Establishment of Traffic Signal Policies and Procedures for Adoption on Saskatchewan's Highway Network

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ABSTRACT

The Saskatchewan Ministry of Highways and Infrastructure (the Ministry) completed a study in 2015 to expand their compliment of safety countermeasures along medium to high volume corridors and intersections. The report recommended to only consider the implementation of traffic signals where certain operational and safety conditions were met. The Ministry has not traditionally used signals at isolated, high speed rural intersection as a safety countermeasure because of the risk that collision severity will increase, in addition to compromising the intended mobility of these free-flowing major highway systems.

Within this context, the Ministry retained Tetra Tech to assist in the development of policies and procedures for signal adoption. The policies will guide the Ministry to determine whether traffic conditions are/are not favourable to support signal implementation at locations under review. Policy statements were developed from current industry practices and from other jurisdictions' guidelines and policy documents. A total of 13 statements were recommended to address: conditions where traffic signals could be considered, conditions where they may not be appropriate and other policy decision items.

The current procedures adopted by the Ministry date back to 1989, and followed closely to the Transportation Association of Canada (TAC) guidelines of that time. As part of this latest initiative, Tetra Tech reviewed the current TAC procedures as well as other industry practices to confirm the approach that should be adopted that represents the Saskatchewan context. The recommendation for the Ministry was to adopt a hybrid of approaches used in North America jurisdictions that address the following:

- Achieving a minimum traffic volume for various time periods (eight-hour, four-hour and peak-hour volumes);
- Meeting a specific collision experience threshold that demonstrates under certain conditions, installing signals can benefit an intersection by reducing collisions of a high severity and type sufficiently to offset the increase in similar/lower severity collisions;
- Coordinated signal system to address adequate progression of vehicles along the main corridor; and
- Demonstrated improvement in the level of service and delay.

This paper will present a summary of current industry practices, to discuss the establishment of policies and preferred warrants for adoption by the Ministry, as well as to provide the findings of a calibration check that applied the recommended policy statements and warrant procedures on four candidate intersections.

INTRODUCTION

The Saskatchewan Ministry of Highways and Infrastructure completed a study in February 2015 titled 'Safety Countermeasures for Saskatchewan Highways' for the purpose of expanding their compliment of safety countermeasures along medium to high volume corridors, and intersections. As part of this study, a review of current industry practices was completed to confirm the effect that installing traffic signals could have on the safety performance of an intersection. With respect to considering the installation of traffic signals to address safety issues, the report recommended that the Ministry only consider such, when the following operational and safety conditions apply:

- The Canadian Traffic Signal Matrix Warrant Procedure (TAC, 2007) is met;
- The National Cooperative Highway Research Program (NCHRP) collision experience warrant is met;
- Traffic analysis confirms a significant reduction in delay for traffic on the minor road; and
- Other countermeasures including roundabouts have been deemed inappropriate for the context.

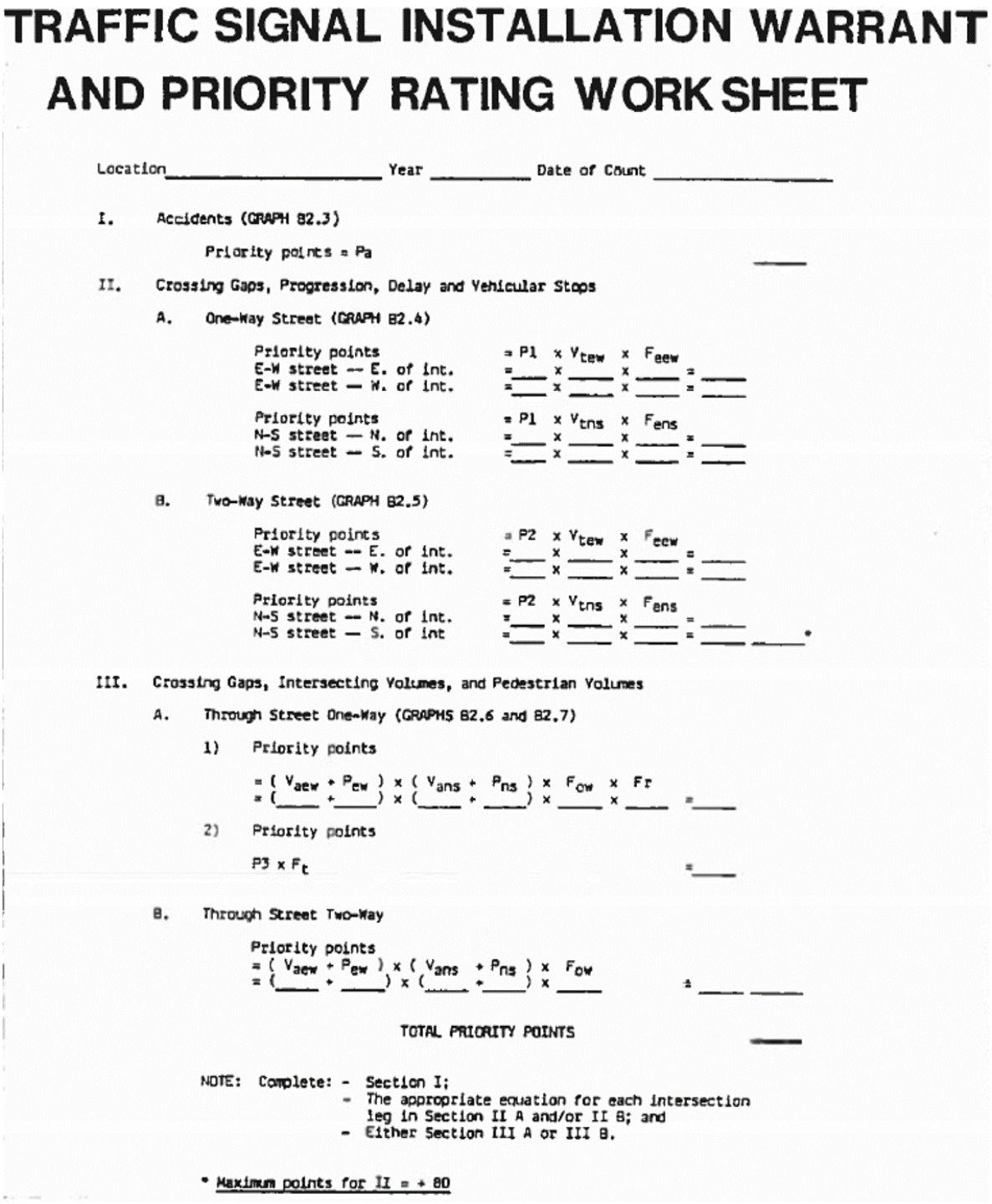
According to this 2015 study, traffic signals are not currently used at isolated, high speed rural intersections. There are some corridors within urban communities that are or have been under the Ministry's jurisdiction, most noticeably on the TransCanada Highway (Victoria Avenue) in Regina and Highway 7 in Kindersley, which were installed and operated by the municipality. In addition, this report states that 'Saskatchewan has no rural traffic signals or roundabouts' and the 'Ministry has not traditionally used traffic signals as a safety countermeasure because of the risk that collision severity will increase, in addition to compromising the economic benefit of free-flowing major highway systems. All-way stop control is occasionally used at rural provincial highway junctions, but never where one of the highways is a four-lane divided facility'.

