Connected Vehicle Pilot Deployment Program Independent Evaluation

Environmental Impact Assessment—Wyoming

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Final Report—July 27, 2022

FHWA-JPO-22-951

U.S. Department of Transportation

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16. Abstract

The Wyoming Department of Transportation's (WYDOT's) primary goal for implementing the Wyoming Connected Vehicle Pilot Deployment (CVPD) was to demonstrate the potential and feasibility of using connected vehicle (CV) technologies to improve safety and mobility along 402 miles of Interstate 80 (I-80) in southern Wyoming. As the lead agency, WYDOT wanted to explore using CV technologies to communicate road and travel information to commercial truck drivers and fleet managers that routinely travel the I-80 corridor. Using data provided by the Wyoming CVPD Team, TTI conducted a qualitative assessment of the environmental impacts of the deployment. There was little evidence, based on the data available at the time this report was prepared, to suggest that the deployment had any direct or indirect environmental impact. This is primarily due to the low sample rate of equipped vehicles in the traffic stream. Because the focus of the deployment was on improving safety and information dissemination during severe weather events, comparing the individual speed profiles of individual fleet vehicles during specific weather events where collisions occur may result in a better understanding of the environmental impacts associated with these changes in commercial fleet vehicle behavior resulting from alert messages.

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Executive Summary

The Wyoming Department of Transportation's (WYDOT's) primary goal for implementing the Wyoming Connected Vehicle Pilot Deployment (CVPD) was to demonstrate the potential and feasibility of using connected vehicle (CV) technologies to improve safety and mobility along 402 miles of Interstate 80 (I-80) in southern Wyoming. As the lead agency, WYDOT wanted to explore using CV technologies to communicate road and travel information to commercial truck drivers and fleet managers that routinely travel the I-80 corridor. The deployment built upon WYDOT's extensive road weather and traveler information systems to provide warnings and alerts about road conditions, particularly during severe winter weather and high wind events. (1)

At a high level, the scope of deployment included implementing the following:(1)

- Deploying around 76 roadside units that could receive and broadcast messages using dedicated short-range communications along various sections of I-80.
- Equipping a combination of WYDOT fleet vehicles (e.g., snowplows, highway patrol vehicles, and others) and commercial trucks—all regular users of I-80—with onboard units capable of receiving alerts and broadcast basic safety messages. A portion of the vehicles could also collect and disseminate environmental and road condition information using mobile weather sensors.
- Developing multiple vehicle-to-vehicle and vehicle-to-infrastructure applications that communicate alerts and advisories to drivers about road conditions. The applications were designed to support the in-vehicle dissemination of advisories for avoiding collisions, managing speeds, implementing detours, and alerting to the presence of downstream work zones and maintenance and emergency vehicles—all based on the vehicle's location in the network.
- Enabling improvements to WYDOT's traffic management center and traveler information practices by using data collected from CVs. Targeted improvements included better activation of WYDOT's variable speed limit and traveler information dissemination systems (e.g., 511, dynamic message signs).

Because no data were provided that would allow the TTI Evaluation Team to estimate the amount of delay savings or reduction in idle times by equipped vehicles, TTI Evaluation Team conducted an analysis of the potential fuel consumption reduction benefits using a simple input-output analysis and hypothetical closures in different sections of the I-.80. The input-output analysis uses capacity and demand to estimate the total amount of delay associated with closing portions of I-80. TTI estimated demand using AADT values reported by the Wyoming CVPD Team. Peak hour demand was assumed to be 10 percent of the measures AADT for the section of roadway. The analysis also assumed that the closure would last for a 1-hour in duration. The analysis shows the potential fuel consumption benefits *if* the CV technology could successfully prevent this hypothetical closure from occurring. This analysis was intended to provide order of magnitude estimates of the potential fuel consumption benefits.

The input-output analysis showed the following:

- On average, preventing a 1-hour closure in the corridor could generate potential fuel consumption savings of approximately 23.8 gallons of gasoline from passenger cars, and 46.5 gallons of diesel from trucks, assuming a 50-50 vehicle mix.

- For a one-hour closure, fuel consumption due to idling was estimated to range from 19.3 to 67.3 gallons of gasoline for passenger cars and 19.4 to 67.3 gallons of diesel for trucks for different section of roadway. This also assumes a 50-50 mix of passenger cars and trucks. Currently, percentage of truck on I-80 ranges from 27 percent and 65 percent of the total traffic stream.
- Potential fuel consumption benefits are greater on the west end of the corridor, where AADT values tend to be higher compared to the east end of the corridor.
- Potential fuel savings are highly dependent on the locations of the incident, the total duration of the incident, input demands at the time of the collision, and many other factors.
- Intuitively, as the portion of vehicle mix changes, so does the amount of fuel consumed by the different vehicle classes. Truck consume fuel at approximately twice the rate of automobiles.
- The results are highly dependent of the duration of closures. Using this analysis, there is an exponential relationship between fuel consumption and total duration of closure.

One could potentially infer environmental benefits based on adherence and conformity to posted regulatory speeds. Better speed compliance and conformity around the speed limit would imply less accelerations, producing a “smoother” trip. Fewer acceleration cycles might result in improved fuel consumption and less emissions.

The Wyoming CVPD Team had two measures associated with speed limit compliance:

- The percentage of vehicles traveling no faster than 5 mph over the posted speed limit.
- The percentage of vehicles traveling within (+/–) 10 mph of the posted speed limit.

WYDOT’s analysis of speed compliance by all vehicles showed the following:

- While the overall percentage of drivers traveling no more than 5 mph above the speed limit improved in the later months of the post-deployment period during all weather conditions, there was only a slight improvement (3 percent) in adherence during the mixed weather category—one of the conditions targeted by the deployment. In all other weather categories, the percentage of vehicles traveling no more than 5 mph over the speed limit declined in the post-deployment period. These speed adherence values are for all vehicles (including both equipped and unequipped vehicles), and the market penetration of CVs in the overall traffic stream was small.
- In terms of the percentage of vehicles traveling within a 10-mph buffer around the posted speed limit (a measure of variability of speed), the data showed a general trend for more uniform speeds around the posted speed limit during all weather conditions; however, as noted by the CVPD Team, this source of improvement may be “coming from the absence of storm conditions that resulted in particularly low speed buffer results in the baseline period.”[(3)]

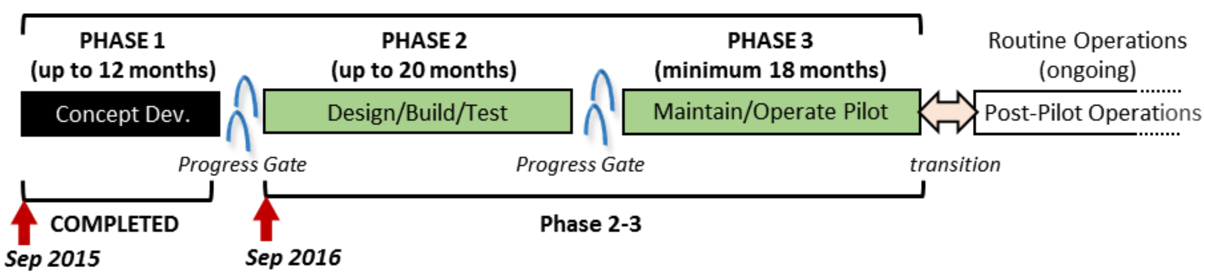
Because the results of the Wyoming CVPD Team’s assessment showed that the speed compliance and uniformity of travel did not improve significantly, there is little direct evidence to suggest that the Wyoming CVPD generated significant emissions or fuel consumption benefits. However, the primary objective of the Wyoming deployment was to reduce the potential for multi-vehicle collections (especially trucks) and preventing secondary collisions during severe weather conditions. As deployed, one would not expect the deployment to have generated substantial reductions in emission or fuel consumption unless a significant collision occurred. Fortunately, no significant, multi-vehicle collisions occurred during period when the level of deployment of CV technology was greatest in the private commercial fleet vehicles. There is insufficient evidence to conclude, however, that the absence of any multi-vehicle collisions was a direct result of the deployment.

Chapter 1. Introduction

Connected vehicle (CV) technologies offer immense potential to improve safety and enhance mobility. The technologies use advanced mobile communications to share information between users of the transportation system (e.g., passenger vehicles, buses, and pedestrians) and the infrastructure. Applications embedded in vehicles, mobile devices, and infrastructure use new levels of information to issue alerts. Using data from CVs, agencies can deploy traffic management strategies designed to improve safety, enhance mobility, and reduce emissions and fuel consumption. To explore the benefits of CV technology, the U.S. Department of Transportation (USDOT) initiated the Connected Vehicle Pilot Deployment (CVPD) Program. USDOT's goals for this program included the following:[(2)]

- To spur early CV technology deployment not just through wireless CVs but also through other elements such as mobile devices, infrastructure, and traffic management centers (TMCs).
- To target improving safety, mobility, and environmental impacts and commit to measuring those benefits.
- To resolve various technical, institutional, and financial issues commonly faced by early adopters of advanced technologies.

On September 14, 2015, USDOT's Intelligent Transportation Systems Joint Program Office (ITS JPO) launched the CVPD Program. [(2)] ITS JPO selected three locations as pilot deployment sites: Wyoming, New York City, NY, and Tampa, FL. Each deployment represents different potential settings for CV technologies. Each site developed different applications to address vastly different problems specific to their needs. For example, the Wyoming deployment focused on better dissemination of travel information during winter weather events to reduce the potential of multi-vehicle collisions involving commercial trucks. The New York deployment focused on improving safety and traffic flow in a very dense urban environment, while the Tampa deployment focused on improving safety and mobility in a typical central business district of a smaller community. As illustrated in Figure 1, each deployment went through a similar life cycle. In Phase 1 of the life cycle, each site developed and refined the concepts behind its deployment. In Phase 2, each site, following the systems engineering approach, designed, built, and tested its deployments. In Phase 3, each site was responsible for managing and operating its deployments under actual traffic conditions. This report focuses on Phase 3 and includes an evaluation of the overall mobility benefits associated with the Wyoming deployment.



Source: Federal Highway Administration, 2015

Figure 1. Flowchart. Three Phases of a Connected Vehicle Pilot Deployment.

Wyoming Connected Vehicle Pilot Deployment

The Wyoming Department of Transportation's (WYDOT's) primary goal for implementing the Wyoming CVPD was to demonstrate the potential and feasibility of using CV technologies to improve safety and mobility along 402 miles of Interstate 80 (I-80) in southern Wyoming. As the lead agency, WYDOT wanted to explore using CV technologies to communicate road and travel information to commercial truck drivers and fleet managers that routinely travel the I-80 corridor. The deployment built upon WYDOT's extensive road weather and traveler information systems to provide warnings and alerts about road conditions, particularly during severe winter weather and high wind events. (1)

At a high level, the scope of deployment included implementing the following:(3)

- Deploying around 76 roadside units (RSUs) that could receive and broadcast messages using dedicated short-range communications (DSRC) along various sections of I-80.
- Equipping a combination of WYDOT fleet vehicles (e.g., snowplows, highway patrol vehicles, and maintenance supervisor vehicles) and commercial trucks—all regular users of I-80—with onboard units (OBUs) capable of receiving alerts and broadcast basic safety messages (BSMs). A portion of the vehicles could also collect and disseminate environmental and road condition information using mobile weather sensors.
- Developing multiple vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) applications that communicate alerts and advisories to drivers about road conditions. The Wyoming CVPD Team designed the applications to support the in-vehicle dissemination of advisories for avoiding collisions, managing speeds, implementing detours, and alerting to the presence of downstream work zones and maintenance and emergency vehicles—all based on the vehicle's location in the network.
- Enabling improvements to WYDOT's TMC and traveler information practices by using data collected from CVs. Targeted improvements included better activation of WYDOT's variable speed limit (VSL) and traveler information dissemination systems (e.g., 511 and dynamic message signs).

Purpose of Report

ITS JPO selected the Texas A&M Transportation Institute (TTI) CVPD Evaluation Team to be the independent evaluator for the mobility, environmental, and public agency efficiency benefits for the CVPD Program. An independent evaluation by a third party that has no personal stake in the project would eliminate potential bias in the findings. USDOT has sponsored an independent evaluation of the CVPD to help inform USDOT of the following:

- The extent to which the CVPD Program was effective in achieving its goals of transformational safety, mobility, public agency efficiency, and environmental improvements.
- The lessons learned that others could use to improve the design of future projects.
- The institutional and financial impacts of the CVPD.
- The best way to apply resources in the future.

This report provides an independent environmental impacts assessment (EIA) associated with the Wyoming CVPD. Because of delays in the deployment and unforeseen external factors (e.g., the COVID-19 pandemic), the Federal Highway Administration (FHWA) revised TTI's evaluation scope to include only data collected by the sites during their evaluation. TTI did not perform an extensive quantitative analysis of the data collected by the Wyoming CVPD Team. Instead, TTI's evaluation was primarily qualitative in nature with some supporting explanatory quantitative analyses appropriately scoped to reduce technical risk and consistent with the nature, quality, and quantity of underlying data. To complete the analysis, TTI used materials and information provided through published information and outcomes of other evaluation efforts, including the following:

- Performance measurement activity performed by the Wyoming CVPD Team.
- The Volpe National Transportation Systems Center's safety impact assessments.
- Site-generated dashboards and lessons-learned logbooks provide by the Wyoming CVPD Team.

This report focuses solely on the EIA associated with the deployment. Other reports have been produced to summarize the independent evaluation of the safety, mobility, and public agency efficiency benefits of the deployment.

