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Night Versus Day Work—Balancing Safety, Operations, and Constructability for Short-Term Operations on Two-Lane Roads

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Final Report VTRC 26-R11

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This project assessed the Virginia Department of Transportation's (VDOT) current AWH practices in Virginia on two-lane roads for short-term projects, the level of variability among practices, and opportunities to improve statewide consistency. Researchers developed and distributed a statewide survey on AWH, conducted interviews with representatives from other state departments of transportation, and analyzed data from Virginia's pavement management scheduling system. The results identified benefits to setting AWH at the district level rather than implementing statewide AWH. The work also identified specific areas that may benefit from statewide consistency without overly affecting local flexibility on decision making. The report recommends developing a framework for decision making and conducting outreach in regard to the existing decision-making tools.

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In Cooperation with the U.S. Department of Transportation
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ABSTRACT

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INTRODUCTION

The Virginia Department of Transportation (VDOT) inserts allowable work hours (AWH), also known as Allowable Closure Hours or Limitations on Operations, requirements into all contracts that limit when maintenance and construction activities can occur. These AWH are typically based primarily on balancing the operational impacts on drivers, the environment, property owners, and construction duration, cost, and complexity implications.

Most VDOT districts have established and published standardized AWH for their interstates, limited access highways, and principal arterials. However, AWH are often established on a project-by-project basis for two-lane facilities, particularly for short-term operations such as paving schedules, which require extensive flagging. This discrepancy creates variability from district to district and even within the same district. Inconsistencies could partly arise from different levels of "pain tolerance"—the degree of queuing and operational impacts that a district is willing to tolerate to allow the work to be completed in a reasonable length of time.

AWH can be set for typical weekdays and weekends, planned special events, or holidays. The VDOT (2022) *Road and Bridge Specifications* establishes statewide policy for restrictions around major state and federal holidays but allows each district to make decisions regarding typical weekdays, weekends, and planned special events. The advantages and disadvantages of AWH restrictions on typical weekdays and weekends are numerous.

Factors that influence districts to establish more restrictive AWH (i.e., restricting work to nights and weekends) include:

- Minimizing queuing and operational delays from lane closures during peak traffic periods.
- Reducing citizen complaints about traffic impacts near their properties.
- Decreasing the risk of rear-end crashes arising from long queues.
- Considering environmental restrictions (e.g., the effects of work on threatened and endangered species).

Factors that influence districts to establish less restrictive AWH include:

- Allowing for quicker overall construction duration and more flexible contractor scheduling, which typically correlates with reduced bid prices. For paving schedules, it is common for the same contractor to be awarded multiple road segments in an area, so the complexity of scheduling for that contractor is magnified if multiple roads have different

restrictions. This complexity is also magnified for construction and maintenance activities that are temperature or weather sensitive.
- Reducing worker injury risks (crashes or workplace injuries arising from inadequate lighting or fatigued workers) and worker perception of safety associated with night work.
- Assessing constructability issues associated with night work. For example, cooler temperatures can inhibit temperature-sensitive work, such as asphalt and pavement markings; quarries and concrete plants may not operate at night; and workers may make more mistakes because of fatigue or inadequate lighting.
- Considering the effects of nighttime work noise, including citizen complaints and local noise ordinances.

These factors and differences in the ways they are prioritized across districts may result in significant variation between and within districts regarding the level of AWH restrictiveness.

PURPOSE AND SCOPE

The purpose of this research was to determine current VDOT practices and the level of statewide variability regarding AWH requirements on two-lane undivided roads. This insight will enable VDOT to understand whether it is possible to increase consistency in AWH requirements across the state while accounting for different characteristics between the various regions. In addition, national best practices and other statewide practices will be identified.

A sample of work zone contracts was reviewed, focusing on the following:

- Work zone sites limited to those on undivided, two-lane, non-limited access roads.
- A spatially and geographically diverse sample.
- Work zones on roads with a variety of traffic volumes.
- Projects with various proximities to school zones and various work zone lengths.

The sample scope did not include special work-hour restrictions for major events (e.g., events at large venues such as stadiums or racetracks) because these restrictions likely would be reviewed on a case-by-case basis, and standard guidelines may not apply. Moreover, this project's scope did not include VDOT's policies for holiday restrictions, which are established on a statewide basis in the *Road and Bridge Specifications* (VDOT, 2022), and did not analyze VDOT's AWH policies for multilane highways.

METHODS

Review National Best Practices

This task determined whether best practices exist nationally or among other state departments of transportation (DOTs) for setting AWH. Researchers accomplished this task by reviewing the existing literature and contacting representatives at other state DOTs. The literature review examined existing research on the effects of night versus daytime work zones.

Survey VDOT District Allowable Work Hour Practices

The research team distributed a survey to district staff to identify district procedures for setting AWH for lane and shoulder closures for short-term operations on two-lane roads. The survey was sent to 119 VDOT employees with the following titles: District Traffic Engineers, District Construction Engineers, District Maintenance Managers, District Traffic Operations Directors, and VDOT Residency Administrators. Survey recipients were also encouraged to share the survey with all staff that have a role in establishing short-term lane closure hour restrictions on two-lane roads.

Assess Existing Flagging Analysis Tool and Identify Possible Improvements

An existing tool developed by the Virginia Transportation Research Council (VTRC) analyzes capacity and delay impacts of short-term flagging operations using *Highway Capacity Manual* (HCM) equations (Transportation Research Board, 2016; VTRC, 2018). VDOT staff were surveyed to determine the level of familiarity with the existing tool and whether any improvements were desired to improve the tool. For example, additional safety, operational, or delay cost components may be added to improve decision making for flagging operations.

Review Paving Schedule Allowable Work Hour Data

This task involved reviewing a sample of 2024 paving schedules. VDOT paving schedules differ from other types of maintenance contracts in that they are submitted once a year, all at the same time. The sample included all districts and a variety of work types. Researchers examined AWH restrictions in the data to determine the level of statewide consistency for similar contracts and to establish patterns that may form the basis for statewide guidelines. Factors that were considered and that are known to affect AWH requirements included average daily traffic (ADT) volume, speed limit, land use, functional class of road, type of work, local laws and ordinances, and schools.

RESULTS

Review National Best Practices

Literature Review

Safety Effects of Night versus Day Work Zones

Several studies have examined the effect of ambient light levels and roadway lighting on work zone safety. This research has practical implications because work zone AWH restrictions frequently limit work exclusively to daytime or nighttime—a decision with safety and operational consequences.

Several studies have used statewide crashes to model characteristics that affect the likelihood of work zone crashes or the possibility of increased injury severity in the event of a

crash. Mohammed et al. (2023) analyzed all work zone crashes in Kentucky from 2016 through 2020 and found an increased likelihood of work zone crashes during daylight hours compared with night hours. A Pennsylvania study, which incorporated work zone crash, weather, incident, and speed data, found a causal effect between work zones and crash risks during the daytime but not at night (Zhang et al., 2022). Other studies examined work zone crash injury severity risks. Osman et al. (2018) used 10 years of Minnesota crash data and a mixed generalized ordered response probit model, finding that nighttime temporal periods (evening and late night) increased the risk of severe injuries. A multinomial-logit model of Nebraska work zone crashes found that the probability of serious or visible injuries is decreased compared with possible injuries for daytime crashes (Khattak and Farooq, 2023).

Additional literature explored the characteristics affecting work zone crash occurrence or injury severity but is limited to interstate crashes. Harb et al. (2008) used 3 years of Florida freeway crash data and regression models and found poor lighting to be a risk factor for work zone crashes. A study of highway work zone fatal and injury crashes in Kansas found that nighttime conditions with no streetlights increased the likelihood of a fatality in the event of a crash (Li and Bai, 2009). In Texas, Ullman et al. (2005) estimated expected crash increases due to daytime and nighttime work zones. The authors found that in Texas, nighttime work zones increase crash rates more than daytime work zones, but this finding is offset by low nighttime annual average daily traffic (AADT) volume, leading to lower crash expectancies at night. When extrapolating results to U.S. highways, results were less consistent, and roads with higher AADT or higher numbers of lanes had higher crash expectancies for nighttime than daytime work zones.

Studies outside the United States present similar findings. Santos et al. (2021) analyzed all work zone crashes from 2013 to 2015 in Portugal using binary logistic and probit regression analyses. Good daytime luminosity conditions (not dawn, dusk, night, or dazzling sun) were found to decrease the likelihood of a crash. A qualitative study of work zone workers in Queensland, Australia, found that workers perceive nighttime work to be hazardous (Debnath et al., 2015). Highway work zone crashes in Egypt from 2010 through 2016 were analyzed using mixed logit models separately for day and night crashes (Zhang and Hassan, 2019). The study found that some characteristics were only significant in one model or the other, and among characteristics significant in both models, the effects were vastly different. For example, rain increased the likelihood of a fatality at night but decreased the likelihood during the day.

The existing literature also highlighted that the factors affecting work zone safety during daytime and nighttime are different and can be analyzed separately to identify factors affecting crash risk. Das et al. (2024) found temporal instability in factors contributing to work zone crashes using fatal work zone crashes in the United States. Similarly, Al-Bdairi (2020) found that different factors affected injury severity in highway work zone crashes in Washington state, depending on the time of day. Mokhtarimousavi et al. (2021) used mixed logit and support vector machine models to study all work zone crashes in Florida from 2015 through 2017. Researchers determined that daytime and nighttime crashes should be modeled separately to effectively determine the contributing factors of daytime and nighttime crashes.

Regional differences, work zone crash data location (all road types versus interstates), work zone crash severity data (all crash severities versus fatal crash data), and work zone crash

outcome (crash expectancy, crash risk, or crash severity) complicate the literature. The potential for an increased risk of crashes during a daytime or nighttime work zone may be region and site specific. Studies tend to agree that when crashes do occur in a work zone, they are more severe at night and less severe during the day.

Operational Analysis of Work Zones on Two-Lane Roads

For two-lane work zones where one lane is closed to travel, there is a significant operational impact that requires traffic control at either end of the work zone. Flaggers, automated flagger assistance devices, temporary traffic signals, and pilot cars are methods used to maintain traffic control. Two-lane work zones with one-way traffic may be modeled by two-phase intersection control (fixed or actuated) methods. Models may be based on signalized intersection theories of capacity and delay or on microsimulation models. The HCM contains methods for modeling a two-lane work zone with a lane closure as a signalized intersection (Transportation Research Board, 2016). The established VDOT tool for analyzing flagging operations is based on these HCM methods.

Because of the operational impact of road closures on two-lane roads, some literature seeks to optimize flagging or signals to minimize user and agency costs. Chen and Schonfeld (2004), Chien et al. (2002), and Schonfeld and Chien (1999) carried out a series of studies that considered work zone characteristics to develop optimization methods of agency and user costs. Cedar (2010) explored optimizing lane closure length by minimizing delay and operational costs under traffic signal control. Finley et al. (2015) used field studies, cost analyses, and motorist delay analyses to compare different methods of traffic control on two-lane highways with one lane closures. Schrock et al. (2016) compared conditions involving portable traffic signals and flaggers to evaluate red light running violations, vehicle delay, queue lengths, signal timing operations, and field operations.

Interviews

Informational interviews were conducted with states near Virginia that responded to a request for an interview. Representatives from six state DOTs were interviewed, including Tennessee, Pennsylvania, Ohio, West Virginia, North Carolina, and South Carolina. The interviews began by providing the interviewee with some background about the structure of VDOT, how short-term maintenance and paving work zones on two-lane roads are managed statewide, and what challenges VDOT faces because of regional differences. This introduction was followed by asking the interviewees a series of questions with the purpose of understanding how other DOTs are similar and different from VDOT on this topic. The types of questions asked varied slightly based on the informal nature of the interviews but included topics such as:

- The structure of the state DOT (districts), including regional differences in the state.
- Statewide or regional guidance regarding AWH on two-lane roads for short-term maintenance and paving contracts.
- Decision-making processes (guidance versus case-by-case basis).
- Pain-tolerance thresholds, such as maximum delay or queue.
- Contractor feedback on existing processes.

- Components that are working well and components that are challenging.
- Software or spreadsheet tools to aid in decision making.
- Any additional helpful thoughts.

Like VDOT, all six DOTs have regional breakdowns that define their structure. Tennessee DOT has 4 regions with 3 districts within each region, Pennsylvania DOT has 11 districts, Ohio DOT has 12 districts, West Virginia DOT has 10 districts, North Carolina DOT has 14 districts, and South Carolina DOT has 7 districts. Respondents routinely described a similar process to VDOT, in which all districts follow statewide guidance on topics for which such guidance exists. However, for other topics, respondents have leeway to work independently to make decisions that best serve their own districts. Some states, like Virginia, have regional differences with variations in population density and geography. Ohio, for example, has snowier regions in the northern part of the state, plains in the western part of the state, and mountains in the eastern part of the state. Several states described districts that operate differently because of large urban areas.