This study also discussed the existing conditions experienced in the province regarding suburban (or satellite) communities that surround Saskatchewan's largest cities (most noticeably Regina and Saskatoon), where development, traffic and population growth have led to increased pressures placed on the highway system. In areas with such pressures, the Ministry has received requests to consider traffic signal installation to better manage gaps in the traffic stream for minor road approaches. Up until recently, the Ministry was reluctant to install traffic signals at isolated, high speed rural intersections due to many safety concerns with respect to an over-representation of certain types of higher severity collisions, specifically right angle and rear ends. With the recommendation for the Ministry to consider traffic signals under certain operational and safety conditions, the Ministry commissioned a review of other jurisdictional practices and current industry standards specific to the use of traffic signals on their high speed rural highway network that would update current policies and practices within the province.

CURRENT POLICIES AND STANDARDS

The current policy administered on provincial highways was developed in 1989 and is included under Section 2500 of the Ministry's Design Manual 2. The policy defines the warranting conditions that must be met to consider installing traffic signals on the highway network within the jurisdiction of the Ministry. The warrants follow the procedures contained in the Manual of Uniform Traffic Control Devices for Canada (MUTCDC) with some localization to better suit Saskatchewan conditions. At the time the policy was developed, all data interpretation and warrant evaluation was completed by department district staff with approvals being obtained through the former Design and Traffic Safety Branch. Joint reviews of signal requirements were completed with municipal staff for highway routes through urban centres. The review

and approval process required that a completed warrant evaluation worksheet for each intersection under review be submitted that followed the procedures outlined in the MUTCDC methodology (prior to it being revised in 2007 with the introduction of the TAC Traffic Signal Warrant Spreadsheet). The sample worksheet is provided as Figure 1.



TRAFFIC SIGNAL INSTALLATION WARRANT AND PRIORITY RATING WORK SHEET

Location_____ Year _____ Date of Count _____

I. Accidents (GRAPH B2.3)

Priority points = Pa _____

II. Crossing Gaps, Progression, Delay and Vehicular Stops

A. One-Way Street (GRAPH B2.4)

Priority points = P1 x V_{tew} x F_{aew}
E-W street — E. of int. = ___ x ___ x ___ = ___
E-W street — W. of int. = ___ x ___ x ___ = ___

Priority points = P1 x V_{tns} x F_{ans}
N-S street — N. of int. = ___ x ___ x ___ = ___
N-S street — S. of int. = ___ x ___ x ___ = ___

B. Two-Way Street (GRAPH B2.5)

Priority points = P2 x V_{tew} x F_{aew}
E-W street — E. of int. = ___ x ___ x ___ = ___
E-W street — W. of int. = ___ x ___ x ___ = ___

Priority points = P2 x V_{tns} x F_{ans}
N-S street — N. of int. = ___ x ___ x ___ = ___
N-S street — S. of int = ___ x ___ x ___ = ___ ___*

III. Crossing Gaps, Intersecting Volumes, and Pedestrian Volumes

A. Through Street One-Way (GRAPHS B2.6 and B2.7)

1) Priority points

= (V_{aew} + P_{ew}) x (V_{ans} + P_{ns}) x F_{ow} x Fr
= (___ + ___) x (___ + ___) x ___ x ___ = ___

2) Priority points

P3 x F_t = ___

B. Through Street Two-Way

Priority points
= (V_{aew} + P_{ew}) x (V_{ans} + P_{ns}) x F_{ow}
= (___ + ___) x (___ + ___) x ___ = ___ ___

TOTAL PRIORITY POINTS _____

NOTE: Complete: - Section I;
- The appropriate equation for each intersection leg in Section II A and/or II B; and
- Either Section III A or III B.

