Highway-Railway
GRADE CROSSING RESEARCH

TP 14288E

SECOND TRAIN WARNING AT GRADE CROSSINGS

Prepared by
Transportation Development Centre

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Second Train Warning at Grade Crossings

by
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IBI
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16. Abstract

A second train incident occurs when pedestrians assume that they can safely traverse an at-grade road-railway crossing, subsequent to the departure of a train, only to be met by a second train in the crossing area. A second train warning system is designed to reduce the risk of collision resulting from this situation. This study was initiated in 1998 to review the benefit and means of deployment of second train warning (STW) systems in Canada.

An industry scan of train warning systems identified two active STW systems. No commercially available STW systems were identified. A functional specification for STW systems was developed.

An assessment of nine candidate sites was undertaken, resulting in a recommendation for the pilot test STW site at the O'Brien Avenue crossing in Ville Saint-Laurent, Quebec. The pilot project installation consisted of static STW signs and flashing beacons at the O'Brien Avenue crossing.

The results of the "before" and "after" observations demonstrated that the STW system resulted in more than a 64% decrease in total violations, which appears to be consistent with those achieved at other STW pilot program locations.

It was concluded that STW systems should be pursued at sites with a high risk of second train incidents/collisions. A qualitative model was developed to rank the at-grade crossings having a potential for second train collisions, with minimal data collection efforts. The results of the qualitative screening would be used to establish a short-list of sites.

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16. Résumé

Un incident mettant en cause un autre train se produit lorsque des piétons croient pouvoir franchir en toute sécurité un passage à niveau, après le départ d'un train, sans se rendre compte de l'arrivée d'un deuxième train dans l'autre direction. Un système d'avertissement de l'approche d'un autre train (AAAT) vise à réduire les risques de collision attribuable à ce genre de situation. La présente étude, entreprise en 1998, avait pour objectif d'examiner les avantages associés au déploiement de systèmes d'AAAT au Canada, et les moyens de procéder à un tel déploiement.

Au terme d'une recherche dans le secteur du transport ferroviaire, deux systèmes d'AAAT automatisés ont été repérés. Mais il n'existait sur le marché aucun système d'AAAT prêt à être installé. Les caractéristiques fonctionnelles d'un système d'AAAT ont donc été élaborées.

Une évaluation de neuf sites candidats a débouché sur la recommandation du passage à niveau de l'avenue O'Brien, à Ville Saint-Laurent, au Québec, pour la tenue de l'essai pilote du système. L'installation du projet pilote comportait des panneaux d'AAAT à message fixe et feux clignotants, au passage à niveau de l'avenue O'Brien.

Les résultats des observations «avant-après» ont démontré que le système d'AAAT a entraîné une baisse de plus de 64 % du nombre total des infractions, baisse qui semble corroborer celle obtenue aux autres endroits où des systèmes d'AAAT ont été étudiés.

Il a été conclu que des systèmes d'AAAT devraient être installés aux sites qui présentent un risque élevé d'incidents/collisions mettant en cause un autre train. Un modèle qualitatif a été élaboré, qui permet de classer les passages à niveau présentant un potentiel de collisions avec un autre train, à partir de données relativement faciles à obtenir. Cette évaluation qualitative devrait servir à établir une liste restreinte de sites.

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Transport Canada

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DEDICATED TO RICHARD (RICK) CLIVE FELSTEAD

As a key member of the project steering committee, Mr. Felstead's wealth of experience and knowledge was invaluable to the project's success. His good nature, kindness, and dedication to his work and colleagues will be sadly missed.

EXECUTIVE SUMMARY

Background and Scope

On April 20, 1995, a westbound freight train struck and killed two pedestrians at the Park Street public crossing, mile 125.15 on the Kingston Subdivision in Brockville, Ontario. The Transportation Safety Board of Canada determined that the pedestrians walked into the path of the westbound train while their concentration was fixed on a passing eastbound train at the same crossing. This type of collision is termed a "second train collision". Between 1989 and 1999 inclusive, 15 second train collisions involving pedestrians occurred in Canada, 11 of which occurred at grade crossings.

In 1998, a Transport Canada project team was assembled to participate in a study to address the use of second train warning (STW) systems for pedestrians. The intent of an STW system is to provide pedestrians with additional information to reduce the risk of a collision resulting from pedestrians assuming that they can safely cross at a level crossing subsequent to the departure of the first train. The project team prepared a Terms of Reference for a Study of a Second Train Warning System at Road Crossings for Pedestrians.

Following a Request for Proposal, Transport Canada retained IBI Group in December 2000 to undertake the Second Train Warning at Grade Crossings study. The study comprised three phases, with their respective objectives as follows:

- **Phase 1: Pilot Test Developmen**t – A review of the existing STW installations and their effectiveness, the development of location criteria, the selection of a pilot test site, the development of a functional specification and cost-benefit model, and the preparation of a Phase 2 plan.
- **Phase 2: Pilot Test Evaluation** – The procurement, installation, demonstration and evaluation of an STW system at an at-grade crossing with an identified risk of second train incidents. The evaluation included "before" and "after" data collection activities undertaken with video monitoring equipment, an assessment of the results, and the preparation of a Phase 3 Plan involving the development of deployment recommendations.
- **Phase 3: Deployment Recommendations** – The formulation of conclusions and recommendations relating to the deployment of STW systems in Canada.

Identification of Second Train Warning Systems

The provision of active STW systems in North America is a relatively new application and, as such, is still under development. A review was conducted of the documents relating to research and active STW projects acquired through previous STW related projects and the subject study.

An industry scan of STW systems was undertaken to locate and assess relevant deployments and initiatives in other jurisdictions. The activities undertaken in the identification of second train warning systems have determined that there are two projects in North America with active STW applications:

- **Baltimore, Maryland –** In response to the frequent second train events at its double track crossings on the Baltimore Central Light Rail Line (CLRL), the Maryland Mass Transit Administration (MMTA) initiated a study at its Timonium crossing to identify and demonstrate an active signing warning system that would increase motorists' awareness and compliance during a second train event. The system proved beneficial in that during the 90

day observation period following the installation, the frequency of illegal pedestrian movements and the incidents of "risky behaviour" associated with second train events were reduced by 80 percent.
- **Los Angeles, California** – The Los Angeles County Metropolitan Transportation Authority (LACMTA) identified concerns with second train collision potential at a number of its at-grade crossings and selected the Vernon Avenue grade crossing on the Metro Blue Line for the installation and demonstration of the STW system. Based on preliminary results, there was a significant reduction in pedestrian risky behaviour associated with second train events. Most notable was a 78 percent reduction in the number of pedestrians entering the rail track area less than six seconds before the approaching train.

No commercially available STW systems were identified in the industry scan. Although STW systems/signs are not explicitly recognized in the ITS Architecture for Canada, their purpose and operations are intrinsic to the functions outlined in 2.8.1 Basic At-Grade Crossing Control User Sub-Service and 2.8.2 Advanced At-Grade Crossing User Sub-Service.

Other STW programs and systems in Canada, the United States and the United Kingdom were reviewed and taken into consideration in this study. In addition, other recent work in the field of pedestrian safety technologies was incorporated into the design and assessment of the STW pilot project and sign prototype.

Development of Location Criteria

In order to effectively implement STW systems it was necessary to develop criteria for identifying locations that have a high risk of a second train collision. From the existing body of literature on STW and other rail warning systems and their implementation, the following criteria were identified as the most important to be taken into account for developing site location prioritization models:

- **Multiple Track Roadway-Rail Intersection (Mandatory)** – two or more tracks at the grade crossing;
- **Collision History (Qualitative)** – violations of the warning system and train-pedestrian conflicts;
- **High Pedestrian Volumes (Quantitative or Qualitative)** – the relative proportion of daily pedestrian volume, i.e., numbers of pedestrians who cross the tracks (daily) at roadway-rail intersections (RRI);
- **Number of Second Train Events (Quantitative)** – the number of second train events that occur at a particular RRI during a specified period of time;
- **High Train Volumes in Both Directions (Quantitative or Qualitative)** – the number of trains passing by the RRI site per day in each direction of travel;
- **Whistle Prohibition (Qualitative)** – all else being equal, it is expected that an anti-whistling RRI site will have a higher collision potential than sites where whistling in not prohibited, since whistling serves to provide an audible warning from an approaching train;
- **Visibility (Qualitative)** – pedestrians' sightline of the approaching trains: an important factor affecting their "exposure (to risk)";
- **Train Operating Speeds (Qualitative)** – train operating speeds and speed differentials at the crossing;
- **Train Warning System In Use (Qualitative)** – the types and configuration of the warning system(s) currently being used at RRIs can have varying levels of effectiveness with respect to warning pedestrians about the potential of a second train event.

A number of these criteria were applied in the selection of the candidate pilot test sites and were assessed for consideration in the priority ranking system for all RRIs in Canada.

Selection and Assessment of Candidate Sites

A short list of candidate sites was generated by the Project Steering Committee (PSC) through consultation with Transport Canada and commuter rail agency staff in the Greater Toronto and Montreal areas. The qualitative screening of the candidate sites was undertaken based on the following criteria:

- Previous second train collision experience;
- Local knowledge of crossing operations and pedestrian behaviour;
- Potential for second train events;
- Potential for high and consistent pedestrian activity; and
- Prevalent train operating speeds and speed differentials.

A total of three Toronto area sites and six Montreal area sites were identified as candidate sites for the STW pilot project. Based on the site assessments and input provided by the PSC members, it was recommended that the O'Brien Avenue crossing of the Deux-Montagnes line in Ville Saint-Laurent, Quebec, be carried forward as the preferred pilot test site for the STW installation.

Functional Specification

The market scan of STW systems confirmed that there were no complete, commercially available STW systems available. The systems deployed at Timonium Station (Baltimore) and at the Vernon Avenue Crossing (Los Angeles) were custom applications developed jointly by the client and the supplier. Therefore, for the Transport Canada project it was decided to first develop general specifications for the STW system. Through the review of the evaluation criteria for second train warning systems, two types of signs were identified as viable alternatives:

- Type 1 – limited state, pre-programmed light-emitting diode (LED) sign; or
- Type 2 – static sign warning with alternating flashing beacons.

