

# **North Carolina Department of Transportation**



## **WORK ZONE SAFETY & MOBILITY PROCESS REVIEW December 2019**

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**Work Zone Safety & Mobility Process Review  
North Carolina Department of Transportation**

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## **EXECUTIVE SUMMARY**

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The North Carolina Department of Transportation (NCDOT) is committed to providing safe work zones for all workers and road users while minimizing traffic congestion and adverse impacts on road users and local communities. In response to changes to the Federal Highway Administration's Work Zone Safety and Mobility Rule 23 CFR 630 Subpart J, NCDOT developed its Work Zone Safety and Mobility Policy in 2007. We continue working to fulfill the intent of this policy, which is to support the systematic consideration and management of work zone impacts related to safety, mobility, operations, and training.

This report is an update to the Process Review that was submitted to FHWA in December 2017. Since then, NCDOT has continued to implement strategies found to be effective and added additional measures to fulfill all the goals and intent of the Rulemaking and NCDOT's Safety and Mobility Policy. In addition, NCDOT continues to enhance some pre-existing process elements while still working on improving others such as the collection and usage of work zone data.

## **PURPOSE AND OBJECTIVE**

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In 2007, the North Carolina Department of Transportation (NCDOT) committed to systematic consideration and management of work zone impacts related to safety, mobility, operations, and training through the Work Zone Safety & Mobility Policy. The purpose of this review is to assess the effectiveness of the current practices in managing work zone impacts and determining where improvements can be made. In addition, the process review will ensure compliance and adherence to FHWA's Work Zone Safety and Mobility Rule.

## **APPROACH**

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A process review meeting was held in November 2019 with NCDOT Work Zone Traffic Control (WZTC) and the FHWA - NC Division Operations Engineer to review the results of the 2017 report and to discuss recent updates and/or improvements.

## **RESULTS AND RECOMMENDATIONS**

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The process review meeting reviewed the results of the 2017 report and evaluated whether any improvements or innovations have resulted in safer or better mobility in our work zones. The highlights of the successes and areas for improvement are described below, along with recommendations to overcome these challenges.

### **New Practices**

***Smart Work Zones.*** Smart and connected technology has been implemented in an increasing number of projects throughout North Carolina over the past couple of years. In the 2017 Process Review, we noted the use of a queue warning and alternate routing system on a project near the Virginia State Line on I-85 just north of Henderson and another in Davie County on I-40 between Winston-Salem and Statesville.

WZTC has coordinated closely with our Traffic Systems Management and Operations Unit (TMSO) in our efforts to use technology in work zones to motorists' advantage.

In 2019, NCDOT introduced Dynamic Zipper Merge Systems to our work zone strategy toolkit. Dynamic Zipper Merge Systems are similar to the previously used Portable Queue Warning Systems in that they automatically detect traffic conditions, namely slow/stopped traffic, and change the messages on portable changeable message signs to warn drivers before they reach the back of the traffic queue. To take it one step further, Dynamic Zipper Merge Systems are capable of driver merge instructions. Once congested conditions are met and the traffic queue reaches a specified length, the system will no longer tell motorists which lane is closed in advance. This forces the motorists to use all open lanes up to the merge point and then take turns to merge into a single lane. Once conditions are no longer present, the system will revert back to standard lane closure messaging. The Dynamic Zipper Merge System has been a key solution to reduce long queue lengths in effort to decrease the risk of back of queue crashes. NCDOT has only used Dynamic Zipper Merge Systems for projects that require long term lane closures and the final design does not increase roadway capacity.

Two projects currently under construction are using these systems. The first Dynamic Zipper Merge System was installed and in operation in May 2019 on I-77 in Surry County near Elkin. NCDOT was able to observe the traffic in real time the moment the system was turned on. Drivers immediately began to use both lanes to the merge point, thus reducing the traffic queue length significantly. The other project is on I-40 in Davie County between Winston-Salem and Statesville. Just last year, this project utilized a Portable Queue Warning System. It was a straightforward process replacing a couple of devices and upgrading that system to a Dynamic Zipper Merge System. Both projects required long term lane closures on 4-lane divided highways to complete full depth concrete replacement that could not be reopened to traffic within one work period. This made these projects perfect candidates for the Dynamic Zipper Merge System.

