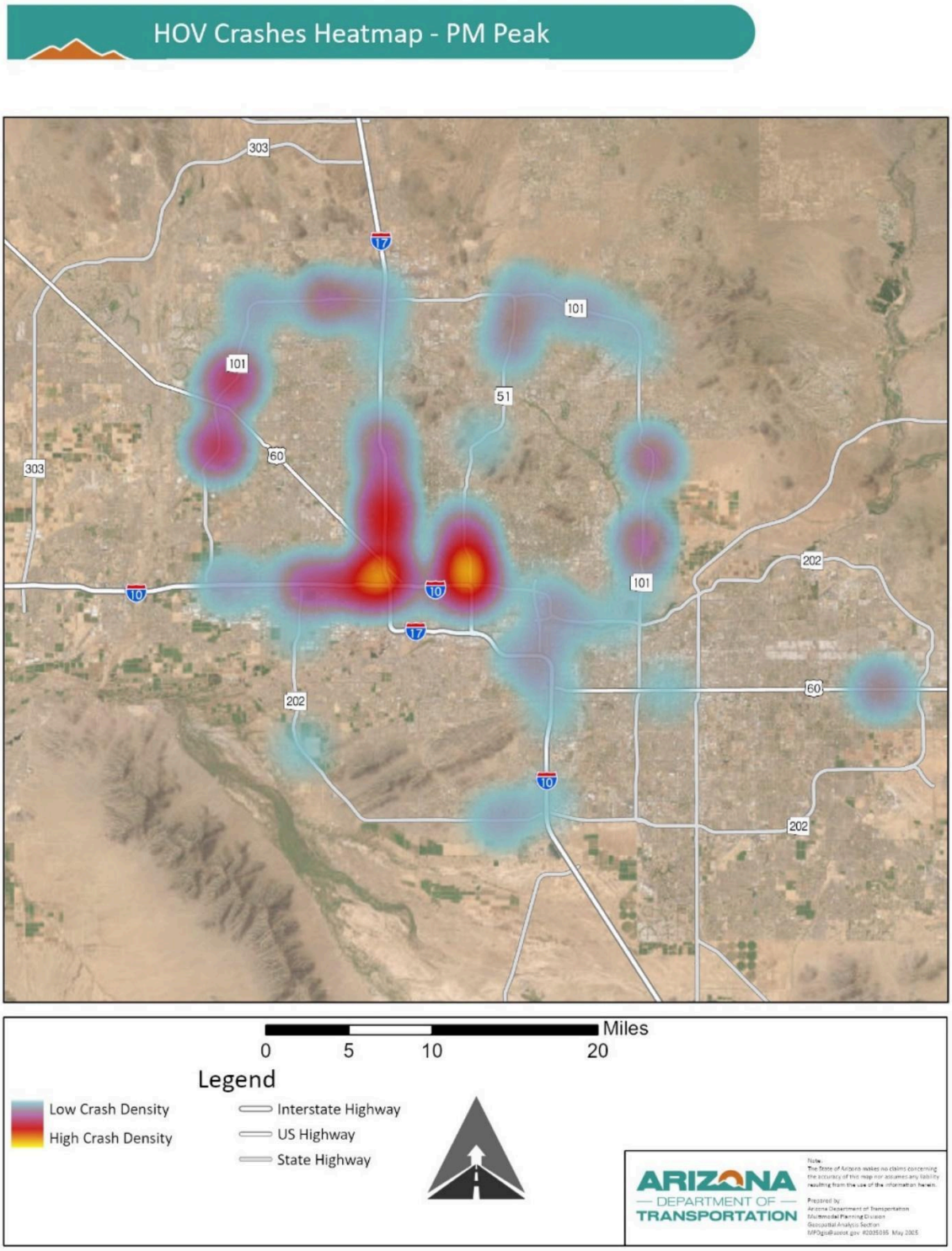


Figure 9. HOV Lane Crash Volume Distribution

Texas DOT performed analysis on HOV lane crashes and found that the majority of crashes occurred due to speed differences between the HOV and general purpose lanes (TDOT, 2003). Coordination with the traffic safety team will continue to analyze and visualize crash data for the purposes of targeted safety management.

In addition, analysis was performed to identify a correlation between crash clearance times in HOV lanes and degraded segments. Figure 10 displays the average roadway clearance time in minutes for each segment of peak period HOV lane crashes. Average roadway clearance times range from zero minutes to over 180 minutes. The map shows there is not a significant correlation between roadway clearance times and segment degradation. Most segments have an average crash clearance time of less than 15 minutes. This indicates exceptional performance for ADOT's procedures to clear roadways of hazards in a timely manner.