Organization of Report

The organization of this report is as follows:

- Chapter 2 is a summary of the Wyoming CVPD. The chapter summarizes the deployment goals and objectives, infrastructure, and vehicle subsystems implemented to support the deployment. The chapter contains a brief explanation of the applications and the evaluation conditions.
- Chapter 3 provides TTI's assessment of the environmental impacts of the deployment in the I-80 corridor, based on the data provided by the Wyoming CVPD Team.

Chapter 2. Wyoming Deployment

This chapter briefly summarizes WYDOT's goals and objectives for the deployment, the infrastructure and vehicle subsystems that made up the system, and the application used in the deployment. This chapter also summarizes the general operating conditions during the deployment.

Detailed information on the design and implementation of the Wyoming CVPD is available in the following references:

- *Connected Vehicle Pilot Deployment Program Phase 2: System Architecture Document—WYDOT CV Pilot*. [4]
- *Connected Vehicle Pilot Deployment Program Phase 2: System Design Document (SDD)—Wyoming CV Pilot*. [5]

Deployment Goals and Objectives

WYDOT's objectives for the deployment were as follows:[3]

- Deploy and operate a set of vehicles equipped with an OBU using DSRC connectivity. These vehicles included a combination of WYDOT snowplows, WYDOT fleet vehicles, WYDOT highway patrol vehicles, and private commercial fleet vehicles to broadcast J2735 BSMs and collect vehicle weather and road condition data for use in WYDOT's TMC. These vehicles also received roadway and traffic alerts wirelessly from the TMC so that drivers would have better information about current travel conditions to make better travel decisions.
- Deploy infrastructure devices (RSUs) with DSRC connectivity to transmit advisories and alerts to equipped vehicle traveling along I-80 in Wyoming.
- Leverage data provided by the equipped vehicle to develop and demonstrate a suite of V2V and V2I applications to support a variety of wide-area travel advisories and traffic management functions, including the following:
    - Setting and removing VSLs along the I-80 corridor.
    - Supporting 511 and other traveler information.
    - Supporting road weather advisories and freight-specific travel guidance through WYDOT's Commercial Vehicle Operations Portal (CVOP).

System Components

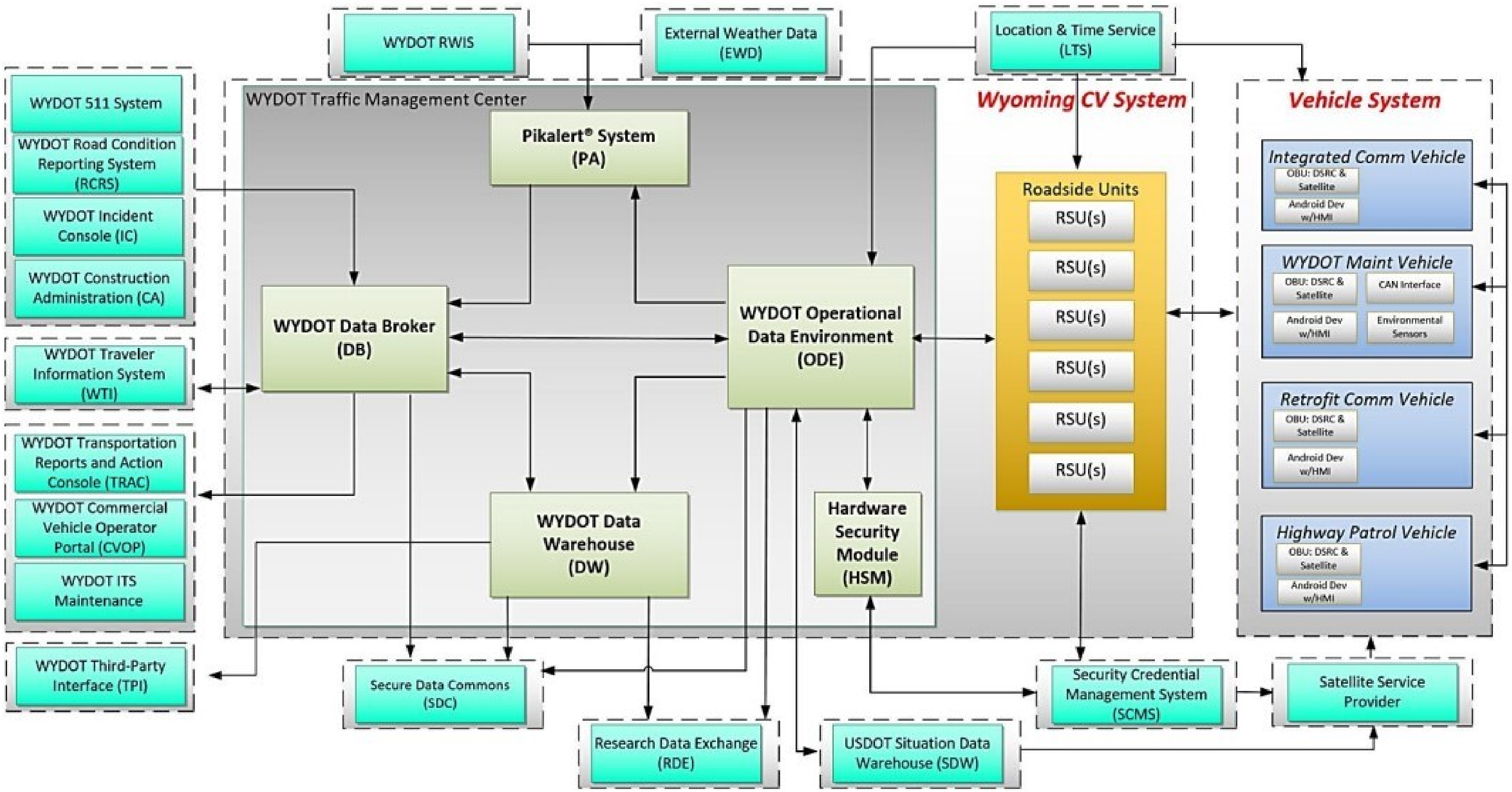
The Wyoming CVPD was comprised of both infrastructure and vehicle subsystems. Figure 2 provides an overview of the system architecture associated with the deployment. The following provides a brief description of the primary infrastructure and vehicle subsystems of the deployment.

Infrastructure Subsystems

The infrastructure systems included all the components and back-office systems needed to generate and distribute advisories and alerts for CV Pilot vehicles. Except for the RSUs, the bulk of the infrastructure subsystem components were located at WYDOT's TMC. Additionally, the Wyoming CVPD Team developed external interfaces to share the advisories and alerts with the public and commercial vehicle operators.

The following provides a brief description of the components of the Wyoming CVPD infrastructure subsystems:(3)

- Roadside units—These are physical devices installed along I-80 to provide two-way communications (via DSRC) between equipped vehicles and WYDOT's TMC for the purposes of exchanging information. The Wyoming CVPD Team used a combination of both fixed and portable RSUs in the deployment. These devices also provided application support, data storage, and other support services (e.g., security certificate handling). WYDOT installed 76 RSUs in the corridor. Figure 3 shows the locations where RSUs were deployed along I-80.
- Operational data environment (ODE)—The ODE communicated with the RSUs to retrieve data collected from equipped vehicles. The ODE performed basic data quality checks on the data and then shared the information with other system components for analysis and distribution. The ODE was in WYDOT's TMC.
- Hardware security module (HSM)—This black box provided security credentialing and certificate management services for WYDOT. The HSM was operated by a private company and provided security credentialing for the traveler information messages (TIMs) broadcast from the TMC.
- Pikalert system—The Pikalert system supported the integration and fusion of CV and non-CV weather data for the purposes of generating adverse weather alerts and advisories about driving conditions on I-80. The Pikalert system was not developed as part of the Wyoming CVPD but is an existing alerting system developed by WYDOT for generating alerts and advisories from external weather sources.
- Data broker—The infrastructure system component was responsible for receiving and analyzing information from the ODE, Pikalert, and other external systems, and distributing it to other systems and services, including third-party data services such as FHWA's Secure Data Commons.
- Data warehouse (DW)—This component was responsible for storing various TMC- and CV-related data for use in conducting the Wyoming CVPD Team's performance evaluation. The DW was responsible for timestamping and geotagging log data from CV and non-CV sources collected, generated, and shared with the Wyoming CV system.



Source: Wyoming Department of Transportation, 2017

Figure 2. Diagram. System Architecture of Wyoming CVPD. [4]

Source: Wyoming Department of Transportation

Figure 3. Map. RSU Locations on I-80.

The Wyoming CVPD Team used 76 DSRC RSUs along I-80. The RSUs provided services for wave service announcements, TIM distribution, BSM logging, OBU log offloading via IPv6, OBU certificate top-offs, and over-the-air updates for OBUs. Security was provided by a private secure credential management system (SCMS) for application certificates.

Vehicle Subsystem

WYDOT divided the deployment fleet into two groups: friendly fleet vehicles and partner CV fleet vehicles. Friendly fleet vehicles were those vehicles over which the Wyoming CVPD Team had more access and was able to collect identifiable information from the vehicles. Friendly fleet vehicles included WYDOT snowplows (WY), stakeholder fleet vehicles (TH), and WYDOT highway patrol vehicles (HP). Because these vehicles are public or informed partner fleets, the CVPD Team could track and collect detailed information from these vehicles. Partner CV fleet vehicles included all other vehicles, namely those from private stakeholders, who could not be tracked or accurately counted out of security and privacy concerns. Table 1 provides a breakdown of the number of vehicles in the deployment fleet.

Table 1. Number of CV Devices Installed as Part of Wyoming CVPD.

Vehicle Type	Deployment Category	Actual
WYDOT maintenance fleet (snowplows)	Friendly	53
WYDOT highway patrol	Friendly	66
State pool fleet	Friendly	18
Medium-duty friendly fleet	Friendly	21
Heavy-duty/commercial fleet	Partner CV fleet	167
Total equipped vehicles	**Not applicable**	**325**

Source: Wyoming Department of Transportation, 2022[3]

Because of these complications and because of the Federal Communications Commission's decision to reallocate the DSRC 5.9-GHz spectrum, WYDOT's DSRC device vendor decided in December 2020 that it would no longer support, warranty, develop, or repair its OBU and RSU devices. As a result, the Wyoming CVPD Team pivoted to using a combination DSRC- and satellite-based OBUs. With the combination OBUs, vehicles received inbound alerts while traveling anywhere in the corridor and still upload vehicle performance logs when they passed an RSU.

All equipped vehicles in the deployment had the following core capabilities:(3)

- The ability to broadcast and receive SAE J2735 Basic Safety Messages (BSs) via DSRC from other connected devices (vehicles and RSUs).
- The ability to receive alerts and traveler information messages (TIMs) from the infrastructure via both DSRC and satellite communications.
- The ability to display alerts and advisories received by the vehicle while enroute to drivers.

Onboard Applications

The Wyoming CVPD deployed four onboard applications to provide drivers with key information to help improve their safety. These applications included the following:

- FCW.
- Stationary Vehicle Alert (SVA).
- Infrastructure-to-Vehicle Situational Awareness (I2V-SA).
- Spot Weather Impact Warning (SWIW).

The Wyoming CVPD Team deployed a fifth application, Work Zone Warning, to provide approaching drivers with information about conditions that exist in work zones. This application used a portable RSU station deployed at the work zone location to transmit alerts to approaching drivers.

Table 2 provides a brief description of each of the deployment applications.

Table 2. Applications Included as Part of Wyoming CVPD.

Application	Description
FCW	Issues an alert if there is a threat of a front-end collision with another CV in the travel lane and direction. FCW will help drivers avoid and reduce the severity of front-to-rear vehicle collisions. The system does not take control of the vehicle to avoid a collision.
SVA	A specialized version of FCW in which a downstream vehicle is parked on the side of the road or an adjacent lane along I-80. The application alerts drivers to the situation and helps them avoid or mitigate a potential collision with the parked vehicle.
I2V-SA	Provides relevant road condition information including weather alerts, speed restrictions, vehicle restrictions, road conditions, incidents, parking, and road closures. The information is broadcast from RSUs and received by the CV.
Work Zone Warning	Communicates information to approaching vehicles about conditions at a work zone ahead. Approaching vehicles receive information about work zone activities or restriction information that could present unsafe conditions, such as obstructions in a vehicle's travel lane, lane closures, lane shifts, speed reductions, or vehicles entering or exiting the work zone.
SWIW	Enables localized road condition Information, such as fog or icy roads, to be broadcast from an RSU and received by a CV.

Source: Wyoming Department of Transportation Connected Vehicle Pilot Website [3]

System Operations

The following provides a brief description of the operational conditions under which the system was evaluated by the Wyoming CVPD.