Functional specification requirements for both systems were developed and included the following:

- Warning system activation and logic;
- Sign location and number;
- Auxiliary lights and sounds;
- Bilingualism;
- Fail-safe requirements;
- Sign content during second train events and "non-second train" periods;
- Sign mounting, dimensions and location; and
- Manufacturing costs.

Risk-Mitigation Cost-Benefit Model

The valuation of the overall benefits and costs is a critical factor in determining the net effectiveness of the implementation of STW systems. A detailed assessment of the risk reductions attributable to STW systems was performed that provided an estimate of their effectiveness. Using these results in conjunction with an analysis of the societal benefits and costs led to the establishment of a benefit/cost ratio for the effect of STW countermeasures.

Table 1 provides a summary of the benefits and costs that were considered in the development of the risk-mitigation cost-benefit model.

Table 1: Benefits and Costs Associated with STW System Implementation	
Benefits	**Costs**
• Reduction in second train collisions • Fewer fatalities • Reduced burden on emergency services • Reduced burden on health care system • Avoidance train/schedule delays • Increased profits to rail/train operators • Reduced litigation/insurance claims	• Capital costs • Operating costs • Maintenance costs • Administrative costs

Based on the review of the two sign types and the relative cost of each installation, it was recommended that the Type 2 – Static Sign be used for the pilot project.

Pilot Test Site

The pilot project installation consisted of static STW signs and flashing beacons at the O'Brien Avenue crossing of the Deux-Montagnes line. The installation was completed in November 2002. The O'Brien Avenue / Deux-Montagnes RRI consists of a four-lane roadway crossing two sets of electrified tracks. Sidewalks are present on both sides of O'Brien Avenue and accommodate approximately 400 pedestrians in the eight peak hours of the day. Although pedestrians use both sidewalks, the majority (approximately 75%) cross on the west side of the roadway.

The Deux-Montagnes commuter line accommodates approximately 56 trains per day. During the eight hour pedestrian and train activity count undertaken on August 9, 2001, no second train events were observed; however, the train schedule and "near second train events" during the field observations suggest that the site could experience an average of one to three second train events per day.

Given that the pedestrians cross on the east and west sides of the RRI, it was proposed that four signs be installed to be viewed from all four quadrants of the intersection. A monitoring system was installed and consisted of two camera assemblies (a total of four cameras) located east and west of the RRI within the railway right-of-way. The cameras were situated and configured to observe pedestrian actions within the four waiting areas approaching the rail line.

Sign Comprehension Survey

At the conclusion of Phase 1 of the project, it was recommended that the proposed sign content be tested to ensure that the majority of the public would understand the proposed STW static sign design. A survey area was set up in Central Station in Montreal. Survey participants were asked to view an enlarged photo of one of the approaches to the O'Brien crossing with the STW sign overlayed into its approximate pilot test location. The standard warning sign and beacon assembly indicated "Attention! 2 Trains" with a sign tab "Aux feux jaunes". Participants were asked their opinion of what they would expect if the beacons were flashing. In addition to this response, general demographic information regarding the participant's gender, approximate age and language most used were recorded.

The survey clearly demonstrated that the proposed STW display was appropriate for the pilot installation at the O'Brien Avenue crossing. Over 80% of the survey participants understood that the warning system was to alert them of a second train approaching or two trains at/near the crossing.

STW System Installation and Commissioning

The STW system, including the signs, beacons and video logging equipment, was installed in October and early November 2002. CN Rail staff undertook the complete installation under contract with IBI Group.

The monitoring system was activated in November 2002 to facilitate the "before" operations at the at-grade crossing prior to the activation of the STW system. The STW system was commissioned at the O'Brien Avenue crossing of the Deux-Montagnes CN Line in March 2003.

"Before" and "After" Data Collection

The "before" data was collected through continuous videotaping of the crossing during a two-month period between November 2002 and January 2003. Subsequently, the tapes were reviewed and "pedestrian-train incidents" were identified. A "pedestrian-train incident" occurred when "one train (although sometimes it could be two) passed through the O'Brien Avenue crossing of the Deux-Montagnes CN line during the activation period, with at least one pedestrian within the warning system area." The objective of the review was to identify and document the total number of "violations" and "non-violations" that were committed by pedestrians and cyclists at the O'Brien Avenue/Deux-Montagnes crossing during a "pedestrian-train incident".

The STW system was then commissioned at the O'Brien Avenue crossing of the Deux-Montagnes CN line. The "after" analysis phase included the period when the warning system was fully functional and included observations from March 2003 through October 2003. The videotapes were reviewed and "pedestrian-train incidents" were identified. A "pedestrian-train incident" occurred when "two trains passed through the O'Brien Avenue crossing at the Deux-Montagnes CN line from opposite directions during the STW system activation period, with at least one pedestrian within the warning system area".

Second Train Warning System Effectiveness

Based on an analysis of the before and after violation observations, the STW system resulted in a decrease in the total violations at the pilot test crossing. Table 2 shows a summary of the observations with and without the STW system in place.

Table 2: Summary of Total Observations and Violations				
Observation	Before Observations		After Observations (STW System Active)	
	Count	Percentage	Count	Percentage
Violators	1,553	83.1%	157	30.8%
Non-Violators	251	13.4%	352	69.2%
Non-Applicable Observations	66	3.5%	0	0.0%
Total	1,870	100.0%	509	100.0%

The results translate into over a 64% decrease in total violations (including pedestrians and cyclists) with the STW system in place. Table 3 depicts a summary of the STW effectiveness reported at the pilot site and other installations in North America. The results obtained at the O'Brien Avenue Pilot Project test site appear to be consistent with those achieved at other STW pilot program locations.

Table 3: Comparison of STW Installation Effectiveness Results	
Site Installation	Effectiveness Reported
Timonium Crossing – Maryland	80%
Vernon Avenue Crossing – Los Angeles	14% to 73% [1]
O'Brien Avenue Crossing – Montreal	64%
Note: (1) The range represents the effectiveness observed for the different definitions of risky behaviour provided in the assessment.	

Risk Mitigation Cost-Benefit Evaluation of STW System

A risk-mitigation cost-benefit model was developed to determine the net benefits of providing a second train warning system at a crossing in Canada. The following characteristics and facts were incorporated into the model:

- Cost of the second train warning system;
- Societal cost of "The Loss of a Human Life";
- Delay to passenger trains resulting from a second train collision;
- Cost of passenger time;
- Delay to freight trains resulting from a second train collision; and
- Anticipated effectiveness of a second train warning system.

A risk-mitigation benefit-cost (B/C) evaluation was undertaken to assess the net benefit of the STW system with respect to its performance in making improvements to the level of safety for pedestrians at RRIs where second train events occur. Having established the effectiveness of the STW system at the O'Brien Avenue pilot location, attention was then turned to the cost-benefit analysis of installing such systems at other RRI locations, assuming similar safety performance effects.

Benefits and Costs of STW System

In developing a B/C model, both direct and indirect benefits and costs of a treatment were identified and measured (quantitatively) in monetary terms. The benefits and costs of primary focus are the "societal" benefits and costs. Table 4 provides a summary of the benefits and costs associated with the STW system countermeasure.

Table 4: Benefits and Costs Associated with STW System Implementation

Benefits	Costs
• Reduction in second train collisions • Fewer fatalities • Reduced burden on emergency services • Reduced burden on health care system • Avoidance of train/schedule delays • Increased profits to rail/train operators • Reduced litigation/insurance claims	• Capital costs • Operating costs • Maintenance costs • Administrative costs

<u>Estimator of Second Train Collisions Avoidable</u>

Using the effectiveness estimator EFF (STW) of 64.38% from the pilot test site, an estimator of the "expected number of second train collision pedestrian fatalities that can be avoided per RRI per year" (CA/RRI/year) was derived. The 95% confidence limits for the EFF (STW) are 49.06% (lower) and 75.10% (upper).

Based on the findings in Phase 1 of the study, 11 recorded pedestrian fatalities in Canada over the 11-year period 1988-1998 resulted from collisions involving a second train. There are about 255 RRIs in Canada where a second train collision could potentially occur. This means that there have been 0.043 fatalities per RRI over an 11-year period (11 fatalities/255 sites) or 0.004 fatalities per RRI per year.

Since upper and lower confidence limits of the EFF (STW) estimator are 49.06% and 75.10%, respectively, this means that the number of pedestrian-train collisions that can be prevented per RRI per year (CA/RRI/year) due to STW system implementation is given by:

$$0.4906 * 0.004 < \textbf{Estimated CA/RRI/year} > 0.7510 * 0.004$$

or

$$0.00192 < \textbf{Estimated CA/RRI/year} > 0.00295$$

The total societal cost savings is the sum of the societal cost savings of "human life" and the estimated direct cost savings due to pedestrian-train collisions that are prevented. The costs for a "typical" pedestrian-train collision at an RRI that would impact the movement and schedule of 10,000 commuters (which is equivalent to 10 commuter trains), and the societal cost savings per RRI per year was estimated by the components listed in Table 5.

Table 5: Estimated Cost Savings – Prevention of Pedestrian – Train Collision		
Cost Savings	**Description**	**Estimate**
Societal Cost Savings of "Human Life"	$2.0 million per death	$2.0 million
Commuter Delay	10,000 passengers are delayed one hour at $10/hour	$100,000
Commuter Rail Operations	Provision of alternative transportation at $10/passenger	$100,000
Emergency Services	Variable – assumed $10,000 per collision	$10,000
Crew "Trauma" and Alternative Crew Provision	Variable – assumed $10,000 per collision	$10,000
Contract Penalties and Material Damages	Variable – assumed $10,000 per collision	$10,000
Total		$2,230,000

The estimated cost savings per collision were then multiplied by the probability of a second train collision at an RRI in any given year.

