QUICKZONE DELAY ESTIMATION SOFTWARE: NOVA SCOTIA CASE STUDIES

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ABSTRACT

QuickZone is a work zone delay estimation software program developed by the United States Department of Transportation, Federal Highway Administration (FHWA) designed to quantify work zone impacts in terms of queues, user delay, travel behavior and costs. FHWA contracted with Mitretek Systems, a non-profit scientific and engineering research corporation, contracted to develop QuickZone. In 2001, the Nova Scotia Department of Transportation and Public Works acquired a beta version of QuickZone from Mitretek Systems to beta-test and provide feedback on various aspects of the look, feel and use.

QuickZone is one of the first analytical tools that allow for quick and flexible estimation of impacts to motorists due to roadway construction. QuickZone allows users to 1) Quantify corridor delay resulting from capacity decreases in work zones; 2) Identify delay impacts of alternative project plans; and 3) Support tradeoff analyses between construction costs and delay costs. The software support all four phases of the project development process including policy, planning, design and operation.

The Nova Scotia Department of Transportation and Public Works has been using QuickZone software to help analyze a number of construction projects where traffic delays were expected to have a significant impact on its highway users. In addition, the Department has been a key partner in development process by providing feedback to the software developers to help them improve the software and its application.

This paper will address three topics. First the paper will describe the development of the software, its intended uses and the role of the Department in the software development process. Second, the paper will outline several case studies from Nova Scotia where QuickZone has been used to assist in the planning of highway improvement projects. Finally, the paper will provide some guidance on how QuickZone can be applied in other Provinces throughout Canada.

1.0 Introduction

In many areas of Canada and the United States, highway traffic volumes are increasing and there is greater demand from highway users to minimize delays. Highway construction work zones can be the source of significant delay to motorists and many highway agencies have found it necessary to better plan construction work which affects existing facilities to minimize the delays imposed on the highway users. The delay imposed by highway construction work zones is not a hard cost, such as the concrete, steel or stone necessary to build a highway. Rather, delay is considered to be a soft cost, or the value of a motorist's time stuck in congestion due to highway construction. Only recently have highway agencies begun to take into account the soft cost of highway construction.

In all but a few high-visibility roadway construction and refurbishment projects, the soft cost of traveler delay is typically not considered when key decisions about project staging and duration are made. The 1998 United States Department of Transportation Federal Highway Administration (FHWA) report "Meeting the Customer's Needs for Mobility and Safety During Construction and Maintenance Operations" identifies this issue and recommends the development of an analytical tool to estimate and quantify work zone delays. To this end, the FHWA sponsored the development of QuickZone, an easy-to-master analytic tool that allows for quick and flexible estimation of work zone delay supporting all four phases of the project development process (policy, planning, design and operations).

The overall goal in terms of ease-of-use for QuickZone is less than one hour to input and check a QuickZone network, and less than three minutes to analyze the data and produce delay profiles over the project duration. Target users of QuickZone include state and local traffic construction, operations, and planning staff as well as construction contractors. QuickZone allows these users to:

- Quantify corridor delay resulting from capacity decreases in work zones;
- Identify delay impacts of alternative project phasing plans; and
- Support tradeoff analyses between construction costs and delay costs.

1.1 QuickZone 1.0

QuickZone development began in April 2000 using a rapid prototyping approach. This implies that a series of prototypes with limited capability be released to a set of beta testers for evaluation. The QuickZone Tool Review Committee, a sub-group of the FHWA Strategic Work Zone Analysis Team, was formed and drew from a user base of contractors, DOT planners and local agency personnel. The tool review committee was to help guide and evaluate the development of QuickZone Version 1.0 as well as beta test early versions of the software. The tool review committee responded not only in terms of look and feel of the product, but in terms of how they imagined using the tool.

QuickZone Version 1.0 was made generally available in June 2002. Since that time approximately 109 licenses have been sold at a cost of $199. Sales of QuickZone have occurred across the United States to contractors, universities, and various state and local DOTs.

QuickZone has also been purchased by users in foreign countries including Canada, South Africa and Japan. In addition, numerous training classes and seminars have been sponsored by FHWA and state DOTs to further promote the use of QuickZone throughout the United States.