* Maximum points for II = + 80

Figure 1: Evaluation Work Sheet

The warrant procedure effectively assigned priority points based on several factors:

- The relative effect from which the installation of a traffic signal is expected to have on the existing safety performance of the intersection (i.e., its ability to improve the traffic safety and reduce certain types of collisions).
- The net effect that signals would have on the availability of crossing gaps at the intersection and downstream, the progression of vehicles as influenced by signals, the expected delay and the number of stops introduced by signals.
- The application of expansion factors that capture a subjective judgment on the probable increase in traffic volume at the subject intersection due to the introduction of signals (perceived improvement to the network attracts more vehicle trips than it otherwise would have).
- The average vehicular and pedestrian volumes recorded during the peak period counts.
- The increased safety, capacity and mobility due to a reduction in the number of conflict points for one-way streets compared to two-way operations, where applicable.
- The probable randomness of vehicles arriving at the subject intersection where upstream signals are as close as 450m, the effects of out-of-phase vehicular volumes reducing otherwise available crossing gaps between platoons for one-way streets, and the degree of difficulty experienced by vehicles and pedestrians caused by gap interruptions.

The localization of the national standards to better suit Saskatchewan's conditions appears to be reflected in average vehicular volumes with the TAC procedure considering the average volume divided by 1,000 to assist in determining priority points for Parts II and III (refer to Figure 1), whereas this is reduced to 400 in Design Manual 2.

An overall score is developed by summing the priority points received by each of the factors noted above. The policy and procedures outlined in Design Manual 2 are silent on the number of priority points required to confirm that the warrant for traffic signals is met. Therefore, it is assumed that the Ministry relied on the conditions stated in the MUTCDC methodology to determine when the warrant was met or not (i.e., equal to or exceeding 100 priority points).

OTHER NORTH AMERICAN JURISDICTIONAL PRACTICES

Establishing traffic control consistency and expectations enhances safety on a transportation network. Therefore reaching out to other jurisdictions to understand their practices and procedures is an important step in the overall development of policies and warrants. Other North American jurisdictions viewed as having comparable road environments as well as being neighbouring provinces and states were polled as part of updating and revising Saskatchewan's practices.

From the review of current policy documents and warrant procedures applied in Saskatchewan and other jurisdictions, and through supplemental information gathered as part of a jurisdictional scan, a summary of parameters or elements applied to traffic signal warrants is presented in Figure 2. These parameters dictate the warranting conditions that suggest traffic signal installation may benefit the operation and/or safety of road users. They form the basis of the criteria, parameters or elements that have been included in the development or adoption of the warrant procedures and policies for consideration by the Ministry.

Criteria	Parameters	SK	BC	AB	MB	ON	TAC	FHWA
Minimum Traffic Volume	Minimum Eight Hour Vehicle Volume	X	✓	TAC Guidelines	TAC Guidelines	✓	X	✓
	Minimum Six Hour Vehicle Volume	✓	X			X	✓	X
	Minimum Four Hour Vehicle Volume	X	✓			✓	X	✓
	Peak Hour Volume	X	✓			X	X	✓
	Combination Warrant	X	✓			✓	X	✓
	Projected Volumes	X	✓			✓	X	✓
	Population	X	✓			✓	✓	✓
Delay	Delay to Cross Traffic	X	X			✓	X	X
	Peak Hour Delay	X	✓			X	X	X
Safety Analysis	Analytical Safety Analysis and Prediction	X	X			✓	X	X
	Collision Experience	✓	✓			✓	X	✓
	Pedestrian Volume	✓	X			✓	✓	✓
	School Crossing	X	X			X	✓	✓
Traffic Operation	Interruption of Continuous Traffic	X	✓			X	X	✓
	Progressive Movement	✓	✓			X	X	✓
	Platoon Adjustment Factor	X	X			X	✓	X
	Intersection Spacing	✓	X			X	✓	✓
	Intersection Near a Grade Crossing	X	X			X	X	✓
	System Warrant	X	✓			X	X	✓
	Posted Speed	✓	✓			✓	✓	✓
Intersection and Roadway Configuration	Intersection Configuration	X	X			✓	✓	X
	Lane Configuration	X	✓			✓	✓	✓
	Traffic Composition	X	X			X	✓	✓

Figure 2: Summary of Jurisdictions Traffic Signal Parameters

Observations regarding the application of warrant procedures for traffic signal installation include:

- Most of the authorities use minimum traffic volume criteria with variations between their application and thresholds considered.
- Calculation of vehicle delays are based solely on traffic volumes; delay at a subject intersection would perhaps be better quantified through traffic analysis to understand the magnitude of delay encountered and the possible improvements that signals may offer given specific site context data and information.
- As a starting point, the revisions to the crash experience warrant proposed in the NCHRP 204 report should be adopted (refer to the next Section of this paper). For additional safety analysis, the InSAT tool developed as part of the crash experience warrant (NCHRP 204) can be used to quantify the expected safety benefits of considering intersection improvements including traffic signal installation as well as other measures in an urban, suburban, or rural areas. A similar application has been developed and documented in the Ontario Traffic Manual (OTM book 12) for safety analysis of intersection improvement options.
- Three of the four Canadian jurisdictions reviewed (excluding Alberta) have developed policies specific to the implementation of traffic signals, with Alberta defaulting to the current TAC standards in lieu of any formal policy statements. Only British Columbia and Alberta have formally developed policies regarding the use of roundabouts, with both adopting a roundabout 'first' policy.
- It is understood that jurisdictions in the United States apply the procedures outlined in the Federal Highways Administration's (FHWA) MUTCD for determining traffic signal warrants, with various jurisdictions implementing alternative traffic control measures where possible instead of signals.