Regarding statewide guidance on AWH for short-term maintenance projects on two-lane roads, most interviewees described a process that allows for district decision making and flexibility. For example, Tennessee has no statewide AWH guidelines for two-lane roads. Headquarter construction offices are given latitude in decision making and use local knowledge to make case-by-case decisions. Daytime AWH are preferred, when possible, based on worker preference and cost considerations, with the understanding that nighttime work is appropriate in situations such as on higher AADT roads. In Pennsylvania, two-lane road AWH decisions are also made at a district level, supported by historical volume data. Ohio AWH decisions are typically left to the 12 districts for case-by-case decisions on two-lane roads. Similarly, North Carolina districts set their own AWH for two-lane roads. Typically, districts try to do as much daytime work as possible, but some variation exists between the 14 districts because of regional differences in urban and rural areas, and more night work occurs in urban areas. In some less frequent cases, the North Carolina central office is asked to assist in developing AWH. South Carolina is the only state that has statewide guidance on AWH for lane closures and flagging on two-lane roads. The statewide guidance uses a volume-based threshold of 800 vehicles per hour per lane for when closures on two-lane roads may occur. Exceptions may be made on a case-by-case basis depending on knowledge of what has worked in the past or by special request from a contractor. No interviewees described written AWH guidelines for two-lane roads.

When asked whether states use metrics such as a maximum queue or a maximum delay when planning work zones, some states described the goal as keeping queues from forming. Other states described thresholds like what their state aims for on limited-access roads of 3/4 to 1 mile.

Regarding working with contractors and receiving feedback about existing AWH, Tennessee and South Carolina representatives stated that AWH are in the contract bids, and contractors are aware of what is expected at that stage. Representatives from Pennsylvania, Ohio, and South Carolina report that contractors sometimes give feedback when changes to AWH are requested on a particular project, and in Pennsylvania, contractors sometimes express an interest in more statewide consistency.

When asked about what practices are working well and what may be a challenge, interviewees gave a variety of responses, as expected. The interviewees sometimes mentioned interstate processes, likely because more interstate tools and processes are involved.

Comments about what works well included:

- The advent of probe-based traffic data has supported more data-driven decision making (Tennessee).
- The process of gathering volume data and having a statewide guideline works smoothly, for the most part (South Carolina).

Comments about what presents a challenge included:

- AWH must be based on factors such as when concrete plants are open and avoiding noise ordinances, which are becoming more common (Ohio).
- Maintaining one lane of operations without affecting constructability. Full midday closures from 9 am to 3 pm may be considered more frequently in the future to address this challenge (North Carolina).
- Collecting volume data to support the decision-making process (South Carolina).

States discussed using data-driven tools or software to help support AWH decision making. Comments included using StreetLight (an analytics provider platform) for volume data, flagger user cost tools, HCM approaches for queuing, and Replica (a web-based mobility data platform) to assist with detour planning.

Survey VDOT District Allowable Work Hour Practices

From the pool of recipients, 53 survey responses were received. Thirty-eight of those responses were complete surveys, and 15 were partial responses for which the recipient did not fully complete the survey. Partial responses were retained for analysis, resulting in varying numbers of responses for individual questions.

Question 1—Responses by District and Residency

Multiple responses were received from all nine VDOT districts, and responses were captured from 18 of the 31 residencies (58%), as Figure 1 shows.

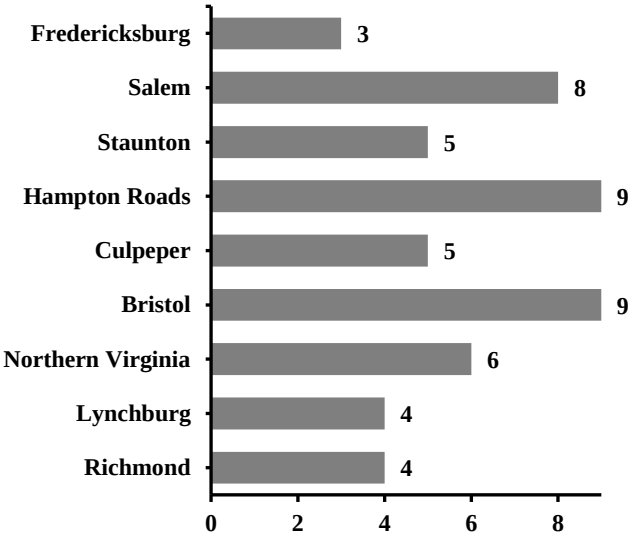


Figure 1. VDOT District Responses (N = 53)

Question 2—Roles Responsible for Setting Allowable Lane and Shoulder Closure Hours

The second survey question asked who is responsible for setting allowable lane and shoulder closure hours in the respondent's district. Respondents could select multiple responses, and most did so. The District Traffic Engineer (or designee) and District Traffic Operations Director (or designee) were the most commonly selected responses (Figure 2). Other responses included District Engineer, Signal and Freeway Operations Engineer, Resident Engineer, and the Residency. When the responses are analyzed by district, Bristol consistently cites the District Traffic Operations Director. Northern Virginia (NOVA) consistently cites the District Traffic Operations Director and the District Traffic Engineer. For all other districts, responses were less consistent.

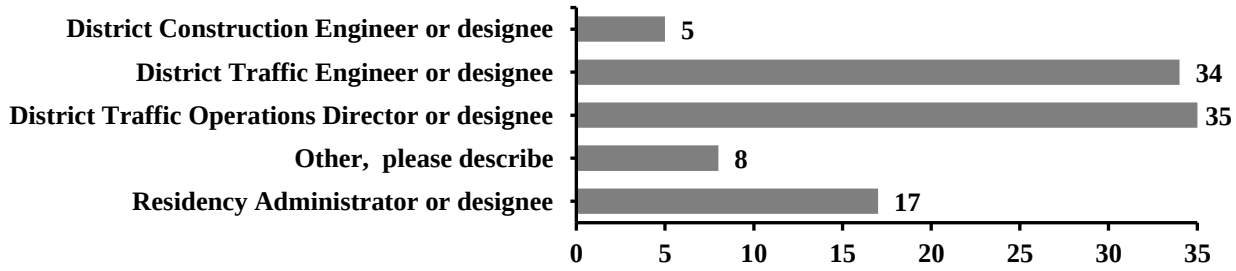


Figure 2. Who is Responsible for Setting Allowable Lane and Shoulder Closure Hours Restrictions in Your District (N = 53)

Question 3—Procedure for Establishing Allowable Lane and Shoulder Closure Hours

The third survey question asks how districts establish allowable lane and shoulder closure hours for short-term maintenance and construction activities on two-lane roads. The most frequent response, selected by 23 respondents (43%), was that documentation or guidance listing allowable lane and shoulder closure hour requirements for different circumstances is used (Figure 3). Another 18 respondents (34%) selected that the hours are decided on a case-by-case

basis. Most respondents who checked "Other" used the text box to describe that they use both procedures, have written guidelines, and make decisions on a case-by-case basis. As a followup to this question, respondents were asked to provide that documentation.

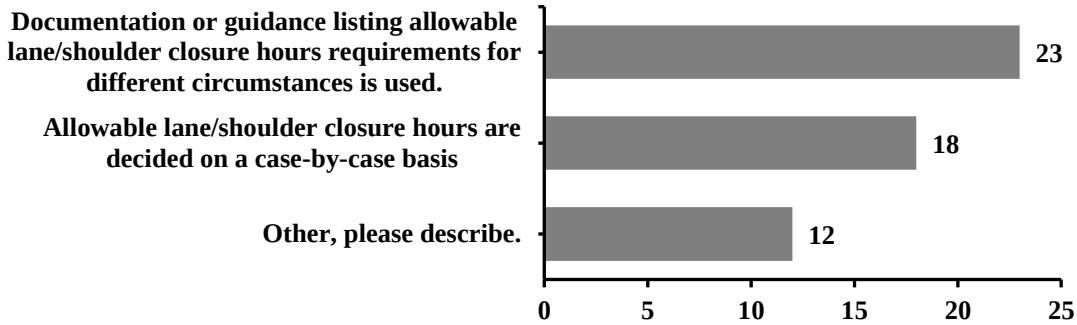


Figure 3. How Districts Establish Allowable Lane and Shoulder Closure Hours for Short-Term Maintenance and Construction Activities on Two-Lane Roads (N = 53)

Question 4—Factors Considered in Setting Allowable Lane and Shoulder Closure Hours

Question 4 asks what factors are considered in the current practice for setting allowable lane and shoulder closure hours. Respondents were presented with many choices (Figure 4). Most respondents (82%) selected day of the week, AADT, and delays as the factors influencing allowable lane and shoulder closure hours. The cases in which respondents selected "Other," the responses frequently included factors such as hourly volumes and special or seasonal events.

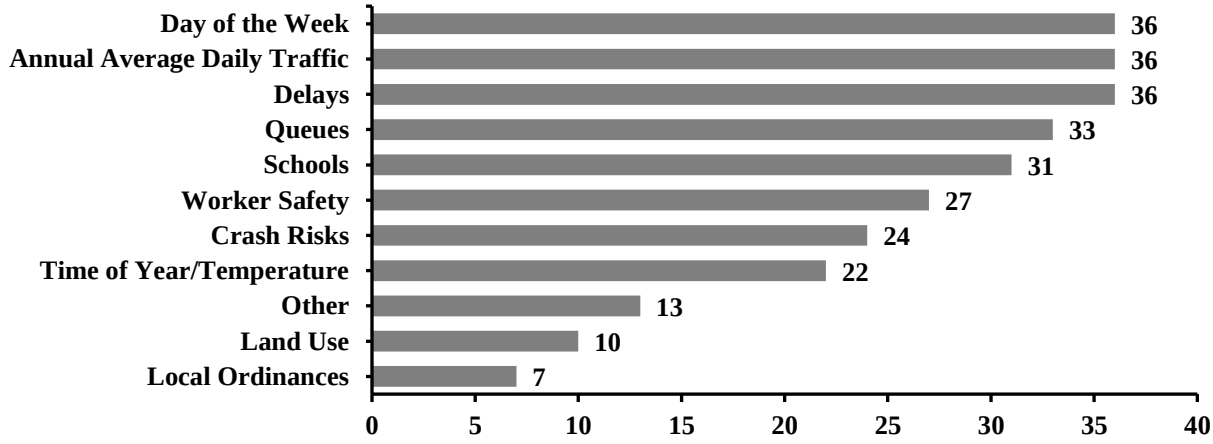


Figure 4. Factors Influencing Allowable Lane and Shoulder Closure Hours (N = 44)

Question 5—Thresholds Contributing to Allowable Lane and Shoulder Closure Hours

The next question asked whether districts had quantifiable pain thresholds for setting allowable lane and shoulder closure hours. The question asked whether a value for "minutes of delay" or "miles of queue" was used. Most responses stated that "No threshold is specified" (13 responses) or "Other" and described various other methods for setting closure hours. Figure 5 shows the values given for the few responses with quantifiable thresholds. The average response for minutes of delay tolerated was 17 minutes among 9 responses. The average number of miles of queue tolerated was about 2 miles across 7 responses. The responses varied considerably. For

maximum delay, responses ranged from 8 to 30 minutes, and for maximum queue, the answers ranged from 0.25 to 5 miles, indicating that "pain tolerance" varies considerably across districts.

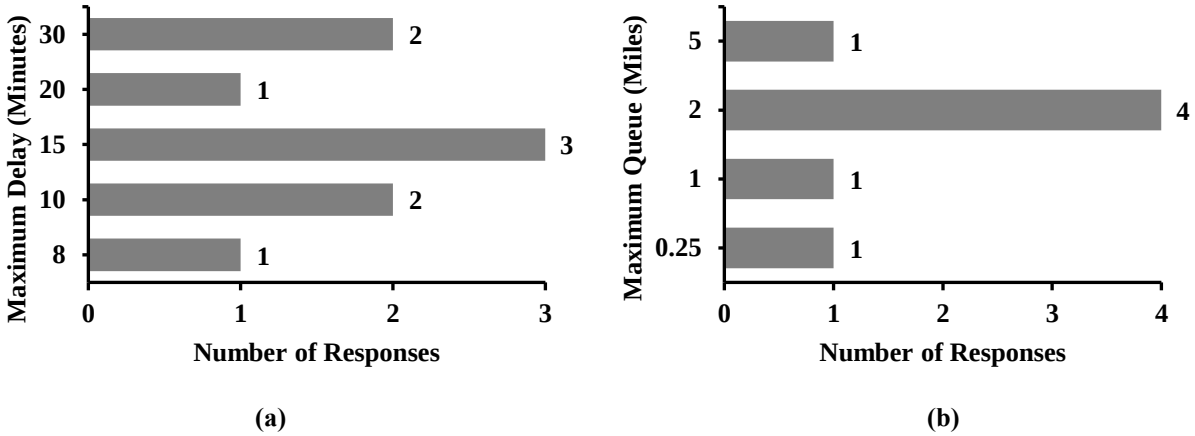


Figure 5. District Tolerance: (a) Minutes of Delay (N = 9); (b) Miles of Queue (N = 7)

Questions 6 and 7—Allowable Lane and Shoulder Hours Process Across Primaries and Secondaries, Residencies and Localities

Respondents were then asked whether the process for setting allowable lane and shoulder closure hours varies by primary or secondary roads, or by residency or locality. As Figure 6a shows, about one-half of the respondents said the process does not vary for primaries and secondaries. Among those who said the process does vary, many explained that their district has guidelines for AWH on primaries and more flexible or no guidelines on secondaries. Most respondents stated that the process for setting allowable lane and shoulder closure hours does not vary by residency or locality. Of the respondents who stated that the process varies, some respondents said that decisions are made by leaning on the residency for local knowledge.