Capital Cost of STW System

Based on the costs incurred at the O'Brien Avenue pilot project site, the capital costs associated with a general second train warning installation were estimated. The cost of materials for the pilot test site was $20,519.34 and labour costs were $44,273.41, for a total installation cost of $64,792.75. Maintenance costs are estimated to be approximately $2000.00 per year.

Benefit/Cost Ratio

With the societal cost savings per RRI per year (due to expected reductions in collisions as a result of STW implementation) and costs for implementing an STW system identified and estimated, the benefits were then compared to the costs of installing and maintaining the system. The benefit-cost ratio of the system was computed by converting all yearly costs and benefits into present values (PV) using a 6% discount rate:

$$B/C = PV_{benefits}/PV_{costs}$$

Table 6 is a summary of the PV costs and benefits and the benefit-cost ratio for the Type 2 STW static sign type.

Table 6: Benefit-Cost Ratio for STW System Implementation		
Type 2 Static Sign	**Estimated Value for 15 Year Life Cycle**	
	Lower 95% Confidence Limit	**Upper 95% Confidence Limit**
PV of Costs	$80,549.73	$80,549.73
PV of Benefits	$41,668.90	$63,785.86
Benefit-to-Cost Ratio	0.52	0.79

Based on the analysis provided for the above scenario, benefit-cost ratio is less than 1.0 for the implementation of STW system. In order to achieve a benefit-cost ratio of approximately 1.0, one of the following would need to be realized:

- The costs associated with supply and installation would need to be reduced to less than $47,000 (NOTE: The "upper bound" of the societal benefits was used for determining the $47,000 value, rather than the exact point estimator); or
- The total societal cost savings (or economic benefits) per RRI per year would have to increase by approximately $Y. To achieve this additional $Y in societal cost savings per RRI per year would require that the total cost of a human life and a typical collision at an RRI would have to increase to approximately $2.82 million from the current estimate of $2.23 million (i.e., $2.0 million cost of a "human life" plus $230,000 operational and person-delay costs due to a typical collision at an RRI). (NOTE: The "upper bound" of the societal benefits was used for determining the $2.82 million value, rather than the exact point estimator).

Functional Specification for General Deployment of STW Systems in Canada

Based on a review of the effectiveness and installation of the static sign STW system at the O'Brien Avenue crossing, the initial functional specification developed for the pilot project was refined for general deployment and includes:

- Warning system activation and logic;
- Sign location and number;
- Auxiliary lights and sounds;
- Bilingualism;
- Fail-safe requirements;
- Sign content during second train events and "non-second train" periods; and
- Sign mounting, dimensions and location.

Based on the review of the STW pilot site installation, a number of considerations were noted:

- The need for supplemental beacons mounted on the backside of the primary beacons should be determined on a site-by-site basis. These additional beacons may be required should the signs/beacons be located such that the pedestrian's view of the primary beacons is hindered from a potential viewing area;
- Battery back-up and "critical" components should considered for a permanent deployment of an STW system;
- The Type 1 STW sign (LED sign) should be considered for a permanent deployment of an STW system; and
- Sturdier mounting brackets should be considered to address wavering and potential dislodging of the sign.

Site Installation Prioritization in Canada

In order to develop a program for full deployment of STW systems across Canada, it is necessary to develop criteria and an approach for identifying locations that have a high risk of second train events.

<u>Qualitative Model</u>

Through discussions with the PSC, and based on the field investigations undertaken as part of the pilot project site selection, there are locations with lower probabilities of a second train incident due to the nature of their location or operations. These would include crossings with:

- Little or no pedestrian traffic (multi-track grade crossing in a rural or remote area);
- Low train volumes and/or probability of second train events; and/or
- Low probability for second train events to coincide with pedestrian activity.

Based on a review of the location criteria identified through the research of STW collisions and warning systems and the availability of data at the sites across Canada, it was determined that a qualitative model would be used to generate a short list of sites that have a higher potential of second train events.

The qualitative model would be based on a weighted index of the site attributes found in Table 7.

Table 7: Qualitative Model Location Criteria

Qualitative Location Criteria	Measure Description	Criteria Weight
Pedestrian Volume	Low, medium and high activity	0.4
Train Volume	Estimated number of trains per day	0.3
Whistle prohibition	Prohibited/no prohibition	0.1
Train Operating Speeds/Speed Differential	Low, medium and high speeds/speed differentials	0.2
	Total	1.00

Data collection efforts would be required by the various operating agencies to develop the qualitative model; however, local knowledge of the crossing locations would generate the majority of the information required to build the model.

<u>Quantitative Screening – "Exposure to Risk" Model</u>

After all RRIs are ranked using the qualitative screening model, the high-risk sites with the greatest potential for a second train collision occurrence should be selected for further detailed investigation. This more rigorous process is to be carried out using a quantitative model. In order to implement the quantitative model, it will be necessary to collect relevant quantitative data for the short-listed sites and to conduct on-site audits to record/document the site-specific criteria such as visibility and warning system configuration. Two basic types of data are required at each of the RRIs in order to compare and prioritize them on a quantitative basis:

i) Daily pedestrian volume counts, in one hour increments, for a typical day; and
ii) Daily second train event counts, in one-hour increments, under typical railway operations.

The "Exposure to Risk" Index, or train "meets" occurring with pedestrian presence, is the best quantitative criterion measure to use for prioritizing site locations. The exposure index is calculated with the following equation:

$$E_x = P_X/P_T * ST_X$$

where:

E_X = Exposure index at site RRI_X

P_X = Pedestrian volume at RRI_X
P_T = Total pedestrian volume at all short-listed sites
ST_X = Number of second train events at RRI_X

Using this type of comparison method for all RRIs would provide an exposure index as a criterion for ranking the RRIs for STW system implementation. Once the "Exposure to Risk" Index is calculated, the sites would be ranked in ascending order. This index could be supplemented with the other qualitative criteria such as visibility and existing warning system configuration.

Recommendations

1) STW warning systems should be pursued at sites with a high risk of second train incidents/collisions.

2) Data collection efforts should be undertaken by the various rail authorities to provide a complete qualitative assessment of all RRIs in Canada with the potential for second train collisions.

3) The results of the qualitative screening should be used to establish a short list of sites on which full site audits should be performed and data collection efforts focussed to develop the quantitative priority ranking model.

4) Studies should be conducted to continuously monitor locations after the installation of STW systems and measure their long-term effectiveness.

5) As pedestrian and train volumes (i.e., "exposures to risk") as well as operational and environmental characteristics at the various RRIs are expected to change over time, it is imperative that recommendations 1 through 4 are repeated on a regular basis. This will ensure that resources and funds are used as efficiently as possible in order to maximize the safety benefits.

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GLOSSARY

A number of terms were defined to facilitate discussion and understanding during the study and for this document. Provided below is the terminology and abbreviations formulate for these purposes:

AMT	Agence Métropolitaine de Transport
B/C	Benefit-Cost
CCTV	Closed Circuit Television Camera
C-G Method	Comparison Group Method
CLRL	Central Light Rail Line (Baltimore)
CN	Canadian National Railway
CP	Canadian Pacific Railway
EB Method	Empirical Bayes Method
FRA	Federal Railroad Administration
ITS	Intelligent Transportation System
LACMTA	Los Angeles County Metropolitan Transportation Authority
LED	Light-Emitting Diode
LRT	Light Rail Transit
MBL	Metro Blue Line
MMTA	Maryland Mass Transit Administration
N/A	Not Applicable or Not Available
Passive Sign	A static sign posted to warn pedestrians of the potential for second train events at an RRI.
PSC	Project Steering Committee established for the STW project, as defined and documented in Section 1.2.
PSCM	Project Steering Committee Meeting
PV	Present Value
RRI	Roadway-Rail Intersection (at-grade)
Second Train Collision	Two trains passing through an RRI, one after the other, within the same activation period, where one or both of the trains strikes a pedestrian.
Second Train Event	Two trains passing through an RRI on separate tracks, within the same activation period.
Second Train Incident	Two trains passing through an RRI, one after the other, within the same activation period, with pedestrians within the warning system area.
SEPTA	Southeastern Pennsylvania Transportation Authority

STW	Second train warning
STW system	An active sign display that is activated when a second train event occurs at an RRI.
TAC	Transportation Association of Canada
TCRP	Transit Cooperative Research Program
USDOT	United States Department of Transportation
Violation (of rail warning equipment)	A person that encroaches upon the railway right-of-way (i.e., entire area between the warning system gates) prior to the completion of the warning system device activation.

1. INTRODUCTION

1.1 BACKGROUND AND SCOPE

On April 20, 1995, a westbound freight train struck and killed two pedestrians at the Park Street public crossing, mile 125.15 on the Kingston Subdivision in Brockville, Ontario. The Transportation Safety Board of Canada determined that the pedestrians walked into the path of the westbound train while their concentration was fixed on a passing eastbound train at the same crossing. This type of collision is termed a "second train collision". Between 1989 and 1999 inclusive, 15 second train collisions involving pedestrians occurred in Canada, 11 of which occurred at grade crossings.

In 1998, a Transport Canada project team was assembled to participate in a study to address the use of second train warning (STW) systems for pedestrians. The intent of an STW system is to provide pedestrians with additional information to reduce the risk of a collision resulting from pedestrians assuming that they can safely cross at a level crossing subsequent to the departure of the first train. The project team prepared a Terms of Reference (see Appendix A) for a Study of a Second Train Warning System at Road Crossings for Pedestrians.

Following a July 2000 Request for Proposal, Transport Canada retained IBI Group in December 2000 to undertake the Second Train Warning at Grade Crossings study. The study comprised three phases, with their respective objectives as follows:

Phase 1: Pilot Test Development – A review of the existing STW installations and their effectiveness, the development of location criteria, the selection of a pilot test site, the development of a functional specification and cost-benefit model, and the preparation of a Phase 2 plan.