Each of the procedures currently in use today include parameters from each of the main warranting criteria with exception of delay (in terms of seconds/vehicle). Both British Columbia and Ontario have adapted their warranting procedures to include a component that specifically addresses delay, whether from a strict application of the magnitude of traffic volumes (Ontario) or expressed in terms of delay per vehicle-hours combined with traffic volume thresholds (British Columbia). The previous TAC procedure prior to the 2007 update, which is still considered by the Ministry in their latest design guide, accounted for delay as a component of the net effect that signals would have on the availability of crossing gaps at the intersection and downstream, the progression of vehicles, the expected delay and the number of stops introduced. As noted in the Ministry's review of safety countermeasures, delay should be considered as part of determining the need for a traffic signal at a subject intersection and not necessarily just to confirm the warrant.

The remaining four criteria are all captured in varying ways by the procedures, and as such, require different parameters as part of warranting traffic signals. The intent of this review summary is not to imply that all parameters have to be addressed in one way or another when determining the appropriate procedures for adoption by the Ministry, but rather to identify any gaps amongst the varying procedures, such as delay, that should be considered as part of establishing policies and warranting procedures for use by the Ministry to improve upon current practices. In fact, as part of determining which parameters should be adopted, it may be possible that some of these parameters such as 'school crossing' are not included at this time since there are very few occurrences of schools being located in areas where the Ministry is the road authority. However, the Ministry can reference TAC's current guidelines such as the Pedestrian Crossing Control Guide (published in 2012) if asked to address such an issue.

NCHRP Web-Only Document 204

The National Cooperative Highway Research Program web-only report 204, "Crash Experience Warrant for Traffic Signals" was published in 2014. This report found that there is a threshold value of observed crashes beyond which signal installation is likely to improve safety. However, the threshold value was found to vary by area type, the number of intersection legs and the number of lanes on each intersection approach. The current methodology adopted by the FHWA includes a warrant that captures collision experience with the warrant met when five or more reported collisions of types 'susceptible' to correction by traffic signals have occurred within a 12 month period (similar to BC's current warrant). The current warrant practice adopted in Ontario includes a similar procedure; however, the Ministry of Transportation Ontario (MTO) has also developed a more robust methodology that seeks to quantify expected safety benefits should a traffic signal be installed. The research completed by the NCHRP seeks, in a similar vain to MTO, to establish a more robust warrant requirement that addresses an apparent contradiction within the engineering community: many jurisdictions now state in their best practices that alternate options to traffic signal installation be considered prior to implementing signals with others reducing the warrant threshold (priority point scoring), which increases the likelihood of signals being warranted. NCHRP's research recommends that the proposed 'collision experience warrant' be adopted in the next edition of the MUTCD and revise the approach to consider installing signals should a one year collision history or a three year collision history demonstrate that signals will in fact improve, not deteriorate, the safety performance of the subject intersection.

The following points present a summary of the intersection safety analysis tool (InSAT) developed as part of this research to establish a methodology to address traffic signal crashes and expected safety performance:

- InSAT can be used to predict the potential crash numbers for an intersection even if the crash data is not available. If the crash data is available, then the tool will be able to compare the crash data before and after the intersection is signalized.
- InSAT was specifically developed to support the evaluation of a change in traffic control (e.g., conversion from stop to signal control) at a subject intersection. However, it can also be used to evaluate the safety effect of alternative geometric design elements and traffic control features.
- InSAT is intended to be used to evaluate intersection safety. The intersection can be located in an urban, suburban, or rural area.
- The default coefficients for the predictive models used in InSAT are taken from the Highway Safety Manual. They limit InSAT to specific combinations of intersection legs and major road lanes, and for intersections where the roads serve two-way traffic.
- InSAT can be used to evaluate the safety effect of installing or removing a traffic control signal.
- InSAT can accommodate a crash period that is one to five years in duration (consecutive years for which observed crash data are available).
- The Empirical Bayes (EB) Method is used as the basis for combining the model prediction and the observed crash data.

Through the establishment of this tool, the expected intersection performance can be quantified prior to making any proposed changes. The output of the work completed to develop this analysis tool are published as tables that define the threshold values of observed crashes beyond which signal installation is likely to improve safety. Beyond these outputs for traffic signal thresholds, this tool can be used for other applications where a quantified safety benefit can be expected. For ease of adoption, the focus is on the application of the published tables that define an expectation of when traffic signal installation can be beneficial to improving intersection safety.

Table 1 indicates the conditions considered in the establishment of the revised collision experience warrant as derived from the InSAT tool. These conditions provide an indication of the locations that may be suitable candidates for the installation of signals, and not just in meeting collision history requirements.