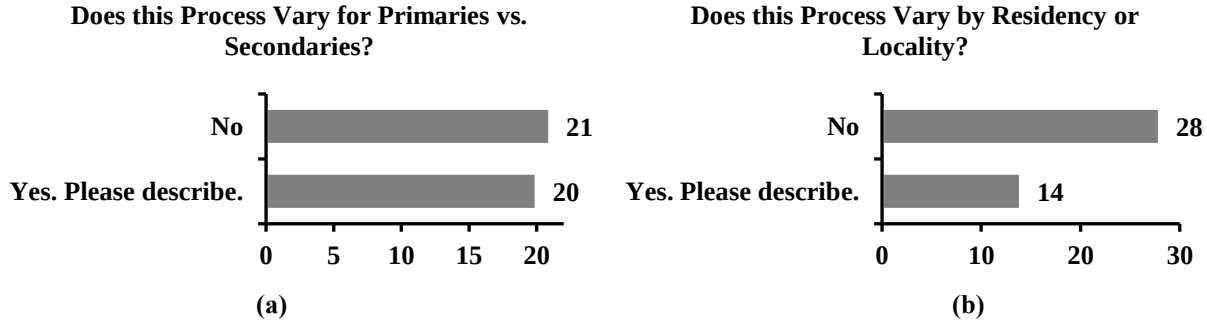


Figure 6. How the Allowable Lane and Shoulder Closure Hour Process Varies by: (a) Primaries and Secondaries (N = 41); (b) Residencies and Localities (N = 42)

Question 8—Importance of Consistency in Allowable Lane and Shoulder Closure Hours

The next question asked respondents how important it is for allowable lane and shoulder closure hours to be consistent across VDOT districts (Figure 7). The median response was that consistency is "slightly important." Responses trended toward consistency not being important, with only 23% of respondents stating they feel consistency is very or extremely important. When

responses are broken down by the respondents' job duties (District Construction, District Maintenance, District Traffic, Residency, Other), the median response for each group is "slightly important," except for District Maintenance staff that more frequently stated that consistency is "moderately important." Breaking down the responses by district, the median response for Culpeper, Fredericksburg, Lynchburg, Richmond, Salem, and Staunton was "slightly important." The median response for Bristol, Hampton Roads, and Northern Virginia was "moderately important."

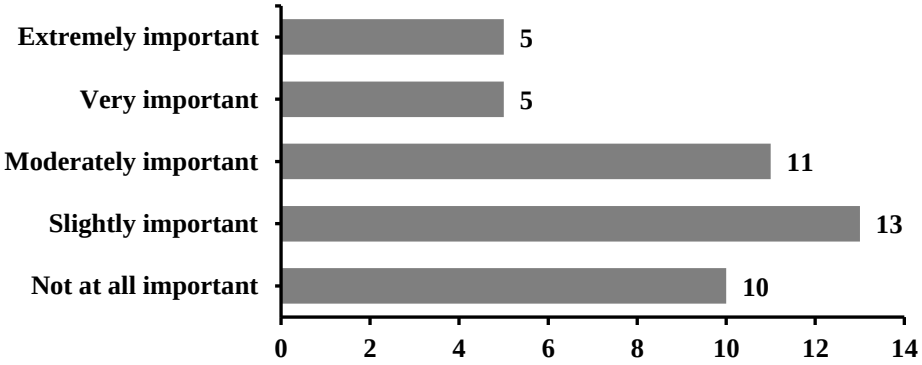


Figure 7. Responses on How Important It Is that Allowable Lane and Shoulder Closure Hours are Consistent Across VDOT Districts (N = 44)

Questions 9 and 10—What is Working Well and What is a Challenge

For the next series of questions, respondents were asked what is working well (question 9) and what is a challenge (question 10) for the current process for setting Allowable Lane and Shoulder Closure Hours on two-lane roads. When asked what is working well, respondents described the major themes, which included the following:

- Districts described that the overall process for setting AWH works well, describing no issues and few complaints.
    - "Our current methodology works well 95% of the time. There will always be hiccups where you have to adjust on the fly" (Staunton).
    - "Our current NOVA Lane Closure policy is working well" (Northern Virginia).
    - "No issues" (Hampton Roads).
    - "We don't get too many complaints from contractors regarding the hours" (Salem).
- Respondents mentioned that good communication with those who have local knowledge and the flexibility to follow the local knowledge also allow the AWH process to work well.
    - "Traffic Engineering (TE) and the residency communicating" (Lynchburg).
    - "Ability to make the decision here based on our immediate knowledge of traffic and patterns in our area" (Staunton).
    - "Flexibility to meet local needs" (Salem).
    - "Let residency dictate it with recommendations from TE based on volume" (Fredericksburg).

- Respondents described that having documented guidelines to rely on is helpful.

    - "The documented closure guidelines from District Operations" (Richmond).
    - "Following guidance set forth in VDOT Road and Bridge Standards Section 108.02" (Bristol).
    - "Having allowable hours as a guide on primary routes is a helpful starting place" (Fredericksburg).

When asked to describe what is challenging, respondents described the major trends, including the following:

- Some respondents reiterated that the AWH process is working well and that they do not have challenges to report.

    - "So far, hasn't been an issue" (Staunton).
    - "Nothing" (Bristol).
    - "I do not see any" (Lynchburg).

- Managing citizen complaints and resident expectations was cited as a challenge.

    - "From my perspective, the process is too subjective and based too heavily on gut-feel and the fear of citizen complaints" (Lynchburg).
    - "The current public culture is unlike anything in the past. Nobody wants to be inconvenienced or delayed" (Staunton).
    - *"*Local expectation of the citizens" (Northern Virginia).
    - "[The] tendency is to be more conservative towards traffic and less concerned about accomplishing the work efficiently and economically" (Salem).

- Balancing conflicting needs and wants between industry and the public and regional differences in public expectations were also identified.

    - "Industry desires more daytime working hours and longer working periods" (Salem).
    - "Being too restrictive can greatly affect [the] ability of crews to work in a safe and efficient manner" (Bristol).
    - "Residencies have different pain tolerances" (Hampton Roads).

- Lack of local information, data, tools, and time was identified as a barrier for analysis and planning.

    - "Not having software analysis tools to analyze traffic volumes and provide queue lengths and delay, etcetera" (Hampton Roads).
    - "Lack of knowledge in contractor schedule, resources, means, and methods during project development" (Staunton).
    - "The amount of time spent looking up traffic data and land use in the area to understand the potential impact of flagging operations" (Salem).

- "Getting good data on hourly traffic patterns" (Culpeper).

Questions 11–14— Exceptions to the Allowable Lane and Shoulder Closure Hours

The next series of questions asked respondents how exceptions are made to the allowable lane and shoulder closure hours during both the design phase (Table 1) and the construction phase (Table 2), as well as how frequently exceptions are made. These questions were posed only to respondents who answered question 3 by saying that their district uses guidance or documentation to set AWH on two-lane roads. As a result, the number of responses for these questions is much fewer than for other questions. Table 1 shows the responses to how exceptions are made to the guidance during the design phase and how frequently. Six responses were provided, which indicated that exceptions were made between 10 and 50% of the time.

Table 1. Who Makes Decisions (N = 14) and How Frequently Are Exceptions Made (N = 6) during the Design Phase

District	Who Makes Exception Decisions	How Frequently Are Exceptions Made
Richmond	Emergency Operations, DTE	10%
Northern Virginia	Operations, Regional Operations Director, DTE/DTOD, Traffic Engineering	50%, 30%
Bristol	DTOD	50%
Culpeper	DTE, DTOD, District, and Residency	30%
Hampton Roads	DTOD, DE, DTE, DME, DCE	10%

DCE = District Construction Engineer; DE = District Engineer; DME = District Maintenance Engineer; DTE = District Traffic Engineer; DTOD = District Traffic Operations Director.

Table 2. Who Makes Decisions (N = 14) and How Frequently Are Exceptions Made during the Construction Phase (N = 8)

District	Who Makes Exception Decisions	How Frequently Are Exceptions Made
Richmond	District Operations, DTE, DTOD	20%
Northern Virginia	Operations, Traffic Engineering, DTE, DTOD	40%, 50%
Bristol	DTOD	50%
Culpeper	ACE/CM, Residency, Traffic, DTE, DTOD, DE	10%, 30%
Hampton Roads	ACE and DTE/DTOD, DTE through DE	70%
Salem	TOC	30%

ACE = Area Construction Engineer; CM = Construction Manager; DE = District Engineer; DTE = District Traffic Engineer; DTOD = District Traffic Operations Director; TOC = Traffic Operations Center.

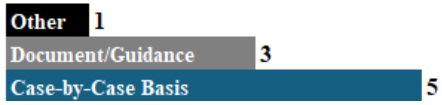
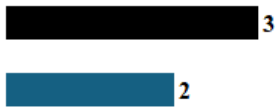
Table 2 shows the responses to who makes exceptions to the guidance during the construction phase and how frequently. Eight responses were provided. Exceptions were estimated to occur between 10 and 70% of the time.

Question 15—VDOT District Allowable Lane and Shoulder Closure Hours Documentation

Question 15 asked respondents to upload a copy of their district's allowable lane and shoulder closure hours documentation. Follow-up emails were sent to respondents to acquire documentation for additional districts. Table 3 summarizes district AWH and survey responses. The first column is the district, the second column details the roads included in the AWH written guidance, and the third column describes what factors are considered in the AWH written

guidance. The fourth and fifth columns break down the survey responses to question 3 by district. Question 3 asked how AWH are set in each district—by using documentation and guidance, on a case-by-case basis, or other. Column four is the breakdown of the three response options by district, and column five describes the responses for those who checked "Other." District AWH guidelines vary significantly on the roads included (interstates, arterials, primaries, secondaries, etcetera) but share similarities in the way AWH are written. Detailed AWH are often provided for work zone closure type (one-lane, shoulder), road section (by milepost), direction (N, E, S, W), day of the week, season, and reservable or express lanes if present. AWH may vary by some or all these factors. District AWH guidelines also vary in the level of documented detail for making exceptions to the guidance. Some of the district AWH documents are formulated as AWH tables, others have written descriptions of the exception process, including some or all of the following: the circumstances under which exception requests may be submitted; who the various points of contact are; what levels of escalation may be required for different circumstances; the information included in a request; when requests must be submitted; and the timeframe for approving requests. Table 3 describes AWH guidelines by district.