Phase 2: Pilot Test Evaluation – The procurement, installation, demonstration and evaluation of an STW system at an at-grade crossing with an identified risk of second train incidents. The evaluation included "before" and "after" data collection activities undertaken with video monitoring equipment, an assessment of the results, and the preparation of a Phase 3 Plan involving the development of deployment recommendations.

Phase 3: Deployment Recommendations – The formulation of conclusions and recommendations relating to the deployment of STW systems in Canada.

This report is a summary of each of these Phases.

1.2 PROJECT STEERING COMMITTEE

A Project Steering Committee (PSC) was established to review and comment on the progress of the work, serve as a forum for information exchange and, as appropriate, provide advice and make decisions concerning technical aspects of the work and its results. The PSC was composed of the following:

- Sesto Vespa, Transportation Development Centre, Transport Canada;
- Anthony Napoli, Transportation Development Centre, Transport Canada (Consultant);
- Daniel Lafontaine, Rail Safety Directorate, Transport Canada;
- Denis Galarneau, Surface Branch, Ontario Region, Transport Canada;
- Rene Turgeon, Surface Branch, Quebec Region, Transport Canada;

- Ion Chiosa, Montrain, Canadian National Railway;
- Rick Felstead, Canadian Pacific Railway;
- Kevin Campbell, GO Transit; and
- Vernon Hartsock, Maryland Mass Transit Administration (MMTA).

2. PHASE 1 SCOPE

Phase 1 included the development and background work required for the pilot test of the second train warning system. The following is a brief summary of the activities required to complete Phase 1 of the study. In addition, a reference is made to the specific section of the report wherein a description of the activity findings can be located.

Identification of Second Train Warning Systems – An information gathering exercise to document the study/deployment of second train warning systems (**Section 3**).

Study Site Selection – This activity consisted of two components. The first component included the development of location criteria to identify roadway-rail intersections (RRI) with the likelihood of second train events, incidents and collisions (**Section 4**). The location criteria were used to select the preferred candidate site for the pilot project and were refined for use in the deployment planning for STW systems. The second component involved the application of these criteria to a number of short-listed sites to select a preferred pilot test site (**Section 5**).

Development of Functional Specification – Development of a functional specification for a second train warning system that could be deployed at a variety of candidate RRIs at which the second train warning would produce a positive benefit (**Section 6**).

Development of Risk-Mitigation Cost-Benefit Model – Preparation of a model to assess the net benefits of a second train warning system at an RRI (**Section 7**).

3. IDENTIFICATION OF SECOND TRAIN WARNING SYSTEMS

The provision of active STW systems in North America is a relatively new application and, as such, is still under development. **Table 3-1** provides a review of the documents relating to research and active STW projects acquired through previous STW related projects and the subject study.

3.1 RESEARCH ACTIVITIES

IBI Group has undertaken the following activities to obtain existing literature relating to STW systems/projects:

- TRIS on-line inquiry – a database hosted by the U.S. National Transportation Library;
- TRANweb search;
- Librarian discussion forum;
- Detailed Internet search; and
- Posting of a request on the International Rail Forum discussion group to solicit information relating to STW systems/initiatives.

3.2 RECENT PUBLICATIONS

Overall, the study documents provided by the PSC and those already possessed by IBI Group constituted the readily available literature. Provided in **Table 3-1** is a listing of the documents obtained to date and their principal content. Detailed summaries of each document are included in **Appendix A**.

Table 3-1 Second Train Warning Publications Summary

Document	Key Components
1. Terms of Reference for Study of a Second Train Warning System at Road Crossings for Pedestrians, Transport Canada, July 1998	Incident reports, candidate sites, example projects, technologies and evaluations.
2. Identification of Second-Train Warning Systems for Pedestrians, TP 13018, Transportation Development Centre, Transport Canada, May 1997	Candidate Second Train Warning systems.
3. Session 8 – Light Rail Transit Systems, Hartsock, V., Grade Crossing Technologies – The New Millennium, Texas Transportation Institute, October 1999	Site selection, sign development, activation logic and circuitry for a number of North American projects (Los Angeles, Massachusetts, Portland etc.)
4. New Technologies for Improving Light-Rail Grade Crossing Safety, Meadow, L. and Curry, J., Seventh National Conference on Light Rail Transit, November 1995	Safety and enforcement issues, grade crossing new technology review, demonstration projects

Table 3-1 Second Train Warning Publications Summary	
Document	**Key Components**
5. Pedestrian Control Systems for Light-Rail Transit Operations in Metropolitan Environments, Korve H. et al, Seventh National Conference on Light Rail Transit, November 1995	Rail-pedestrian crossing environment, existing pedestrian control devices, static and dynamic second train warning signs, other pedestrian safety measures and pedestrian crossing design considerations.
6. Integration of Light Rail Transit into City Streets, Korve H. et al, Seventh National Conference on Light Rail Transit, November 1995	Pedestrian crossing treatment including STW systems
7. Second Train Coming Warning Sign Demonstration Project, Maryland Mass Transit Administration, February 1999	Sign selection and specifications, sign selection survey, signal control specifications, data collection activities/methods and before & after study results
8. Proceedings of the Second Workshop on Rail-Highway Grade Crossing Research, TP 13536, Transportation Development Centre, Transport Canada, November 2000	Incident reporting, data collection and integrity, collision analysis, human factors, current research initiative including STW systems.
9. Study of a Second Train Warning System at Road Crossings for Pedestrians – Transport Canada Meeting Minutes, September 1998	Second train incident characteristics, human factors and other STW project initiatives.
10. Second Train Coming Warning Sign Demonstration Project, Maryland Mass Transit Administration and Sabra, Wang & Associates, February 2001	This document is an updated report on the Maryland test site discussed in References #3 and #7. The STC warning sign demonstrated favourable results during the 30-day "after" period where illegal pedestrian and risky driver behaviour was reduced by 80%. The STW system was well received and understood.
11. Second Train Coming Warning Sign Demonstration Project, Khawani V., Los Angeles County Metropolitan Transportation Authority	Site selection criteria, sign specifications and operations, data collection and evaluation and before and after studies.
12. Pedestrian Warning and Control Devices, Guidelines and Case Studies, Siques J., Korve Engineering Inc.	Discussion of various pedestrian safety treatments at rail-highway intersections including passive and active warnings.
13. Use of Animation in LED Pedestrian Signals to Improve Pedestrian Safety, Van Houten, R., et al., ITE Journal, February 1999	A review of pedestrian behaviour (primarily the observation of turning vehicles) before and after the installation of the "animated eyes" display on standard pedestrian heads.

Table 3-1 Second Train Warning Publications Summary	
Document	**Key Components**
14. ITS Animated LED Signals Alert Drivers to Pedestrian Threats, Van Houten, R., and Malenfant, L., ITE Journal, July 2001	A study of two applications of the "animated eyes" at a mid-block traffic signal and in a parking structure exit. The study focused on the changes to driver and pedestrian behaviour relating to watching for and yielding to one another at these critical locations.
15. The Economics of Railroad Safety, Savage, I., Kluwer Academic Publishers, 1998	The main part of the publication includes a discussion of the economics of rail safety including: • The level of care taken by the rail operator, its employees and the public; • Encouraging a higher level of care within the rail right-of-way by all parties; and • The associated costs of a rail collision to each party.
16. The Cost of Highway Crashes, Miller et al., FHWA, 1991	The documents outlines the three measures of crash costs for highway collisions: • Comprehensive • Years lost plus direct costs; and • Human capital
17. Grade Crossing Safety in the Chicago Area: An Environmental Analysis of the Potential Noise Impacts from the Swift Rail Development Act's Locomotive Horn Sounding Requirement, Laffey, S., Transportation Quarterly, Eno Transportation Foundation Inc., Volume 54, Number 1, Winter 2000	A study to review the number of residents and institutions impacted by train whistle blowing in Northeastern Illinois. The paper provides an overview of the spatial analysis undertaken to determine the implications of the horn-sounding requirement of the Swift Rail Development Act of 1994. In addition, a brief summary is provided from other sources of the collision potential of at-grade crossings with and without whistle-blowing restrictions.
18. Second Train Warning – Project Implementation Plan, Transportation Development Centre, Transport Canada, July 2000	The Project Implementation Plan included a summary of the second train warning project objective, background (including Transport Canada and other STW initiatives), study implementation approach and work processes and estimated schedule.

3.3 RECENT PROJECTS

3.3.1 Baltimore, Maryland – Timonium Station

In response to the frequent second train events at its double track crossings on the Baltimore Central Light Rail Line (CLRL), the Maryland Mass Transit Administration (MMTA) initiated a study to identify and demonstrate an active signing warning system that would increase motorists' awareness and compliance during a second train event.

The project resulted in the installation of an active STW system at the Timonium crossing, a heavily traveled RRI. The project study report (Reference 6, Table 3-1) includes a summary of the problem definition, the sign design and installation, the before and after data collection activities, a sign comprehension survey and the project conclusions.

During the 90-day observation period following the installation, the frequency of illegal pedestrian movements and the incidents of "risky behaviour" associated with second train events were reduced by 80 percent. Based on the road user's survey undertaken as part of this project, the STW sign was well received and understood by motorists.

3.3.2 Los Angeles, California – Metro Blue Line's Vernon Avenue Crossing

The Los Angeles County Metropolitan Transportation Authority (LACMTA) identified that an important contributing factor of train-vehicle and train-pedestrian collisions at its at-grade crossings on the Metro Blue Line (MBL) are a result of the poor detection by motorists/pedestrians of second train events. The LACMTA, in conjunction with the Transportation Research Board, conducted a study to install and test STW signs.

The LACMTA selected the Vernon Avenue grade crossing on the Metro Blue Line for the installation and demonstration of the STW system. The demonstration project included a focus group to evaluate word and graphics-activated signs, relay circuit modifications to identify two trains using the crossing during the same activation period, installation of video surveillance equipment, and a before and after assessment of its effectiveness.