Table 1: Candidate Elements for the Proposed Crash Experience Warrant

Element	Conditions
Control Types	Two-way Stop Control Converted to Signal Control
Area Type	Urban and Rural
Time Period for Crash History	1 Year, 3 Years
Crash Severity Categories	All Severities, Fatal and Injury
Crash Type Categories	All Types, Angle
Intersection Legs	3, 4
Major Road AADT	Range: Based on Volumes in FHWA MUTCD Warrants 1 and 7
Minor Road AADT	Range: Based on Volumes in FHWA MUTCD Warrants 1 and 7

From this list of candidate elements, four crash warrant tables were produced that indicated favourable situations where traffic signals might be considered for the collision history observed. However, only two

of these tables were recommended for adoption in the next edition of the MUTCD procedures. Those that addressed all collision types were not carried forward.

In establishing the recommended warrant procedures, it was determined that the crash severity category focus on fatal and injury collisions rather than including property-damage only (PDO) collisions as well. The reason cited was with respect to these types of collisions not being reliably or consistently reported in some jurisdictions [i.e., variations in the threshold limit (dollar value) by jurisdictions that classify when a collision is a PDO and when it is not]. Angle collisions were proposed instead of considering all types since they are the most predominant crash type that satisfies current warrant procedures that focus on types susceptible to correction by traffic signals. The intent to focus on angle collisions only is to avoid situations where the warrant may be met by other types of collisions at subject intersections that are uninfluenced by the presence of a signal.

Two crash history time periods were considered:

- One year: suitable for a 'quick response' that allows jurisdictions to respond in a timely manner if only a short crash history exists rather than waiting for more evidence to suggest a need exists and a recent degradation in intersection safety is evident.
- Three year: to provide thresholds that will have a more subtle effect on safety that is only detectable using a longer period of evaluation.

To satisfy the one year and three year histories, the following tables document the NCHRP's recommended thresholds.

Table 2: One Year Collision History Warrant for Rural Areas

Area Type	Number of Lanes on Each Approach		Total Angle Collisions and Pedestrian Collisions		Total Fatal and Injury Angle Collisions and Pedestrian Collisions	
	Major	Minor	Four Legs	Three Legs	Four Legs	Three Legs
Urban	1	1	5	4	3	3
	2+	1	5	4	3	3
	2+	2+	5	4	3	3
	1	2+	5	4	3	3
Rural	1	1	4	3	3	3
	2+	1	10	9	6	6
	2+	2+	10	9	6	6
	1	2+	4	3	3	3

Table 3: Three Year Collision History Warrant for Rural Areas

Area Type	Number of Lanes on Each Approach		Total Angle Collisions and Pedestrian Collisions		Total Fatal and Injury Angle Collisions and Pedestrian Collisions	
	Major	Minor	Four Legs	Three Legs	Four Legs	Three Legs
Urban	1	1	6	5	4	4
	2+	1	6	5	4	4
	2+	2+	6	5	4	4
	1	2+	6	5	4	4
Rural	1	1	6	5	4	4
	2+	1	16	13	9	9
	2+	2+	16	13	9	9
	1	2+	6	5	4	4

When applying Table 2 and Table 3, rural refers to those intersections where the major road speed exceeds 40 mph (64 km/h) or intersections located in an isolated community with a population less than 10,000. Angle collisions include those that occur at an angle and involve one or more vehicles on the major road and one or more vehicles on the minor road.

By applying the warrant requirements specified above, those locations where the collision experience does not meet the proposed warrants could see the safety performance deteriorate with the installation of traffic signals, whereas those meeting these requirements are expected to see an improvement.

ESTABLISHMENT OF TRAFFIC SIGNAL POLICIES

The establishment of policies is intended to guide the Ministry and their vendors in determining whether the traffic conditions may or may not be favourable for traffic signals. The policy suggestions below have been developed from current industry practices and from the review of other jurisdictions' guidelines and policy documents. They address conditions where traffic signals could be considered, conditions where they may not be appropriate and other policy decision items related to traffic signals.

The need to consider traffic signals or another form of traffic control or improvement is largely based on one or a combination of factors, most commonly:

- Requests from municipalities, members of the public or political pressures;
- Perceived safety or operational issues that lead to a perceived reduction in the level of service (LOS) or comfort level of travellers, or increased risks being taken to enter or exit the main traffic stream;
- Intensified development or changes to the proposed/existing land use are being considered or implemented; or
- Changes to the road network are expected to alter traffic patterns and flows.

These factors are an indication that traffic signals may be required to maintain or improve the roadway operation. They should be reviewed in relation to the following policy statements where traffic signals are deemed to be an appropriate option for consideration.