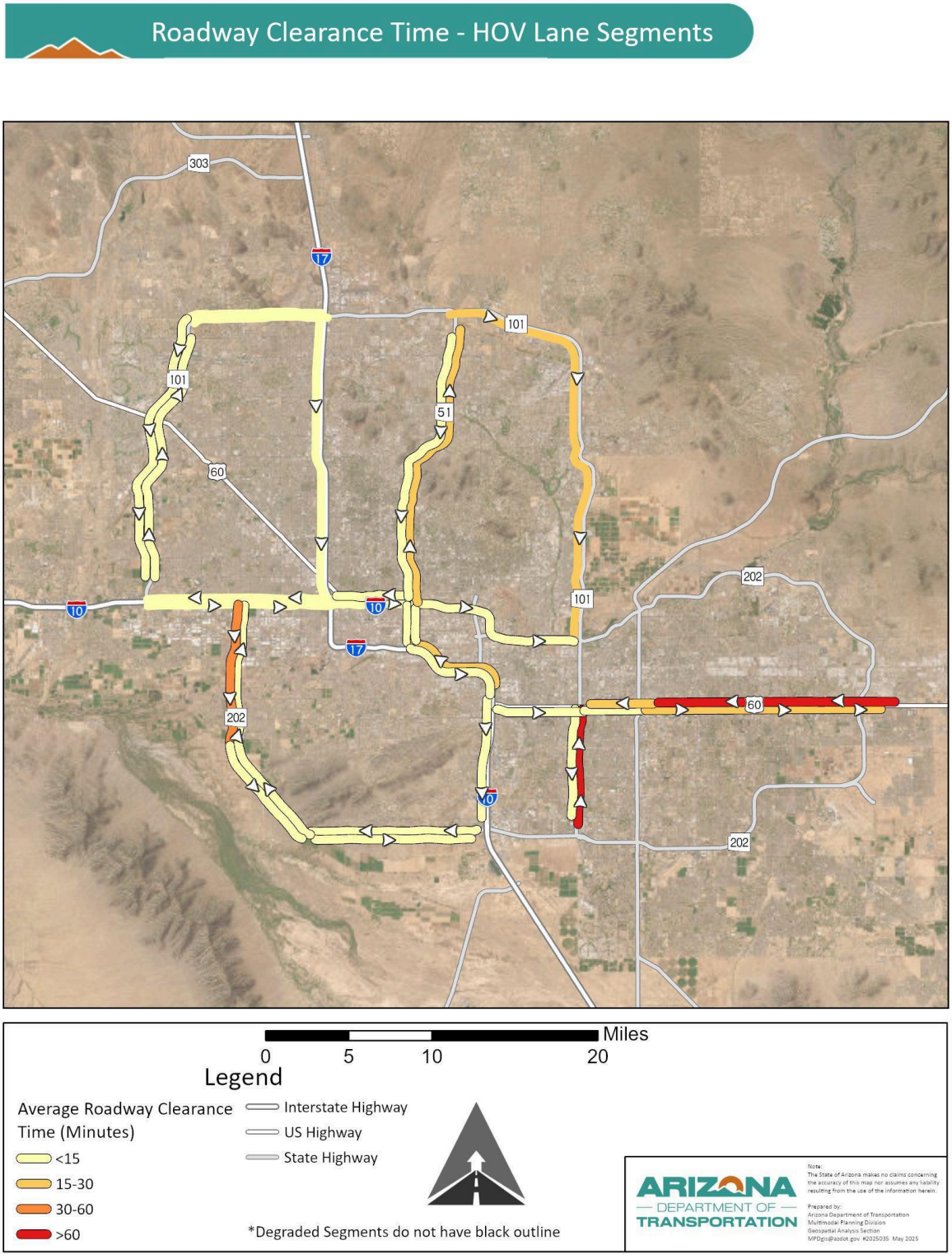