1.2 Utilization of QuickZone in Nova Scotia

The Nova Scotia Department of Transportation and Public Works began using the QuickZone software in 2001. Several high profile projects on heavily traveled two-lane, two-way highways in the province had created significant delays to highway users. Construction field staff were looking for an easy to use tool to help better plan construction projects so that delays could be minimized.

The department initially used actual traffic flow observations from a highway construction work zone as input to gain confidence in the software, The estimated queuing and delays which were output from QuickZone matched closely to the observations in the field. During this evaluation period departmental staff provided data and feedback to the developers of QuickZone to further assist them in future software improvements.

After the departmental staff became comfortable using QuickZone, and trusted the outputs it gave, it was then used to help with the planning of a number of construction projects which were anticipated to create significant delays for highway users. QuickZone was used to modify project phasing on several projects and on other projects it was used to modify the hours of work which would be permitted. This included several projects which required work to only be carried out during night time hours.

1.3 Case Study Overview

QuickZone has been widely used by the Nova Scotia Department of Transportation and Public Works. The Nova Scotia case studies presented here are just two of the many applications of QuickZone and are classified as an “Urban Arterial” application—medium to high volume roads with signals and at-grade intersections. In addition, recurring congestion may be a problem in which case lane closures are restricted depending upon traffic volume and time-of-day. The first case study is the Little Bras d'Or Bridge: Nova Scotia, Canada a medium volume two-lane road where major structural repairs to bridge required flagging operations. The second is Reeves Street: Nova Scotia, Canada also a medium volume two-lane road where an intersection reconstruction required periodic lane closures on major route through Nova Scotia province.

The case study summaries provide an analysis of how QuickZone was utilized for each case study. The analysis includes a listing of key observations that are important to how QuickZone was used for each project; an overview, which includes a description of the project location, to better orient the reader and provide context; a discussion on network design for each case study; and finally an analysis of the results and how they were used. In addition, a summary of other selected projects where QuickZone has been used is also provided.

2.0 Nova Scotia QuickZone Applications

2.1 Little Bras d'Or Bridge: Nova Scotia, Canada

Cape Breton Island is on the north-east tip of Nova Scotia and is connected to the mainland by a man-made causeway. The main road through Nova Scotia is the Trans-Canada Highway that runs through Cape Breton Island and over to the port of North Sydney which provides the ferry link to the province of Newfoundland. The Trans-Canada Highway, along with the port of North Sydney, is the primary link for the movement of people and goods to and from that province.

Access to North Sydney from the Trans-Canada highway is only available via two bridges: the Great Bras d'Or and Little Bras d'Or bridges. The Little Bras d'Or bridge provides the only crossing over the Bras d'Or gut which connects Bras d'Or Lake with the Atlantic Ocean. Currents in the gut are very strong as the tides move in and out of an inland lake. In the spring of 2001 a major structural rehabilitation project was started on the Little Bras d'Or bridge which consists of 4 x 100' steel girder spans and was built in 1959.

The bridge carries a two lane, two way highway. It was necessary to close one lane to carry out repairs. Traffic flow was controlled by signals, and later during peak traffic flow hours by flaggers. As the project progressed into late spring, traffic volumes increased and motorists began to experience significant delays. Local residents, businesses, politicians and emergency services were very vocal about the delays which resulted. Political pressure forced the work to be rescheduled for November. In anticipation of the November bridge work, the provincial transportation engineer started to look for tools which would help him predict the impact of the proposed closure so that he could make objective decisions on when work could take place. He discovered the QuickZone V 0.99 beta software on the internet and realized the value it could have on testing various approaches to work zone staging for the Little Bras d'Or project.

2.1.1 Network Design

The network for the Little Bras d'Or bridge is simple in design and consists of six links and four nodes as shown in Figure 2.1.1. The only complication with the Little Bras d'Or network is the existence of two-way one lane operations which QuickZone V 0.99 Beta (and Version 1.0 as well) cannot explicitly handle. Only link 2 of the Little Bras d'Or network was designated as a work zone. Cleary, links 2 and 5 will both be affected by the construction. However, since QuickZone V 0.99 Beta is limited with analyzing flagging operations, each direction of traffic flow had to be analyzed separately. Therefore, only the inbound direction was analyzed since this had the highest demand and would result in the maximum queue and delay for the entire network. QuickZone 2.0 now includes features to directly analyze two way, one-lane operation.