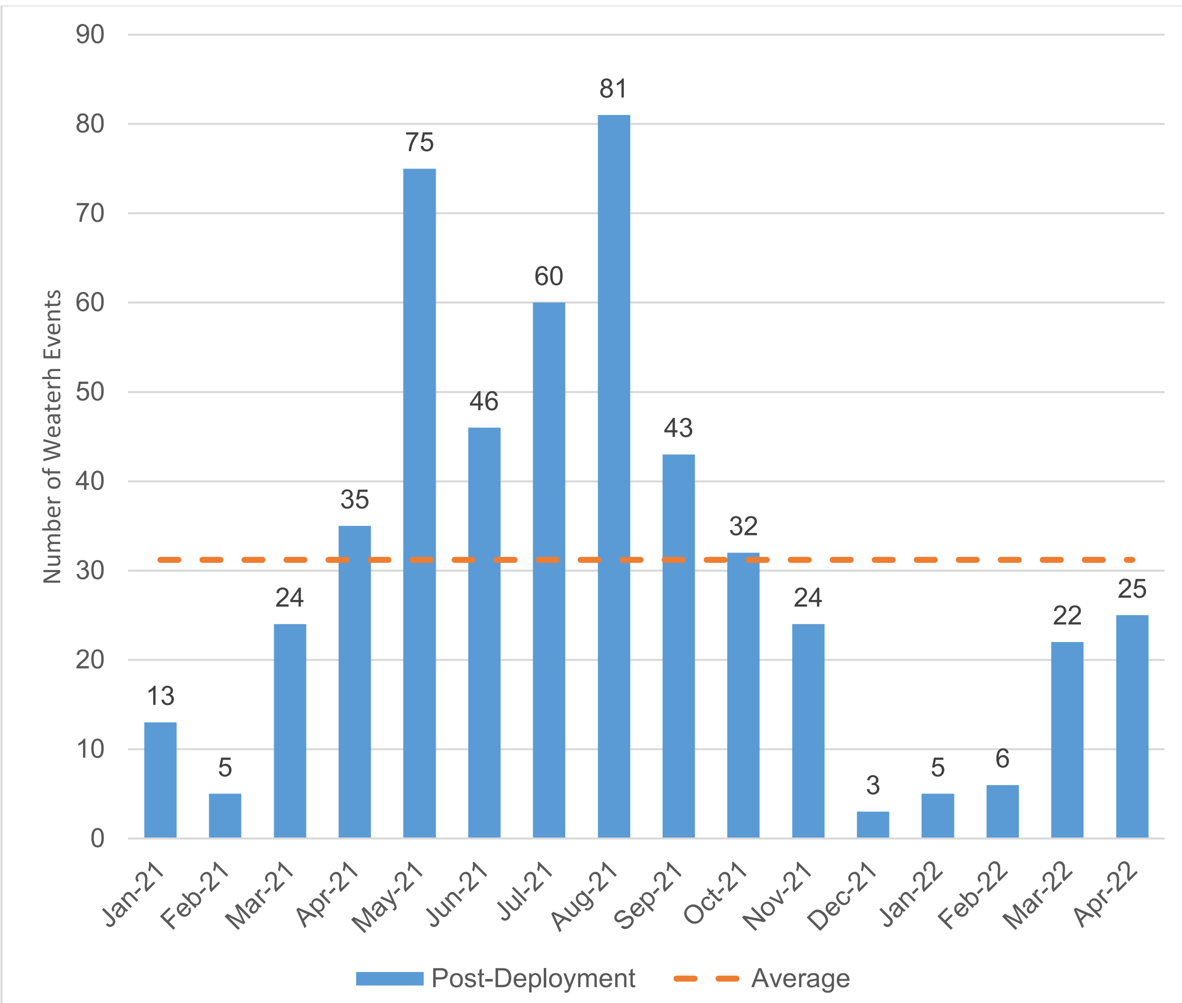
Baseline Conditions

The Wyoming CVPD Team collected pre-deployment data beginning in December 2016 through November 2017. [3] The purpose of this pre-deployment data collection effort was to create a baseline of the expected level of operations and system performance during sever weather events. The Wyoming CVPD Team also examined crash data before December 2016. During the baselining period, the Wyoming CVPD collected data only from traditional, non-CV data sources. No data from CV vehicles were available because the CV technology had not yet been outfitted in the vehicles.

WYDOT reported that the 2016–2017 winter was one of the most severe on record, especially the number and intensity of strong wind events in the corridor.[3] The Wyoming CVPD Team reported 41 separate significant weather events on I-80 between December 2016 and May 2017.[3] These weather events resulted in WYDOT's extensive use of VSL systems and dynamic message signs, constant updates of the Wyoming traveler information system and the CVOP, and numerous road closures. Crashes numbered 1,310 in total, of which 225 trucks were blown over due to extremely strong winds. WYDOT also reported nine fatalities during these weather events.

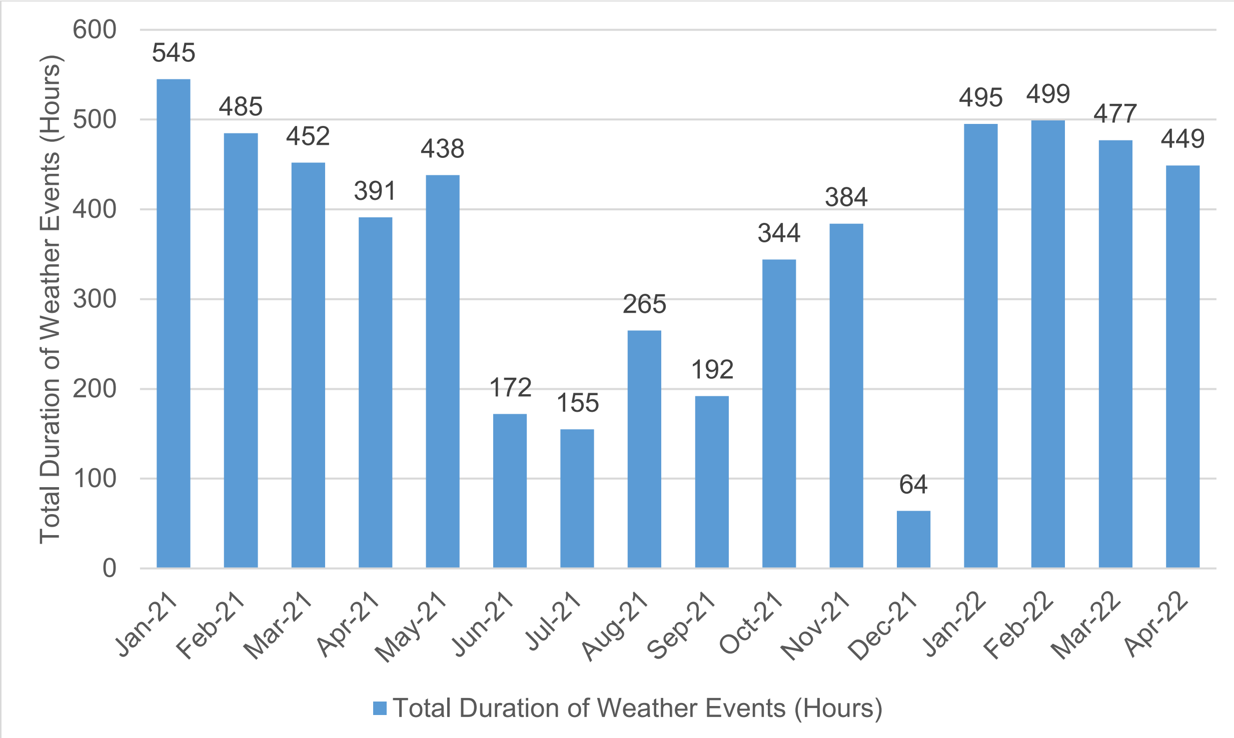
Post-Deployment Operations

The Wyoming CVPD entered the post-deployment evaluation phase (Phase 3) in January 2021 and collected performance data until April 2022.[3] During the post-deployment period, WYDOT reported 499 severe weather events, lasting a total of 5,807 hours.[3] The bulk of these events impacted at least half of the I-80 deployment corridor, with the most severe storms (in terms of severity, complexity, and coverage) occurring during the winter. In February 2021 and January 2022, the I-80 corridor experienced only five major weather events, but their average duration was over 100 hours each. During the summer months, the I-80 corridor experienced significantly more severe weather events (between 45 and 85 events). These storms tended to have a short duration (between 2.5 and 5 hours). Figure 4 shows the number of severe weather events occurring in the I-80 corridor during the post-deployment period, while Figure 5 shows the total duration that the corridor experienced inclement weather for each month. Figure 6 shows the average storm duration (in hours) per severe weather event.



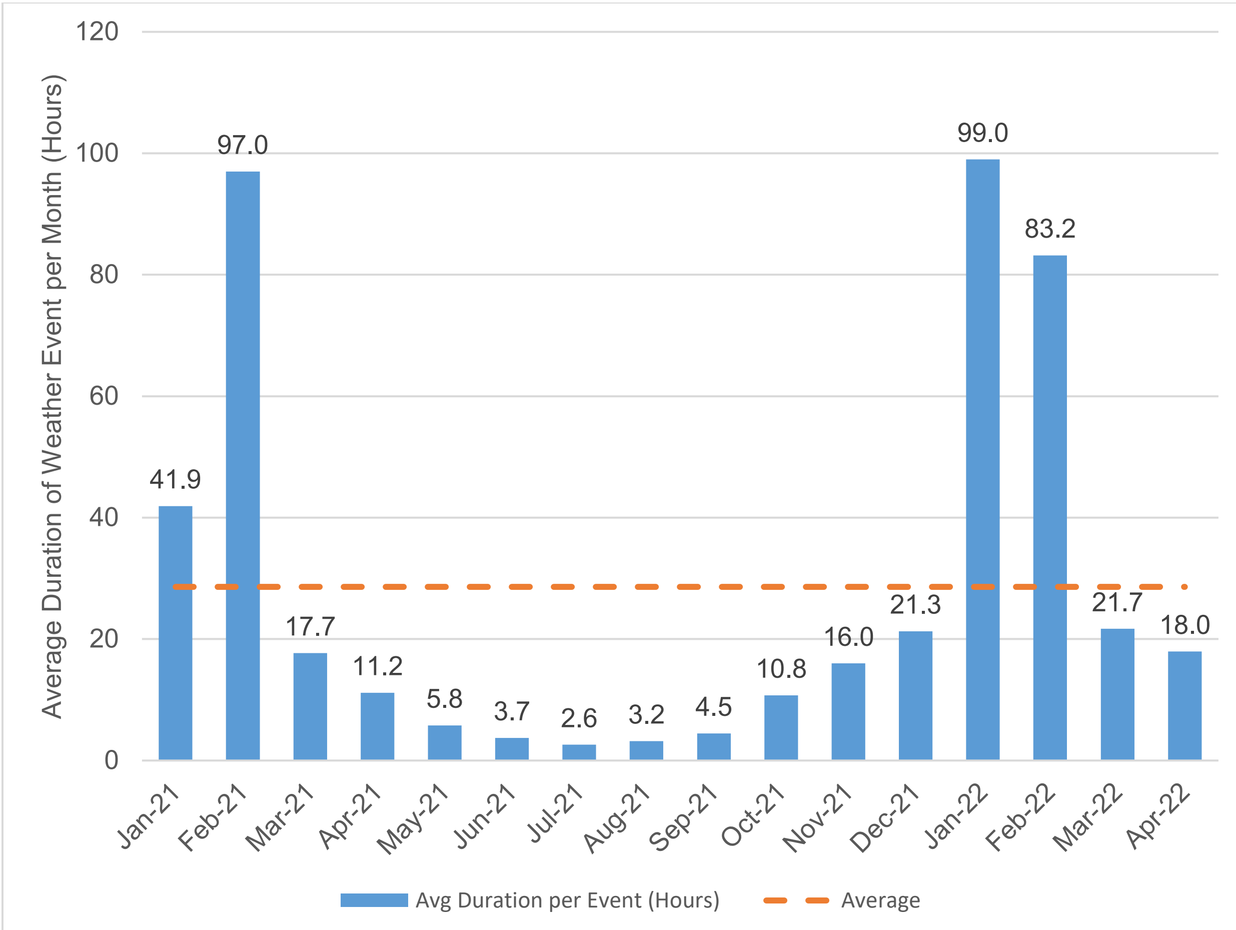
Source: Wyoming Department of Transportation, 2022

Figure 4. Graph. Number of Weather Events in I-80 Deployment Corridor [3]



Source: Wyoming Department of Transportation, 2022

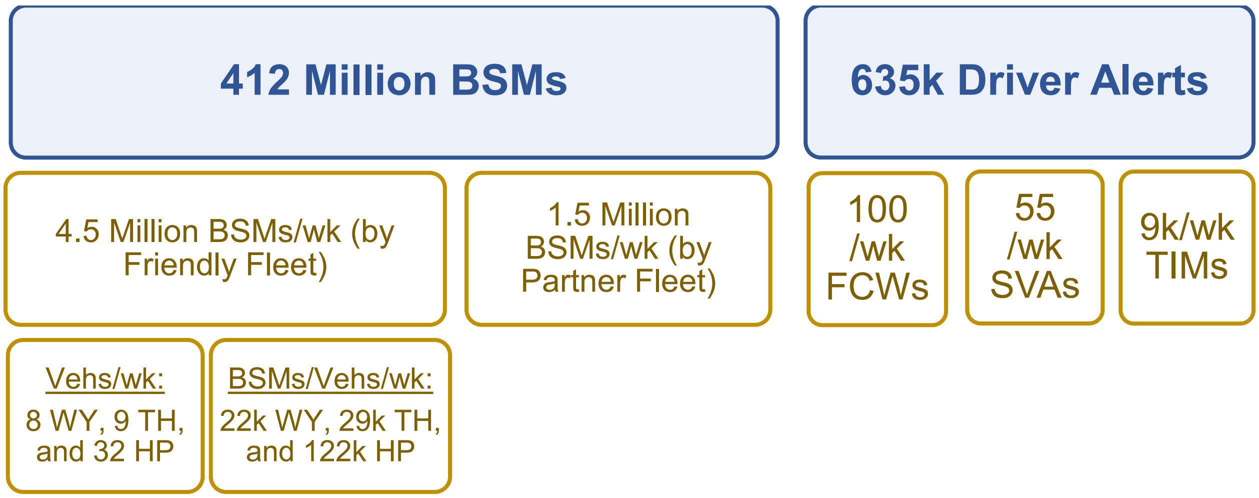
Figure 5. Graph. Total Duration of Severe Weather Storms in I-80 Deployment Corridor. [3]



Source: Wyoming Department of Transportation, 2022.