Connected Lane Closure Devices were introduced on projects late 2018. Connected Lane Closure Devices are essentially small GPS transmitters attached to or adjacent to the merge taper flashing arrow board and attached to or adjacent to the last traffic control device in the lane closure. These devices transmit their location to navigational companies and the NCDOT State Traffic Operations Center (STOC). The goal is to allow motorists to see active lane closure information in any navigational software they are using. This is one of many efforts to increase our vehicle to infrastructure resources and prepare NCDOT for automated driving vehicles. These devices have been on many projects over the past year; however, we have found that the communication languages between the devices, the navigational companies, and NCDOT are incompatible at times. NCDOT has had and will continue to have correspondence with navigational companies, the STOC, and the device manufacturers to bridge this gap.

**Work Zone Traffic Control Design Manual.** NCDOT WZTC released its Design Manual on the WZTC website for use in July 2019. This manual is meant to serve as a traffic control design resource for TMP designers. It does not provide a one size fits all solution to design concerns. It is an online document that will be updated and expanded as necessary and will be instrumental in the implementation of the upcoming Work Zone Designer Training course.

## Improvements to Current Practices

**Nighttime Work Operations.** Daily time restrictions for construction activities continue to play a large role in the way we build our roadways and bridges. Working during the night limits the number of motorists exposed to the work zone and limits the number of motorists exposed to the construction hazards. To continue NCDOT's commitment to mobility and safety during construction operations occurring at night, Sequential Flashing Warning Lights, Presence Lighting, and Digital Speed Limit Signs are standard practice for interstate and/or primarily nighttime construction operations.

We continue to see overwhelmingly positive feedback from the construction industry and our regional traffic partners on the Sequential Flashing warning lights. We have seen several more manufactures produce these lights as they see the demand for them rise. These lights have been placed in every primary nighttime construction project for the last two years.

Work Zone Presence Lighting has been used on most primary nighttime construction projects in the past two years to supplement the Contractor's portable tower lighting already onsite. NCDOT management and field staff support WZTC's effort to increase the amount of light in active work zones, not only for worker safety, but for motorist awareness. In practice, WZTC was made aware of two observations:

1. Motorists did not pass the first Presence Light until after they were already in the active work area.
2. During certain operations, the Presence Lights presented some challenges for the Contractor including space conflicts with equipment and the requirement to reposition the lights throughout the night as work progressed.

To address both issues, Presence Lights are now used in advance of the lane closure. Motorists now see the first Presence Light approximately a mile and a half in advance of the lane closure merge taper and at regular intervals between 500' and 1000' depending on the light fixture size and distance from the merge taper. As the motorist gets closer to the lane closure merge taper the spacing between the lights decrease to create the effect of traveling at a faster speed than their actual travel speed. These changes went into effect statewide mid-October 2019 to make the change in the field and has been and will be a part of all Contracts with Presence Lighting since.

Digital Speed Limit Signs (see additional information in 'Work Zone Speed Limit Reductions' section) continue to display the speed limit brightly and clearly to motorists during the night and day. These signs are regulatory speed limit signs with LED displays for the speed limit numbers. The speed limit is changed remotely and immediately by personnel depending on the operation. NCDOT was finding that there were inconsistencies across projects whether the Digital Speed Limit Signs were only visible to motorists during nighttime lane closures or whether they were left visible to motorists throughout the day as well. The ideal is that the Digital Speed Limit Signs completely take the place of existing stationary speed limit signs for the duration of the work in that area. This has been communicated to our area construction staff for current and upcoming projects.

WZTC also began testing the effect of the Presence Lights and Digital Speed Limit Signs on motorist speeds early fall 2019. Six projects were selected across the state to capture speed data for three different conditions:

1. No Presence Lighting and no Digital Speed Limit Signs
2. No Presence Lights and with Digital Speed Limit Signs
3. With Presence Lighting and with Digital Speed Limit Signs

As of December 2019, 4 of the 6 projects completed the data capture. We plan to analyze the data beginning early 2020 and present our findings. Speed compliance is the ultimate goal we hope to accomplish with the use of Work Zone Presence Lighting and Digital Speed Limit Signs by making the entire work zone more conspicuous to the motorist. We plan to analyze the data beginning early 2020 and present our findings.