Traffic data was made available through the Nova Scotia Department of Transportation and Public Works. Hourly traffic volume data was obtained from the Department's Traffic Census Team. The traffic census data is not available on-line so specific requests were made to the Traffic Census Team for information on each site studied. Turn around time for data was usually within 24 hours. This data was only been available in "raw" counts, so some re-calculation was required in order to develop the necessary daily and hourly demand factors which QuickZone uses for its demand inputs. Seasonality factors were also available for each highway section from the Traffic Census Team. Most traffic data is unclassified so assumptions were made for percent of heavy vehicles.

A critical factor to provide accurate predictions is to accurately estimate the work zone capacity. While QuickZone does not directly estimate capacity loss due to a work zone (some guidelines based upon the Highway Capacity Manual are included), there is a fair amount of research available on multi-lane highways, but very little on two lane two-way highways under a full lane closure. Estimates of capacity loss were based upon observations made on various types of sites over the past few years.

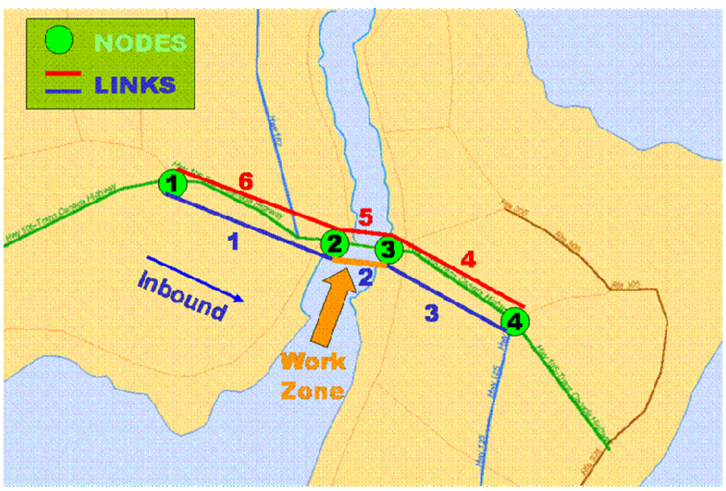

Figure 2.1.1 Little Bras d'Or Bridge QuickZone Network

2.1.2 Results

Due to the impacts of traffic delays, the initial construction project was stopped and basic repairs were made in order to keep the bridge safely open until a better solution could be found so as to not impact motorists as much. In 2004, the initial analysis performed at this site was updated for a milling and repaving project on the same section of highway. QuickZone was used to support the decision to do the work at night and also to define the nighttime work hours, which would have to be followed by the contractor. It is anticipated that the structural repairs started in 2001 will re-start and be finished in 2005.

2.2 Reeves Street: Nova Scotia, Canada

Nova Scotia is one of Canada's Atlantic maritime provinces located on the east coast with a provincial population just under 1 million. Nova Scotia is composed of several islands and peninsulas with key commercial and population centers connected by the Trans Canada Highway. Port Hawkesbury is a key commercial location on Cape Breton Island just south of the Trans Canada Highway. The town of Port Hawkesbury includes a number of major industrial facilities representing companies such as Georgia-Pacific, Statia Terminals, USG, and the Sable Offshore Oil Company. The town also includes a number of residential communities.

In 2001, the intersection of Reeves Street and Trunk 4 in Port Hawkesbury, a location along a key access route to the Trans Canada Highway, was slated to be upgraded. Both Reeves Street and Trunk 4 are generally 2-lane highways with certain sections upgraded to include designated turn lanes in built-up areas. Average Annual Daily Traffic (AADT) was on the order of 8,000 vehicles per day with approximately 10% of those being trucks. Truck traffic is concentrated during the daytime on weekdays, while trucks make up fewer than 5% of traffic volume on weekends. Most of the traffic volume at this location in Port Hawkesbury is through traffic continuing on to some of the industrial centers near the town or to points further north.