POLICY STATEMENTS: CONDITIONS WHERE TRAFFIC SIGNALS MAY BE FAVOURABLE

- Traffic signals are generally considered to be an appropriate traffic control device (and possible safety enhancement) in:
  - Urban areas (within urban municipal limits).
  - Urban fringe areas, which can typically be identified by:
    - Transitional area from a rural cross-section to an urban cross-section;
    - Presence of reduced speeds (80 km/h or less); and
    - Presence of barrier curb and gutter.
- Where a future interchange is identified on the provincial network, traffic signals (or an alternate form of traffic control or intersection improvements) may be considered as part of the interchange staging to defer such capital expenditures within urban and urban fringe areas.
- Areas in close proximity to urban centres that demonstrate either the following conditions are evident either through a review of available data and/or observations made in the field:
  - Noticeable delays to the minor road traffic waiting to enter the major road.
  - Known collision history, trends, severity, frequency, etc.
- One or more of the warranting conditions must be met to consider the need for traffic signals further, which includes satisfying:
  - Minimum traffic volumes, collision history, operational conditions (i.e., acceptable delay).
- Collision experience demonstrates that signals are expected to improve the overall safety performance of the intersection:
  - Through application of the Crash Experience Warrant from NCHRP 204.
- Other safety and/or operational measures did not provide satisfactory improvements to the safety and/or operational performance of the intersection:
  - A noticeable reduction in the collision frequency, trends and/or severity.
  - The intersection LOS is not improved to meet the Ministry's acceptable levels (LOS C or greater for rural highway corridors).
- Other traffic control/intersection treatments are considered inappropriate for the site context (i.e., four-way stop control, roundabout, additional lanes, etc.).
- Concerns are expressed by municipal partners, members of the public or industry stakeholders that suggest the Ministry consider a review of the intersection for the purpose of determining appropriate improvements that may address those concerns.
- An engineering study suggests that traffic signals be considered further where sufficient analysis has yet to be completed to determine the suitability of traffic signals.

- Through traffic analysis, confirm that a significant reduction in delay for traffic on the minor road can be achieved for existing and future conditions (as agreed upon with the Ministry):
  - Isolated intersections:
    - As demonstrated by an improvement from unacceptable to acceptable intersection operational performance, or
    - A reduction in delays in the design hour in the order of 50% or higher.
  - Signalized corridors:
    - Progression of the main road can be achieved while improving the delay experienced by minor road traffic.
- Where the signalization of an intersection adjacent to an existing or proposed signalized intersection(s) is expected to improve the progression of traffic along the major road (i.e., through coordination).

POLICY STATEMENT: CONDITION TO BE MET PRIOR TO CONSIDERING TRAFFIC SIGNALS

- Prior to signals being installed, the hierarchy of improvements currently adopted by the Ministry must have been implemented at the subject location. Typically these are implemented from lower cost to higher capital cost investments as illustrated below:

POLICY STATEMENTS: CONDITIONS WHERE TRAFFIC SIGNALS MAY NOT BE APPROPRIATE

- Traffic signals should be avoided in rural high speed environments (i.e., posted speed limits exceeding 90 km/h).
- Traffic signals should not be installed if their introduction will seriously disrupt progressive traffic flow on the main road to an unacceptable level (as determined by traffic analysis).
- Traffic signals should not be considered on:
  - Freeways (or future/planned freeways);
  - Divided highways identified as future freeways; and
  - National highway core routes where the posted speed is 90 km/h or greater (unless compatible with a staged plan).

POLICY STATEMENTS: OTHER TRAFFIC SIGNAL CONSIDERATIONS

- Where traffic signals are deemed to be warranted, the posted speed of the roadway should be 90 km/h or less.
- The installation of Advanced Warning Flashers at a signalized intersection should follow the guidelines contained in TAC's MUTCDC.

- Where existing traffic signals are installed, a review of the warrant procedure can be applied to determine whether traffic signals are still an acceptable solution to address safety and/or operational concerns that may have arisen since installation or continue to remain unsolved after implementation.
  - This may be applicable if there is a change to traffic patterns.
- Where traffic signals are no longer justified and a decision is made to remove such, removal should be accomplished following the procedures outlined in the FHWA's MUTCD:
  - Determine the appropriate traffic control to be used after signal removal.
  - Reconcile any sight distance restrictions, as required.
  - Inform the public and stakeholders of the removal decision with supporting justification.
  - Install the appropriate traffic control to replace signals and flash/cover the signal heads for a minimum of 90 days.
  - At the discretion of the Ministry, it may be desirable to conduct an engineering (removal) study confirming the need to remove a signal, and then remove the signal.

Table 4 presents a summary of the policy statements that both favour the installation of signals as well as those that suggest signals may not be appropriate for the location under review. These guidelines are meant to assist the practitioner with the application of each policy statement and to determine overall compliance of the location in support of or against considering signals further. After review of the policy statements for a specific location, engineering judgment may be required as some of the policy statements may support signal implementation while other policy statements do not support the implementation. The actual warrant procedures should be followed to determine if there is support from the policy statements to proceed further with a review of signalization.

Table 4: Policy Application Review

Policy Statement	Response	Comments / Rationale (application of policy statement)	Compliance
Urban area/urban fringe area.	YES / NO	*Is the intersection under review located within an urban environment?*	<u>One or more</u> (preferably more) of these statements should be favourable towards a review of signals for the subject intersection, i.e., answered YES.
Future interchange location.	YES / NO	*Is the intersection under review identified as a future interchange location?*	
In close proximity to an urban centre with noticeable delays/ known collision history trends.	YES / NO	*Does this intersection demonstrate such conditions that might benefit from signal installation (excessive delay / specific collision trends that signals might help improve)?*	
One or more warranting conditions met.	YES / NO	*Are one or more of the warranting conditions met through application of the warrant procedures or as determined by other means (i.e. other engineering studies such as a safety assessment, detailed capacity analysis etc.)?*	
Collision experience demonstrates signals may improve the overall safety.	YES / NO	*Is there an expected improvement in the safety performance of the intersection from signal installation as determined through application of the Crash Experience Warrant?*	