Table 3. Districts and Allowable Work Hour (AWH) Written Guidance

District	Roads and Segments with AWH Written Guidance	Written Guidance AWH Breakdown	Survey Responses on Two-Lane AWH Decision Making (Question 3)	Survey "Other" Comments
Bristol	Interstates 77, 81, 381; US 23, 19, 52; Routes 11, 140, 75, and 11/58; Business 23; Old Airport Hwy	Closure type, road section, direction, day of week, season		AWH in special provisions in land use permits.
Culpeper	Interstates 64, 66; US 29; Routes 3, 15, 17, 20, 22, 28, 53, 55, 208, 211, 215, 229, 522, 601, 605, 606, 631, 643, 649, 654, 656, 666, 676, 694, 729, 742, 743, 1140, 1150	Closure type, direction, section, day of week		
Fredericksburg	Interstate 95; All routes and segments in Caroline, Essex, Gloucester, King George, King and Queen, King William, Lancaster, Matthews, Middlesex, Northumberland, Richmond, Spotsylvania, Stafford, and Westmoreland Counties; City of Fredericksburg	Closure type, direction, section, day of week, season		AWH exist for interstate, primary, and some secondary. Else case-by-case.
Hampton Roads	Interstates 64, 95, 264, 464, 564, 664; Routes 10, 32, 143, 164, 171, 179, 199, 321, 184; US: 13, 17, 58, 60, 258, 460	Closure type, direction, section, day of week, season, managed lanes		For roads not in doc, residency sets case-by-case based on count data and knowledge.
Lynchburg	Routes 460, 460BUS, 29, 29BUS, 24, 501, 360, 58	Closure type, segment, day of week		
Northern Virginia	Interstates 66, 395, 95, 495; Routes 267, 28; Some major primary arterials (Routes 7, 15, 26, 110, 123, 234, 286); primary and major secondary arterials (with average daily traffic greater than 10,000 vehicles per day); secondary roadways	Closure type, direction, section, day of week, direction, reservable lanes, express lanes		
Richmond	Interstates 95, 64, 295, 85, and 195; State Routes 288, 150, 76, 10, 5, 6, 30, 33, 54, 73, 106, 147, 155, 156, 157, 161, 197, 249, 273, 356, 602, 604, 613, 615, 617, 621, 623, 625, 627, 632, 636, 637, 638, 640, 642, 643, 647, 650, 651, 653, 655, 656, 657, 659, 672, 675, 678, 683, 686, 711, 717, 720, 746, 754, 802, 904, 1261; US 1, 33, 60, 250, 301, 360, 522	Closure type, direction, section, day of week		For roads not in doc, AWH set on case-by-case basis.
Salem	Interstates 77, 81, 581; US 220; Routes 8, 11, 114, 117, 122, 220, 221, 419, 460; Primary Routes (1–599)	Closure type, direction, section, day of the week, season		AWH exist for higher volumes roads. For roads not in doc, AWH set on case-by-case basis.
Staunton	Interstates 81, 64, 66; primary arterials	Closure type, direction, section, day of the week, season		Follow written AWH hours.

Bristol District Allowable Work Hours

Researchers reviewed the Bristol District Special Provision for Limitation of Operations dated July 10, 2023. The provision provides AWH for selected interstates (77, 81, and 381) and roadways (US 23, 19, and 52; Routes 11, 140, 75, and 11/58; Business 23; and Old Airport Highway). Interstate AWH are broken down by the closure type (dual-lane, single-lane, or shoulder), section, direction, and day of the week. Other roads are broken down by section and the day of the week.

Culpeper District Allowable Work Hours

Researchers reviewed the Culpeper District Procedural Memorandum dated September 18, 2023, the Culpeper District Allowable Work Hours Lane Closure Exception Request Forms for Residency Review and District Review, and AWH Tables dated July 22, 2024. The Culpeper District's AWH for 2024 included lane and shoulder closures on Interstates 64 and 66 and lane closures on many other roads (State Routes 3, 15, 17, 20, 22, 28, 53, 55, 208, 211, 215, 229, 522, 601, 605, 606, 631, 643, 649, 654, 656, 666, 676, 694, 729, 742, 743, 1140, and 1150 and US 29). AWH detail the type of closure to which the AWH applies, such as lane or shoulder closure, and the day of the week (Monday through Thursday, Friday, Saturday, or Sunday). The Culpeper District also provided the lane closure exception request forms, which may be for residency or district review and include request details and the timeframe for submitting requests. Standard school restrictions are defined in the memorandum.

Fredericksburg District Allowable Work Hours

Researchers reviewed Fredericksburg's I-95 AWH documentation, which breaks down I-95 into segments and provides AWH based on direction (northbound or southbound), the day of the week (Monday through Thursday, Friday, and Saturday through Sunday), and the type of closure (shoulder, single-lane, two-lane, or complete). In addition, Fredericksburg has guidance on allowable lane closure hours for all other routes and segments in Caroline, Essex, Gloucester, King George, King and Queen, King William, Lancaster, Matthews, Middlesex, Northumberland, Richmond, Spotsylvania, Stafford, and Westmoreland Counties and the City of Fredericksburg (dated August–September of 2015). The guidance gives a standard policy for all routes and segments in each county and then lists specific sections of routes where the policy diverges from the standard.

Hampton Roads District Allowable Work Hours

Researchers reviewed the document "Allowable Lane Closure Hours for the State Highway System in the Hampton Roads District" dated January 2024. AWH are provided for Interstates 64, 95, 264, 464, 564, and 664 and other select roads, such as State Routes 10, 32, 143, 164, 171, 179, 199, and 321 and US 13, 17, 58, 60, 258, and 460. AWH are broken down by work zone location (work beyond the shoulder, shoulder closures, lane closures, full directional closures, ramps, and managed lanes). The document also provides guidance on the procedure for specific closure types, a methodology to update interstate allowable lane closures using the VTRC Allowable Lane Closure Hours Spreadsheet Tool, the use of the Lane Closure Advisory

Management System, the use of VA Traffic, procedures for express lanes, precedence guidance, and Hampton Roads Harbor Crossings.

Lynchburg District Allowable Work Hours

Researchers reviewed a spreadsheet covering the Lynchburg Allowable Lane Closure Hours for routes in the Lynchburg district. AWH are provided for State Routes 460, 460BUS, 29, 29BUS, 24, 401, 360, and 58. AWH are broken down by segment and day of the week.

Northern Virginia District Allowable Work Hours

The "NOVA District Lane Closure Guidelines," updated February 2024, provides lane closure hour tables for Interstates 66, 395, 95, and 495, sections of limited access Routes 267 and 28 and some major primary arterials (State Routes 7, 15, 26, 110, 123, 234, and 286), primary and major secondary arterials with ADT greater than 10,000 vehicles per day, and secondary roadways. Segments and their respective AWH are broken down by work zone type (complete road closure, multiple-lane closure, two-lane closure, single-lane, or shoulder closure) and the day of the week (weekday versus weekend). Interstates are further broken down by direction (e.g., north versus south), reservable lanes, and express lanes. The document also provides guidance on complete road closures, general restrictions, subdivisions, express lanes, ramps, non-VDOT roads, holidays, and the process for exceptions.

Richmond District Allowable Work Hours

The Richmond District Procedural Memorandum on Allowable Work Hours, effective March 1, 2024, provides AWH for limited access highways (Interstates 95, 64, 295, 85, and 195 and State Routes 288, 150, and 76). A document for Richmond Major Primary and Secondary AWH includes State Routes 10, 5, 6, 30, 33, 54, 73, 106, 147, 155, 156, 157, 161, 197, 249, 273, 356, 602, 604, 613, 615, 617, 621, 623, 625, 627, 632, 636, 637, 638, 640, 642, 643, 647, 650, 651, 653, 655, 656, 657, 659, 672, 675, 678, 683, 686, 711, 717, 720, 746, 754, 802, 904, and 1261 and U.S. Routes 1, 33, 60, 250, 301, 360, and 522. The memorandum also provides directions on whom to contact if an exception to the standard AWH is needed and how frequently the hours are updated (semi-annually).

Salem District Allowable Work Hours

The Salem District AWH Summary spreadsheet was updated in 2022 and is currently being updated. The spreadsheet includes Salem primary road lane closures AWH and lane and shoulder closures AWH for the Salem and Bristol Districts. The spreadsheet includes Interstates 77, 81, 381, and 581 and State Routes 8, 11, 114, 117, 122, 220, 220 Alt, 220 Expressway, 221, 419, 460, and 460 Bypass. A standard restriction of no peak-hour work and night work as directed applies for all other primary routes in the Salem District.

Staunton District Allowable Work Hours

Researchers reviewed the document on Staunton District Allowable Work Hours for Planned Interstate Lane Closures and Events dated October 28, 2015. This document includes AWH for Interstates 81, 64, and 66 and breaks down AWH by direction, segment, season, and the day of the week. The document notes the process for exceptions, which are made at the Regional Traffic Operations Manager's discretion. The document also provides guidance on primary road lane closures, including avoiding peak hours and making special considerations for schools and major traffic generators.

Questions 17 and 18—Familiarity with VTRC Two-Lane HCM Excel Tool

VTRC (2018) previously developed an Excel tool, the Two-Lane Highways Work Zone HCM Tool, based on HCM methodologies (Transportation Research Board, 2016). The tool may be used to estimate delay because of work zone flagging operations on a two-lane road. Survey recipients were asked about their familiarity with the tool (question 17) and whether they had feedback (question 18). Results show that VDOT staff use the tool infrequently (Figure 8). A follow-up email was sent to the respondents who stated they had seen the tool but never used it, asking whether they had any recommendations on improving the usefulness of the tool. One comment raised the challenge that the tool requires hourly volume data, which are not always available.

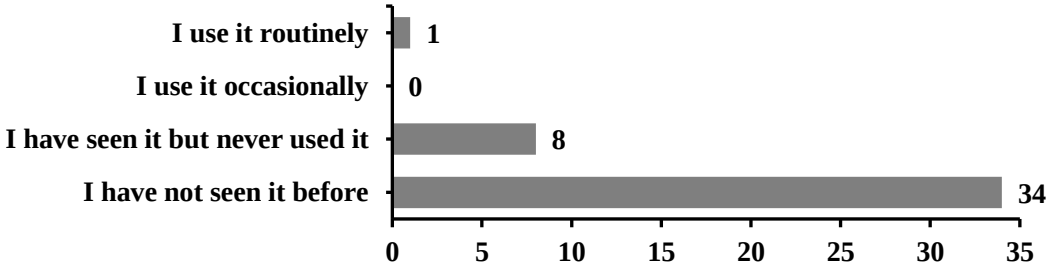


Figure 8. Familiarity with Two-Lane Highways Work Zone Highway Capacity Manual Tool (N = 43)

Question 19—*Virginia Work Area Protection Manual* Flagging Procedure

The next question asked about flagging operations. "*The* Virginia Work Area Protection Manual *(VWAPM) states that flaggers should not hold traffic for more than 8 minutes per direction on roads with 500+ ADT* (VDOT, 2025)*. Does your district have a different practice?*" Most responses (82%) stated that their district does not have a different practice (Figure 9). The remaining 7 responses stated, yes, they do have a different practice and described it. One of those responses said they follow VWAPM, indicating the respondent should have selected "No." One respondent selected "No" to describe their unfamiliarity with the metrics used. Another respondent said they use 5 minutes for a cutoff, and another said they typically do not set a limit. The remaining 3 "No" responses described that they do their best to follow the VWAPM guidance, but sometimes, extenuating circumstances prevent them from adhering. Based on the responses, the VWAPM flagging guidelines are generally followed.

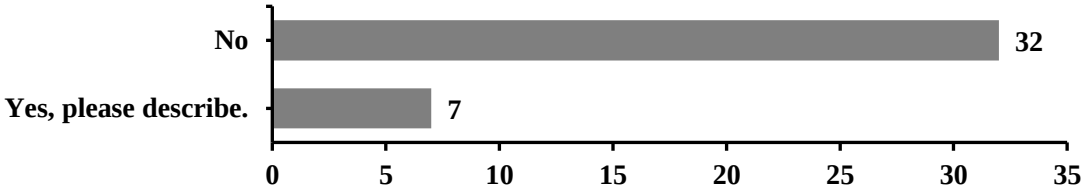


Figure 9. Question Asking Whether Respondents' Districts Follow Flagging Guidelines Different from the *Virginia Work Area Protection Manual* Guidance (N = 39) (VDOT, 2025)

Question 20—School-Related Allowable Work Hours

The following question asks the respondent what restrictions would be placed on paving or maintenance activities in front of schools during the school year. Most respondents stated that they would include some level of restrictions (Figure 10). Only 3 of the 38 respondents (7.9%) stated that no additional restrictions would be implemented because of the school's presence. The most frequent response was only to restrict work during morning and evening peak hours, which was cited by 14 respondents (36.8%). The next most common response (13 responses, or 34.2%) was "Other," in which case most respondents described using a combination of the provided responses, depending on which was most appropriate for the situation, decided on a case-by-case basis. Fewer respondents chose the most restrictive options, restricting work to nights and weekends or to summertime only.