Based on preliminary results documented by Vijay Khawani of LACMTA, there has been a significant reduction in pedestrian risky behaviour associated with second train events since the installation of the STW system. Most notable is a 78 percent reduction in the number of pedestrians entering the rail track area less than six seconds before the approaching train.

3.3.3 New York, New York – New Hyde Park Grade Crossing

The New York State Department, in conjunction with Alstom Signalling, is developing and testing an Intelligent Grade Crossing that employs ITS technologies to perform a number of functions to improve the safety and reduce delays at RRIs. The New Hyde Park grade crossing of the Long Island Railroad is the site of this project.

The Intelligent Grade Crossing transmits information to nearby variable message signs to inform drivers and pedestrians of current conditions at the RRI. The system has the ability to provide motorists with information such as "Train at Station", "Do Not Enter Crossing – Exit Blocked" and "Another Train is Approaching".

Through discussions with the Project Manager from Alstom Signalling, initial data has been collected relating to gate time improvements; however, to date, there has been no assessment of the variable message sign component of the project.

3.3.4 STW Sign Application Under Development

GELcore is currently developing a specification for an LED train warning sign that could be used at a single or double track crossing to alert pedestrians/motorists of an approaching train. The 450 mm by 400 mm sign depicts a pedestrian standing at a double track railway crossing and four LED arrays shaped as trains to signify trains in each direction on either track. The LED trains have three functions:

1) Unlit – signifying no train;
2) LED array on – stationary train; or
3) LED array flashing mode – moving train.

A text message is not provided in the GELcore sign specification.

GELcore is currently preparing the sign for use by the Southeastern Pennsylvania Transportation Authority (SEPTA); however, SEPTA has not approved the specification nor installed the sign within its system.

3.4 OTHER APPLICABLE TECHNOLOGIES

In an effort to identify similar intelligent technologies currently being tested for pedestrian warning applications, research activities in the roadway intersection field were also pursued. A recent development in pedestrian ITS technology is the Signal EyesTM LED also referred to as the "animated eyes" display intended to remind pedestrians to watch for vehicles crossing their intended path.

Two formal studies of the "animated eyes" have been undertaken (References 12 and 13, Table 3-1). The first study focussed on the improvement of pedestrians' observation of turning vehicles at an intersection; the second study's objective was to increase drivers' awareness of approaching pedestrians at a parking garage exit and a mid-block signal. In both studies, the pedestrian and driver behaviour improved significantly, resulting in a reduction of pedestrian-vehicle conflicts. The project team acquired the sign specifications from the manufacturer for use in the development of the STW system functional specification.

3.5 ITS ARCHITECTURE FOR CANADA

The ITS Architecture for Canada provides a unified framework for integration to guide the co-ordinated deployment of ITS programs within the public and private sectors. It offers a starting point from which stakeholders can work together to achieve compatibility among ITS elements to ensure unified ITS deployment for a given region. The ITS Architecture for Canada is based on a group of User Services that define the functionality of ITS components and the information flows among ITS elements to achieve total system goals. The User Services are hierarchically organized with 8 User Service Bundles, 35 User Services, 90 User Sub-services, and over 1,800 User Service Requirements.

The ITS Architecture for Canada includes separate Logical and Physical Architectures. The Logical Architecture defines processes and data flows between processes required to support the User Services defined for the ITS Architecture for Canada. The Physical Architecture provides a physical representation (though not a detailed design) of the important ITS interfaces, in the form of Architecture Flows, and major system components, in the form of Subsystems. The Physical

Architecture provides a high-level structure around the processes and data flows defined in the Logical Architecture.

The ITS Architecture for Canada also includes 79 Market Packages that group the different Physical and Logical elements required for transportation service implementations (e.g., basic or advanced highway-rail intersections). These Market Packages provide a focussed view of the architecture for use in designing deployment projects.

Second train warning systems/signs are not explicitly recognized in the ITS Architecture for Canada; however, their purpose and operations are intrinsic to the functions outlined in Basic At-Grade Crossing Control (2.8.1 User Sub-Service) and Advanced At-Grade Crossing (2.8.2 User Sub-Service).

3.6 SUMMARY

The activities undertaken in the identification of second train warning systems have determined that there are three projects underway in North America with active STW applications. Consultation with the respective project managers for these projects was undertaken, as necessary, for the balance of the project tasks.

4. DEVELOPMENT OF LOCATION CRITERIA

In order to effectively implement STW systems it was necessary to develop criteria for identifying locations that have a high risk of a second train collision. To this end the following three main tasks were addressed:

1) Establish location criteria for identifying RRI types that have the greatest probability or likelihood of second train collisions;
2) Develop a site location prioritization model; and
3) Identify data requirements for implementing the site selection prioritization model.

4.1 OBJECTIVES

This section describes a process for identifying and prioritizing RRI with respect to the requirement for an STW system. Specifically, there are two major objectives:

1) Develop location criteria for identifying RRI types that have the greatest likelihood of second train incidents. The location criteria will be used to rank the list of short-listed pilot test candidate sites identified in **Section 5**. This includes information on the following:
   - History of collisions;
   - Factors that contribute to higher potential for second train incidents, or "exposure factors", e.g., volume of pedestrians, volume of trains, probability of second train events at level crossings, limited sightlines, and other geometric, environmental, traffic and infrastructure attributes.

2) Identify typical locations and a priority rating system to rank grade crossings for potential STW system installation based on the location criteria. (The priority ranking system was refined during Phase 3 of the project).

4.2 SITE LOCATION CRITERIA

There are a number of criteria/factors that could be considered for identifying RRIs that have the greatest potential or likelihood of a second train incident. From the existing body of literature on STW systems and their implementation, criteria were identified as the most important to be taken into account for developing site location prioritization models.

4.2.1 Rationale

The best criteria to use in developing a site location prioritization model are those that provide a quantitative basis for estimating and comparing the risks of a second train collision occurring at all sites being considered. With these risks computed, it would then be possible to prioritize the site locations with respect to the requirement for an STW system. For example, data on the average number of second train incidents (per day) occurring at each location would provide the most reliable quantitative measure for prioritizing the site locations. Although less reliable, data on the expected frequency of second train events (by time of day) coupled with data on pedestrian volumes (by time of day) would also provide an objective quantitative basis for comparing the risk levels at site locations.

Since it is not expected that quantitative information will be readily available on all of the criteria and factors that need to be considered in a quantitative prioritization model, the first step for prioritizing RRIs would involve a qualitative analysis to differentiate and compare the potential risks attributable to each site location. Also, some criteria can be categorized as surrogates (i.e., approximations) for others, if necessary. For example, if no data on the number of second train events (per day) is available, then it will be necessary to use a surrogate measure such as the train volumes (per day) passing by a site location. At the end of this step it would be possible to develop a "short-list" of high-risk sites for consideration. The next step would then involve the implementation of a data collection program in order to conduct a detailed evaluation using a quantitative model for identifying and prioritizing high-risk RRI locations.

The rationale, therefore, for the design of the prioritization models (both qualitative and quantitative) is to provide a basis for comparing the risk levels for the various site locations, regardless of the amount of quantitative information available on the criteria. **Sections 4.2.2** through **4.2.10** provide discussions of the main criteria that should be considered for ranking RRIs with respect to their potential for a second train collision.

4.2.2 Multiple Track Roadway-Rail Intersection (Mandatory Criterion)

If there are two or more sets of railway tracks, then the site is considered a potential site. This criterion must be met for a site location to be considered for an STW system installation.

4.2.3 Collision History (Qualitative Criterion)

The number of second train collisions will provide another criterion for ranking the RRIs for STW system implementation. However, the collision history, on its own, will not provide sufficient information for ranking RRIs with respect to their potential for a second train collision. The collision history should be reviewed, taking into account any improvements that have been made in the past to the warning systems or the RRI. However, it must be noted that since second train collisions are rare events, a secondary measure to reflect the potential of second train collisions is necessary. It is therefore suggested that violations and conflicts be used as surrogate measures for conducting safety analyses.

4.2.4 High Pedestrian Volumes (Quantitative or Qualitative Criterion)

The daily pedestrian volume (i.e., numbers of pedestrians who cross the RRI tracks (daily) at the given site) should be used as the criterion. If available, daily pedestrian crossing counts by time of day is the best criterion to use. This would permit the development of "pedestrian crossing probability distributions" by time of day that can be compared to second train event occurrences to estimate the probability of second train incident occurrences.

In the absence of reliable pedestrian volume data (which is expected, given that pedestrian crossing counts are not typically collected at RRIs, at least on a regular basis), it is anticipated that some type of surrogate measures will be needed. The surrogate measure should be correlated with levels of pedestrian activity (e.g., high pedestrian generators – urban vs. rural, adjacent land use). This would permit a qualitative criterion for ranking pedestrian activity (e.g., high, medium and low classifications).

4.2.5 Number of Second Train Events (Quantitative Criterion)

Compared to High Train Volumes in Both Directions, a second train event is a better indicator for predicting the likelihood of the joint arrival of a pedestrian and a second train at an RRI. Essentially, this information amounts to the count of second train events that occur at a particular RRI during a specified period of time, as well as the specific time that each occurred. Using this criterion, however, requires data that is not generally available for all RRIs. The ability to predict second train incidents with any degree of accuracy is dependent upon this data being available. If further information was available on the exact time of the day for each second train event, then this is the best information for predicting the likelihood of a second train incident --i.e., pedestrian presence and second train event occurrence. There are different procedures that could be considered for collecting the second train event data, including: collecting administrative scheduling information, implementing manual data collection methods at RRIs, or counting second train events at RRIs using electronic auto-recording equipment.

4.2.6 High Train Volumes in Both Directions (Quantitative or Qualitative Criterion/Surrogate for Number of Second Train Events)

Train volumes, in particular volumes in each direction of travel, are a surrogate criterion to use in the absence of second train event data. The overall criterion would be the number of trains passing by the RRI site per day in each direction of travel. If the time of day for the trains passing through the RRI were available, it would be possible to estimate the number of second train events directly.