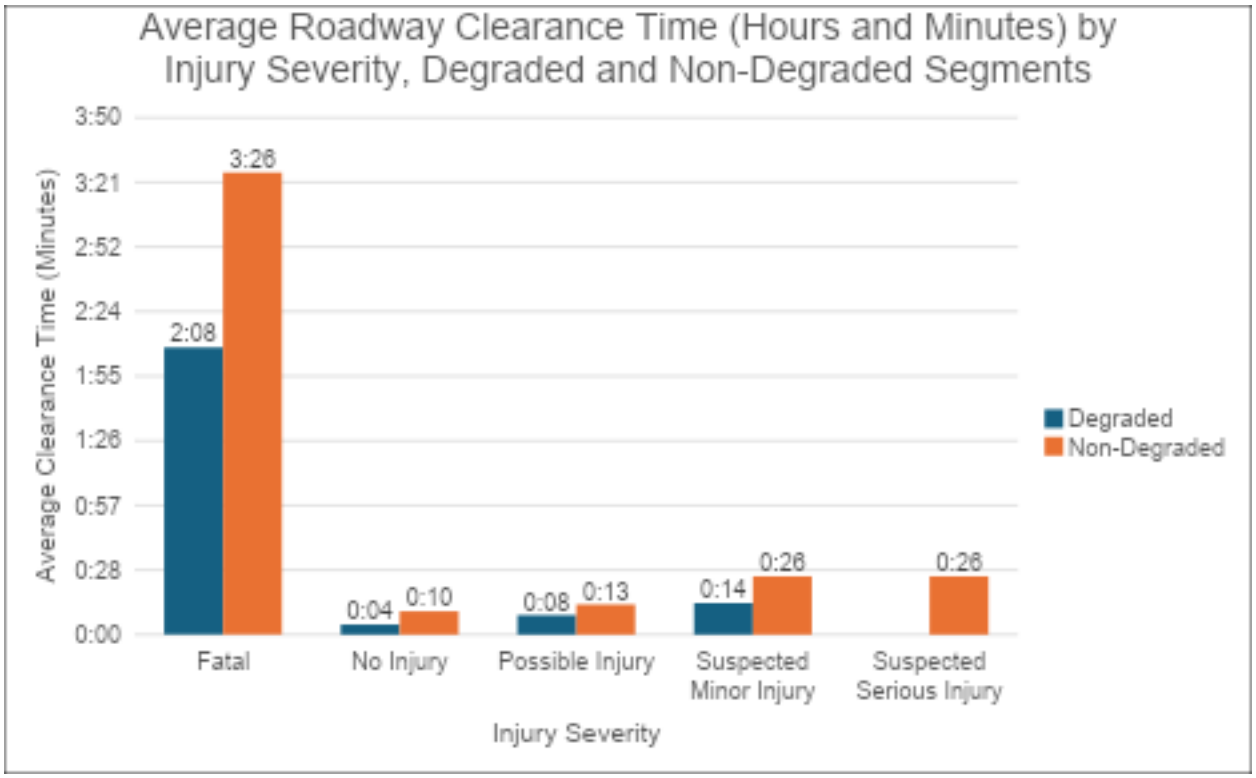