Table 4: Policy Application Review

Policy Statement	Response	Comments / Rationale (application of policy statement)	Compliance
Other safety/operational measures did not provide satisfactory improvements.	YES / NO	*Have other safety and or operational measures been implemented to address known problems that have not adequately addressed such problems?*	
Other traffic controls considered inappropriate for the site context.	YES / NO	*Are other traffic control options (i.e. four-way stop, roundabouts etc.) considered to be inappropriate for the subject location?*	
Engineering study findings.	YES / NO	*Have there been any engineering studies performed to address the concerns at the subject location that recommend the installation of traffic signals? The need to consider such a study may have arisen from concerns expressed by municipal partners, members of the public or industry stakeholders.*	
Desirable signal progression achievable.	YES / NO	*Is the installation of a signal upstream or downstream of another signal expected to improve the operation through a signalized corridor?*	
Hierarchy of intersection improvements adequately tried and tested.	YES / NO	*Has the Ministry's toolbox or hierarchy of possible improvement options been tried and tested at the subject intersection? If not, these should be considered prior to proceeding any further with signal implementation.*	Should be answered YES prior to reviewing signals further.
Located in a rural high speed environment.	YES / NO	*Is the intersection under review located within a rural environment?*	<u>All</u> responses should be favourable towards a review of signals for the subject intersection, i.e., all should indicate NO.
Possibility to disrupt progressive traffic flow.	YES / NO	*Will the introduction of signals seriously disrupt progressive traffic flow on the main road to an unacceptable level?*	
Freeway/divided highway/national highway core route.	YES / NO	*Is the intersection under review located on an existing or future freeway, or on a core route with high posted speed limits? (Note: signals may be acceptable if part of a staged plan).*	

The initial nine statements presented in Table 4 largely describe situations that may be favourable for considering a traffic signal at a subject intersection. As a minimum, at least one of these statements should have a response of YES; however, the preference would be to have several YES responses indicating compounding issues at the subject intersection, which has been the focus of an engineering study. Such studies should review a comprehensive array of improvement options and determine traffic signals to be a suitable improvement over other alternatives and conclude that other countermeasures have been implemented but without the desired outcomes to address known concerns. If such options have yet to be explored, the hierarchy of improvement options available to the Ministry should be adequately tried and tested prior to proceeding any further with signal implementation.

There are certain situations where traffic signal installation is deemed to be unfavourable due to the intended function of the roadway(s) for the subject intersection as well as the expectation of drivers to encounter traffic signals in areas where they are not commonly deployed. To address these situations,

the last three policy statements should each receive a NO response prior to considering signal implementation. However, if low cost corridor improvements are part of a staged implementation plan required to defer large capital funding until it is available, the practitioner may want to consider traffic signals in those situations described in the three last policy statements, as long as signalization is not the ultimate improvement for corridors with these attributes and will improve the safety of the intersection. In summary, to consider traffic signals further:

- At least one of the initial nine statements have a response of YES;
- The hierarchy of improvement options available to the Ministry have been adequately tried and tested; and
- None of the last three statements receive a YES response (all should be NO) with except if a signal is part of a staged implementation.

WARRANT CONDITIONS FOR SASKATCHEWAN

The five main criteria or groupings of parameters listed in Figure 2 include minimum traffic volume, delay, safety, traffic operation and intersection/roadway configuration. Naturally these criteria overlap and should not be viewed as discrete areas (i.e., delay is often considered to be component of traffic operation and could have been grouped together).

In lieu of having their own guidelines or standards for certain situations, the Ministry typically defaults to the national standards published by TAC or equivalent organizations. The latest traffic signal warrant procedure published by TAC was in 2007. Since then, at least two Canadian provinces have opted to align their traffic signal warrant procedures more closely to the current FHWA methodology than to the TAC procedure and perhaps other jurisdictions may also have followed in a similar manner or be considering such. As the warrant procedures adopted by the FHWA and others address a wider array of possible situations where traffic signals may improve the conditions for traffic progression, conflicts, operations and other intersection related concerns, and as they reflect more recent industry practices (especially when considering the safety implications associated with traffic signals), it is suggested that the Ministry adopt a similar set of procedures to those of the FHWA, BC and Ontario, with some revisions that address the current Saskatchewan context. The procedures presented to the Ministry for adoption are defined in Table 5.

Table 5: Preferred Warrant Conditions for the Ministry

Warrant No.	Metric	FHWA	ON	BC	Comment	Proposed Metric for Adoption
1	Eight Hour Vehicular Volume	✓	✓	✓	FHWA and BC warrant thresholds are identical, ON thresholds are close to FHWA/BC	✓
2	Four Hour Vehicular Volume	✓	✓	✓		✓
3	Peak Hour Vehicular Volume	✓	X	✓		✓
4	Pedestrian Volume	✓	✓	X		X
5	School Crossing	✓	X	X		X
6	Coordinated Signal System	✓	X	✓	BC standard is close to FHWA	✓
7	Crash Experience	✓	✓	✓	ON and BC thresholds are close to FHWA	✓
8	Roadway Network	✓	X	✓	BC threshold is close to FHWA	✓
9	Intersection Near a Grade Crossing	✓	X	X		X
-	Safety Analysis	✓	✓	X		✓
-	Operational Analysis	-	-	-		✓

Note: The warrant numbers reference the FHWA procedures since Ontario (ON) and BC have adopted different numbering based on their adoption of individual warrant conditions

The following warranting parameters, conditions or justifications are under review for adoption by the Ministry that determine when a subject intersection may be a suitable location for traffic signal installation provided the policy statements presented previously are favourable. These are not listed in any particular order of preference, but rather follow closely to the order presented in other jurisdictional procedures for ease of cross-referencing, and to list similar parameters together.