**Significant Projects Appearance.** NCDOT WZTC remains committed to safe and efficient work zones and continues to improve the appearance of significant work zones. As introduced in the 2017 WZ Process Review, Work Zone Performance Pavement Markings and High Visibility Devices have been used on many projects mostly with mostly success. Work Zone Pattern Masking has had some highs and lows.

As a refresh, Work Zone Performance Pavement Markings are long life markings (polyurea, epoxy, thermoplastic, polymer, and cold applied plastic - removable tape) to provide a more durable and higher performing work zone pavement marking over traditionally used paint for temporary traffic patterns that will be in place for 12 months or more. The markings are required to last the full duration of a traffic pattern without replacement or reapplication for a period of 12 months. The markings are also required to meet certain retroreflectivity numbers to improve nighttime work zone visibility. NCDOT has an on-call contract with a private company to perform mobile retroreflectivity readings across the state. These scans are completed at typical driving speeds without having exit the vehicle. Retroreflectivity scans of work zone performance pavement markings across the state have yielded various results. Yellow and white markings retroreflectance has not always met the numbers required by the Contract, but the nighttime visibility is far greater than what we experienced before we began this practice. WZTC will reevaluate whether or not the required retroreflectivity numbers are appropriate for our purpose. Work Zone Performance Pavement Markings will also be essential when autonomous vehicles become common and sensors are used to detect lane and edge lines.

High Visibility Devices are all new drums and stationary and portable work zone signs required for projects on interstates and freeways with durations of 24 months or more. New devices enhance visibility to improve both safety and mobility through a high-speed work zone. Fluorescent vertical sign post reflector strips were added as a requirement to stationary signs earlier this year to further enhance sign conspicuity. We will continue the use of High Visibility Devices to enhance our high profile, long duration interstate and freeway projects.

Work Zone Pattern Masking, a flat, black, liquid material applied by spray mechanism to conceal the entire existing pavement surface, continues to be used on projects with both

successes and failures. Many factors must come together for a successful application including the product makeup, application equipment and methods, roadway surface preparation and the weather. NCDOT is learning that very high humidity or low temperatures cause long dry times and affect the setup of the material, and thus the overall performance of it. Work Zone Pattern Masking has been applied to projects on I-40 in Burke County and Wake County, I-77 in Iredell County, I-40 in Iredell County, and I-485 in Mecklenburg County. WZTC has been in constant coordination with NCDOT construction personnel to yield the best results of this product, but we realize that more applications are necessary to fine tune it. We are confident that we will arrive at the correct material specification and application methods to be able to eliminate traditional pavement marking grinding.

**Mobility Measurements using Intelligent Technology.** As previously mentioned, WZTC been monitoring the mobility for several work zones on NC interstates and freeways using iPeMS, a third party system that collects and processes vehicle probe data. We experienced some data setbacks a couple of years ago, but this monitoring has been successful to date. Weekly, single page snapshots are compiled and distributed to personnel in the NCDOT Traffic Management Unit and to the NC Division FHWA Operations Engineer. We are able to see the ebb and flow of the work zones' mobility throughout the phases of construction. Soon, with historical data, we will begin to look at congestion caused by the work zone itself as opposed to recurring congestion that would exist whether the work zone was in the area or not. WZTC is in coordination with the analysts with iPeMS and iteris.

**Work Zone Traffic Analysis Research.** FREEVAL-WZ, a work zone software developed by the Institute for Transportation Research and Education (ITRE) at North Carolina State University to evaluate the impacts of work zones on the highway network, was mentioned as a research tool in the 2017 WZ Process Review. Since then, another version of the software, FREEVAL-NC, was released. FREEVAL-NC is more user friendly and has fewer malfunctions than its WZ predecessor. Training was held at the NCDOT Transportation Mobility and Safety Division in May 2019 with the researchers from NC State and various NCDOT units to get familiar with the program. FREEVAL-NC has been used since to estimate traffic queue lengths and approximate cost to road users during lane closures. ARTVAL, another ITRE software developed to evaluate the work zone impacts on urban arterials, remains under development. The research committee held a meeting in November 2019 and are progressing towards a final, usable ARTVAL product by the second quarter of 2020.