Figure 10. HOV Lane Crash Clearance Time

Injury severity was inspected to see how crash clearance time was impacted by the severity of injuries sustained in a crash. Table 8 visualizes the average crash clearance time by crash injury severity for degraded segments versus non-degraded segments. For crash injury severity of all segments, the less severe injuries have very low roadway clearance times. This indicates ADOT's efficiency in clearing the roadway in these frequent cases of less severe crashes. The procedures for more severe crashes are more in-depth than those for no injury or possible injury crashes and must be handled thoroughly on a case-by-case basis. For the degraded segments versus non-degraded segments average roadway clearance times by injury severity, the non-degraded segments included higher roadway clearance times than the degraded segments. This may be due to the fact that there are twice as many non-degraded segments than degraded segments, so the sample size impacts the comparison.

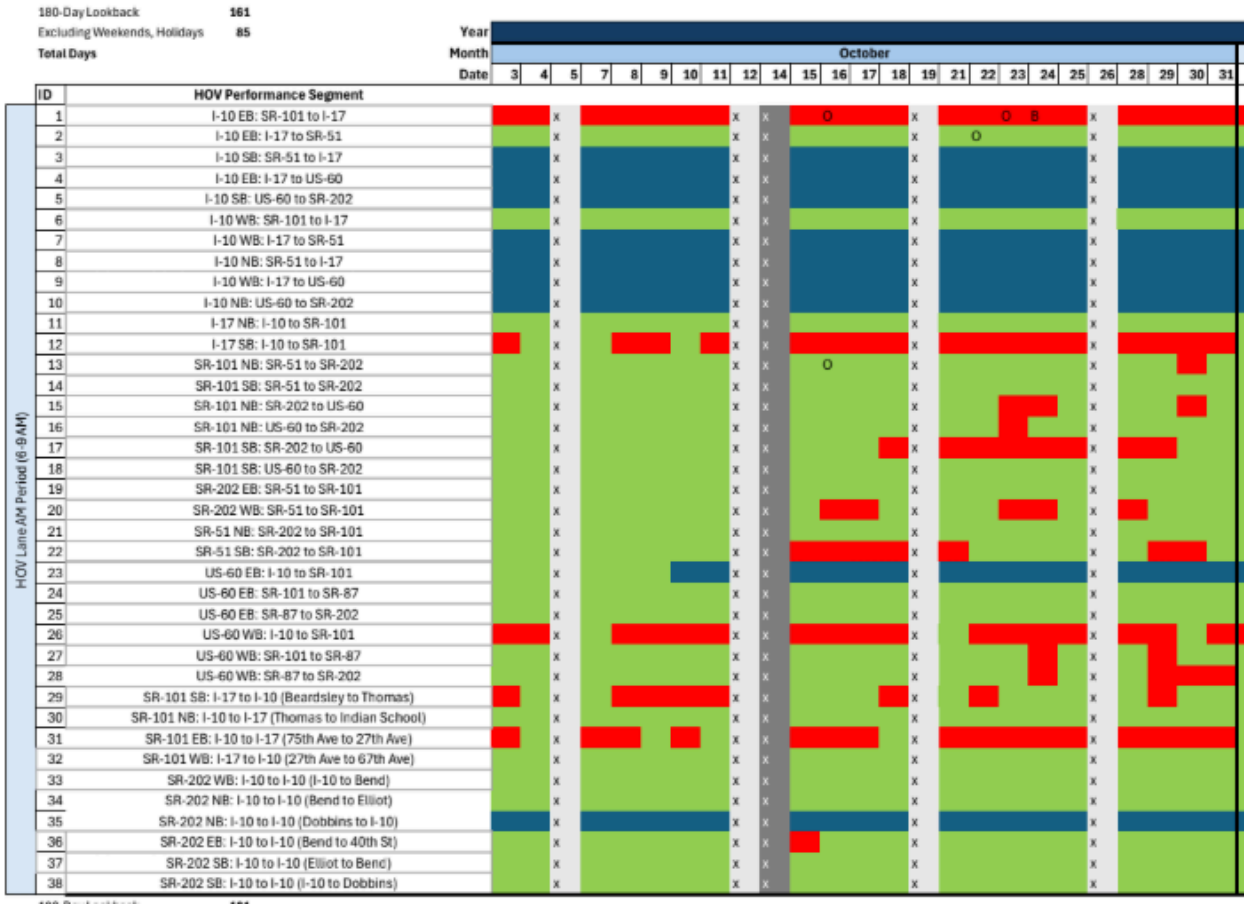
Table 8. Crash Clearance Timeline



A thematic map was developed that shows the HOV lane degradation status for each day along each segment. Figure 11 shows the thematic mapping of segment compliance and crash data. The calendar excludes weekends and observed holidays. It is separated into AM and PM periods to analyze any trends for the peak periods. The full thematic mapping for the reporting period can be seen in Appendix A. The thematic mapping is a more useful reference to analyze trends of degradation throughout the

180-day reporting period since each day is categorized with any HOV lane crash that occurred.

Figure 11. HOV Lane Crash Thematic Segment Mapping



Trends can be analyzed for weeks throughout the analysis period where more degradation happens than other days, or if more severe crashes occur on degraded segments. The PM Period includes higher rates of degraded days as compared to the AM Period. Higher rates of degradation occur throughout the months of October and March compared to the other months within the reporting period. More crashes tend to occur on days of degraded segments. This may be tied back to the variable speeds with stop and go congestion creating a higher potential for collisions. The thematic mapping allows for an in-depth inspection of the possible root causes for HOV lane degradation that the other Crash Frequency and Roadway Clearance measures cannot.

Responsible Parties: ADOT MPD Traffic Safety

Countermeasure #9: Vehicle Occupancy Updates

Among the recommendations to address HOV lane speed degradation recommended by FHWA, Guidance (23 USC 166) is to increase the occupancy requirement for eligible HOVs. The current operation of Arizona's HOV lanes require carpools to have two or more passengers. The proposed benefits of implementing a HOV-3 policy are a reduction in congestion, time savings and improved air quality. Enforcement and/or technology is needed to ensure the lanes aren't misused and would require alignment with Countermeasure #4.

Changes: No implementation at this time, but a communication plan would be needed to ensure the proper vision is communicated to the public.
Progress: ADOT's mitigation plan for vehicle occupancy requirements will be multifaceted and will include the following actions:

- Research: Continued research will be to analyze increased ridership for vehicles after HOV-3 implementation.