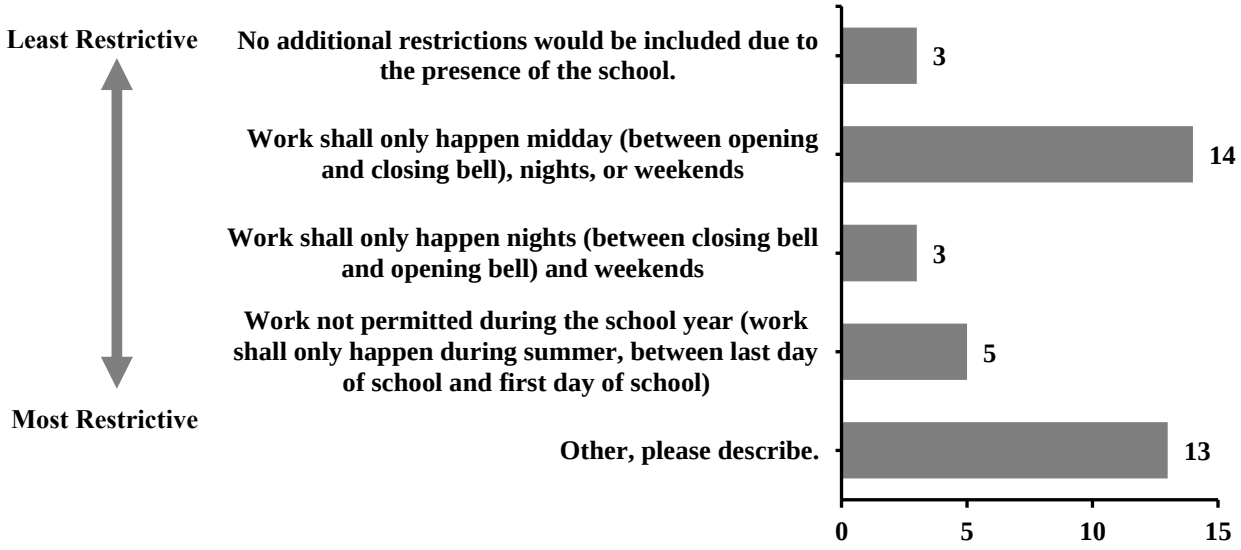


Figure 10. What Restrictions Would Be Placed on Paving or Maintenance Activities in Front of a School (N = 38)

Questions 21–24—Hypothetical Scenarios Allowable Work Hours

The next set of questions was hypothetical scenarios with individual characteristics changed for each scenario. The purpose of these questions was to capture the differences in responses among districts when provided with a consistent location description. Table 4 shows the characteristics for each scenario, with the characteristics that change in bold text. Question 21 describes a 2-mile paving schedule on a minor arterial, question 22 describes a 2-mile paving

schedule on a major arterial, question 23 describes a 2-mile paving schedule on a major arterial near a large job generator, and question 24 describes a mobile work zone for striping on a major arterial. All scenarios are 55 mph, rural, two-lane, and rolling terrain roads and have little seasonal variation.

Table 4. Hypothetical Scenario Questions 21–24

21. Consider a hypothetical scenario with the following characteristics: • **3,000 ADT.** • **2% trucks.** • 55 mph speed limit. • Rural two-lane road with no homes immediately abutting the road. • Primary—functionally classified as **minor arterial.** • Rolling terrain. • Little seasonal variation (route does not serve large recreational or tourism destinations). • **2-mile paving schedule (you are planning out next year's paving contracts).**	**22. Consider a hypothetical scenario with the following characteristics:** • **9,000 ADT.** • **3% trucks.** • 55 mph speed limit. • Rural two-lane road with no homes immediately abutting the road. • Primary—functionally classified as **minor arterial.** • Rolling terrain. • Little seasonal variation (route does not serve large recreational or tourism destinations). • **2-mile paving schedule (you are planning out next year's paving contracts).**
23. Consider a hypothetical scenario with the following characteristics: • **9,000 ADT.** • **3% trucks.** • 55 mph speed limit. • Rural two-lane road with no homes immediately abutting the road. • Primary—functionally classified as **major arterial.** • Rolling terrain. • Little seasonal variation (route does not serve large recreational or tourism destinations). • **2-mile paving schedule (you are planning out next year's paving contracts).** • **The work zone is near a large job generator with predictable shift changes.**	**24. Consider a hypothetical scenario with the following characteristics:** • **9,000 ADT.** • **3% trucks.** • 55 mph speed limit. • Rural two-lane road with no homes immediately abutting the road. • Primary—functionally classified as **major arterial.** • Rolling terrain. • Little seasonal variation (route does not serve large recreational or tourism destinations). • **Operations consist of a mobile work zone for striping**.

ADT = average daily traffic.

Responses to the four scenarios did vary (Table 5). The most common restriction for question 21 (a lower ADT road) was prohibiting work during peak hours. For question 22 (a relatively higher ADT road), the responses were mixed, typically selecting "other," only weekday night work or weekday night and weekend anytime restrictions. For question 23 (relatively higher ADT near a large job generator with shift changes), the most frequent response was to prohibit work during peak periods. Finally, for question 24 (a relatively higher ADT road with a mobile work zone), the response was typically no restrictions or just peak hour restrictions. Real work zones from the pavement management scheduling system (PMSS) dataset, representing those from questions 21 and 22, will be discussed in following sections.

Table 5. Responses to Four Hypothetical Scenario Questions (N = 38)

Response	Question 24	Question 23	Question 22	Question 21
Other, please describe.	4 (11%)	11 (29%)	4 (11%)	4 (11%)
Only allow work during weekend nights.	1 (3%)	2 (5%)	1 (3%)	1 (3%)
On weekdays, only allow work from end of PM peak to start of AM peak; no restrictions on weekends.	6 (16%)	14 (37%)	11 (29%)	0 (0%)
Prohibit work during typical weekday AM and PM peak periods.	19 (50%)	11 (29%)	22 (58%)	13 (34%)
No restrictions.	8 (21%)	0 (0%)	0 (0%)	20 (53%)

Question 25—Subdivision Hypothetical Scenario Allowable Work Hours

The next question asked respondents what restrictions they place in paving schedule contracts for typical subdivision streets that are functionally classified as "local." This question was open-ended, and 34 respondents filled out the text box (Figure 11). The responses were categorized into N/A (not applicable; the respondents stated they were not involved in these decisions), none (respondents stated they would not place restrictions in a typical subdivision), or some restrictions. The level of restrictions the respondents stated they would place varied, but they typically would restrict work to avoid peak hours or restrict work to daytime hours. Some respondents also described a combination of the two.

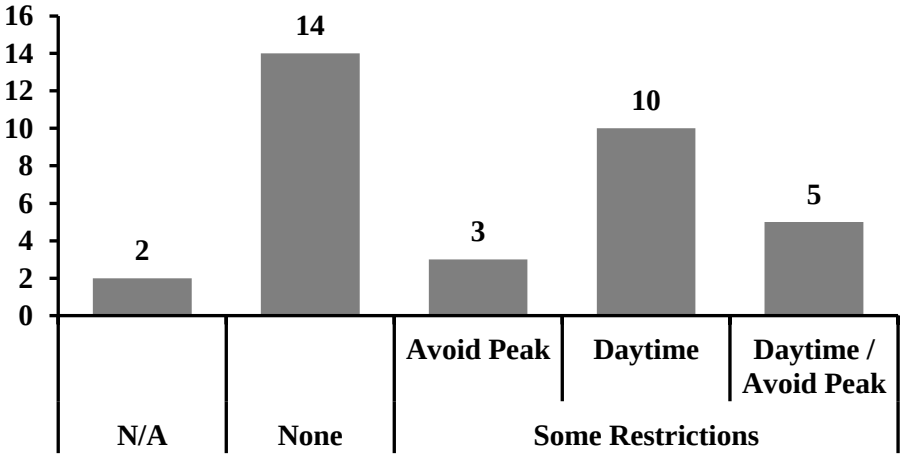


Figure 11. Responses to a Hypothetical Scenario about Paving Schedules in Typical Subdivisions (N = 34)

Question 26—Prioritization for Allowable Lane and Shoulder Closure Hours

Question 26 asked respondents to prioritize elements that are considered in setting allowable lane and shoulder closure hours in order of importance. Table 6 shows the seven considerations, including operations, back-of-queue crash risk, nighttime worker safety, construction duration, public concerns, quality of construction, and constructability considerations. The considerations are presented in order of their average ranking by the respondents (most important to least important). Considerations were ranked in order of 1 through 7, where 1 is the most important, so a lower average translates to a higher ranking. Sixteen of the 38 respondents ranked operations as the number one consideration. Eight

respondents ranked back-of-queue crash, and 9 respondents ranked nighttime worker safety as the most important element when selecting allowable lane and shoulder closure hours. Most considerations were ranked highest by at least one person and lowest by at least one other person.

Table 6. Considerations when Selecting Allowable Lane and Shoulder Closure Hours and Average, Minimum, Maximum, Most Important Count, and Least Important Count (N = 38)

Considerations	Average	Most Important Count	Least Important Count
Operations: Minimize excessive delays to drivers, which will frustrate drivers and could lead to more risky/aggressive driving in flagging situations.	2.18	16	0
Back-of-queue crash risk: Only allow work during periods of low traffic volumes in order to reduce the risk of crashes within or at the back of the queue.	2.97	8	3
Nighttime worker safety: Minimize restrictions that require night operations, so as to reduce increased risk associated with nighttime work operations.	3.63	9	3
Construction duration: Allow as large a window as possible to facilitate timely completion of work and potentially reduce costs for VDOT by affording contractors greater scheduling flexibility.	4.16	3	4
Public concerns: Minimize risk of complaints from local elected officials or the public.	4.92	1	14
Quality of construction: Minimize nighttime construction to avoid impacts to quality of construction; reduce likelihood of work quality being impacted by tired workers and/or poorer visibility for completing work tasks.	4.92	1	5
Constructability: Select hours which will ease materials delivery and meet temperature restrictions.	5.21	0	9

The rankings were broken down by the respondents' functional area to better understand how job roles may affect focus areas when selecting AWH. Table 7 shows the average rankings for all respondents and each functional area. Green correlates to the highest ranked considerations, and red correlates to the lowest ranked considerations. Yellow is in the middle. Considerations are listed in the same order as in Table 6, from highest to lowest ranked on average. Some differences exist between functional areas. However, sample sizes of individual functional areas are low. For example, district construction respondents ranked the quality of construction and constructability slightly higher than average and public concerns and operations lower than average. District maintenance respondents ranked public concerns higher than average and nighttime worker safety and quality of construction lower than average. District traffic respondents ranked operations and back-of-queue crash risk slightly higher than average and nighttime worker safety slightly lower than average. Respondents from residencies ranked nighttime worker safety higher than average and back-of-queue crash risk and operations lower than average.

Table 7. Average Rankings for Considerations when Selecting Allowable Lane and Shoulder Closure Hours by Respondents' Functional Area

	All Respondents (N = 38)	District Construction (N = 4)	District Maintenance (N = 7)	District Traffic (N = 14)	Residency (N = 12)	Other (N = 1)
Operations	2.18	2.75	1.86	1.71	2.83	1.00
Back-of-Queue Crash Risk	2.97	3.25	2.57	2.36	3.75	4.00
Nighttime Worker Safety	3.63	3.50	4.43	4.21	2.58	3.00
Construction Duration	4.16	4.00	4.00	4.00	4.25	7.00
Public Concerns	4.92	5.50	4.29	5.29	4.92	2.00
Quality of Construction	4.92	4.25	5.71	5.21	4.33	5.00
Constructability	5.21	4.75	5.14	5.21	5.33	6.00

Green shading indicates the most important factors, and red shading indicates the least important factors.

Question 27—Additional Comments

The survey's final question asked respondents to include any additional information related to allowable lane and shoulder closure hours for short-term construction or maintenance projects on two-lane roads. Fourteen responses were received for this question. Most additional comments reflect a desire for flexibility, balance, and AWH decisions to remain with those most familiar with the location. A couple of comments stated that respondents were interested in better guidance on this topic.

Assess Existing Flagging Analysis Tool and Identify Possible Improvements

The existing tool refers to the Two-Lane Highways Work Zone HCM Tool, an Excel-based tool that calculates capacity and delay impacts due to short-term flagging operations based on HCM methods (Transportation Research Board, 2016). This task aimed to improve the existing tool based on feedback from VDOT staff that currently use the tool. Based on the survey, researchers determined that although some staff have heard of the tool, almost none use it, and feedback was limited. Researchers reached out to the respondents who had some familiarity with the tool. One concern about the tool was that it requires hourly volume data, which are not always available at that disaggregate level. This concern echoes challenges raised by other state DOTs, which is collecting the data to make good decisions can be one of the most challenging tasks. Based on the lack of additional feedback regarding any need for improvements, no modifications were made to the existing spreadsheet. Based on the existing literature, the VDOT tool, which follows current HCM methods, is reasonable for estimating queues at two-lane road work zones. Improving awareness of the existing tool may support VDOT staff in developing AWH guidelines or setting AWH when guidelines do not exist.

Review Paving Schedule Allowable Work Hours Data

Statewide paving schedule data for 2024 were procured from PMSS. This dataset contains information about individual paving segments such as event identification, district, roadway functional classification, year, county, route name, milepost, location description, road name, segment length, road width, number of lanes, approximate volumes, longitude and latitude, cost details, project award status, and segment description and notes. The full dataset includes 33,622 rows, with 4,189 unique parent identifications correlating to unique segments.