**Maintenance / Utility Traffic Control Guidelines (MUTCG).** This manual was created and made available on the NCDOT WZTC website to provide information and guidance to all persons working inside the Highway Right of Way in North Carolina. To date the manual has been well received by both the industry and internal NCDOT maintenance staff and is available on the NCDOT WZTC website. A chapter was added to address short term sidewalk disruptions. NCDOT has put extra emphasis on pedestrian maintenance for the past couple of years, but it mostly relevant to our long term construction projects. Chapter 6 lists appropriate measures to take when a sidewalk will be closed or blocked for durations of 1 hour up to 7 days. After a 7-day disruption in a single location, a TMP is necessary.

## **Review of Ongoing Successful Practices**

**Traffic Safety & Operations Meetings.** Safety & Traffic Operation Meetings continue to be added and utilized on most Design Build and Category I Significant projects. These are held on a biweekly or monthly basis and are planned and executed by the Division Incident Management Engineer. Law Enforcement, emergency services, construction staff, traffic engineering staff, contractor staff, public information officers and the TMP design team meet to discuss recent traffic issues including WZ crashes, upcoming schedule, traffic shifts, lane and road closures, incident response issues, etc. In addition, they discuss specific solutions to these traffic related issues to improve the congestion and traffic operations in and around the project. We will continue this practice with all upcoming Design-Build and Category I Significant Projects.

**IMPACT Let List Meetings.** These meetings are held on a quarterly basis and continue to provide valuable information to the public information staff members. The participants of the meeting include WZTC, which is responsible for the development and/or oversight of the Transportation Management Plans (TMPs), and TSMO, which is responsible for statewide coordination of incident management and intelligent transportation systems efforts. Projects discussed during the meetings are categorized as High, Medium or Low Impact on traffic mobility. These meetings also help establish early communication between what goes in the TMP and how the work zone operates in the field. A long term goal is to be able to discuss projects two to three years in advance of the Let date to foster early involvement and prevent last minute issues. We also use the results of these meetings to select candidate projects for our “HAWKS” program. This program utilizes off-duty State Highway Patrol Officers to monitor and patrol selected work zones. This is described in more detail below.

**HAWKS (Helping All Work Zones Keep Safe).** HAWKS is a joint initiative between NCDOT and North Carolina State Highway Patrol (NCSHP) to utilize off-duty law enforcement officers to monitor and patrol work zones. This initiative provides dedicated enforcement in a specific work zone to improve safety and mobility. NCDOT prioritizes the work zones using crash rates, existing congestion, average speeds, and roadway tier classification (statewide, regional, sub regional) as the scored criteria. Projects with the higher scores are selected for the program and notifications are sent to the Resident Engineer and the State Highway Patrol Office for staffing and scheduling assignments.

**Work Zone Speed Limit Reductions.** The Work Zone Traffic Control Section is continuing to apply speed limit reductions in most cases during high speed lane closures and other traffic control situations that warrant a lower speed. All speed limit reductions still require an ordinance once the project and/or operation meets certain criteria. The advantage of variable speed limit reductions has been evident on interstate and freeway resurfacing projects, subject to primarily nighttime lane closure operations, with normal traffic patterns existing during the daytime. We continue to implement variable speed limit reductions easily with the use of Digital Speed Limit Signs. The speed displayed on the signs can be changed throughout the work area immediately and simultaneously from a device. As soon as the operation concludes, the speed limit can again be changed immediately to the existing speed limit.

Longer term speed limit reductions in work zones have separate criteria and are used when



highway geometrics have been altered and/or usable shoulders have been eliminated. When these types of conditions exist, the reduced speed limits are displayed on standard regulatory speed limit signs.