4.2.7 Whistle Prohibition (Qualitative Criterion)

All else being equal, it is expected that an anti-whistling RRI site will have a higher collision potential than sites where whistling in not prohibited, since whistling serves to provide an audible warning from an approaching train. From the literature, a higher proportion of second train collisions occur at RRIs where train whistling has been prohibited. The Federal Railroad Administration (FRA) has concluded that "whistle bans, whether 24-hour, or night time-only, increase the risk of accidents at crossings", based on the following two findings:

1) **Nation-Wide Study of Train Whistle Bans** (USDOT-FRA, April 1995) determined that, on average, whistle ban crossings experienced 84% more collisions than crossings without the bans; and
2) **Florida's Train Whistle Ban** – the number of nighttime only collisions were reduced by 68% when the nighttime whistle ban was removed (USDOT-FRA, October 1995).

Therefore, another criterion for consideration in site selection would be a "whistle prohibition index" to differentiate between the potential risk of collisions at anti-whistling and whistling RRIs.

4.2.8 Visibility (Qualitative Criterion)

In this report visibility refers to pedestrians' sightline of the approaching trains, and is an important factor affecting their "exposure (to risk)". Adequate sight distance for pedestrians is based on the time required to view an approaching train, make a decision to cross the tracks, and traverse the tracks safely. For RRIs where the views of trains are blocked by fixed obstructions, this increases the potential for second train collisions. Also, combinations of second trains at the same time, in particular if one of the trains is stopped in the station, can result in severely restricted visibility of trains approaching from the other direction. Therefore, a site visibility criterion should be used in the evaluation process for considering the priority listing of the most likely RRI candidates for STW treatment. This site visibility index should be determined during an on-site audit of the RRI.

4.2.9 Train Operating Speeds (Qualitative Criterion)

The mix of train types (passenger vs. freight) varies considerably from RRI to RRI. This will result in not only different train speeds, but also most importantly varying train speeds at a particular RRI. Pedestrian expectations of time available for crossing an RRI are mainly based on their experiences. When the train speeds are quite variable at an RRI the pedestrian is not able to judge the crossing time available for making a safe traverse over the tracks. The time available during one crossing occasion may be considerably less than that of another occasion.

Considerable difference between train speeds can also produce situations with high potential for second train collisions. The presence of a slow moving train can give pedestrians a false sense of security by drawing their attention away from a second approaching train or by biasing their perception of the speed of the second train.

4.2.10 Train Warning System in Use (Qualitative Criterion)

The types and configurations of the warning system(s) presently being used at RRIs can have varying levels of effectiveness with respect to warning pedestrians about the potential of a second train event. A "train warning system index" should therefore be used as another qualitative criterion towards evaluating the potential risk of a second train collision at the RRI and ranking it for STW system implementation. This index measuring the adequacy of existing train warning systems would be determined during a site audit of the RRI.

4.3 SITE LOCATION PRIORITIZATION METHODS

Section 4.2 identified a number of criteria for evaluating the various RRIs being considered for STW treatment, and establishing a priority listing for potential STW system installation based on these location criteria. In order to develop a priority listing of RRIs ranked according to the need for a STW system, the criteria must be weighted and combined in a rational manner.

Sections 4.3.1 and **4.3.2** provide two methods for ranking RRIs. The method employed is dependent on the amount and type of data available for the site location criteria. The first method is a "qualitative" method and has been formulated based on the assumption that limited data will be available for the initial prioritization of the RRIs. The second method assumes that data will be available on major criteria (e.g., pedestrian volumes and second train events/train volumes) and is a "quantitative" model. Regardless of the method applied, the end result is to generate a list of RRIs ranked according to the potential risk of a second train collision occurrence. With the list established, the top ranking RRIs can be further investigated by:

- Discussions with train operators to identify "highest risk" RRIs;
- Discussions with rail maintenance staff;
- Audits of operations and characteristics of the sites; and
- Completion of pedestrian counts and assessments of risky behaviour.

4.3.1 Qualitative Screening

This method is based on the development of a prioritization method given that limited data on pedestrian and train volumes is available. This method was employed in the selection of the pilot test site from the nine sites located in Toronto and Montreal, identified by the PSC as potential candidates (refer to **Section 5** of this report).

The location criteria will be weighted by "weighting factors" to differentiate among the levels of importance to be assigned to each criterion. Based on the information obtained through previous research, discussions with the PSC and activities completed in this study, preliminary weighting factors were generated to assist in the selection of the preferred candidate site for the pilot project. Included in **Table 4-1** are the weighting factors proposed for this phase of the study.

The most objective method for determining the weighting factors (in the absence of available quantitative measures) is expert evaluation. This process is carried out by assembling an expert panel of traffic safety professionals (minimum of five members). In this case, the PSC members served as the expert panel, given their knowledge of the second train issue.

Each panel member assigned weighting factors to each criterion based on his/her own expert opinion. In order to ensure that each expert's opinion is of equal weight, the sum of the weighting factors should be equal for each expert evaluation (i.e., total of 1.0, as in **Table 4-1**). The final weighting factors were computed as average values of those obtained from all experts on the panel.

Table 4-1 Preliminary Qualitative Screening Process			
Criteria	**Index**	**Weight**	**Total**
Pedestrian Volumes	Pedestrian Volume Index ❑ 1 = Low activity ❑ 3 = Medium activity ❑ 5 = High activity	0.25	
Train Volumes	Train Volume Index ❑ 1 = 1-80 trains per day ❑ 2 = 81-160 trains per day ❑ 3 = 161-240 trains per day ❑ 4 = 241-320 trains per day ❑ 5 = > 320 trains per day	0.20	
Collision Potential	Collision Potential Index ❑ 1 = Low collision potential ❑ 3 = Medium collision potential ❑ 5 = High collision potential	0.15	
Whistle Prohibition	Whistle Prohibition Index ❑ 1 = Whistling not prohibited ❑ 5 = Whistling prohibited	0.05	
Visibility	Site Visibility Index ❑ 1 = Visibility not restricted ❑ 2 = Visibility moderately restricted ❑ 3 = Visibility severely restricted	0.10	
Train Operating Speeds/Speed Differentials	Train Operating Speed/Differential Index ❑ 1 = Low operating speeds/differentials ❑ 3 = Medium operating speeds/ differentials ❑ 5 = High operating speeds/differentials	0.15	
Warning System	Train Warning System Index ❑ 1 = Adequate warning system in place ❑ 3 = Warning system could use improvement ❑ 5 = No active warning system	0.10	
Total Score		1.00	

4.3.2 Quantitative Screening – "Exposure to Risk" Model

After all RRIs are ranked using the qualitative model, the highest-risk sites with the greatest potential for a second train collision occurrence will be selected for further detailed investigation. This more rigorous process is to be carried out using a quantitative model. In order to implement the quantitative model, it will be necessary to collect relevant quantitative data for the short-listed sites (e.g., frequency of second train events and pedestrian volume data) and to conduct on-site audits to record/document the site-specific criteria such as visibility and warning system configuration.

Specifically there are two basic types of data required at each of the RRIs in order to compare and prioritize them on a quantitative basis:

1) Pedestrian volume counts; and
2) Second train event counts.

If the above data is available it is feasible to calculate the "Exposure (to risk)" Index Criterion for prioritizing site locations for STW implementation.

Using the pedestrian daily crossing counts at an RRI (as a percentage of all pedestrian daily crossings at the sites in Canada), in conjunction with the expected number of train events per day at an RRI (i.e., number of second train events per day), an index measuring the "exposure (to risk)" can be estimated. Using this type of comparison method for all RRIs would provide a direct quantitative "exposure (to risk)" index as the major criterion for ranking the RRIs for STW system implementation.

This index could be supplemented with the other qualitative criteria discussed in **Section 4.2** in order to arrive at a final prioritization index for each RRI. The recommended model for the ranking of the short-listed sites in Canada has been formulated as part of Phase 3 of this study.

5. SELECTION AND ASSESSMENT OF CANDIDATE SITES

5.1 LOCATIONS

At the February 21, 2001 Project Steering Committee Meeting (PSCM #1), it was decided that the focus should be on identifying a pilot test candidate site located in Greater Toronto or Montreal areas. In general, daily train traffic, both commuter and freight, is higher in these areas than in the rest of Canada. In addition, it was anticipated that, provided a suitable candidate site could be found, a site located in one of these two areas would reduce the costs associated with the design, tender and monitoring of the STW system for Phase 2 of the project.

5.2 SHORT LIST OF CANDIDATES

5.2.1 Rationale

The qualitative screening of the candidate sites was undertaken based on the following criteria:

1) Previous second train collision experience;
2) Local knowledge of crossing operations and pedestrian behaviour;
3) Potential for second train events;
4) Potential for high and consistent pedestrian activity; and
5) Prevalent train operating speeds and speed differentials.

5.2.2 Steering Committee Selection

It was determined that, given the number of potential sites, the PSC would rely on the knowledge of the local Transport Canada and commuter rail agencies for a "short list" of potential sites. Included in **Table 5-1** is a summary of the candidate crossing locations suggested by the PSC local representatives.

Table 5-1 Short List of Candidate Crossing Locations – STW Pilot Project	
Toronto Candidate Crossing Locations	**Montreal Candidate Crossing Locations**
• Brampton GO Station/ Mill Street (15.4, Halton Subdivision) • Tannery Street (20.85, Galt Subdivision) • Queen Street (20.12, Galt Subdivision)	• O'Brien Avenue (7.37 Deux-Montagnes Subdivision) • Westminster Avenue (0.04 Vaudreuil and 4.48 Westmount Subdivisions) • Wilderton Avenue (48.81 Adirondack Subdivision) • 3^{e} Avenue (18.07 Vaudreuil and 23.57 Kingston Subdivisions) • Woodland Avenue (12.15 Vaudreuil and 17.52 Kingston Subdivisions) • Baie d'Urfé Station (13.8 Vaudreuil and 19.21 Kingston Subdivisions)

5.3 SITE AUDITS AND DATA COLLECTION

For each of the candidate sites identified in **Section 5.2**, an assessment of site was undertaken and included:

- Completion of site audit prompt list during site visit;
- Video documentation of grade crossing;
- Digital photos of grade crossing and pedestrian facilities;
- Train event data; and
- Train schedule data.