Figure 6. Graph. Average Duration of Severe Weather Storms in I-80 Deployment Corridor. [3]

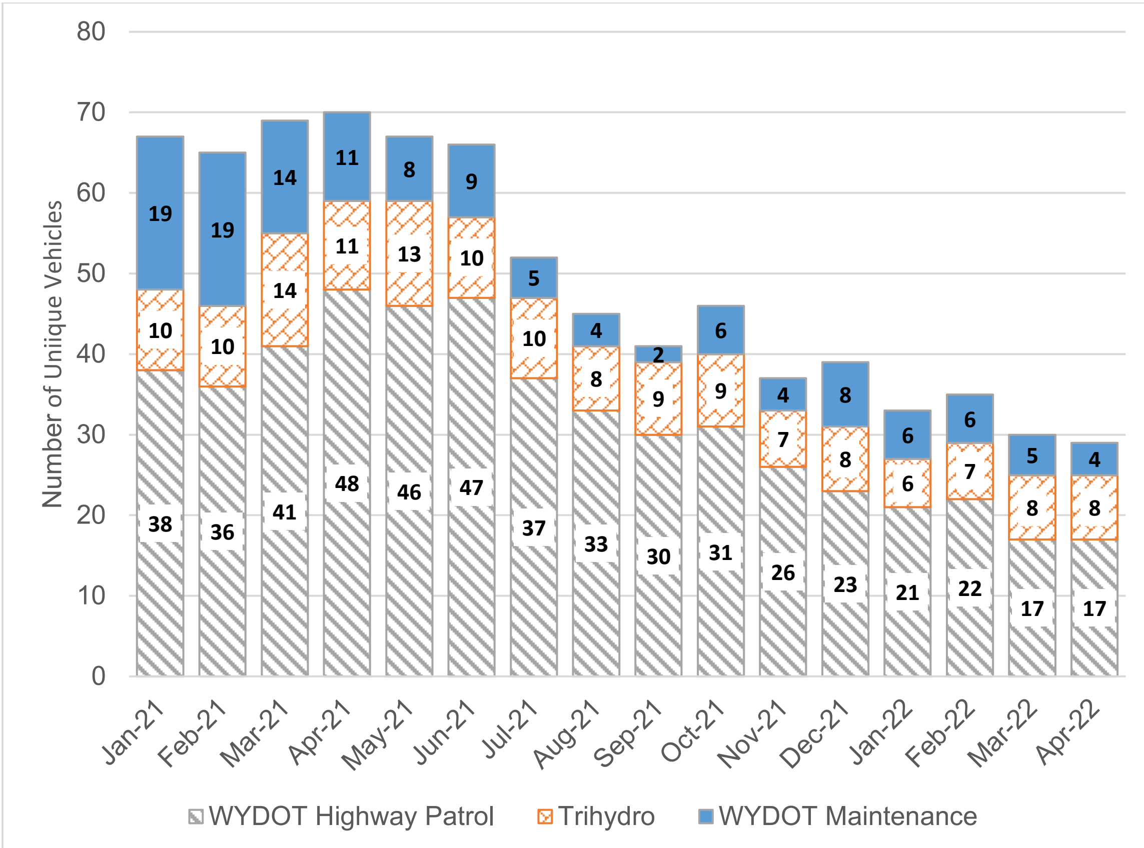
Figure 7 shows some basic operations statistics associated with CV operations in I-80 during the deployment periods. The Wyoming CVPD Team registered over 412 million BSMs and 635,000 driver alerts between January 1, 2021, and April 30, 2022.



Source: Wyoming Department of Transportation, 2022

Figure 7. Diagram. Summary of CV Operations in I-80 Deployment Corridor. [3]

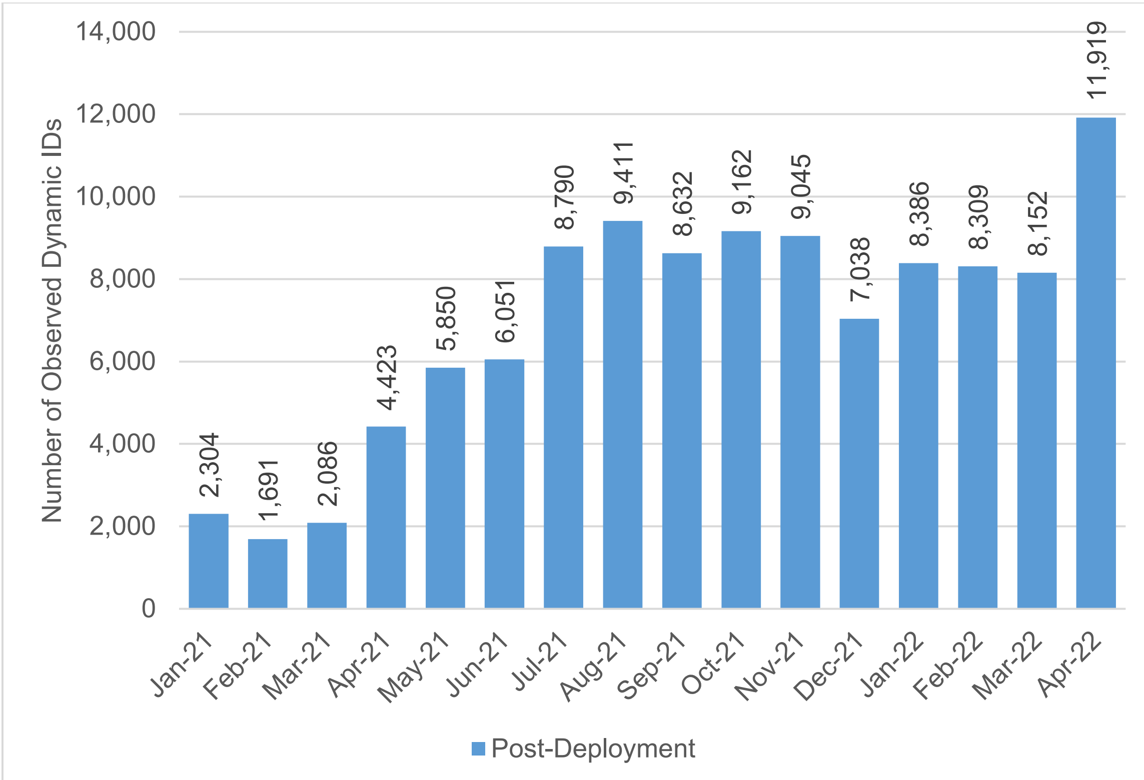
Figure 8 shows the number of friendly fleet CVs using the I-80 deployment corridor between January 2021 and April 2022. [3] On average, the Wyoming CVPD Team observed 50 unique friendly fleet vehicles per month traveling on I-80 throughout the post-deployment period. The Wyoming CVPD Team reported that most of these vehicles were Wyoming HP vehicles. The Wyoming CVPD reported significantly fewer WYDOT snowplows and stakeholder test vehicles during the same period, fluctuating between 2 and 20 vehicles per month.



Source: Wyoming Department of Transportation, 2022

Figure 8. Graph. Number of Observed Friendly Fleet Vehicles on I-80 Deployment Corridor. [3]

Figure 9 shows the number of dynamic vehicle IDs associated with partner fleet vehicles observed on I-80 each month during the post-deployment period. Because the vehicle IDs with partner fleet vehicles are dynamic (for security and privacy reasons), it is impossible to know the exact number of partner vehicles operating in the corridor between January 2021 and April 2022, but the figure shows an increased trend in the number of partner vehicles using the network during the post-deployment period.



Source: Wyoming Department of Transportation

Figure 9. Graph. Number of Observed Partner Fleet Dynamic IDs in I-80 Deployment Corridor [3]

Chapter 3. Environmental Impact Assessment

FHWA's Congestion Mitigation and Air Quality Improvement (CMAQ) Program website [6] identifies three ways that transportation improvement projects typically reduce motor vehicle fuel consumption and emissions:

- Improving traffic flow, thereby reducing vehicle idling and stop-and-start driving conditions that are associated with higher levels of emissions.
- Encouraging changes in travel behavior that reduce motor vehicle miles traveled (e.g., shifts to ridesharing, transit, bicycling, or walking).
- Using technology to reduce the rates of emissions (e.g., through purchases of cleaner buses or retrofits of diesel vehicles).

Even though the scope of the deployment focused on the "system's impact on accurate and timely reports on road weather condition, information dissemination, and safety,"[3] TTI conducted a qualitative environmental assessment of the impacts of the deployment using these performance measures collected by the Wyoming CVPD Team. TTI did not collect field data or conduct any modeling analysis in this assessment.

Direct Measurement of Fuel Consumption and Emission Benefits

A common way to assess potential fuel consumption and emission benefits associated with the deployment would have been to directly compare the speeds and acceleration/deceleration cycles of equipped and unequipped vehicles. Unfortunately, the Wyoming CVPD Team's experimental plan and privacy protocol did not allow this type of data to be collected, so the TTI Evaluation Team turned to other mechanisms for estimating the potential environmental impacts of the deployment.

Estimate of Environmental Benefits through Improved Traffic Flow

The primary focus of the Wyoming deployment is to reduce the number and severity of crashes involving commercial vehicles during severe weather events. History has shown that when multi-vehicle collisions involving trucks occur on I-80 in the deployment area, these collisions tend to block flow on the highway for extended periods, creating an idling condition for trucks and other traffic. Intuitively, reducing the number and severity of collisions on I-80 can significantly reduce the amount of time that commercial vehicles spend driving during stop-and-go conditions. Assuming all severe crashes result in stop and go travel on I-80 for the entire duration of the incident, one could estimate the potential delay savings for an individual commercial vehicle through the reduction in severe collisions using the following equation:

Delay Savings = Change in Number of Severe Crashes * Average Duration of Severe Crash (Eq. 1)

or

Delay Savings = Number of Severe Crashes * Change in Average Duration of Severe Crash (Eq. 2)

Because the Wyoming deployment focused primarily on commercial fleet vehicles, delay savings could then be computed by multiplying the average number of commercial fleet vehicles impacted by these severe events to obtain a total amount of delay savings benefits to commercial fleet vehicles. Equations 3 could then be used to estimate total fuel savings, assuming that delay saving is equivalent to reductions in idle time. The fuel consumption rates during idling developed by the Argonne National Laboratory [7] estimate the total amount of fuel savings resulting from the reductions in severe collision.

$$FC = I * n * R \qquad \text{(Eq. 3)}$$

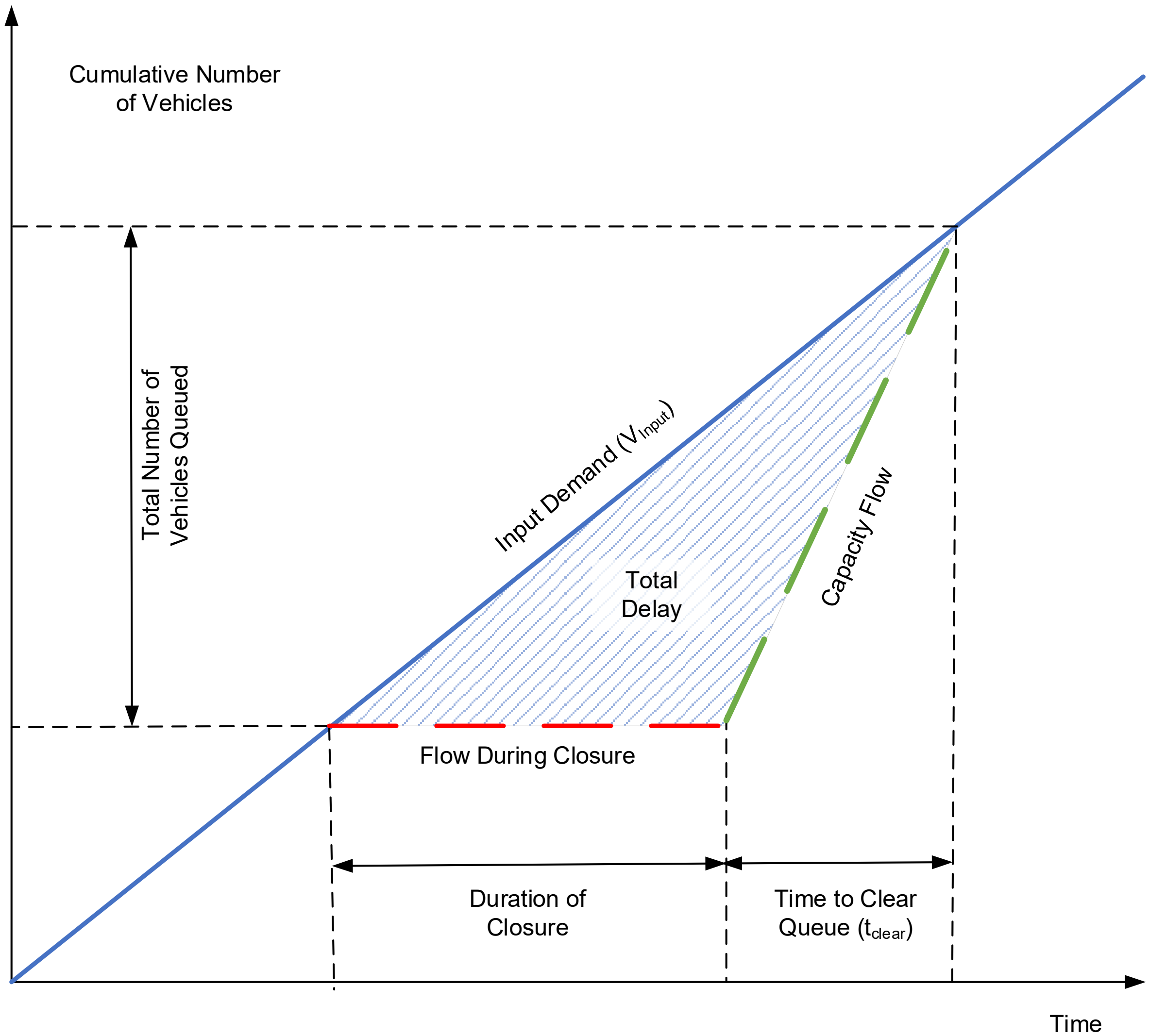
Where:

- FC = total amount of fuel consumed by idling (gallons).
- I = average duration spent idling (hours of idling per vehicle).
- n = number of vehicles experiencing idling (vehicles).
- R = rate of fuel consumed while idling (gallons per hour of idling).