**\$250 Work Zone Speeding Fine.** This practice has been used in North Carolina for over 20 years. The NC general statute for \$250 speeding fine was revised to allow the penalty to be used in sections of a work zone where the actual work is taking place. Previously, the wording of the law required the penalty to be applied for the entire work zone. The public was frustrated that fines were levied in areas where no work is taking place particularly with long Interstate resurfacing projects. To date, we have experienced little concerns from the law enforcement community and frustrated drivers. The lesson learned is to use this technique “judiciously” and the compliance rates will dramatically improve, along with law enforcements willingness to enforce this fine.

**Work Zone Supervisor.** North Carolina requires a Work Zone Supervisor for each company that performs work within our Right of Way. We also require it for each Division within NCDOT. Contractors and NCDOT Divisions are allowed to determine how many Work Zone Supervisors they need based on their work load, but they must have at least one. The requirements are based on years of experience (work zone experience and supervisory experience) as well as the successful completion of an approved Work Zone Supervisor course. Once a person is qualified as a Work Zone Supervisor, they have two major responsibilities:

1. They must be available to work crews to assist and answer work zone set up questions
2. they are also responsible for making sure all their employees have adequate work zone training to safely carry out their tasks.

On Category I Significant projects, we require a Work Zone Supervisor to be staffed directly to the project. A project special provision is added to the contract that stipulates the duties and responsibilities of this requirement. The purpose of this position is to provide NCDOT with a point of contact that is responsible for safety and mobility in the work zone. This position is also responsible for ensuring coordination between projects in the same network, monitoring queues, and coordinating with traffic management centers. This practice has provided better communication between the traffic management centers and project personnel.

**Work Zone Reviews.** The Work Zone Traffic Control Section implemented procedures and or guidelines for the review of work zones in 2013 (WZ Safety Audits). We also established a work zone scoring system that objectively evaluates the work zones by scored categories and an overall score. In 2018, we began regular nighttime work zone reviews. Most interstate construction operations happen during the night hours between 9pm and 5am. Reviewing work zones at night provides opportunity to evaluate the nighttime work operations procedures including the use of Sequential Flashing Warning Lights and Work Zone Presence Lighting, as well as review the visibility of the pavement markings and work zone signs. Conclusions made from the work zone review is provided to the Contractor, Division personnel and the NCDOT Construction Office. We use this information to determine if there is any correlation between work zone crashes and the type of work, entity performing the work, and the possibility of training requirements.

**Work Zone Review Annual Summary Reports.** Data derived from the Work Zone Reviews is compiled and summarized bi-annually indicating the results or findings of field safety audits. These reports help assist us in determining whether NCDOT Standards and Practices are implemented in the field consistently, uniformly, and effectively to provide a satisfactory level of safety, traffic flow and construction efficiency. In addition, they reveal techniques or technologies needed to improve overall safety, traffic flow and construction efficiency or identify current standard practices that may need updating based on observations and/or feedback. These reports are available online in the following location:  
<https://connect.ncdot.gov/projects/WZTC/Pages/Manuals-Guidelines.aspx>

## **Upcoming improvements to Current Practices**

**Work Zone Training Requirements.** Currently, the NCDOT Work Zone Training Requirements include those for Flaggers and Work Zone Supervisors. The Work Zone Installer Certification will be a requirement for all personnel responsible for the setup and installation of work zone traffic control devices inside the highway right of way beginning June 1, 2020. Recertification requirements mimic those of Flaggers and Work Zone Supervisors. Work Zone Designer Training remains under development for training requirements for personnel involved in the design of TMPs. However, additional guidelines and design requirements including the Work Zone Traffic Control Design Manual are available on the work zone website.

## **Areas for Improvement**

**Work Zone Data.** Work zone data collection and usage is still an area where improvements can be made. The availability of speed data is becoming more accessible through the INRIX program and Iteris technology and we are in the beginning stages of evaluating mobility of the work zone through this data. We met our goal set in December 2015 for implementation of mobility evaluation but will continue to grow as more data is analyzed in 2020-2021.

We are continuing to review work zone crash information. We review these reports and make determinations on whether the work zone may or may not have had an impact in the crash but we can only concentrate on fatal crashes that were within the limits of a work zone due to limited staff and time. Other work zone crashes are reviewed on a project by project basis. As technology improves and government silos are reduced, this information will allow us to be timelier in the assessment of the crash reports, but also may help drive the content and audience of our work zone training.