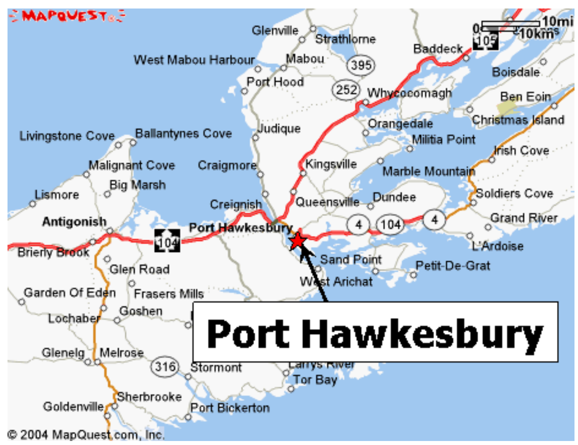

Figure 2.2.1 Port Hawkesbury, NS

The reconstruction involved a major upgrade of the intersection including additional dedicated turn lanes to accommodate higher traffic volumes and to improve safety. In order for construction to take place, overall capacity of the intersection would be reduced due to narrow lanes widths and periodic lane closures. Construction was slated to take place only during daylight hours because of cost and safety concerns. However, it was also evident that any construction taking place during the day would have an impact on motorists, since the Reeves Street/Trunk 4 intersection carries a large amount of traffic. Therefore, in order to reduce the impact to motorists as much as possible, QuickZone Version 1.0 was used to test various construction phasing alternatives, including analyzing the possibility of a detour route, and to also provide the necessary data to justify the additional expense of night work.

2.2.1 Network Design

The network for the signalized Reeves Street intersection is a fairly basic design and consists of 12 links and 6 nodes including a detour route as shown in figure 2.2.2 below. As shown in figure 2.2.3 below, Reeves Street ends at a "T" intersection with roads Trunk 4 and Trunk 4a. The left turning movement continues on to Trunk 4 and carries most of the traffic volume. The right turning movement continues on to Trunk 4a and terminates shortly thereafter in large industrial area. In order for QuickZone to analyze the intersection, only the left turning movement headed north-east and the right turn movement headed south-west were modeled. This can be considered a corridor unto itself with the capacity limited primarily by the left turning movement lanes and signal phasing. The detour route consisted of Sydney Road which cut through a mostly residential section.

Detailed traffic data was available for this intersection from a traffic study which was carried out in 2000. The demand data, along with the signal timing plans, helped to determine the capacity of the intersection. Thus, the capacities of the various turning movements helped to determine the capacity of each link. Capacities under work zone conditions were estimated by the engineer from prior experience with flagging operations. The capacity and demand along the detour route was measured during the peak periods and on weekends by hand.

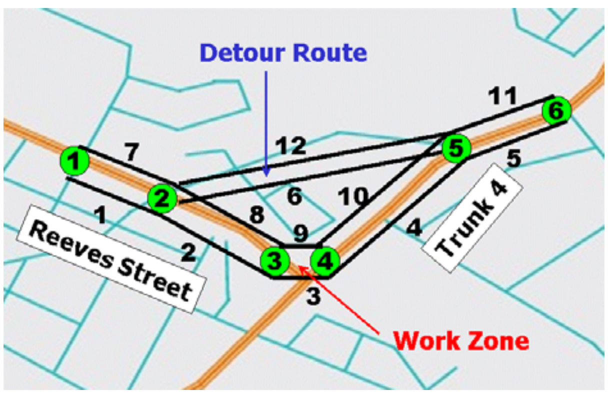

Figure 2.2.2 Reeves Street QuickZone Network

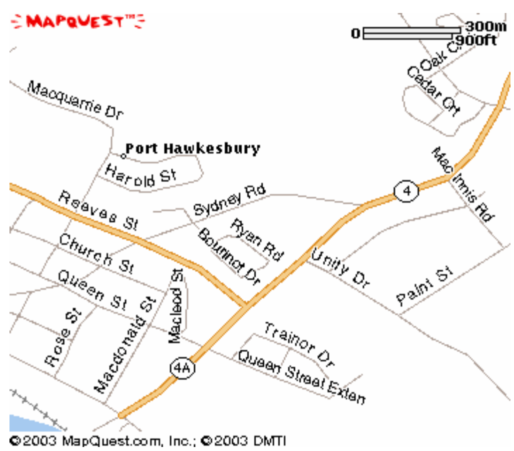

Figure 2.2.3 Reeves Street Intersection

2.2.2 Results

The local engineers suspected that the reconstruction of the Reeves Street intersection would result in significant queuing and delay and that doing the construction at night could potentially mitigate many of these impacts. Initial results from QuickZone proved these suspicions and showed an estimated maximum queue of 4.1 miles resulting in a 70 minute delay occurring on Friday evenings. Queuing and delay were also seen on Monday, Tuesday, Wednesday and Thursday but were approximately half the length and duration as seen on Friday evenings. Detour traffic was estimated at 10,000 vehicles per week. Knowing that the queuing, delay and detour volumes through the residential areas would be contentious issues with residents, the local engineers tested various construction phasing scenarios with QuickZone.