Unfortunately, no data was provided that would allow the TTI Evaluation Team to estimate the amount of delay savings or reduction in idle times by equipped vehicles. For privacy protection, the Wyoming CVPD Team did not collect information related to trip by individual equipped vehicles. Therefore, it is not possible to estimate the reduction in fuel consumption or changes in emissions for equipped vehicles based on the data provided by the Wyoming CVPD Team.

To assess the potential fuel consumption benefits, the TTI Evaluation Team conducted an analysis of hypothetical closures in different sections of the I-.80. To conduct this analysis, the TTI Evaluation Team used a simple input-output analysis shown in Figure 10. The analysis methodology uses input and output flows to estimate the approximate delay associated with a reduction in capacity on a freeway. To perform this analysis, the TTI Evaluation Team assumed the following:

- Total delay associated with an accident or closure can be estimated by comparing input demands and output flows at a macroscopic level.
- The deployment of CV technology was directly attributable to preventing a collision from occurring in the corridor.
- The collision occurs during the time of the peak hour flow.
- Peak hour demand is 10 percent of the total average annual daily traffic. (Note: In urban areas, demand in the AM peak period is around 8 percent to 12 percent.)
- The collision results in a total closure of a section of I-80 for 1-hour in duration. No diversion of traffic is possible around the incident scene, therefore, the output flow while the closure is in place is 0 vehicles per hour per lane.



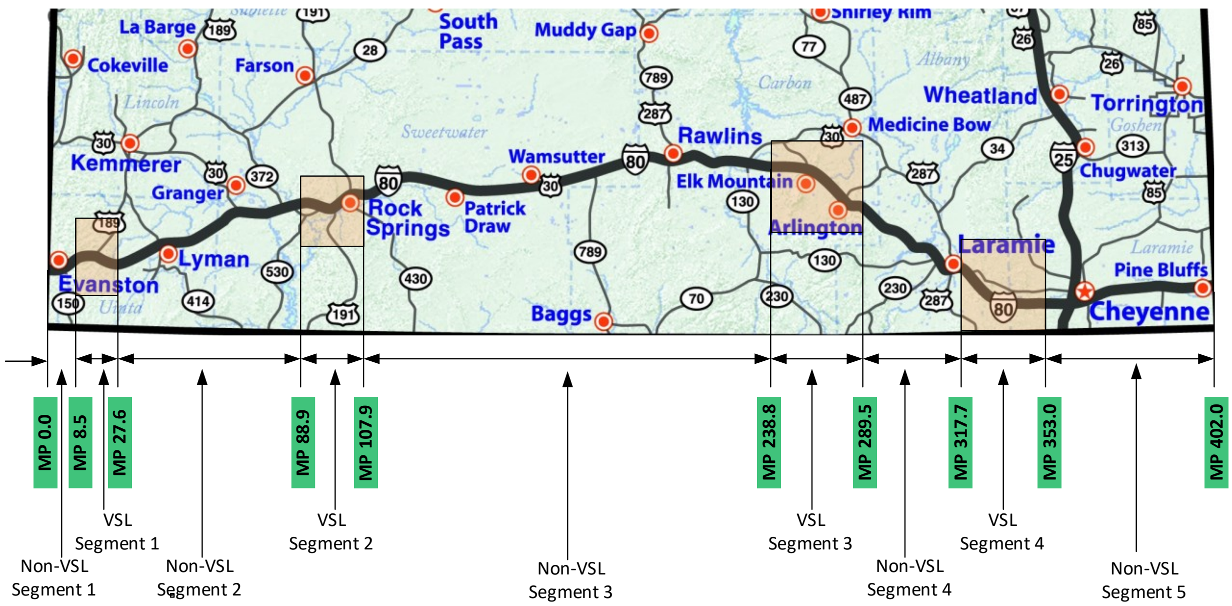
Source: Texas A&M Transportation Institute, 2022.

Figure 10. Illustration. Simplified Input-Output Analysis for Full Closure Incident

- The closure impacts only one direction of flow on I-80 in each segment. The closure does not impact traffic flow in the opposite direction.
- The direction distribution of traffic on I-80 is 50 percent.
- Upon removing the closure, traffic can begin flowing past the incident scene at capacity instantaneously.
- The capacity of the all sections of I-80 is 2,200 vehicle per hour per lane. Capacity is uniform in all sections of I-80, regardless of the geometric condition (i.e., grade) and direction of flow.
- While delayed, vehicles in the queue are idling for the entire duration of the closure. Because crashes frequently occur during winter conditions, the engines are assumed to be loaded.

- The total number of vehicles in the queue represents the total number of vehicles experiencing idling.
- The percentage of trucks traveling in the peak hour flow is 50 percent. The composition of the traffic steam is consistent in all sections of I-80.

The first step in the process is to estimate the peak period demand. The Wyoming CVPD Team divided the deployment area into nine segments based on the locations of the variable speed limit (VSL) systems. (See Figure 11). [8] The Wyoming CVPD Team provided average daily traffic (ADT) values for each quarter for each analysis. Using these quarterly values, the TTI Evaluation Team estimated the total number of vehicles in each segment by multiplying the ADT by the number of days in each quarter. These values were then summed to provide the total annual number of vehicles traveling in each segment. TTI then estimated the annual average daily traffic (AADT) by dividing the total annual number of vehicles traveling in each segment by the total number of days per year (365 days). The peak hour volume in each segment was then estimated by multiplying the AADT by the assumed proportion of travel in each segment occurring the analysis peak hour (10 percent) and by the direction distribution (50 percent). Table 4 shows the results of these computations.



Source: Texas A&M Transportation Institute, 2022.

Figure 11. Map. Location of Analysis Section Used by Wyoming CVPD Team.

The next step is to estimate the total amount of delay caused by the collision. Assuming that the peak hour flow is 10 percent of the AADT and a directional distribution of 50 percent, the TTI Evaluation Team computed the peak hour flow for each analysis section. Assuming a capacity flow of 2,200 vehicles per hour per lane, the TTI Evaluation Team applied the input-output approach to compute the time for the queue caused by the incident to clear using the following computations:

$$\text{Input} = \text{Output} \qquad \text{(Eq. 4)}$$

The input into the incident location can be estimated using the following relationship:

Input = Peak Flow * (Duration of Incident + Time to Clear Queue) (Eq. 5)

$$Input = V_{Input} * (1\ hr + t_{Clear})$$

$$Input = V_{Input} + (V_{Input} * t_{Clear})$$

The output from the incident scene can be estimated using the following relationship:

Output=(Flow during closure* Duration of Closure)+(Capacity Flow * Time to Clear Queue) (Eq. 6)

$$Output = (0\ vph * 1hr) + (2{,}200\ vphpl * 2\ lanes * t_{Clear})$$

$$Output = 4{,}400\ vph * t_{Clear}$$

Equating input and output, the following relationship develops:

$$V_{Input} + (V_{Input} * t_{Clear}) = 4{,}400\ vph * t_{Clear} \quad \text{(Eq. 7)}$$

Solving for t_{clear}, Equation 7 becomes:

$$V_{Input} + (V_{Input} * t_{clear}) = 4{,}400\ vph * t_{clear} \quad \text{(Eq.8)}$$

$$V_{Input} = (4{,}400\ vph * t_{Clear}) - (V_{Input} * t_{Clear})$$

$$V_{Input} = (4{,}400\ vph - V_{Input}) * t_{Clear}$$

$$t_{Clear} = V_{Input} / (4{,}400\ vph - V_{Input})$$

Once the time to clear the queue has been computed, the total number of queue vehicles can be computed using Equation 4. The total delay caused by the closure can then be computed by computing the shaded area in Figure 10. The average delay per vehicle in each segment can be computed by dividing the total delay for the closure by the total number of queued vehicles. Table 5 shows the results of these computation for each segment in the Wyoming CVPD.

The TTI Evaluation Team used the average delay per vehicle to estimate the amount of fuel consumed during the closure using Equation 3. The TTI Evaluation Team assumed that average delay per vehicle was equivalent to the time spent idling. To separate the impacts of trucks from passenger cars, the TTI Evaluation Team assumed that the traffic stream was composed of 50 percent trucks. For this analysis, TTI used the fuel consumption rate of a large sedan (0.59 gallons of gasoline per hour of idling) for passenger vehicles and a tractor-semitrailer (1.15 gallons of diesel per hour of idling) for trucks. [(7)] TTI assumed loads were placed on all engines for this analysis.

Table 6 shows the results of these computations. These values shown in the table represent the potential fuel consumption savings if the applications deployed in the corridor were successful at preventing a single, 1-hour full closure of I-80. It should be noted that these potential fuel savings are highly dependent on the locations of the incident, the total duration of the incident, input demands at the time of the collision, and many other factors. These estimates are only intended to provide an order of magnitude estimate of the potential benefits.

Figure 12 shows the fuel consumption benefits that could potentially be achieved by reducing closures in the different sections of the roadway. For a one-hour closure, fuel consumption due to idling was estimated to range from 19.3 to 67.3 gallons of gasoline for passenger cars and 19.4 to 67.3 gallons of diesel for trucks. Potential fuel consumption benefits are greater on the west end of the corridor, where AADT values tend to be higher compared to the east end of the corridor.

Table 3. Fuel Consumption during Idling for Different Vehicle Types. [7]

Vehicle Type	Class	Fuel Type	Engine Size (Liter)	Gross Vehicle Weight (Lbs)	Idling Fuel Use with No Load (gal/hour)	Idling Fuel Use with Load (gal/hour)
Compact sedan	1	Gasoline	2	—	0.16	0.29
Compact sedan	1	Diesel	2	—	0.39	0.39
Large sedan	1	Gasoline	4.6	—	0.39	0.59
Medium heavy truck	6	Gasoline	5–7	19,700–26,000	0.84	—
Delivery truck	5	Diesel	—	19,500	0.84	1.1
Tow truck	6	Diesel	—	26,000	0.59	1.14
Medium heavy truck	6-7	Diesel	6-10	23,000–33,000	0.44	—
Transit bus	7	Diesel	—	30,000	0.97	—
Combination truck	7	Diesel	—	32,000	0.49	—
Bucket truck	8	Diesel	—	37,000	0.90	1.50
Tractor-semitrailer	8	Diesel	—	80,000	0.64	1.15

A dash denotes not applicable.

Source: Argonne National Laboratories

Appendix A holds to computations for the sensitivity analysis for the percent trucks while Appendix B contains the computations for the sensitivity analysis for different event durations.