5.3.1 Site Audits

A site audit prompt list was compiled by IBI Group to facilitate the collection of pertinent crossing information at each candidate site. A copy of the audit prompt list is included in **Appendix B**. Items on the prompt list included:

- **Site visit information** – study location/intersecting roadway, railway authority, subdivision and mileage, municipality/road authority, date, time and weather/road conditions
- **Railway function and alignment** – track configuration, alignment, types of trains, operating speeds, visibility along track from pedestrian/motorist perspective, noteworthy operations in the vicinity of the crossing, whistle blowing status and observed second train events/incidents
- **Adjacent land uses** – land use types, train station presence, primary generators of pedestrians, parking facilities and operations at adjacent land uses
- **Warning systems** – type of warning system, layout and operations, presence of passive signs, opportunity for improvement and visibility of devices by motorists and pedestrians
- **Pedestrian facilities and warning devices** – observed pedestrian volumes, pedestrian warning systems/signs, objects that restrict visibility, observed pedestrian infractions, and sidewalk location, condition and utilization
- **Intersecting roadway function** – roadway function (i.e., collector, arterial, highway), traffic volumes, travel lanes, adjacent driveway access, operating speeds and conditions, and signage readability, visibility

IBI Group and Transport Canada staff conducted site visits at the Toronto and Montreal sites on April 30, 2001, and May 28, 2001, respectively. Copies of the completed site audit forms are included in **Appendix C**.

5.3.2 Data Collection

The respective railway operators supplied train event data from the SafeTran recording/monitoring systems. The amount of data provided was a function of the activity at the crossing and the memory capacity of the equipment. Generally, four to five days of event data was obtained at each crossing. The data collection dates for each site are listed in **Table 5-2**.

Table 5-2 Candidate Pilot Test Sites – Train Event Data Collection		
Location	**Start Date/Time**	**End Date/Time**
Tannery Street	N/A	N/A
Queen Street	N/A	N/A
Brampton GO Station/Mill Street	Discussion with CN representative	
3^{e} Avenue	May 24, 2001 (6:22 am) June 2, 2001(7:20 am)	May 29, 2001 (4:40 pm) June 6, 2001 (9:25 am)
Woodland Avenue	May 26, 2001 (10:25 pm) June 3, 2001 (3:30 pm)	May 29, 2001 (3:31 pm) June 6, 2001 (7:16 am)
Wilderton Avenue	N/A	N/A
O'Brien Avenue	Discussion with CN representative	
Westminster Avenue	N/A	N/A
Baie d'Urfé	June 2, 2001 (10:20 pm)	June 6, 2001 (8:28 am)

5.4 ASSESSMENT OF CANDIDATE SITES

The candidate sites were evaluated using the primary criteria outlined in **Section 5.2.1** and the site-specific information collected during the site visits. Included in **Table 5-3** is a summary of the principal criteria for the candidate sites. Included in **Sections 5.4.1** through **5.4.9** is a detailed review and assessment of each site.

At the beginning of each site review, a table like the one shown in **Figure 5-1** is included to provide a "high level" rating based on the primary selection criteria for that particular site. This rating was undertaken to provide a cursory review of the candidate locations, including the suitability of the site for the monitoring system installation. This criterion is specific to the pilot test evaluation. Included in **Section 5.5** is the application of the location criteria to the candidate sites.

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	●	○	○	●	○	○	◎	2.5 ●	

Figure 5-1 Sample Location Criteria

A legend for this table follows below.

Legend:

- **Peds** – Number of pedestrians (full circle = high pedestrian activity, partial circle = medium activity, empty circle = low pedestrian activity);
- **Trains** – Train volumes in both directions (full circle = relatively high volumes compared to other candidate sites, empty circle = relatively low volumes);
- **Events** – Estimated probability of second train events (full circle = good probability, empty circle = low probability);
- **Whistle** – Whistle prohibition in effect (full circle = yes, empty circle = no);
- **Visibility** – Pedestrians have limited visibility of one or more train approaches (full circle = both approaches, partial circle = one approach, empty circle = visibility adequate);

- **Speed –** High train speed and/or high speed differentials (full circle = high operating speeds and/or speed differentials, empty circle = low operating speeds);
- **Site –** Physical layout and operations of the site conducive to installing the signs, and can the crossing be viewed with one or two close-circuit television (CCTV) cameras, (full circle = good physical features and operating conditions, empty circle = poor physical layout and/or operating conditions);
- **Total –** The number included in the total column is a sum of the scores attained in each criteria (full circle = 1.0, partial circle = 0.5, empty circle = 0).

Table 5-3 Second Train Warning – Assessment of Candidate Sites

Location	# of Tracks	Number of Trains Per Day	Second Train Events	Pedestrian Activity	Second Train Collision History [1]	Whistle Prohibition	Visibility	Train Operating Speeds	Comments
Tannery Street	2	6 commuter 18 freight	N/A	High	1994	Yes	Fair	60 km/h	Low train volumes
Queen Street	2	6 commuter 18 freight	N/A	Low	No	Yes	Fair	75 km/h	Low train volumes
Brampton GO Station/Mill Street	2	10 commuter 44 freight	3 events per day	High (PP)	1998	Yes	Good	55 km/h	Police patrol crossing from time to time
3^{e} Avenue	4	18 passenger 26 commuter 56 freight	1.0 events per day	High	No	Yes	Fair	90-105 km/h (fr) 100-150 km/h (pass)	Two pairs of two tracks with refuge in between
Woodland Avenue	4	18 passenger 26 commuter 56 freight	0.75 events per day	Medium	No	Yes	Good	90-105 km/h (fr) 100-150 km/h (pass)	Two pairs of two tracks with refuge in between
Wilderton Avenue	2	10 passenger 20 freight	N/A	High	No	Yes	Good	50 km/h (fr) 80 km/h (pass)	
O'Brien Avenue	2	54 commuter 2 freight	1-3 events per day	Medium	No	Yes	Good	100 km/h (fr) 65 km/h (pass)	Low pedestrian volumes mid-day
Westminster Avenue	2	36 commuter	N/A	High	No	Yes	Fair	25 km/h	Police patrolling crossing. "Busy" environment

Table 5-3 Second Train Warning – Assessment of Candidate Sites

Location	# of Tracks	Number of Trains Per Day	Second Train Events	Pedestrian Activity	Second Train Collision History [1]	Whistle Prohibition	Visibility	Train Operating Speeds	Comments
Baie d'Urfé Station	4	18 passenger 26 commuter 56 freight	1.09 events per day	Medium (PP)	Yes	Yes	Good	90-105 km/h (fr) 100-150 km/h (pass)	Two pairs of two tracks with refuge in between Low ped. volumes mid-day

Notes:
(1) Second train collision history involving pedestrians.
fr = freight train   pass = passenger train   ped. = pedestrian   PP = AM and PM commuter peaks

5.4.1 Tannery Street, Mississauga, Ontario

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	●	○	○	●	○	○	◎	2.5 ●	Not Considered

The Tannery Street at-grade intersection represents a high pedestrian crossing of the Galt Subdivision in the centre of Streetsville (Mississauga). The pedestrian activity results from interactions between the retail uses on the east side of the line with the residential and educational (secondary school) uses on the west side.

GO Transit operates five eastbound trains in the morning and five westbound trains in the afternoon to accommodate travel to employment areas in Toronto. Second train events at this location result from simultaneous freight train arrivals or GO Transit/freight second train events. The relatively low number of trains reduces the probability of second train events and thus this location was not considered an acceptable site for pilot project purposes.

5.4.2 Queen Street, Mississauga, Ontario

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	◎	○	○	●	●	○	○	2.5 ●	Not Considered

The Queen Street crossing of the CP mainline is located along a curved section of the Galt Subdivision east of the Streetsville GO Station. The adjacent land uses do not include significant pedestrian generators and therefore, the pedestrian activity at this location is moderate to low. GO train operations are identical to the Tannery Street crossing. For the same reason noted at the Tannery Street crossing, this site was not carried forward as an acceptable test site for the STW system.

5.4.3 Brampton GO Station/Mill Street, Brampton, Ontario

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	●	●	◎	●	◎	○	◎	4.5 ●	Possible Location

The Mill Street crossing of the Halton Subdivision is located immediately west of the Brampton GO Station. The crossing accommodates heavy pedestrian volumes during the morning and afternoon peak periods and moderate volumes throughout the day.

GO Transit operates four eastbound trains in the morning and four westbound trains in the afternoon to accommodate travel to employment areas in Toronto. Second train events at this location result from a freight train travelling through the area while a GO train is stopped in the Brampton station. Approximately 44 freight trains travel along this section of the Halton Subdivision each weekday. Railway enforcement personnel patrol this crossing on a regular basis in an attempt to prevent pedestrians from entering the track area during the activation of the warning system.

Recognizing the relatively low train volumes, and the existing enforcement activities, it is anticipated that the pilot test study duration would be lengthy to ensure a suitable number of “untainted” observations, i.e., without the presence of enforcement activities.

5.4.4 3^{e} Avenue, Île Perrot, Quebec

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	●	●	○	●	◉	●	○	4.5 ●	Possible Location

The 3^{e} Avenue crossing of the Vaudreuil (CP) and Kingston (CN) subdivisions is located just south of Highway 20. The roadway crosses two sets of two tracks. The CN and CP tracks are separated by approximately 15 m. The configuration and separation distance of the two sets of tracks has the potential to complicate the placement and visibility of the second train warning signs.