Status: Inactive
Results: After extensive research, there are state DOTs that have increased HOV lane requirements from HOV-2 passengers to HOV-3 passengers. VDOT implemented this change in sections of the state routes (VDOT, 2024). The change incentivizes more carpooling and therefore fewer cars on the road. A change from HOV-2 to HOV-3 would need to be paired with Countermeasure #3 as more signage would be needed to inform drivers when and which sections are two or three or more passengers. While cars carrying two passengers are unable to travel in the HOV-3 lanes, these lanes are opened up for alternative options such as buses and carpooling services.

The Colorado DOT implemented HOV-3 on specific state routes, however these are used on toll and express lanes where drivers use a switchable HOV transponder and sticker (CDOT, 2022). Similar methods could be used for HOV lane access. FHWA and CalTrans teamed up in 2002 to conduct a study on the effects of transitioning between HOV 3+ to HOV 2+ for the traveling public. The study found that lowering the vehicle occupancy to HOV 2+ was detrimental to the flow of traffic by reducing speeds significantly (FHWA, 2002). The report also details that violation rates increased with HOV 3+. Coordination to AZDPS would be vital for sustainability if a change to HOV 3+ occurred.

An alternative to segments of a highway being 3+ passengers include designating peak hour restrictions for the number of passengers. More analysis is needed to understand the challenges and benefits to implementing the countermeasure and its effects on the traveling public. If the occupancy requirements increased, data would need to be

collected to monitor temporal changes in ridership in the HOV lanes to determine the benefits of the change.

Responsible Parties: ADOT MPD

Next Steps

Progress continues to be made in improving the reliability of the HOV lanes throughout the Phoenix metropolitan area. As population increases within the state, new and innovative solutions for congestion mitigation will be needed. ADOT will continue to collect the speed data for internal purposes to allow for continued analysis and planning purposes.

For the purposes of sustainability planning, extensive documentation has been developed that reviews the process for collecting, downloading and analyzing the HOV lane speed data. The goal of this documentation is to improve knowledge management and allow for redundancy in knowledge for ease of training new staff members. This is part of the agency's succession planning. While this report is the last official document for the HOV lane degradation analysis, ADOT is dedicated to improving the public safety and level of service and will continue to collect and analyze the data for customers as needed. Continued analysis will help ADOT and its business partners make proactive decisions for planning for the challenges of the future.

Countermeasures will continue to be reviewed and research performed with partners such as MAG. Research is vital to staying on the cutting edge of emerging technologies described in the report. MPD has a dedicated research team that can be leveraged in the future for understanding these technologies and best practices for implementation. Collaboration with partners such as MAG, AZDPS and FHWA will continue to encourage communication. ADOT's goal is to ensure the effectiveness of HOV lanes and monitor and evaluate performance to make adjustments to improve level of service for the traveling public.

References

Arizona Commerce Authority (2025). Population estimates 2025. Retrieved from: https://oeo.az.gov/labor-market/industry-employment

Arizona Department of Public Safety. (2024). HOV lane citation data.

ADOT requests updated HOV lane citation annually in April, this data is used for updating countermeasures and is not shareable.

CalTrans (2009). An Evaluation of the Consequences and Effectiveness of Using Highway Changeable Message Signs for Safety Campaigns. https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/f0017233-p300-final-report.pdf

Candelieri, D. (2023). Rules of the road: how do HOV lanes work? Retrieved from: https://fox5sandiego.com/rules-of-the-road/how-do-hov-lanes-work-chp-explains/

Colorado Department of Transportation. (2022). HOV 3+ frequently asked questions. Retrieved from: https://www.codot.gov/programs/expresslanes/facts/hov-3-faq

E-ZPass Virginia Service Center. (2024). About e-zpass. Retrieved from: https://www.ezpassva.com/about/

Federal Highways Administration. (2002). Effects of Changing HOV Lane Occupancy Requirements: El Monte Busway Cast Study. Retrieved from: https://ops.fhwa.dot.gov/freewaymgmt/publications/hov/elmontefinalreport.pdf

Federal Highways Administration. (2003). Converting HOV lanes to HOT lanes. Retrieved from: https://www.fhwa.dot.gov/policy/otps/vpqrrt/sec1.cfm

Federal Highways Administration. (2015). Crash Prediction Method for Freeway Facilities with High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) Lanes. Retrieved from: https://highways.dot.gov/research/publications/safety/hsis/Crash-Prediction-Method-for-Freeway-Facilities

Federal Highways Administration. (2017). Lessons Learned from Regional Congestion Pricing Workshop (RCPWs). Retrieved from: https://ops.fhwa.dot.gov/publications/fhwahop18015/fhwahop18015.pdf

Federal Highways Administration. (2018). Federal-Aid Highway Program Guidance on High Occupancy Vehicle (HOV) Lanes.

https://ops.fhwa.dot.gov/freewaymgmt/hovguidance/hovguidance.pdf

Konishi, H., & Mun, S.-I. (2010). Carpooling and congestion pricing: HOV and HOT lanes. *Regional Science and Urban Economics, 40(4),* 173-186.