Table 4. Computation of Annual Average Daily Traffic for Analysis Periods (March 2021 through February 2022)

Analysis Segment	Average Daily Traffic– Mar 2021–May 2021	Average Daily Traffic– June 2021–Aug 2021	Average Daily Traffic – Sept 2021– Nov 2021	Average Daily Traffic – Dec 2021– Feb 2022	Total Annual Number of Vehicles (Mar 2021– Feb 2022)	Annual Average Daily Traffic (vehs/day) (Mar 2021– Feb 2022)
Non-VSL Segment 1 (MP 0 – MP 8.5)	16,649	21,474	18,647	12,486	6,327,933	17,337
VSL Segment 1 (MP 8.5 – MP 27.6)	14,974	19,190	16,500	11,377	5,668,518	15,530
Non-VSL Segment 2 (MP 27.6 – MP 88.9)	14,554	18,024	15,604	11,182	5,423,520	14,859
VSL Segment 2 (MP 88.9 – MP 107.9)	21,351	24,438	22,335	17,528	7,822,593	21,432
Non-VSL Segment 3 (MP 107.9 – MP 238.8)	12,973	17,389	15,119	9,901	5,060,223	13,864
VSL Segment 3 (MP 238.8 – MP 289.5)	12,362	16,356	13,972	9,009	4,724,318	12,943
Non-VSL Segment 4 (MP 289.5 – MP 317.7)	12,586	16,618	14,608	9,596	4,879,736	13,369
VSL Segment 4 (MP 317.7 – MP 353.0)	12,810	16,881	15,243	10,184	5,035,245	13,795
Non-VSL Segment 5 (MP 353.0 – MP 402.0)	11,657	15,123	13,293	8,733	4,459,393	12,218
Total	13,490	17,468	15,267	10,318	5,166,053	14,154

Source: Texas A&M Transportation Institute based on data contained inn Reference 3, 2022

Table 5. Computation for Estimated Average Delay for 1 hour, Full Closure for Each Analysis Segment

Analysis Segment	Non-VSL Segment 1	VSL Segment 1	Non-VSL Segment 2	VSL Segment 2	Non-VSL Segment 3	VSL Segment 3	Non-VSL Segment 4	VSL Segment 4	Non-VSL Segment 5	Corridor Average
AADT (vehs/day)	17,337	15,530	14,859	21,432	13,864	12,943	13,369	13,795	12,218	14,154
Peak Hour Proportion (percent)*	10	10	10	10	10	10	10	10	10	10
Directional Distribution (percent)*	50	50	50	50	50	50	50	50	50	50
Inflow Volume (vehs/hr)	867	777	743	1072	693	647	668	690	611	708
Capacity Flow (vehs/hr/lane) *	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200
Number of Lanes per Direction	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hours)*	1	1	1	1	1	1	1	1	1	1
Time to Clear Queue (t) (hours)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total Number of Queue Vehicles	1,080	943	894	1,417	823	759	788	818	709	843
Total Delay (veh-hours)	132.4	101.0	90.8	228.0	76.9	65.4	70.6	76.0	57.2	80.8
Average Delay (hours/vehicle)	0.12	0.11	0.10	0.16	0.09	0.09	0.09	0.09	0.09	0.10

*Assumed values

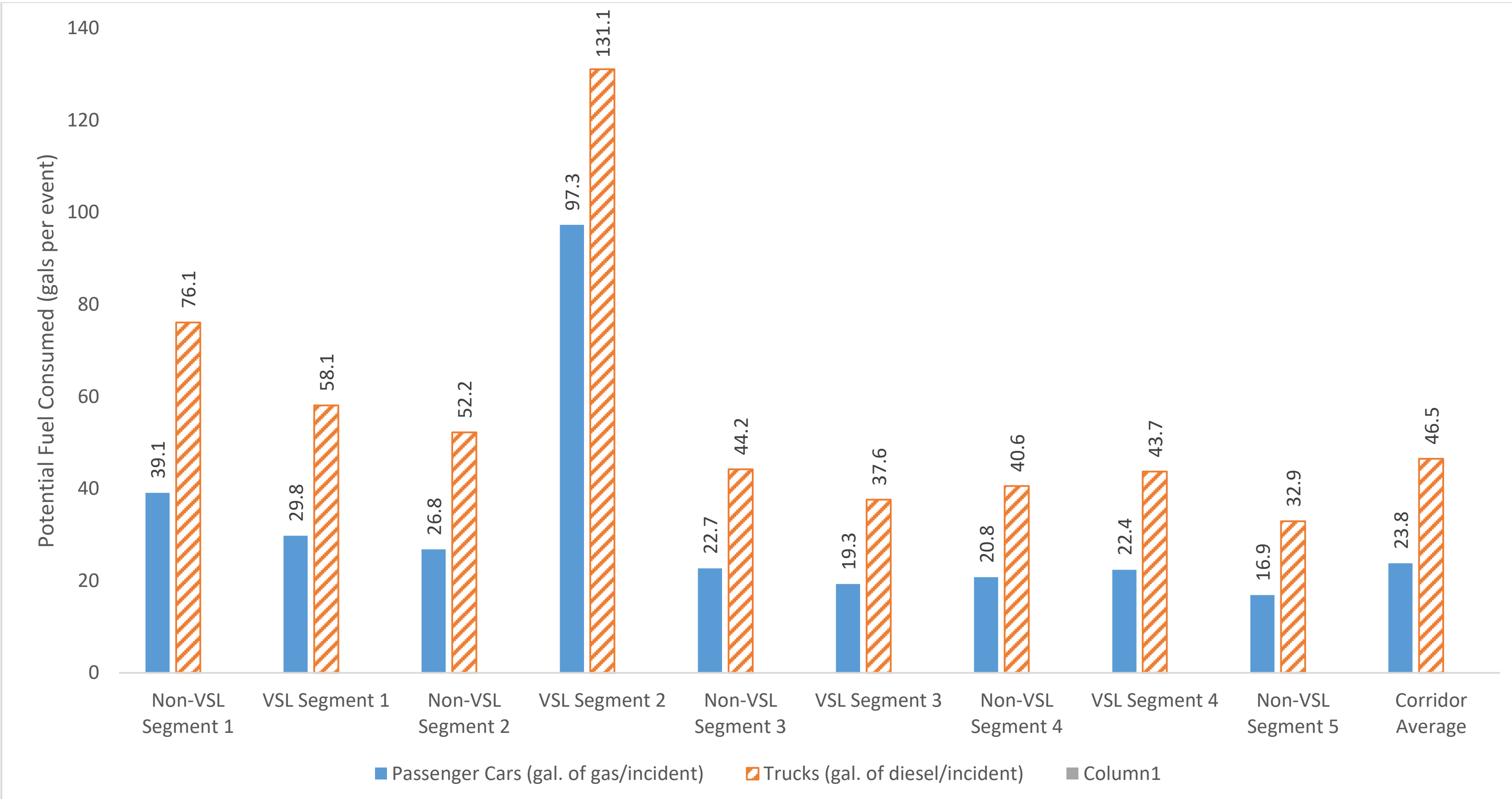
Source: Texas A&M Transportation Institute, 2022

Table 6. Estimates of Fuel Consumption Potential Benefits for a 1-hour, Full Closure by Analysis Segment

Analysis Segment	Non-VSL Segment 1	VSL Segment 1	Non-VSL Segment 2	VSL Segment 2	Non-VSL Segment 3	VSL Segment 3	Non-VSL Segment 4	VSL Segment 4	Non-VSL Segment 5	Corridor Average
Average Delay (hours/vehicle)	0.12	0.11	0.10	0.16	0.09	0.09	0.09	0.09	0.09	0.10
Total Number of Queue Vehicles	1,080	943	894	1,417	823	759	788	818	709	843
Percent Trucks (percent)	50	50	50	50	50	50	50	50	50	50
Fuel Consumption Rate—Passenger Car (gals. of gas/ hour)*	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate—Trucks (gals. of diesel/ hour)*	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed by Passenger Cars (gal. of gas/incident)	39.1	29.8	26.8	67.3	22.7	19.3	20.8	22.4	16.9	23.8
Total Fuel Consumed by Trucks (gal. of diesel/incident)	76.1	58.1	52.2	131.1	44.2	37.6	40.6	43.7	32.9	46.5

*Based on values from fuel consumption rated from the Argonne National Laboratories

Source: Texas A&M Transportation Institute, 2022



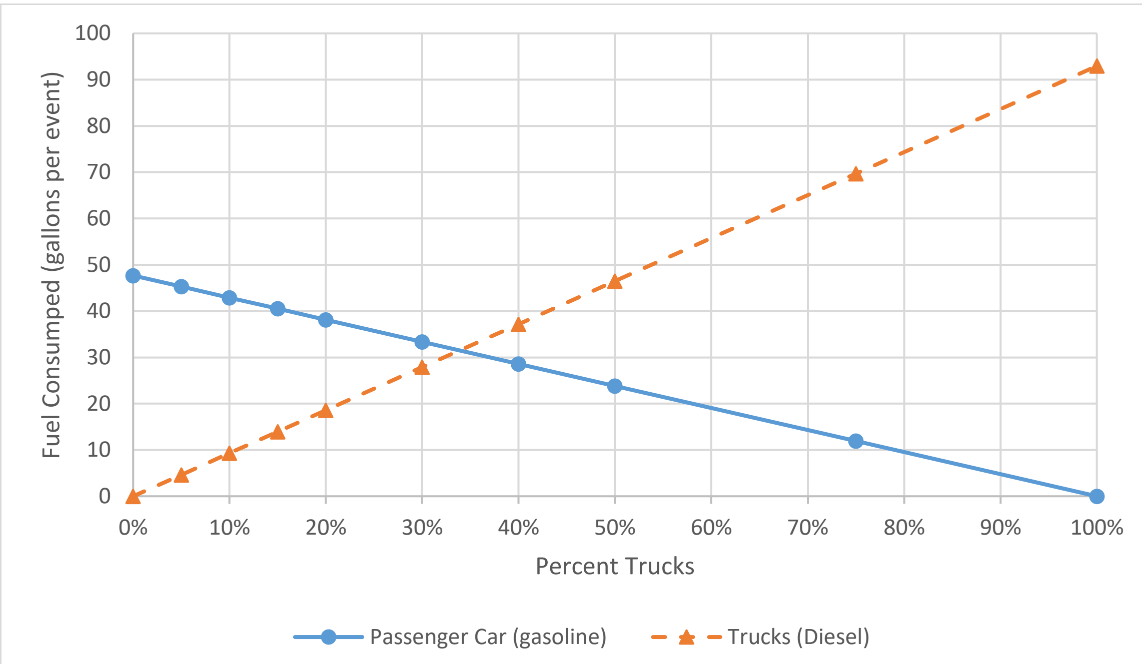
Assumes Full Closure for 1-hour in Duration

Source: Texas A&M Transportation Institute, 2020

Figure 12. Graph. Potential Fuel Consumption for 1-hour Closure Event on Different Segments of I-80 in Wyoming.

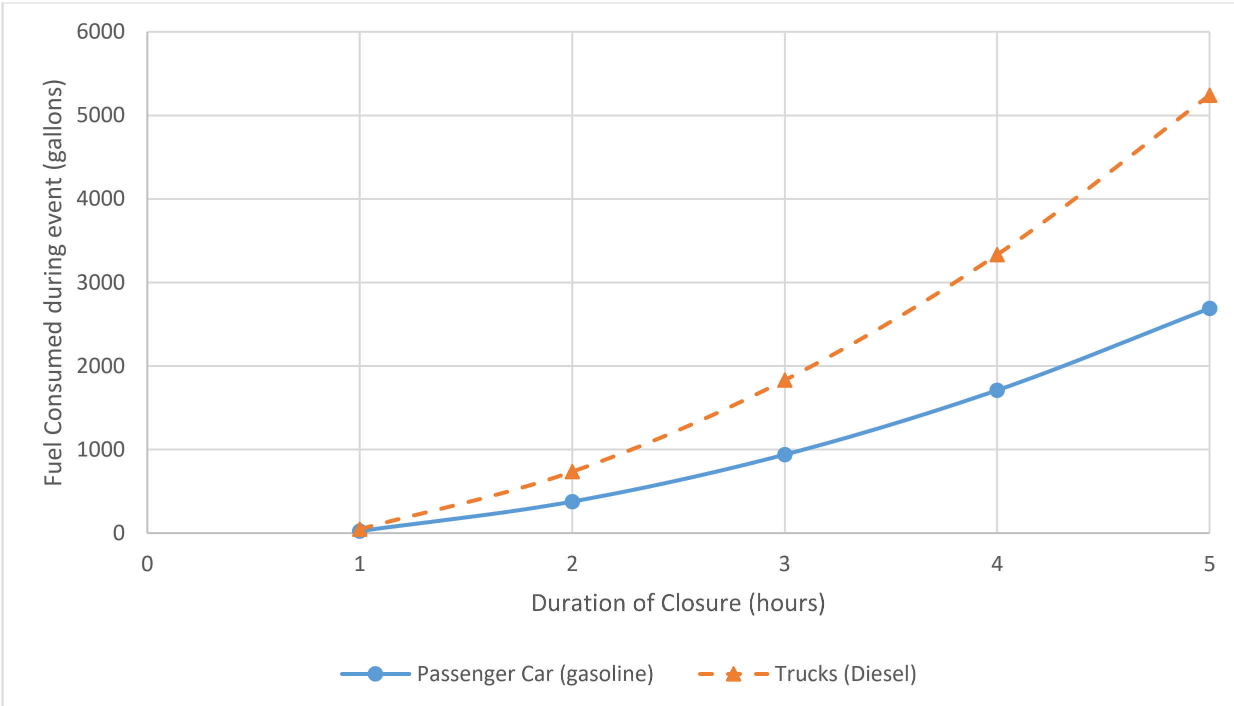
This analysis assumes that trucks represent half the vehicles in the traffic stream. A review of 2020 traffic data from the Wyoming Department of Transportation shows that trucks represent between 27 percent and 65 percent of the total traffic stream. (9) Figure 13 shows how the potential fuel consumption changes a result of different percentages of truck volumes in the corridor. Obviously, as the percent of trucks increase the greater amount of fuel is consumed during the closure also increases. According to the Argonne National Laboratories, trucks consume approximately twice the amount of fuel as passenger cars while idling with a load. (7)

Figure 14 shows an analysis of the impacts of different incident durations on potential fuel consumption. Closure durations were varied from 1 to 5 hours. This analysis shows that full consumption follows an exponential trend as the duration of closure increases. This analysis shows importance of rapidly detecting and clearing closures from an environmental perspective.



Source: Texas A&M Transportation Institute

Figure 13. Graph. Change in Potential Fuel Consumption for a 1-hour Closure with Traffic Stream Composition.



Source: Texas A&M Transportation Institute, 2020

Figure 14. Graph. Potential Fuel Consumption for Different Durations of Closures.