To analyze cases with AWH restrictions, a number of data cleaning steps were performed. First, because the scope of this work is limited to two-lane roads, the *System* variable was filtered to remove interstates, the *Functional_Class* variable was filtered to remove interstates, and *Num_Lanes* was filtered to remove any lane counts other than 2. This filtering leaves 3,756 unique segments. Following this filtering, researchers reviewed the variables indicating additional notes and comments (*Segment_Comment, NS_Item_Addnl_Dec, Std_Notes,* and *Misc2*) to determine the allowable lane and shoulder closure hour restrictions. Specific phrases were scanned for in each variable for each segment. If the variables contained any of the phrases, they were flagged as having an AWH restriction. The notes and comments for each segment were then manually reviewed to determine if the phrase indicated an AWH restriction and what that restriction was. Table 8 shows the phrases searched for in each variable. Four segments were removed, which had work hour restrictions to avoid the Annual State Fair of Virginia and Bat Winter Hibernating Season because such restrictions were not in the scope of this study.

Table 8. Phrases Used to Screen for Allowable Work Hour Restrictions

Segment_Comment	***NS_Item_Addnl_Dec***	***Std_Notes***	***Misc2***
"time restrictions-no"	"am "	"all work must be completed between the hours of:"	"time"
"time restrictions-none"	"pm "	"all work must be completed after:"	
"no res time restriction"	"school"	"all work must be completed before:"	
"restrict"	"2024"		
"work hrs"	"day work"		
"work hours"	"night work"		

After filtering, 869 (21%) unique segments were identified containing some form of AWH restrictions. Despite the overall dataset containing contracts from all nine districts, the dataset of segments with noted AWH restrictions was much smaller and primarily limited to segments in Richmond and Fredericksburg, with very few segments from Culpeper, Hampton Roads, Lynchburg, Salem, and Staunton and none from Bristol or NOVA (Figure 12). The takeaway is that not all districts utilize PMSS for AWH in the same way. Some districts may use PMSS to note additional exceptions to existing guidance, and others may not use it to list AWH at all.

Researchers reviewed the 869 segments for the type of AWH restrictions (e.g., day work only, night work only, or peak-hour restrictions) and day of week or seasonal restrictions (referred to in this section as allowable work days) (Figure 13). Among all districts, the most common AWH restrictions in the PMSS data were for day work only, followed by peak-hour and night work-only restrictions. For allowable work days, the most common restrictions were related to school calendars. Such restrictions usually involved restricting work to the summertime only. The second most common day of the week restriction was to restrict work to when school is not in session, which is a broader scope than summertime only and may include some combination of summertime, weekend, and nighttime work.

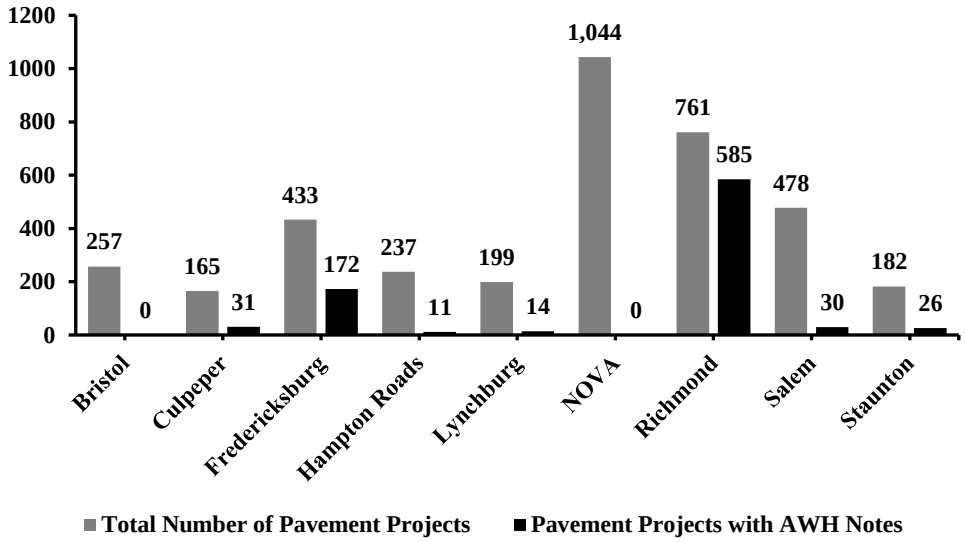


Figure 12. Number of Unique Paving Contracts in Each District in the Full Pavement Schedule Dataset and in the AWH Dataset. AWH = allowable work hours.

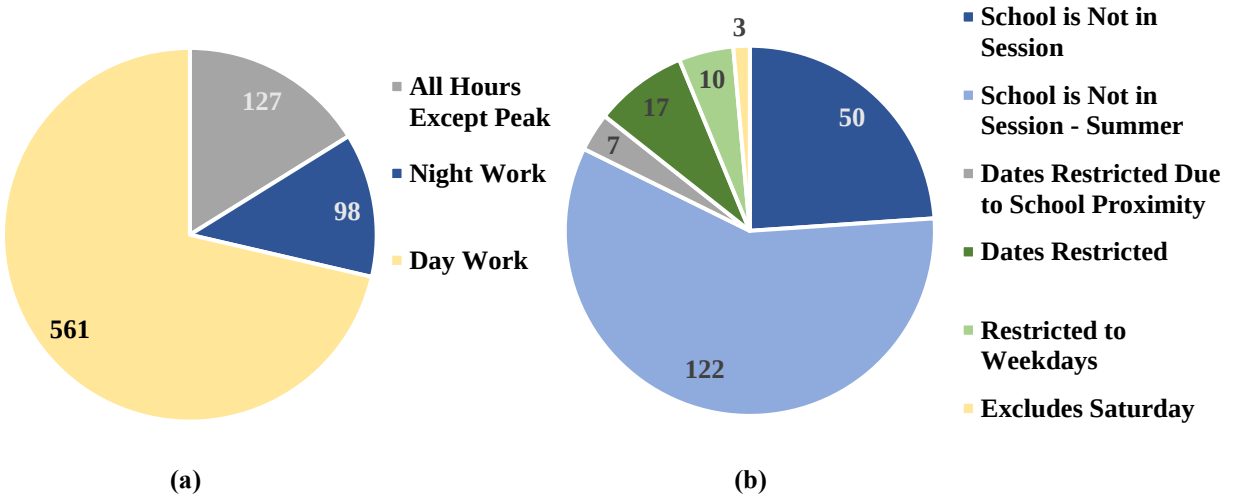


Figure 13. (a) Allowable Work Hours (N = 786) and (b) Allowable Work Days (N = 209) for All Districts

The AWH were broken down by district to observe any patterns within districts. However, sample sizes for some districts were small, so comparisons across districts may not be reasonable.

In Richmond, most additional restrictions are related to day work only (N = 433), some are peak hour restrictions (N = 116), and a few are night work only restrictions (N = 34). Regarding allowable work day restrictions, 100 of the 583 segments restrict work to the summer when school is not in session. This scenario differs from other districts, where the school-related restrictions are not strictly summertime only.

The distribution of AWH for Fredericksburg is similar to Richmond because the distribution primarily includes restrictions for day work only (N = 121), with some for night work only (N = 24). Thirty-nine segments have school-related restrictions, most of which are described as when school is not in session (N = 32). Some restrictions define specific dates when work must start or finish because of the presence of a school (typically summer-related dates, N = 7).

The sample size for Culpeper District AWH is small (N = 31), but compared with other districts, a higher percentage of hourly restrictions were night work-only restrictions rather than day work-only or peak-hour restrictions. The day-of-week restrictions are primarily related to specific dates defined in the project.

Similarly, the Staunton sample contains 26 segments. Nine cases with AWH, all night work contracts, were recorded in PMSS. Nineteen cases with allowable work day restrictions were also recorded, all for when school is not in session.

In the Salem District, 30 segments were reviewed. Most of the AWH restrictions in PMSS were night work restrictions (N = 10), with a couple of peak-hour restrictions, although the sample size is small. The day-of-week restrictions are mostly school-related restrictions (summer work only, N = 15), but some are related to specific dates (N = 3), weekday-only restrictions (N = 4), and no Saturday work restrictions (N = 3).

In the Lynchburg District, 14 segments were reviewed. Ten cases with AWH were written into PMSS, which were all night work contracts. PMSS also included 14 cases with allowable work day restrictions. These restrictions included school-related restrictions (summer work only), specific date restrictions, and restrictions for weekday work only.

In the Hampton Roads District, only 11 segments were reviewed. Seven cases had AWH, most of which were restrictions to avoid peak hours (N = 6). A few allowable work day restrictions were in place for restrictions related to specific dates and schools.

Case Studies

Select segments and their AWH were then analyzed as case studies from the PMSS dataset. Researchers selected segments for analysis using the characteristics listed in questions 21 and 22 of the VDOT survey to examine two subsets of segments with similar characteristics. Table 9 shows the characteristics for questions 21 and 22 in the left column. The right column shows the corresponding variables in the PMSS dataset that were used to filter the PMSS segments. For this analysis, all unique segments, not just those with AWH in the comments and notes, were analyzed to review a subset of similar roads with and without AWH restrictions. Three sources were used to identify AWH for each segment: first, AWH in the comments from the PMSS dataset were extracted; second, the expected AWH based on the district AWH guidelines were determined; and third, the relevant paving contract for each segment was reviewed for additional AWH notes.

Table 9. Hypothetical Survey Question Characteristics and Corresponding Variable Categories from Pavement Contract Data

Question 21 Characteristics	Equivalent Data Characteristics
3,000 Average Daily Traffic	*Traffic_Group* = X: 2,000–2,999; or XI: 3,000–3,999
55 mph Speed Limit	Acquired via VDOT Speed Limit Maps and Google Maps
Rural Two-Lane Roads	*Num_Lanes* = 2
Primary—Functionally Classified as Minor Arterial	*System* = Primary, *Functional_Class* = Minor Arterial
2-Mile Paving Schedule	*Length_M* is ≥ 1 and ≤ 3
Rolling Terrain	No Data
Little Seasonal Variation	No Data
2% Trucks	No Data
Question 22 Characteristics	**Equivalent Data Characteristics**
9,000 Average Daily Traffic	*Traffic_Group* = XIV: 6,000–9,999
55 mph Speed Limit	Acquired via VDOT Speed Limit Maps and Google Maps
Rural Two-Lane Roads	*Num_Lanes* = 2
Primary—Functionally Classified as Major Arterial	*System* = Primary, *Functional_Class* = Principal Arterial
2-Mile Paving Schedule	*Length_M* is ≥ 1 and ≤ 3
Rolling Terrain	No Data
Little Seasonal Variation	No Data
3% Trucks	No Data

The PMSS dataset of unique segments (N = 4189) was filtered based on the characteristics in Table 9 to find case studies like the segments described in question 21 on the VDOT survey. The filtered dataset included segments where the traffic group was between 2,000 and 3,999, the speed limit was predominantly 55 mph, the road was two lanes, it was a primary road, it was a minor arterial, and the road length was between 1 and 3 miles. The result was 18 segments. Table 10 presents details of those 18 segments, including the district, the route, the speed limit, whether a school is nearby, the segment length, the traffic group, AWH from the PMSS data, AWH from the district AWH guidelines, and AWH from the paving contract.

Similarly, the PMSS dataset (N = 4,189) was filtered based on the characteristics in Table 9 to find case studies like the segments described in the VDOT survey question 22. The filtered dataset included segments where the traffic group was between 6,000 and 9,999, the speed limit was predominantly 55 mph, the road was two lanes, it was a primary road, it was a principal arterial, and the road length was between 1 and 3 miles. The result was 20 segments. Table 11 shows those segments, relevant site characteristics, and whether AWH appear in the PMSS data, the district guidance, or in the paving contracts.