1. Minimum Traffic Volumes:
   - Eight hour minimum traffic volumes.
   - Combination of conditions used to analyze the eight hour minimum traffic volumes.
   - Four hour minimum traffic volumes.
   - Peak hour minimum traffic volumes
2. Collision Experience
3. Coordinated Signal System
4. Capacity Analysis (LOS and Delay)

The intent of applying the warranting factors is to determine which factors govern the need for signals or not. Signals are considered to be warranted when each of the following conditions are met, i.e., all have to be met to satisfy the need to consider traffic signals:

- One of the four minimum traffic volume warrants are met.
- The collision experience can be demonstrated either from a review of historical crashes or the predicted safety benefits are met.

- Where applicable, the coordinated signal system demonstrates acceptable performance for traffic progression along the corridor.

- A satisfactory reduction of delays in the design hour, particularly for minor road traffic, as confirmed through capacity analysis.

Meeting these conditions also assumes that the policy statements have been applied and demonstrate the need for signals including the trial of other safety countermeasures or intersection treatments/ improvements. The metrics provided in the volume warrants and collision experience, provide practitioners with a guide as to the magnitude of the traffic volumes and reported collisions required to meet these components. The other conditions will likely have to be determined through some form of engineering review or larger study to determine their applicability.

CALIBRATION CHECK

A calibration check of the recommended policy statements and warrant procedures was performed on four candidate intersections identified by Ministry regional staff. The purpose of the check was to apply the statements and procedures, and then determine whether any refinement of either were required to address conditions specific to Saskatchewan. It also served to provide examples and to inform the Ministry as to how these statements and warrants are to be applied going forward. A representative sample of candidate sites was chosen to capture various settings and travel patterns that could be used to demonstrate whether those locations would meet the policy statements and their ability to then meet/ or not meet the warranting conditions. The four locations chosen and the rationale for their selection is noted as follows:

- Highway 1 (TransCanada Highway) and 9th Avenue NW at Moose Jaw
  - Rationale: located on the urban fringe of Moose Jaw (first intersection providing access into the city from the west).
- Highway 46 and the Pilot Butte Access (Grid 624), east of Regina
  - Rationale: on a highway with significant commuter traffic between the City of Regina and satellite communities including Pilot Butte.
- Highway 22 and the Mosaic K3 Mine Access, east of Esterhazy
  - Rationale: the intersection has very distinct peak hour periods due to mine shift changes from the K3 site as well as at least one other adjacent mine site.
- Highway 6 and Highway 16 north junction, near Dafoe
  - Rationale: isolated intersection in a very rural location, but on a major trucking route between Saskatoon and Yorkton.

From a review of the traffic signal policy statements, two locations from the four demonstrated conditions considered to be favourable for further review when seeking to address operational and/or safety enhancements though implementation of traffic signals. These two locations include the intersection of Highway 1 and 9th Avenue in Moose Jaw, and the intersection of Highway 46 and Grid 624 at Pilot Butte. The other two locations are in high speed rural areas with no evidence of safety or operational concerns that would benefit from the implementation of traffic signals.

Of the two locations shortlisted from the policy statement review, one demonstrated a need to review traffic signals or an alternate form of control further, but only after other measures are tried and tested, or ruled out for inappropriateness. The intersection of Highway 46 and Grid 624 meets two of the warranting conditions; however, it does not meet the crash experience warrant suggesting that the installation of traffic signals would likely reduce the safety performance from current levels, most likely through an over-representation of rear end collisions. With these considerations in mind, it is suggested that alternate forms of traffic control and safety enhancement be reviewed for their appropriateness and effectiveness prior to pursuing traffic signals further.

CONCLUDING REMARKS

As demonstrated through the recent research completed and documented in the NCHRP Report 204, traffic signal installation can be used as a safety countermeasure to enhance intersection performance, when an over-representation of collisions are observed that can be corrected by traffic signals, i.e. higher severity and angle collisions. The policy statements and warrants developed for the Ministry place an emphasis on the importance of only pursuing the implementation of traffic signals when there is either a perceived or demonstrated safety performance issue in combination with other metrics and analysis. The establishment of the policy statements and warranting conditions are based on current and leading industry practices that can easily be applied by the Ministry and their vendors to convey to non-engineering persons of the minimum thresholds and conditions that must exist prior to installing signals on the provincial network.

Over the years, the Ministry has received ongoing pressure from external stakeholders as well as the public to consider a wider deployment of signals but has shown reluctance due to the inherent safety performance concerns that can be realized after implementation. The work completed by the Ministry now provides the guidance and direction needed to both pursue signals to their satisfaction as well as to provide supporting rationale both for and against their deployment. As the statements and warranting conditions are adopted throughout the Ministry, it is anticipated that refinements will be made to ensure these continue to meet Ministry and other stakeholder needs.

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