Estimate of Environmental Benefits through Changing Travel Behavior

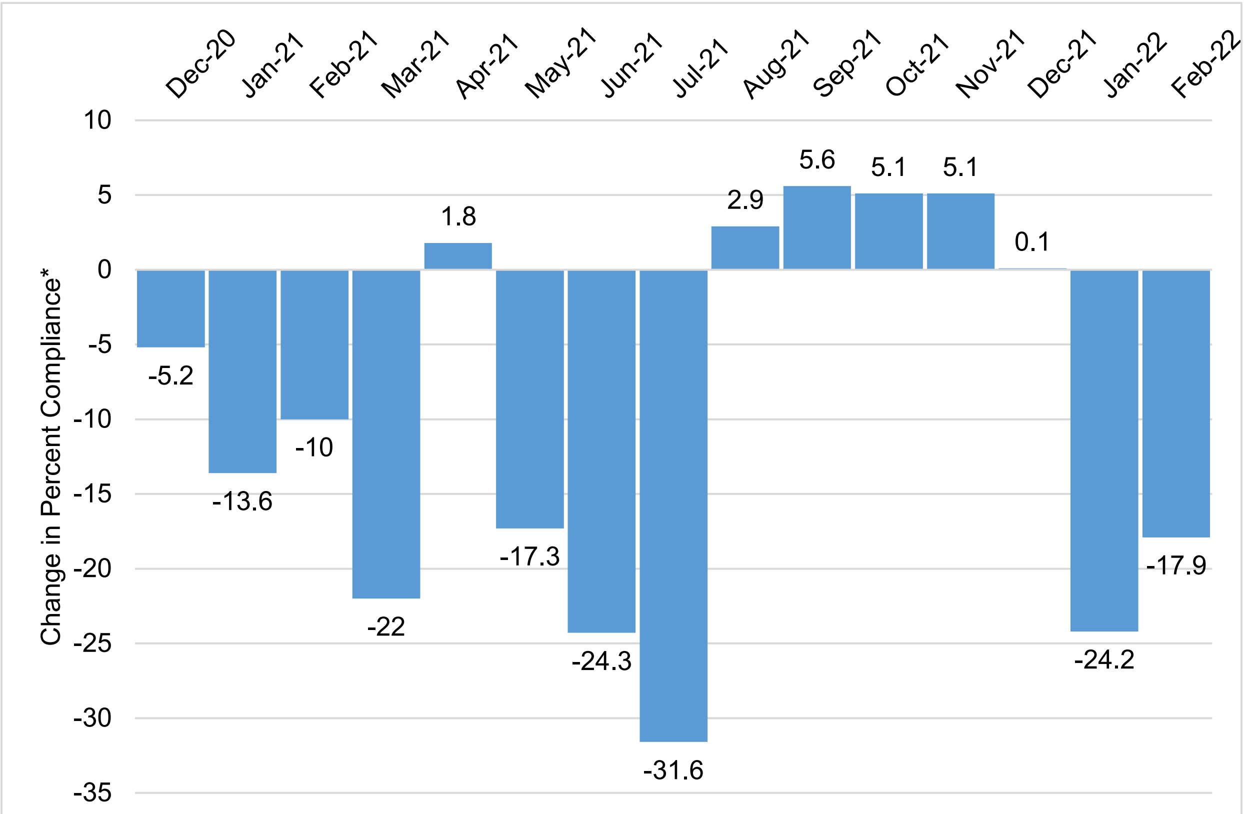
Achieving better conformance and reducing the variability around posted speed limits (i.e., making the speed more uniform with fewer acceleration/deceleration cycles in a single trip) could potentially generate emission and fuel consumption benefits. The Wyoming CVPD Team had two measures associated with speed limit compliance:[3]

- The percentage of vehicles traveling no faster than 5 mph over the posted speed limit.
- The percentage of vehicles traveling within (+/–) 10 mph of the posted speed limit.

The Wyoming CVPD associated the first measure with speed adherence and the second measure with speed variability. The Wyoming CVPD compared the post-deployment speed adherence and speed variability measured in the post-deployment period to that measured in the baseline period (collected in 2016 and 2017) to assess the impact of the deployment.

Figure 15 shows the change in speed limit compliance by month for all traffic during the post-deployment period, compared to the baseline conditions. For this evaluation purpose, the Wyoming CVPD Team classified a vehicle to follow the speed limit if its speed was no more than 5 mph over the speed limit. [3] The figure shows that during the early months in the post-deployment period, fewer vehicles adhered to the posted speed limits compared to the same periods in the baseline. WYDOT attributed this observation to the lingering effects of COVID-19 creating less demand on I-80 in the winter of 2021. During the fall of

2021, WYDOT observed slightly better speed limit compliance by all vehicles as travel demand began returning to pre-pandemic levels.



*Vehicle in compliance is measured speed is no more than 5 mph above the posted speed limit.

Source: Texas A&M Transportation Institute based on data from Reference 3, 2022

Figure 15. Graph. Change in Percentage of Vehicles in Speed Limit Compliance between Post-Deployment and Baseline Periods.

Table 7 shows the change in speed adherence rates in the posted deployment period compared to the baseline conditions for different classifications of weather events. The Wyoming CVPD Team assigned the classification of storm events. The table shows that speed limit compliance declined in the post-deployment period in all but one weather category, the mixed category, which includes the most severe winter weather conditions. This speed limit compliance value is for all vehicles in the traffic stream and not just the CVs. The actual number of CVs in the traffic stream is unknown due to privacy concerns.

Table 7. Comparison of Baseline and Post-Deployment Speed Compliance Rates by Storm Category.

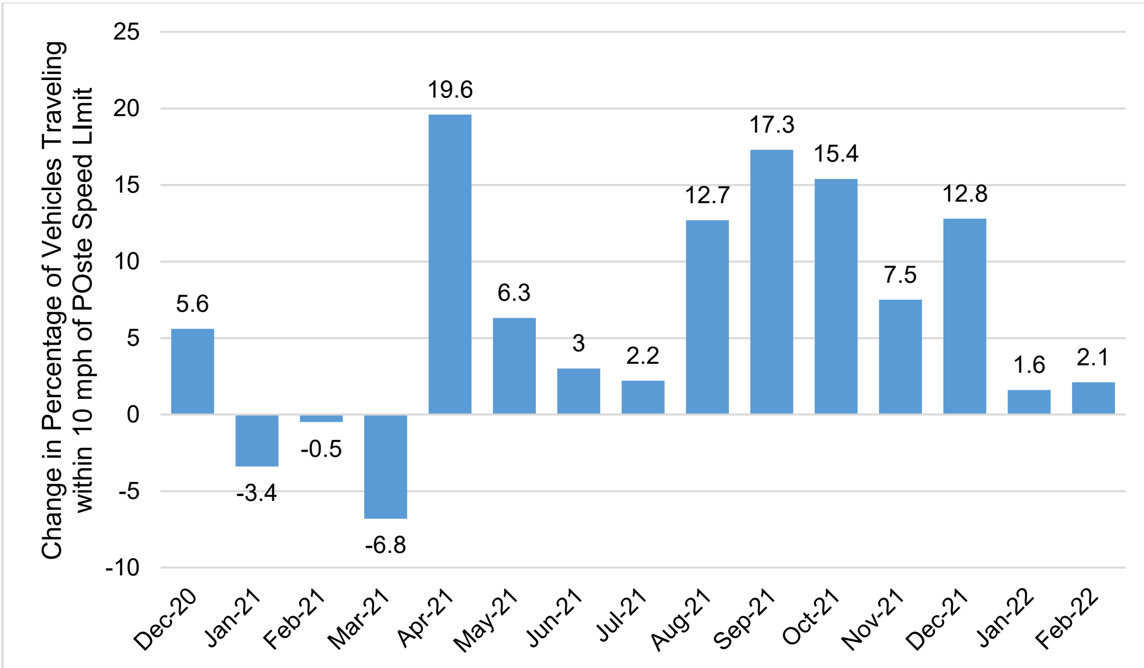
Storm Category	Number of Vehicle Observations (Baseline)**	Percent in Compliance (Baseline)	Number of Vehicle Observations (Post-Deployment)**	Percent in Compliance (Post-Deployment)	Change in Compliance Rate (Percent)
Wind	3,430,866	87.4	13,286,077	73.3	–14.1
Low visibility	147	64.2	6,926,073	55.0	–9.2
Mixed Conditions 1	197,985	79.1	6,963	82.6	3.5
Mixed Conditions 2	2,241.121	80.1	4,594,541	85.0	4.9
Total	**48,396,449**	**84.3.1**	**381,600,828**	**70.4.3**	**–14.0**

*January 2017 through November 2017 ** December 2020 through February 2022.

Vehicle in compliance is measured speed is no more than 5 mph above the posted speed limit.

Source: Wyoming Department of Transportation, 2022

The Wyoming CVPD Team also compared the percentage of vehicles traveling within (+/–) 10 mph of the posted speed limit for each month in the post-deployment period to that in the baseline condition. Figure 16 shows the change in the percentage of vehicles traveling within 10 mph of the posted speed limit between the post-deployment and baseline conditions. The figure shows that more vehicles tended to be traveling closer to the posted speed limit in the later months of the post-deployment conditions; however, better conformity may also be caused by increasing traffic demands (as noted by the Wyoming CVPD team in discussions about speed adherence).



Source: Texas A&M Transportation Institute based on data from Reference 3, 2022

Figure 16. Graph. Change in Percentage of Vehicles Traveling within 10 mph of Posted Speed Limit in Post-Deployment Compared to Baseline Conditions.

Table 8 shows a comparison of the baseline and post-deployment percentage of vehicles to be within 10 mph of the posted speed limit for different storm event categories. The table shows lower percentages of vehicles traveling within 10 mph in the post-deployment period than in the baseline for all storm categories except low-visibility storms. For this storm category, the percentage of vehicles traveling within the 10-mph buffer around the speed limit showed a 2.3 percent improvement. The Wyoming CVPD Team reported that overall speed compliance increased from 58.9 percent to 65.5 percent, an 11.3 percent improvement across all weather conditions.(3) The Wyoming CVPD Team hypothesized that this improvement occurred because of an absence of storm conditions in the baseline period that resulted in particularly low percentages of vehicles being with the 10-mph buffer.(3)

Table 8. Comparison of Baseline and Post-Deployment Speed Buffer by Storm Category. [3]

Storm Category	Number of Vehicle Observations (Baseline)*	Percent Vehicles within 10-mph Buffer of Speed Limit (Baseline)	Number of Vehicle Observations (Post-Deployment)**	Percent Vehicles within 10-mph Buffer of Speed Limit (Post-Deployment)	Change in Vehicles within 10-mph Buffer of Speed Limit
Wind	2,618,285	66.7	13,286,077	62.5	–4.2
Low visibility	134	58.5	6,926,073	60.2	1.7
Mixed Conditions 1	137,739	55.1	6,963	37.5	–17.6
Mixed Conditions 2	1,694,709	60.6	4,564,541	51.6	–9.0
Total	**4,450,867**	**64.0**	**24,783,654**	**59.9**	**–4.1**

*January 2017 through November 2017 **December 2020 through February

Source: Wyoming Department of Transportation, 2022

Chapter 4. Conclusions

Because no data were provided that would allow the TTI Evaluation Team to estimate the amount of delay savings or reduction in idle times by equipped vehicles, TTI Evaluation Team conducted an analysis of the potential fuel consumption reduction benefits using a simple input-output analysis and hypothetical closures in different sections of the I-.80. The input-output analysis uses capacity and demand to estimate the total amount of delay associated with closing portions of I-80. TTI estimated demand using AADT values reported by the Wyoming CVPD Team. Peak hour demand was assumed to be 10 percent of the measures AADT for the section of roadway. The analysis also assumed that the closure would last for a 1-hour in duration. The analysis shows the potential fuel consumption benefits *if* the CV technology could successfully prevent this hypothetical closure from occurring. This analysis was intended to provide order of magnitude estimates of the potential fuel consumption benefits.

The input-output analysis showed the following:

- On average, preventing a 1-hour closure in the corridor could generate potential fuel consumption savings of approximately 23.8 gallons of gasoline from passenger cars, and 46.5 gallons of diesel from trucks, assuming a 50-50 vehicle mix.
- For a one-hour closure, fuel consumption due to idling was estimated to range from 19.3 to 67.3 gallons of gasoline for passenger cars and 19.4 to 67.3 gallons of diesel for trucks for different section of roadway. This also assumes a 50-50 mix of passenger cars and trucks. Currently, percentage of truck on I-80 ranges from 27 percent and 65 percent of the total traffic stream.
- Potential fuel consumption benefits are greater on the west end of the corridor, where AADT values tend to be higher compared to the east end of the corridor.
- Potential fuel savings are highly dependent on the locations of the incident, the total duration of the incident, input demands at the time of the collision, and many other factors.
- Intuitively, as the portion of vehicle mix changes, so does the amount of fuel consumed by the different vehicle classes. Truck consume fuel at approximately twice the rate of automobiles.
- The results are highly dependent of the duration of closures. Using this analysis, there is an exponential relationship between fuel consumption and total duration of closure.

Based on these findings, it is extremely difficult to project any environmental impact improvement based on improved consistency in travel speeds. WYDOT's analysis of speed compliance by all vehicles showed the following:

- While the overall percentage of drivers traveling no more than 5 mph above the speed limit improved in the later months of the post-deployment period during all weather conditions, there was only a slight improvement (3 percent) in adherence during the mixed weather category—one of the conditions targeted by the deployment. In all other weather categories, the percentage of vehicles traveling no more than 5 mph over the speed limit declined in the post-deployment period. These speed adherence values are for all vehicles (including both equipped and unequipped vehicles), and the market penetration of CVs in the overall traffic stream was small.