Table 10. Survey Question 21 Case Studies

District	Route	Speed Limit	School Nearby	Length	Traffic Group	AWH from PMSS Data	AWH from District Guidelines	AWH from Paving Contracts	AWH
Culpeper	US 522N	55	No	2.24	3,000–3,999	-	-	-	No
Culpeper	US 522N	55	No	2.56	3,000–3,999	-	-	-	No
Hampton Roads	US 258E	55	No	2.20	3,000–3,999	-	-	-	No
Hampton Roads	US 258E	55	No	1.15	2,000–2,999	-	-	-	No
Hampton Roads	VA 40E	55	Yes	1.94	2,000–2,999	-	-	-	No
Hampton Roads	BUS US 13N	55/45	No	1.16	2,000–2,999	-	No weekend lane closures. Hours vary by season.	No weekend lane closures. Hours vary by season.	**Yes**
Hampton Roads	BUS US 13S	55/45	No	1.16	2,000–2,999	-	No weekend lane closures. Hours vary by season.	No weekend lane closures. Hours vary by season.	**Yes**
Lynchburg	US 60E	55	No	2.25	2,000–2,999	-	-	No weekend lane closures	**Yes**
Lynchburg	US 501N	55	Yes	1.33	3,000–3,999	-	-	No weekend lane closures	**Yes**
Lynchburg	VA 24E	55/45	No	1.29	3,000–3,999	-	No peak-hour lane closures	Weekday night work only	**Yes**
Richmond	VA 10E	55	No	2.25	3,000–3,999	-	-	-	No
Richmond	VA 10E	55	No	1	3,000–3,999	Peak-hour restrictions	-	Peak-hour restrictions	**Yes**
Richmond	BYP VA 156N	55	No	2.65	3,000–3,999	Peak-hour restrictions	-	Peak-hour restrictions	**Yes**
Salem	VA 57E	55	No	1.97	2,000–2,999	-	No peak-hour lane closures	No restrictions except during NASCAR race week	No
Salem	VA 57E	55	No	1.98	2,000–2,999	-	No peak-hour lane closures	No restrictions except during NASCAR race week	No
Salem	VA 57E	55	No	1.45	2,000–2,999	-	No peak-hour lane closures	No restrictions except during NASCAR race week	No
Staunton	VA 42N	55	No	2.26	3,000–3,999	-	-	-	No
Staunton	VA 42N	55/45	Yes	2.39	2,000–2,999	-	-	-	No

- = no AWH for the segment in the data source. AWH = allowable work hours. PMSS = pavement management scheduling system.

Table 11. Survey Question 22 Case Studies

District	Route	Speed Limit	Length	Traffic Group	AWH from PMSS Data	AWH from District Guidelines	AWH from Paving Contracts	AWH
Bristol	US 19N	55	2.06	6,000–9,999	-	-	-	No
Bristol	US 19S	55	2.06	6,000–9,999	-	-	-	No
Bristol	US 460W	55	2.87	6,000–9,999	-	-	-	No
Bristol	US 23N	55	1.26	6,000–9,999	-	-	-	No
Bristol	US 460W	55	1.56	6,000–9,999	-	-	-	No
Bristol	US 23S	55	2.67	6,000–9,999	-	-	-	No
Bristol	US 23N	60	2.06	6,000–9,999	-	-	-	No
Culpeper	US 211W	55	2.50	6,000–9,999	-	-	-	No
Fredericksburg	US 17N	60	1.55	6,000–9,999	-	-	-	No
Fredericksburg	US 360E	60	1.05	6,000–9,999	-	No peak-hour lane closures (weekdays). Night work only (weekends)	-	**Yes**
Fredericksburg	US 360E	60/45	2.4	6,000–9,999	-	No peak-hour lane closures (weekdays). Night work only (weekends)	-	**Yes**
Fredericksburg	US 17N	60/45	2.08	6,000–9,999	Night work only	Subject to Fredericksburg Dept. of Public Works	Night work only	**Yes**
Lynchburg	BUS US 29N	55	1.71	6,000–9,999	-	-	-	No
Lynchburg	US 58W	60	2.99	6,000–9,999	-	-	No weekend lane closures. No lane closures 8/26–9/3	**Yes**
Lynchburg	US 460E	60	2.7	6,000–9,999	-	-	-	No
Richmond	US 58E	55	1.02	6,000–9,999	-	-	-	No
Richmond	US 58W	55	2.37	6,000–9,999	-	-	-	No
Richmond	US 58E	55	1.46	6,000–9,999	-	-	-	No
Richmond	US 460E	55	1.64	6,000–9,999	Peak-hour restrictions	-	Peak-hour restrictions	**Yes**
Richmond	US 58W	60	1.97	6,000–9,999	Peak-hour restrictions	-	Peak-hour restrictions	**Yes**

- = no AWH for the segment in the data source. AWH = allowable work hours. PMSS = pavement management scheduling system.

For survey questions 21 and 22, researchers expected that suggested AWH restrictions may differ because the case study characteristics included different volumes and road

classifications. The survey respondents typically described that they would set different AWH on these roads. For question 21, the most common restriction that respondents stated would be applied was work prohibited during peak hours (50% of responses), followed by no restrictions (21% of responses). For question 22, the respondents recommended a mixture of restrictions, including "other" (29% of respondents), no peak hour work (29% of respondents), or weekday night and weekend work (37%).

For the segments representing question 21 (Table 10), 11 of the 18 segments (61%) did not have AWH restrictions in the contract. For the 7 segments that did have AWH, the restrictions were either no peak-hour lane closures (N = 2, 11%), weekday night work only (N = 1, 6%), or no weekend work (N = 5, 28%). Three segments had no peak-hour restrictions in the district guidelines for that segment, but they were not included in the contract AWH and, therefore, are marked as having no AWH. For the segments representing question 22 (Table 11), 14 of the 20 segments (70%) did not have documented AWH restrictions. Of the 6 segments with AWH restrictions, four were peak-hour restrictions (20%), one was a night work-only restriction (5%), and one was a weekday-only restriction (5%).

The subset of segments representing lower volume roads had more segments with AWH restrictions (Table 10), in contrast to what the survey responses indicated. In both data subsets, some segments were subject to district AWH guidelines, and some had additional restrictions in PMSS or contract notes. These case studies support how respondents answered the VDOT survey, in that a mix of district guidelines and case-by-case methods are used to set AWH.

DISCUSSION

The existing literature discusses that daytime work zones and the associated higher vehicle volumes present risks, as do nighttime work zones with visibility issues. Weighing these two scenarios against each other is a challenge. This study surveyed VDOT staff, reviewed district AWH documents, and analyzed paving contract data to understand how the decision to balance day and night work is made statewide.

VDOT staff survey responses and sentiments from other state DOT interviews shared similarities. Respondents expressed the value in two-lane road AWH decisions remaining with those who have the most local knowledge (residencies and districts). Staff were interested in increased guidance for improved decision making and consistency statewide.

The district AWH guidance varied meaningfully between districts, reflecting the different needs of each district in regulating AWH. In reviewing the district AWH guidance, one option for increasing consistency statewide may be for some districts with minimal AWH for two-lane roads to expand their written guidelines. A broad volume threshold, such as that used in South Carolina, may have some applications. In cases where the same AWH are assigned routinely on a case-by-case basis, those segments could be added to the district AWH guidelines. Having written guidelines could improve transparency with contractors. One example of this potential improvement is with work zones near schools, which are not captured in most district AWH guidelines, but for which additional AWH restrictions are often applied. Although the PMSS

dataset has limitations, one may observe that the leniency of school-related restrictions appears to vary between districts. In addition, the exception process varies between districts. Another option is to establish statewide priorities for setting AWH rather than establishing statewide AWH.

The PMSS paving contract dataset review showed it is not readily useful for comparing AWH across districts. Some districts do not use this platform to record AWH, and other districts use the platform frequently, particularly to note specific exceptions (school restrictions, seasonal restrictions, etcetera).

CONCLUSIONS

- *VDOT's process for establishing AWH for short-term work zones on two-lane roads at the district level is reasonable and is the preference of VDOT staff.* The VDOT process for setting AWH on two-lane roads is like other state DOT processes in that the decision to use local knowledge is usually made at the district level. VDOT staff supported this model in the VDOT survey to maintain the flexibility needed to meet local needs.

- *The VDOT process for setting AWH on two-lane roads differs from the two-lane road process at other state DOTs in that VDOT districts have written AWH guidelines for some two-lane roads.* VDOT staff expressed in the VDOT survey that having guidelines works well as part of the decision-making process.

- *Although the process for establishing AWH for short-term work zones on two-lane roads is working well, it does present some challenges*. VDOT survey respondents described the challenge of balancing the needs and wants of all parties, managing citizen complaints, and acquiring good traffic data.

- *District AWH guidelines vary between districts.* These guidelines vary in the level of guidance and the types and quantity of roads included, reflecting the different needs of each district.

- *VDOT staff were generally aligned on considerations and factors contributing to AWH decisions.* Most survey respondents (87%) ranked either "operations," "back-of-queue crash risk," or "nighttime worker safety" as the most important considerations from a list of seven considerations in selecting AWH. Most respondents selected day of the week, ADT, queues and delays, and schools as elements that factor into the current practice for setting AWH.

- *District staff have varying levels of "pain tolerance."* For example, during the survey, respondents indicated that their tolerance for maximum delay ranged from 8 to 30 minutes, and their tolerance for maximum queue ranged from 0.25 to 5 miles. In the review of 2024 paving schedules, roads with similar ADT often had different contractual AWH restrictions, with some roads having no restrictions and others being significantly restricted just to nighttime work.

- *VDOT staff were often unfamiliar with analytical tools for assessing flagging operations.* There was some interest from VDOT staff in increased guidance for improved decision making.

- *The PMSS dataset AWH notes and district AWH for select paving contracts differed from the AWH reported in the VDOT survey.* Some VDOT survey responses for school-related restrictions were less restrictive than those written in the PMSS dataset. AWH from the PMSS work zones, representing questions 21 and 22, generally did not align with the responses from questions 21 and 22 on what restrictions would be applied. However, the subset from the PMSS dataset was a small sample size.

RECOMMENDATIONS

1. *The VDOT Traffic Operations Division Work Zone Safety Program Manager, in conjunction with VTRC and the Construction Division, should convene a statewide working group to discuss priorities and ways to improve consistency in district AWH guidelines for two-lane roads*. Not all districts have AWH guidelines for non-limited access roads, and information sharing will help identify areas for improvement. Expanding AWH guidelines may support districtwide decision making and increase consistency between districts.

2. *VDOT Traffic Operations Division, in conjunction with VTRC, should conduct statewide outreach to improve awareness on accessing traffic data and analytical tools that could support decision making, such as the Two-Lane Highways Work Zone HCM Tool.* VDOT staff report that it is challenging to acquire traffic data for all roads, and survey results show VDOT staff are not familiar with the Two-Lane Highways Work Zone HCM Tool. This tool may support staff who expressed interest in increased guidance for decision making.

IMPLEMENTATION AND BENEFITS

Researchers and the technical review panel (listed in the Acknowledgments) for the project collaborate to craft a plan to implement the study recommendations and to determine the benefits of doing so. This process is to ensure that the implementation plan is developed and approved with the participation and support of those involved with VDOT operations. The implementation plan and the accompanying benefits are provided here.

Implementation

With regard to Recommendation 1, VTRC and the VDOT Traffic Operations Division Work Zone Safety Program Manager will convene District Traffic Engineers and other stakeholders to establish statewide priorities regarding two-lane roads AWH. Topics for which to develop guidelines should include priorities for AWH decision making, consistency in making exceptions (including approval authority and timeframes), and school zone restrictions. If appropriate, the development of an Instructional and Informational Memorandum may be pursued. The initial meeting should occur within 12 months of this report's publication. Although

this report focuses on two-lane undivided roads, this stakeholder engagement should, if appropriate, focus more broadly on AWH practices for all road types.

With regard to Recommendation 2, VTRC and the VDOT Traffic Operations Division will conduct outreach to improve awareness of the Two-Lane Highways Work Zone HCM Tool and the data needed for its use. The forum for this outreach may be through publicizing available tools at the work zone safety coordinator roundtable, a VDOT-sponsored webinar, or similar means. A forum for outreach will be established within 12 months of this report's publication.

Benefits

The two implementation efforts will serve to improve the decision-making process for setting AWH on two-lane roads in the state of Virginia. The first recommendation will create more consistent guidelines that may ease the process of future decision making through documentation of exceptions, guidance on school zones, and a framework for the AWH process. Overly restrictive AWH may have constructability and cost implications that may be prevented with flexible guidance. Furthermore, promoting the use of the Two-Lane Highways Work Zone Tool may support anyone seeking additional guidance with decision making. The existing AWH process allows individual districts the flexibility of nuanced prioritization of many competing costs and benefits. Additional guidance and outreach, as described in the recommendations and implementations, will support this process.

The result of the statewide working group may result in districts using consistent best practices for setting AWH that appropriately balance the safety, operational, constructability, and cost impacts of AWH. This process can also mitigate against the perception or reality that some AWH are unnecessarily restrictive or unfairly or inconsistently applied. A fairer, more consistent process may also reduce the likelihood that waivers to the contract's AWH restrictions will be granted during construction. Including fair and reasonable AWH restrictions in the contract is always preferable so that all bidders can factor that information accordingly when submitting their bids.