Maricopa Association of Governments. (2012). 2012 Vehicle Occupancy Study. Retrieved from: https://azmag.gov/Portals/0/Documents/TRANS_2013-02-19_MAG-2012-Vehicle-Occupancy-Study-Final-Report.pdf?ver=2017-04-06-111946-137

Maricopa Association of Governments. (2018). I-10/I-17 "Spine" corridor master plan. Retrieved from: https://azmag.gov/Programs/Transportation/Freeways-and-Highways/I-10-I-17-Spine-Corridor-Master-Plan

Maricopa Association of Governments. (2024). 2024 System Performance Report. Retrieved from: https://azmag.gov/Programs/Transportation/Transportation-Performance

Martin, P., Lahon, D., and Stevanovic, A. (2005) University of Utah. Review of the Effectiveness of the High Occupancy Vehicle (HOV) Lane Extension. Retrieved from: https://www.ugpti.org/resources/reports/downloads/mpc05-174.pdf

Minnesota Department of Transportation. (2017). Sensing from HOV/HOT Lanes Enforcement. Retrieved from: https://mdl.mndot.gov/_flysystem/fedora/2023-01/201705.pdf

Minnesota Department of Transportation. (2021). How it works. Retrieved from: https://www.dot.state.mn.us/ezpassmn/howezpassworks.html

Nevada Department of Transportation. (2023). Transportation Board Votes to Alter HOV Hours of Operation in Southern Nevada https://www.dot.nv.gov/Home/Components/News/News/7717/395?cftype=R7ZGB0ZD#:~:text=Beginning%20in%20May%2C%20HOV%20lane,for%20the%20new%20HOV%20hours.

Sakal, M. (2010). Arizona's speed cameras come down. Retrieved from: https://www.caranddriver.com/features/a15124515/arizonas-speed-cameras-come-down/

Signal-Tech (2022). Retrieved from: https://www.signal-tech.com/information-center/news-and-articles/LED-HOV-Lane-Signs-Put-Toll-Enforcement-Officers-in-the-Drivers-Seat

Supernack, J., Golob, J., T.F., Kaschade, C., Kazimi, C., Schreffler, E., & Steffey, D. (2001). *I-15 Congestion Pricing Project Monitoring and Evaluation Services.* San Diego, CA: San Diego State University Foundation.

Texas Department of Transportation. Scott, A., Cothron, Stephen E., Ranft, Carol H., Walters, David W., Fenno and Dominique Lord (2003). Crash analysis of selected

high occupancy vehicle facilities in Texas. Retrieved from: https://highways.dot.gov/sites/fhwa.dot.gov/files/FHWA-TX-04-0-4434-1.pdf

United States Department of Transportation Federal Highway Administration. (2023). Manual on uniform traffic control devices. Retrieved from: https://mutcd.fhwa.dot.gov/kno_11th_Edition.htm

United States Department of Transportation Federal Highway Administration. (2009). Markings for contiguous preferential lanes. Edition Part 3 Figure 3D-3. Retrieved from: https://mutcd.fhwa.dot.gov/htm/2009/part3/fig3d_03_longdesc.htm

United States Department of Transportation Federal Highway Administration. (2020). Traffic congestion and reliability: trends and advanced strategies for congestion mitigation. Retrieved from: https://ops.fhwa.dot.gov/congestion_report/executive_summary.htm

Virginia Department of Transportation. (2024). Hov lanes. Retrieved from: https://www.vdot.virginia.gov/travel-traffic/commuters/hov/

Xerox. (2015). Xerox demonstrates vehicle passenger detection system to promote adoption of carpooling in europe. Retrieved from: https://news.xerox.co.uk/news/xerox-demonstrates-vehicle-passenger-detection-system-to-promote-adoption-of-carpooling-in-europe