- In terms of the percentage of vehicles traveling within a 10-mph buffer around the posted speed limit (a measure of variability of speed), the data showed a general trend for more uniform speeds around the posted speed limit during all weather conditions; however, as noted by the CVPD Team, this source of improvement may be “coming from the absence of storm conditions that resulted in particularly low speed buffer results in the baseline period.”(3)

It should be noted that the overall objective of the Wyoming CVPD was not intended to produce air quality or emission benefits – but to demonstrate value of providing enhance traveler information during significant winter weather events. The data collected by the Wyoming CVPD Teams was insufficient to allow the TTI Evaluation Team to even do a cursory estimate of the environmental benefits. The actual number of vehicles with the CV technology was small (a total of 325 vehicles of which approximately half were private fleet vehicles). Because of privacy mitigation factors, it was not possible to determine the number of unique private fleet CVs operating in the corridor.

Because the results of the Wyoming CVPD Team’s assessment showed that the speed compliance and uniformity of travel did not improve significantly, there is little direct evidence to suggest that the Wyoming CVPD generated significant emissions or fuel consumption benefits. However, the primary objective of the Wyoming deployment was to reduce the potential for multi-vehicle collisions (especially trucks) and preventing secondary collisions during severe weather conditions. As deployed, one would not expect the deployment to have generated substantial reductions in emission or fuel consumption unless a significant collision occurred. Fortunately, no significant, multi-vehicle collisions occurred during the period when the level of deployment of CV technology was greatest in the private commercial fleet vehicles. There is insufficient evidence to conclude, however, that the absence of any multi-vehicle collisions was a direct result of the deployment.

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Appendix A. Sensitivity Analysis Computations—Percent Trucks

Computation of AADT

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Length (miles)	8.5	19.1	61.3	19	130.9	50.7	28.2	35.3	49.8	402
Q1 (90 Days)	13,028	11,321	11,039	17,321	9,800	9,040	9,473	9,905	9,014	10,270
Q2 (92 Days)	16,649	14,974	14,554	21,351	12,973	12,362	12,586	12,810	11,657	13,490
Q3 (92 Days)	21,474	19,190	18,024	24,438	17,389	16,356	16,618	16,881	15,123	17,468
Q4 (91 Days)	18,647	16,500	15,604	22,335	15,119	13,972	14,608	15,243	13,293	15,267
Q5 (90 Days)	12,486	11,377	11,182	17,528	9,901	9,009	9,596	10,184	8,733	10,318
Total Annual Count	6,327,933	5,668,518	5,423,520	7,822,593	5,060,223	4,724,318	4,879,736	5,035,245	4,459,393	5,166,053
AADT (veh/day) (	17,337	15,530	14,859	21,432	13,864	12,943	13,369	13,795	12,218	14,154

Q1 = (Dec 2020-Feb 2021) – 90 Days; Q2 (Mar 2021-May 2021) – 92 Days; Q3 = (June 2021 - Aug 2021) – 92 Days; Q4 = (Sept 2021-Nov 2021) – 91 Days; Q5 = (Dec 2021 - Feb 2022) -90 Days

Impact of Incident

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Peak Hour Proportion of ADT	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Direction Distribution	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Peak Hour Volume (vph)	867	777	743	1072	693	647	668	690	611	708
Capacity (veh/hr/lane)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Number of lanes	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hrs)	1	1	1	1	1	1	1	1	1	1
Time to Clear Queue (t) (hrs)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total # Vehicle Accumulated (A)	1,080	943	894	1,417	823	759	788	818	709	843
Total Delay (veh-hour)	132.4	101.0	90.8	228.0	76.9	65.4	70.6	76.0	57.2	80.8
Average Delay (hrs/veh)	0.12	0.11	0.10	0.16	0.09	0.09	0.09	0.09	0.08	0.10

Fuel Consumption Per Incident with Different Truck Percentages

0 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	78.1	59.6	53.6	134.5	45.4	38.6	41.7	44.9	33.7	47.7
Fuel Consumed (Truck) - gals of diesel/Incident	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	74.2	56.6	50.9	127.8	43.1	36.7	39.6	42.6	32.0	45.3
Fuel Consumed (Truck) - gals of diesel/Incident	7.6	5.8	5.2	13.1	4.4	3.8	4.1	4.4	3.3	4.6

10 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	70.3	53.6	48.2	121.1	40.9	34.7	37.5	40.4	30.4	42.9
Fuel Consumed (Truck) - gals of diesel/Incident	15.2	11.6	10.4	26.2	8.8	7.5	8.1	8.7	6.6	9.3

15 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	66.4	50.7	45.5	114.4	38.6	32.8	35.4	38.1	28.7	40.5
Fuel Consumed (Truck) - gals of diesel/Incident	22.8	17.4	15.7	39.3	13.3	11.3	12.2	13.1	9.9	13.9

20 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	62.5	47.7	42.9	107.6	36.3	30.9	33.3	35.9	27.0	38.1
Fuel Consumed (Truck) - gals of diesel/Incident	30.5	23.2	20.9	52.4	17.7	15.0	16.2	17.5	13.2	18.6

30 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	54.7	41.7	37.5	94.2	31.8	27.0	29.2	31.4	23.6	33.4
Fuel Consumed (Truck) - gals of diesel/Incident	45.7	34.9	31.3	78.7	26.5	22.6	24.4	26.2	19.7	27.9

40 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	40%	40%	40%	40%	40%	40%	40%	40%	40%	40%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	46.9	35.8	32.1	80.7	27.2	23.2	25.0	26.9	20.2	28.6
Fuel Consumed (Truck) - gals of diesel/Incident	60.9	46.5	41.8	104.9	35.4	30.1	32.5	35.0	26.3	37.2

50 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	39.1	29.8	26.8	67.3	22.7	19.3	20.8	22.4	16.9	23.8
Fuel Consumed (Truck) - gals of diesel/Incident	76.1	58.1	52.2	131.1	44.2	37.6	40.6	43.7	32.9	46.5

75 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	19.5	14.9	13.4	33.6	11.3	9.7	10.4	11.2	8.4	11.9
Fuel Consumed (Truck) - gals of diesel/Incident	114.2	87.1	78.3	196.7	66.4	56.4	60.9	65.6	49.3	69.7

100 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel Consumed (Truck) - gals of diesel/Incident	152.3	116.2	104.4	262.2	88.5	75.2	81.2	87.4	65.8	92.9

Appendix B. Sensitivity Analysis Computations—Closure Duration

Computation of AADT

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Length (miles)	8.5	19.1	61.3	19	130.9	50.7	28.2	35.3	49.8	402
Q1 (90 Days)	13,028	11,321	11,039	17,321	9,800	9,040	9,473	9,905	9,014	10,270
Q2 (92 Days)	16,649	14,974	14,554	21,351	12,973	12,362	12,586	12,810	11,657	13,490
Q3 (92 Days)	21,474	19,190	18,024	24,438	17,389	16,356	16,618	16,881	15,123	17,468
Q4 (91 Days)	18,647	16,500	15,604	22,335	15,119	13,972	14,608	15,243	13,293	15,267
Q5 (90 Days)	12,486	11,377	11,182	17,528	9,901	9,009	9,596	10,184	8,733	10,318
Total Annual Count	6,327,933	5,668,518	5,423,520	7,822,593	5,060,223	4,724,318	4,879,736	5,035,245	4,459,393	5,166,053
AADT (veh/day) (	17,337	15,530	14,859	21,432	13,864	12,943	13,369	13,795	12,218	14,154

Q1 = (Dec 2020-Feb 2021) – 90 Days; Q2 (Mar 2021-May 2021) – 92 Days; Q3 = (June 2021 - Aug 2021) – 92 Days; Q4 = (Sept 2021-Nov 2021) – 91 Days; Q5 = (Dec 2021 - Feb 2022) -90 Days

1-Hour Lane Closure

Impact of Incident

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Peak Hour Proportion of ADT	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Direction Distribution	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Peak Hour Volume (vph)	867	777	743	1072	693	647	668	690	611	708
Capacity (veh/hr/lane)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Number of lanes	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hrs)	1	1	1	1	1	1	1	1	1	1
Time to Clear Queue (t) (hrs)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total # Vehicle Accumulated (A)	1,080	943	894	1,417	823	759	788	818	709	843
Total Delay (veh-hour)	132.4	101.0	90.8	228.0	76.9	65.4	70.6	76.0	57.2	80.8
Average Delay (hrs/veh)	0.12	0.11	0.10	0.16	0.09	0.09	0.09	0.09	0.08	0.10

50 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	39.1	29.8	26.8	67.3	22.7	19.3	20.8	22.4	16.9	23.8
Fuel Consumed (Truck) - gals of diesel/Incident	76.1	58.1	52.2	131.1	44.2	37.6	40.6	43.7	32.9	46.5

2-Hour Lane Closure

Impact of Incident

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Peak Hour Proportion of ADT	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Direction Distribution	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Peak Hour Volume (vph)	867	777	743	1072	693	647	668	690	611	708
Capacity (veh/hr/lane)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Number of lanes	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hrs)	2	2	2	2	2	2	2	2	2	2
Time to Clear Queue (t) (hrs)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total # Vehicle Accumulated (A)	1,946	1,719	1,637	2,488	1,516	1,406	1,457	1,508	1,320	1,551
Total Delay (veh-hour)	1645.4	1432.2	1356.2	2180.4	1246.3	1147.8	1193.0	1238.9	1072.0	1278.0
Average Delay (hrs/veh)	0.85	0.83	0.83	0.88	0.82	0.82	0.82	0.82	0.81	0.82

50 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	485.4	422.5	400.1	643.2	367.7	338.6	351.9	365.5	316.2	377.0
Fuel Consumed (Truck) - gals of diesel/Incident	946.1	823.5	779.8	1253.7	716.6	660.0	686.0	712.4	616.4	734.8

3-Hour Lane Closure

Impact of Incident

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Peak Hour Proportion of ADT	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Direction Distribution	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Peak Hour Volume (vph)	867	777	743	1072	693	647	668	690	611	708
Capacity (veh/hr/lane)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Number of lanes	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hrs)	3	3	3	3	3	3	3	3	3	3
Time to Clear Queue (t) (hrs)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total # Vehicle Accumulated (A)	2,813	2,496	2,380	3,560	2,209	2,053	2,125	2,198	1,931	2,259
Total Delay (veh-hour)	4025.1	3539.9	3364.5	5204.4	3108.9	2877.3	2983.9	3091.5	2697.7	3182.8
Average Delay (hrs/veh)	1.43	1.42	1.41	1.46	1.41	1.40	1.40	1.41	1.40	1.41

50 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	1187.4	1044.3	992.5	1535.3	917.1	848.8	880.3	912.0	795.8	938.9
Fuel Consumed (Truck) - gals of diesel/Incident	2314.5	2035.4	1934.6	2992.5	1787.6	1654.4	1715.8	1777.6	1551.2	1830.1

4-Hour Lane Closure

Impact of Incident

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Peak Hour Proportion of ADT	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Direction Distribution	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Peak Hour Volume (vph)	867	777	743	1072	693	647	668	690	611	708
Capacity (veh/hr/lane)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Number of lanes	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hrs)	4	4	4	4	4	4	4	4	4	4
Time to Clear Queue (t) (hrs)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total # Vehicle Accumulated (A)	3,680	3,272	3,123	4,631	2,902	2,700	2,794	2,887	2,542	2,966
Total Delay (veh-hour)	7271.7	6424.1	6115.7	9299.9	5664.7	5254.0	5443.3	5633.9	4934.2	5795.3
Average Delay (hrs/veh)	1.98	1.96	1.96	2.01	1.95	1.95	1.95	1.95	1.94	1.95

50 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	2145.2	1895.1	1804.1	2743.5	1671.1	1549.9	1605.8	1662.0	1455.6	1709.6
Fuel Consumed (Truck) - gals of diesel/Incident	4181.3	3693.8	3516.5	5347.5	3257.2	3021.0	3129.9	3239.5	2837.2	3332.3

5-Hour Lane Closure

Impact of Incident

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Peak Hour Proportion of ADT	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Direction Distribution	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Peak Hour Volume (vph)	867	777	743	1072	693	647	668	690	611	708
Capacity (veh/hr/lane)	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200
Number of lanes	2	2	2	2	2	2	2	2	2	2
Duration of Closure (hrs)	5	5	5	5	5	5	5	5	5	5
Time to Clear Queue (t) (hrs)	0.25	0.21	0.20	0.32	0.19	0.17	0.18	0.19	0.16	0.19
Total # Vehicle Accumulated (A)	4,547	4,049	3,866	5,703	3,596	3,347	3,462	3,577	3,153	3,674
Total Delay (veh-hour)	11385.2	10084.8	9609.9	14467.1	8913.6	8277.8	8571.1	8866.1	7781.6	9115.5
Average Delay (hrs/veh)	2.50	2.49	2.49	2.54	2.48	2.47	2.48	2.48	2.47	2.48

50 Percent Trucks

Segment Number	N1	V1	N2	V2	N3	V3	N4	V5	N5	Total
Percent Truck	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Fuel Consumption Rate (PC) -- gal of gasoline/hr	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59	0.59
Fuel Consumption Rate (Truck)- gal of diesel/hr	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
Total Fuel Consumed (PC) - gals of gasoline/incident	3358.6	2975.0	2834.9	4267.8	2629.5	2442.0	2528.5	2615.5	2295.6	2689.1
Fuel Consumed (Truck) - gals of diesel/Incident	6546.5	5798.7	5525.7	8318.6	5125.3	4759.8	4928.4	5098.0	4474.4	5241.4

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