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APPENDIX: VDOT SURVEY QUESTIONS

Survey on Setting Allowable Shoulder and Lane Closure Hours for Short-Term Construction or Maintenance Projects on Two-Lane Roads

The purpose of this survey is to assess the state of the practice at VDOT regarding setting of **allowable shoulder and lane closure hours** (also known as Limitations of Operations) for **short-term construction or maintenance projects on two-lane roads.**

There does not exist statewide guidelines for including allowable shoulder and lane closure hours restrictions in contracts, so individual districts develop and implement guidelines at their own discretion. Your responses will contribute to a study to better understand the differences in allowable shoulder and lane closure hours practices across the state and the reasons for those differences.

Note that this study scope does not encompass work restrictions for holidays or local special events (NASCAR races, marathons, music festivals, etc.). Additionally, this study scope does not address allowable hours for closing pedestrian or bicycle facilities.

For more information, see VTRC Project 124991. If you have any questions, please contact Erin Robartes by email (erin.robartes@vdot.virginia.gov) or by phone (434-293-1972) or the Technical Review Panel chair, Marc Lipschultz (VDOT Traffic Operations Division's WZ Safety Program Manager) at Marc.Lipschultz@vdot.virginia.gov.

1. Please provide the following information about yourself:

- ○ Name: _____
- ○ Title: _____
- ○ District: _____
- ○ Residency: _____
- ○ Functional Area: _____

2. Who is responsible for setting Allowable Lane and Shoulder Closure Hours restrictions in your District? Please select all that apply.

- ☐ District Traffic Engineer or designee
- ☐ District Traffic Operations Director or designee
- ☐ Residency Administrator or designee
- ☐ District Construction Engineer or designee
- ☐ Other, please describe. _____

3. How does your District establish Allowable Lane and Shoulder Closure Hours for short-term maintenance and construction activities on two-lane roads?

- ○ **Documentation or guidance** listing allowable lane and shoulder closure hours requirements for different circumstances is used.
- ○ Allowable lane and shoulder closure hours are decided on a **case-by-case basis.**
- ○ Other, please describe. _____

4. What factors into the current practice for setting Allowable Lane and Shoulder Closure Hours? Please select all that apply.

- ☐ Queues
- ☐ Delays
- ☐ Annual Average Daily Traffic
- ☐ Day of the Week
- ☐ Crash Risks
- ☐ Other _____
- ☐ Worker Safety
- ☐ Time of Year/Temperature
- ☐ Land Use
- ☐ Local Ordinances
- ☐ Schools

5. When analyzing potential Allowable Lane and Shoulder Closure Hours on a two-lane primary, what quantifiable "pain-tolerance" thresholds do you use?

- ☐ Maximum delay (minutes): _____
- ☐ Maximum length of projected queue (miles): _____
- ☐ Other: _____
- ☐ No threshold is specified.

6. Does this procedure vary for Primaries versus Secondaries?

- ○ No
- ○ Yes. Please describe. _____

7. Does this procedure vary by Residency or Locality?

- ○ No
- ○ Yes. Please describe. _____

8. How important do you think it is for Allowable Lane and Shoulder Closure Hours to be consistent within VDOT districts and across district lines?

- ○ Not at all important
- ○ Slightly important
- ○ Moderately important
- ○ Very important
- ○ Extremely important

Please explain your response (optional). _____

9. For the current process for setting Allowable Lane and Shoulder Closure Hours on two-lane roads, what is working well? _____

10. For the current process for setting Allowable Lane and Shoulder Closure Hours on two-lane roads, what is a challenge? _____

11. What is the procedure for granting an exception to the Allowable Lane and Shoulder Closure Hours guidance during the design phase (e.g., who makes decisions regarding exceptions, who approves decisions, what factors contribute to the decision)?

---

12. How frequently are exceptions made to the guidance in the design phase?

Select Approximate Percentage: ☐ I do not know

0 1 2 3 4 5 6 7 8 9 1
% 0% 0% 0% 0% 0% 0% 0% 0% 0% 00%

13. What is the procedure for granting an exception to the Allowable Lane and Shoulder Closure Hours guidance during the construction phase (after bid opening) (e.g., who makes decisions regarding exceptions, who approves decisions, what factors contribute to the decision)?

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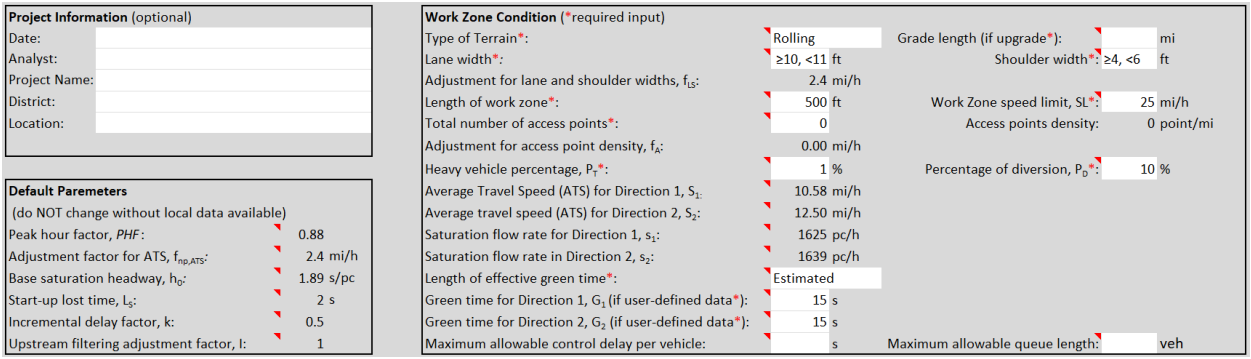
14. How frequently are exceptions made to the guidance in the construction phase?

Select Approximate Percentage: ☐ I do not know

0 1 2 3 4 5 6 7 8 9 1
% 0% 0% 0% 0% 0% 0% 0% 0% 0% 00%

15. Please share with the researchers a copy of the Allowable Lane and Shoulder Closure Hours documentation via this form or by email (erin.robartes@vdot.virginia.gov).

16. There is a VDOT developed Excel tool which estimates queues for two-way flagging operations, "Two-Lane Highways Work Zone HCM Tool." The tool incorporates variables such as terrain, lane width, work zone length, heavy vehicle percentage, green time in each direction, grade, and speed limit to estimate queue and delay in each direction (see figure below).



Project Information (optional)	
Date:	
Analyst:	
Project Name:	
District:	
Location:	

Default Paremeters (do NOT change without local data available)		
Peak hour factor, *PHF*:	0.88	
Adjustment factor for ATS, $f_{np,ATS}$:	2.4	mi/h
Base saturation headway, h_o:	1.89	s/pc
Start-up lost time, L_s:	2	s
Incremental delay factor, k:	0.5	
Upstream filtering adjustment factor, I:	1	

Work Zone Condition (*required input)				
Type of Terrain*:	Rolling		Grade length (if upgrade*):	mi
Lane width*:	≥10, <11	ft	Shoulder width*: ≥4, <6	ft
Adjustment for lane and shoulder widths, f_{LS}:	2.4	mi/h		
Length of work zone*:	500	ft	Work Zone speed limit, SL*: 25	mi/h
Total number of access points*:	0		Access points density: 0	point/mi
Adjustment for access point density, f_A:	0.00	mi/h		
Heavy vehicle percentage, P_T*:	1	%	Percentage of diversion, P_D*: 10	%
Average Travel Speed (ATS) for Direction 1, S_1:	10.58	mi/h		
Average travel speed (ATS) for Direction 2, S_2:	12.50	mi/h		
Saturation flow rate for Direction 1, s_1:	1625	pc/h		
Saturation flow rate in Direction 2, s_2:	1639	pc/h		
Length of effective green time*:	Estimated			
Green time for Direction 1, G_1 (if user-defined data*):	15	s		
Green time for Direction 2, G_2 (if user-defined data*):	15	s		
Maximum allowable control delay per vehicle:		s	Maximum allowable queue length:	veh

17. What is your degree of familiarity with this Excel tool?

- ☐ I have not seen it before.
- ☐ I have seen it but never used it.
- ☐ I use it occasionally.
- ☐ I use it routinely.

18. If you have used the tool, please provide feedback on the functionality. What works well? What could be improved? _____

19. The *Virginia Work Area Protection Manual* (VWAPM) states that flaggers should not hold traffic for more than 8 minutes per direction on roads with 500+ average daily traffic (ADT) volume. Does your District have a different practice?

- ○ No
- ○ Yes, please describe. _____

The following questions ask about the types of restrictions your district would set for specific scenarios.

20. During the school year, what restrictions do you place on paving or maintenance activities in front of schools:

- ○ No additional restrictions would be included due to the presence of the school.
- ○ Work shall only happen midday (between opening and closing bell), nights, or weekends.
- ○ Work shall only happen nights (between closing bell and opening bell) and weekends.
- ○ Work not permitted during the school year (work shall only happen during summer, between last day of school and first day of school).
- ○ Other, please describe. _____

21. Consider a hypothetical scenario with the following characteristics:

- **3,000 ADT.**
- **2% trucks.**
- 55 mph speed limit.
- Rural two-lane road with no homes immediately abutting the road.
- Primary—functionally classified as **minor** arterial.
- Rolling terrain.
- Little seasonal variation (route does not serve large recreational or tourism destinations).
- **2-mile paving schedule (you are planning out next year's paving contracts).**

- ○ No restrictions.
- ○ Prohibit work during typical weekday AM and PM peak periods.
- ○ On weekdays, only allow work from end of PM peak to start of AM peak; no restrictions on weekends.
- ○ Only allow work during weekend nights.
- ○ Other, please describe. _____

22. Consider a hypothetical scenario with the following characteristics:

- **9,000 ADT.**
- **3% trucks.**
- 55 mph speed limit.
- Rural two-lane road with no homes immediately abutting the road.
- Primary—functionally classified as **major** arterial.
- Rolling terrain.
- Little seasonal variation (route does not serve large recreational or tourism destinations).
- **2-mile paving schedule (you are planning out next year's paving contracts).**

  - ○ No restrictions.
  - ○ Prohibit work during typical weekday AM and PM peak periods.
  - ○ On weekdays, only allow work from end of PM peak to start of AM peak; no restrictions on weekends.
  - ○ Only allow work during weekend nights.
  - ○ Other, please describe. _____

23. Consider a hypothetical scenario with the following characteristics:

- **9,000 ADT.**
- **3% trucks.**
- 55 mph speed limit.
- Rural two-lane road with no homes immediately abutting the road.
- Primary—functionally classified as **major** arterial.
- Rolling terrain.
- Little seasonal variation (route does not serve large recreational or tourism destinations).
- **2-mile paving schedule (you are planning out next year's paving contracts).**
- **The work zone is near a large job generator with predictable shift changes.**

  - ○ No restrictions.
  - ○ Prohibit work during typical weekday AM and PM peak periods.
  - ○ On weekdays, only allow work from end of PM peak to start of AM peak; no restrictions on weekends.
  - ○ Only allow work during weekend nights.
  - ○ Other, please describe. _____

24. Consider a hypothetical scenario with the following characteristics:

- **9,000 ADT.**
- **3% trucks.**
- 55 mph speed limit.
- Rural two-lane road with no homes immediately abutting the road.
- Primary—functionally classified as **major** arterial.
- Rolling terrain.
- Little seasonal variation (route does not serve large recreational or tourism destinations).
- **Operations consist of a mobile work zone for striping.**

- ○ No restrictions.
- ○ Prohibit work during typical weekday AM and PM peak periods.
- ○ On weekdays, only allow work from end of PM peak to start of AM peak; no restrictions on weekends.
- ○ Only allow work during weekend nights.
- ○ Other, please describe. _____

25. What restrictions do you place in paving schedule contracts for typical subdivision streets that are functionally classified as "local" (assuming no schools or other special situations are present)?

_____

26. Arrange the following in terms of importance when setting Allowable Lane and Shoulder Closure Hours. Click and drag to move each block (1 = most important, 7 = least important).

Construction duration: Allow as large a window as possible to facilitate timely completion of work, and potentially reduce costs for VDOT by affording contractors greater scheduling flexibility.

Nighttime worker safety: Minimize restrictions that require night operations, so as to reduce increased risk associated with nighttime work operations.

Operations: Minimize excessive delays to drivers, which will frustrate drivers and could lead to more risky or aggressive driving in flagging situations.

Public concerns: Minimize risk of complaints from local elected officials or the public.

Back-of-queue crash risk: Only allow work during periods of low traffic volumes in order to reduce the risk of crashes within or at the back of the queue.

Quality of construction: Minimize nighttime construction to avoid impacts to quality of construction; reduce likelihood of work quality being impacted by tired workers and/or poorer visibility for completing work tasks (6).

Constructability: Select hours which will ease materials delivery and meet temperature restrictions

27. Please include any additional information you would like to share related to Allowable Lane and Shoulder Closure Hours for short-term construction or maintenance projects on two-lane roads.

_____