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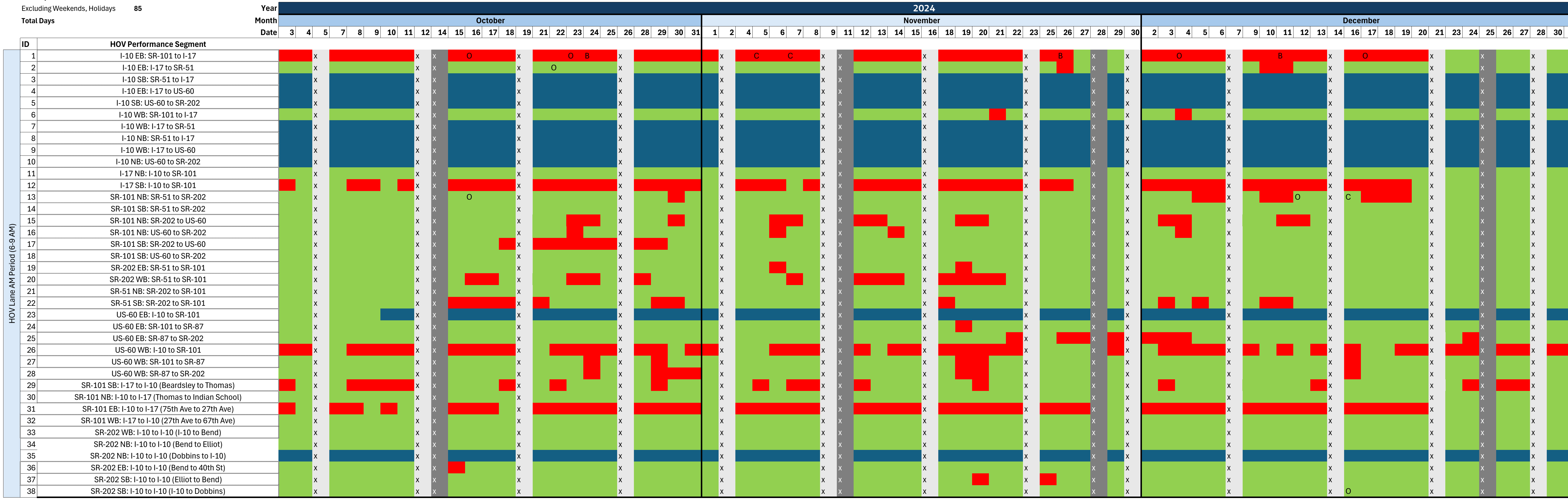
APPENDIX A. Thematic Mapping of Segment Compliance and Crash Data

The Thematic Mapping of Segment Compliance and Crash Data illustrates whether or not an HOV performance segment was degraded or not degraded throughout the 180-day lookback period. The thematic mapping captures individual day degradation status from October 2024 through March 2025, excluding weekends and federal holidays. The thematic mapping is separated into the two HOV Lanes operational peak periods, AM Period (6:00-9:00 AM) and PM Period (3:00-7:00 PM). The legend below includes the color coding used for the thematic mapping in which the non-degraded HOV lanes for a given day are filled green, the degraded HOV lanes for a given day are filled red, dates in which HOV lanes segment degradation data is not available is dark blue, dates with no HOV restrictions on weekends are light gray, and dates with no HOV restrictions on observed holidays are dark gray. The text inside each cell is left blank if no crash occurred on that day for each segment. Cells with letters are designating the KABCOU crash injury severity scale where “K” is Killed, Fatal Injury, “A” is Suspected Serious Injury, “B” is Suspected Minor Injury, “C” is Possible Injury, “O” is No Apparent Injury/Property Damage Only, and “U” is Unknown. Only the most severe crash that occurred on an individual day is included.