**Process Review.** NCDOT is still committed to conduct a bi-annual Process Review to assess performance of existing processes and procedures and make changes that bring about improvements. NCDOT will be using data from the FHWA Work Zone Self-Assessment Program, Safety Audits, and the annual Windshield Review(s) during the process review. Recent organizational changes and budget constraints have had an impact on the needed resources to conduct these reviews. However, NCDOT is working on a recommendation to develop a procedure for conducting process reviews and make it an integral part of the business process.

**Work Zone ITS (on all contracting).** We are in the process of developing a statewide “On

Call” WZ ITS contract for 2020. This effort will focus on utilizing multiple traffic control companies and NCDOT Regional Traffic Engineering Staff to identify and deploy systems in the field.

**Work Zone Crashes & Fatal Data.** From reviewing WZ crash data over the past 18 years, NC’s WZ crashes are increasing, but the WZ fatal crash rates per miles driven are decreasing.

5 year avg. (2014 - 2018) = 5,771 WZ Crashes  
5 year avg. (2014 - 2018) = 23 WZ Fatal Crashes  
2018 = 7,262 WZ Crashes  
2018 = 26 Fatal WZ Crashes  
2019 (as of 12/6/19) = 27 Fatal WZ Crashes

We monitor and analyze this data to determine whether the work zone directly contributed to the occurrence and/or severity of the crash. Often, the work zone had no impact on the occurrence and/or severity. Impaired motorists and speeding motorists continue to be a concern in work zones, however if work zone safety is improved for the average motorist it will also improve for the impaired or speeding driver. With an increased presence of WZ ITS, we will be able analyze and improve these numbers in future years.

## **CONCLUSION**

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NCDOT is determined to promote an agency culture committed to the Work Zone Safety and Mobility Policy. Although progress has been made in getting the requirements of the Rulemaking and North Carolina’s Mobility and Safety Policy implemented, there are still some areas needing improvement. These areas include:

1. Completing the Work Zone Training Program by establishing work zone training requirements for TMP designers
2. Expand the use of feedback for analyzed traffic data back into the training and design processes and procedures project level process and procedures.

Although crash and speed data continue to become easier to obtain with improvements in technology, recent cuts in staffing make it increasingly challenging to dedicate personnel to evaluate this data and create a plan of action based on the results of such analysis. To implement the policy completely, we may have to rely more on the private sector and outsource more of this work. We have already privatized most of the work zone training (Flagger, WZ Supervisor and Installer training) and may need to do the same for evaluating crash and speed data and even auditing existing work zones. Whether the work is outsourced or remains with existing personnel, the NCDOT is committed to providing safe work zones for all workers and road users while minimizing traffic congestion and adverse impacts on road users and local communities.

## REFERENCES

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FHWA Work Zone Safety & Mobility Final Rule

Effective October 12, 2007

Available at: [http://ops.fhwa.dot.gov/wz/resources/final\\_rule.htm](http://ops.fhwa.dot.gov/wz/resources/final_rule.htm)

FHWA Temporary Traffic Control Devices Final

Rule Effective October 4, 2008

Available at: <http://ops.fhwa.dot.gov/wz/resources/policy.htm>

NCDOT Work Zone Safety & Mobility Policy

Effective October 12, 2007

Available at: [https://connect.ncdot.gov/projects/WZTC/Documents/WZSafety\\_and\\_Mobility.pdf](https://connect.ncdot.gov/projects/WZTC/Documents/WZSafety_and_Mobility.pdf)

NCDOT Maintenance / Utility Traffic Control Guidelines

Available at: <https://connect.ncdot.gov/projects/WZTC/Pages/Manuals-Guidelines.aspx>

NCDOT WZTCS – Work Zone Safety Audits Annual Summary Report

Available at: <https://connect.ncdot.gov/projects/WZTC/Pages/Manuals-Guidelines.aspx>

NCDOT WZTCS – Transportation Management Plans Design Manual

Available at: <https://connect.ncdot.gov/projects/WZTC/Pages/Manuals-Guidelines.aspx>