The first QuickZone analysis had the work zone in place and operating with reduced capacity 24 hours a day, 7 days a week. Queuing during the day on Friday and Saturday were predicted to be especially severe. The engineers noted that queuing and delay did not form during the overnight hours on any day and tested a scenario that eliminated construction during daylight hours on Friday and Saturday (essentially shifting work to night). The results of this scenario cut in half the queuing and delay associated with the construction to 2.19 miles and 36.4 minutes respectively. In addition, the number of weekly vehicles on the detour route was reduced to 6,000, a 40% reduction.

Additional refinements in the work zone design, including tweaking the hours and days of operation, enabled the engineers to better schedule the construction activities so as to not impact motorists. Also, the Nova Scotia Department of Transportation & Public Works did not have a night-time construction policy and did not routinely approve projects for night work due to cost and safety concerns. Because of the results generated by QuickZone, the decision was made to carry out some of the most disruptive phases of construction at the Reeves Street intersection at night.

2.3 Other Applications

In addition to the two case studies presented in this document, QuickZone has been widely used throughout Nova Scotia. Two other examples include:

- **Highway 125 – Re-paving Projects**
  QuickZone was used to make the case for night work and to define working hours on two projects on Highway 125, which is the main arterial highway for the city of Sydney and surrounding communities.

- **Highway 104 – Canso Causeway – Repaving, Bridge Repair and Rotary Upgrade**
  QuickZone was used to make the case for night work and to define working hours on three projects at the Canso Causeway, which connects Cape Breton Island with the mainland.

Also, at the 2004 U.S. Transportation Research Board Annual Meeting, Rob Bushman (Rob.Bushman@usask.ca) presented a paper entitled *"Estimating The Benefits Of Deploying Intelligent Transportation Systems In Work Zones"* where QuickZone was used to help estimate the benefits of deploying ITS in work zones. An evaluation was made of the expected benefits of the application of ITS technology to a construction project on I-95 in North Carolina. QuickZone was used to model two situations, a base case without the use of a traffic management system and the alternate case of a traffic management system applied. Estimations were also made of the expected reduction in emissions and the expected reduction in injuries and fatalities. The analysis demonstrated the application of analysis methods that can be applied generally to work zone ITS projects of this type and a favorable benefit/cost ratio expected for the specific project studied. User delay has the potential to provide significant benefits in relation to costs and other benefits, and therefore should be one of the initial decision making criteria. A user delay graph was presented which estimates the amount of delay based on traffic volume and composition.

3.0 Using QuickZone in Other Canadian Provinces

QuickZone has been successfully used to help plan highway construction and maintenance projects in Nova Scotia and in the United States. The projects on which it has been successfully used range from low-volume rural roads to high-volume multilane urban freeways. QuickZone has the potential to be a valuable project planning tool for federal, provincial and municipal highway jurisdictions throughout Canada for many different types of highway facilities.

With regards to the Reeves Street project, without the results of QuickZone, the decision to perform construction at night could not have been made and the impact to motorists would have been more severe. In addition, the use of QuickZone helped Nova Scotia DOT avoid public outcry and complaints as was seen in the Little Bras d'Or project. The Little Bras d'Or Bridge project also highlighted the need for more direct analysis of flagging operations, a feature incorporated into Version 2.0.

The two QuickZone case study projects presented in this document provide potential users with an introduction to the use of QuickZone and different examples of how it has already been used in the field by engineers in Nova Scotia. Clearly, the utilization of QuickZone is not relegated to just one type of roadway facility or location and the case studies presented in this document highlight this. QuickZone can be used for multiple applications including:

- Rural or Urban
- Big Projects/Small Projects
- Operations and Planning
- Freeway and Arterial
- Single Work Zones to Projects with Multiple, Interacting Work Zones
- Full and Partial Lane Closures, Flagging Operations, Periodic Full Closure
- Projects with Good Detour Routes
- Projects with No Detour Routes

For more information regarding QuickZone please visit the QuickZone web site at http://www.tfhrc.gov/its/quickzon.htm. You may also contact:

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