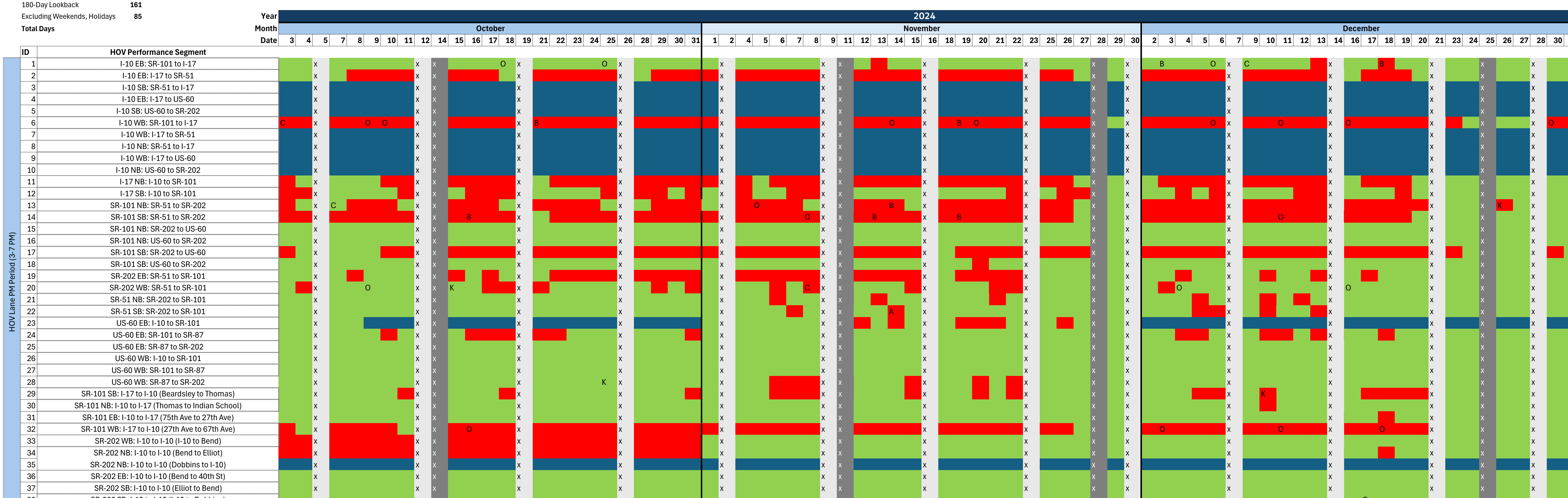
Legend

Color	Meaning
	Acceptable HOV Lane Observed
	Degraded HOV Lane Observed
	Data Not Available
x	No HOV Restriction - Weekend
x	Observed Holidays
K	Killed, Fatal Injury
A	Suspected Serious Injury
B	Suspected Minor Injury
C	Possible Injury
O	No Apparent Injury, Property Damage Only
U	Unknown

180-Day Lookback 161
Excluding Weekends, Holidays 85
Total Days



180-Day Lookback 161
Excluding Weekends, Holidays 85
Total Days



180-Day Lookback **161**

Excluding Weekends, Holidays **85**

Total Days

HOV Lane AM Period (6-9 AM)

ID	HOV Performance Segment
1	I-10 EB: SR-101 to I-17
2	I-10 EB: I-17 to SR-51
3	I-10 SB: SR-51 to I-17
4	I-10 EB: I-17 to US-60
5	I-10 SB: US-60 to SR-202
6	I-10 WB: SR-101 to I-17
7	I-10 WB: I-17 to SR-51
8	I-10 NB: SR-51 to I-17
9	I-10 WB: I-17 to US-60
10	I-10 NB: US-60 to SR-202
11	I-17 NB: I-10 to SR-101
12	I-17 SB: I-10 to SR-101
13	SR-101 NB: SR-51 to SR-202
14	SR-101 SB: SR-51 to SR-202
15	SR-101 NB: SR-202 to US-60
16	SR-101 NB: US-60 to SR-202
17	SR-101 SB: SR-202 to US-60
18	SR-101 SB: US-60 to SR-202
19	SR-202 EB: SR-51 to SR-101
20	SR-202 WB: SR-51 to SR-101
21	SR-51 NB: SR-202 to SR-101
22	SR-51 SB: SR-202 to SR-101
23	US-60 EB: I-10 to SR-101
24	US-60 EB: SR-101 to SR-87
25	US-60 EB: SR-87 to SR-202
26	US-60 WB: I-10 to SR-101
27	US-60 WB: SR-101 to SR-87
28	US-60 WB: SR-87 to SR-202
29	SR-101 SB: I-17 to I-10 (Beardsley to Thomas)
30	SR-101 NB: I-10 to I-17 (Thomas to Indian School)
31	SR-101 EB: I-10 to I-17 (75th Ave to 27th Ave)
32	SR-101 WB: I-17 to I-10 (27th Ave to 67th Ave)
33	SR-202 WB: I-10 to I-10 (I-10 to Bend)
34	SR-202 NB: I-10 to I-10 (Bend to Elliot)
35	SR-202 NB: I-10 to I-10 (Dobbins to I-10)
36	SR-202 EB: I-10 to I-10 (Bend to 40th St)
37	SR-202 SB: I-10 to I-10 (Elliot to Bend)
38	SR-202 SB: I-10 to I-10 (I-10 to Dobbins)

180-Day Lookback **161**

Excluding Weekends, Holidays **85**

Total Days

HOV Lane PM Period (3-7 PM)