For example, pedestrians are able to traverse the first set of two tracks and wait between the two pairs of tracks for a train to pass on the far set of tracks. This situation would require that an STW sign be provided at intermediate locations or that the signs be placed on the far side of the tracks. The former would potentially add an additional two to four STW signs for complete coverage of the crossing. The latter would require a high mounting height that would not be in the normal field of vision for a pedestrian.

During site investigations undertaken mid-day, the pedestrian traffic generation from the surrounding residential and retail was steady. Passenger and freight train volumes along these lines are relatively heavy and train speeds and speed differentials are significant.

This site was considered a possible pilot test location; however, it was not recommended given the projected sign placement issues and additional equipment costs required for the pilot, i.e., additional monitoring equipment would be required to view all potential pedestrian waiting areas.

5.4.5 Woodland Avenue, Beaconsfield, Quebec

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	◉	●	○	●	○	●	○	3.5 ●	Not Considered

The Woodland Avenue crossing has a similar track configuration as the 3^{e} Avenue crossing, i.e., two CN and two CP tracks with a considerable separation distance. The crossing is located immediately adjacent to the Beaurepaire station on the AMT commuter line.

Pedestrian traffic at this crossing is generally coincident with the commuter rail operations in the morning and afternoon peak periods. Pedestrian activity mid-day is low.

This site was considered a possible pilot test location; however, it was not recommended given the projected sign placement issues and additional equipment costs required for the pilot, as noted in the review of the 3^e Avenue site in **Section 5.4.4**.

5.4.6 Baie d'Urfé Station, Baie d'Urfé, Quebec

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	◎	●	○	●	○	●	◎	4.0 ●	Possible Location

This crossing is located along the Vaudreuil and Kingston subdivisions between the 3^e Avenue and Woodland Avenue sites. The four-track configuration found at the adjacent sites is present at this crossing.

This pedestrian-only crossing is located immediately adjacent to the Baie d'Urfé commuter rail station on the AMT system. Pedestrian traffic at this location is generally associated with the morning and afternoon station activities as adjacent land uses are not significant pedestrian generators.

This site was considered to be a possible pilot test location; however, it was not recommended given the projected sign placement issues and additional equipment costs required for the pilot, as noted in the review of the 3^e Avenue site in **Section 5.4.4**.

5.4.7 Wilderton Avenue, Montreal, Quebec

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	●	○	○	●	◎	◎	◎	3.5 ●	Not Considered

The Wilderton Avenue crossing of the Adirondack subdivision is the only at-grade crossing present in the general area. Train traffic is relatively low, with 10 commuter trains and approximately 20 freight trains/switching movements.

Pedestrian generators include the residential/retail use in the vicinity of the site and the Canora Station located on the Deux-Montagnes commuter line west of the crossing. Pedestrian activity is moderate during the mid-day.

This site was not considered a candidate test site, given the train frequency and the low probability of second train events.

5.4.8 O'Brien Avenue, Ville Saint-Laurent, Quebec

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	◎	●	◎	●	◎	●	●	5.5 ●	Preferred Location

The O'Brien Avenue crossing of the Deux-Montagnes subdivision accommodates approximately 54 commuter and two freight trains per day. Based on a review of the AMT commuter rail schedule it is estimated that up to three second train events could occur at the O'Brien Avenue crossing during the morning and afternoon peak periods. Operating speeds for trains range from 100 km/h for passenger trains to 65 km/h for freight trains.

Pedestrian activities at the site during the mid-day field investigations were moderate. Based on information provided by Transport Canada, it is estimated that approximately 250 pedestrians use this crossing on a daily basis. Based on an eight-hour pedestrian and train event count undertaken in August 2001, over 400 pedestrians were observed at the crossing. In addition, four violations of the railway warning device were observed.

5.4.9 Westminster Avenue/Elmhurst Street, Montreal, Quebec

Criteria	Peds	Trains	Events	Whistle	Visibility	Speed	Site	Total	Comments
Score	●	○	⭘	●	●	○	○	3.5 ●	Not Considered

The Westminster Avenue and Elmhurst Street crossings of the Vaudreuil and Westmount Subdivisions are in a high pedestrian area and directly adjacent to the Montreal West commuter rail station. The rail lines accommodate approximately 36 trains per day, 10 of which do not stop at the station. Based on a review of the AMT commuter rail schedule, it is estimated that a maximum of three second-train events could occur as a result of closely scheduled trains at the Montreal West station (within three minutes of one another). There are two major drawbacks of the two sites. First, the operating speeds in the vicinity of the station are typically less than 25 km/h and as a result the potential risk at the site is relatively low compared to the other test sites. Second, railway enforcement personnel patrol the crossings on a regular basis to ensure that pedestrians do not enter the track area during the warning system activation period. Therefore, it was concluded that the combination of these two characteristics might impact study results and the data collection period.

5.5 APPLICATION OF LOCATION CRITERIA

As noted in **Section 5.4**, the qualitative assessment of the candidate sites included criteria for the site suitability for pilot test purposes, which would not be included in the final location criteria used to assess the second train risk potential at multiple track locations throughout Canada. In addition, the preliminary qualitative ranking outlined in **Section 4.3.1** was applied to the candidate sites as verification to the above analysis. Included in **Table 5-4** is a summary of the application of the qualitative location criteria.

Based on the assessment shown in **Table 5.4**, it is apparent that the O'Brien Avenue crossing of the Deux-Montagnes line appears to represent the "highest risk" site, in terms of second train events, identified by the PSC.

Table 5-4 Application of Qualitative Location Criteria								
Location	**Pedestrian**	**Train**	**Collision**	**Whistle**	**Visibility**	**Speed**	**Warning**	**Total**
Weight →	**0.25**	**0.20**	**0.15**	**0.05**	**0.10**	**0.15**	**0.10**	**1.00**
Tannery Street	5	1	1	5	1	1	3	2.4
Queen Street	1	1	1	5	5	1	1	1.6
Brampton GO Station/ Mill Street	5	1	3	5	3	1	1	2.7
3^{e} Avenue	3	2	1	5	3	5	3	2.9
Woodland Avenue	3	2	1	5	1	5	1	2.5
Baie d'Urfé Station	3	2	1	5	1	5	1	2.5
Wilderton Avenue	5	1	3	5	3	3	1	2.7
O'Brien Avenue	3	1	3	5	3	5	3	**3**
Westminster Avenue	3	1	3	5	5	1	1	2.4

5.6 SUMMARY

Based on the review of the data collected, the site observations and input provided by the PSC members, it was recommended that the O'Brien Avenue crossing be carried forward as the preferred pilot test site.

6. FUNCTIONAL SPECIFICATION

6.1 EVALUATION CRITERIA

Based on a review of the existing STW literature and through input from the PSC members, a number of criteria were established to identify a suitable STW system. The primary criteria are as follows:

- Potential for reduction in risky behaviour;
- Availability of system components;
- Reliability;
- Installation cost;
- Maintenance/operating costs; and
- Fail-safe provisions.

The evaluation of STW systems confirmed that there were no complete, commercially available STW systems available. The systems deployed at Timonium Station (Baltimore) and at the Vernon Avenue Crossing (Los Angeles) were custom applications developed jointly by the client and the supplier. Therefore, for the Transport Canada project it was decided to first develop general specifications for the STW system. The second step would be to contact suppliers of the system components to determine whether commercially available components could fulfil the specification requirements.

Through the review of the evaluation criteria for STW systems, two types of signs were identified as viable alternatives:

- Type 1 – limited state, pre-programmed light-emitting diode (LED) sign; and
- Type 2 – static sign warning with alternating flashing beacons.

Section 6.2 provides general functional specification requirements for both systems, followed by the specific functional requirements for each type of STW sign (**Sections 6.3** and **6.4**).

6.2 GENERAL

6.2.1 Activation

The railway authority will provide all train detection circuitry, including signals indicating the detection of the arrival of any train into the RRI "detection zone", and the clearance of this train from the RRI "detection zone". The Second Train Warning System shall include the following features:

- A logic circuit that will activate the STW Sign only upon the receipt of a specific combination of detection signals (interpreted as a command) from the railway detection circuits;
- The logic circuit will only provide an activation signal for the STW Sign if the rail detection circuitry detects a train entering the RRI "detection zone" AND a second train entering the same RRI "detection zone" (regardless of the number of tracks) prior to the clearance of the first train from the RRI "detection zone"; and
- The logic circuit will maintain an activation signal for the STW Sign until both trains clear the RRI "detection zone."

6.2.2 Sign Location and Number

The Timonium Station signs are targeted at motorists, and are therefore mounted on the near side of the tracks, over the roadway. The Vernon Avenue crossing signs are targeted at pedestrians and are located between the tracks, on the side of the pedestrian crossing with the higher pedestrian volumes.

The STW system for this project is targeted solely for pedestrians. It was therefore determined that signs should be located immediately adjacent to the pedestrian crossings. To address liability issues and provide the best possible coverage/result, it was concluded that the signs should be directly visible at all legal pedestrian crossing points.

A key issue is the placement of the sign face relative to the pedestrian crossing. There are two options. The first option is a “far side” placement, whereby a pedestrian would look to the far side of the crossing to view the display. This option is analogous to the placement of pedestrian signal heads at signalized intersections. The advantage of this option is that the STW display would be within the cone of vision of pedestrians even if they were standing right at the train warning system device. The disadvantage is that the display would be blocked from view if a train were present in the crossing.

The second option is a “near side” placement, whereby a pedestrian would look to the near side of the crossing to view the display. This option is analogous to the placement of the train warning system devices. The advantage of this option is that the STW system would always be visible to the pedestrians. The disadvantage is that the display may be outside of the cone of vision of pedestrians if they are standing immediately below the STW display.

After considering the factors, it was concluded that the sign displays should be located on the near side of each potential authorized sidewalk crossing of the RRI (**Figure 6-1**). The signs will be mounted such that the face of the sign and its message/beacons are readily visible to pedestrians approaching the RRI and at their most probable waiting area location.

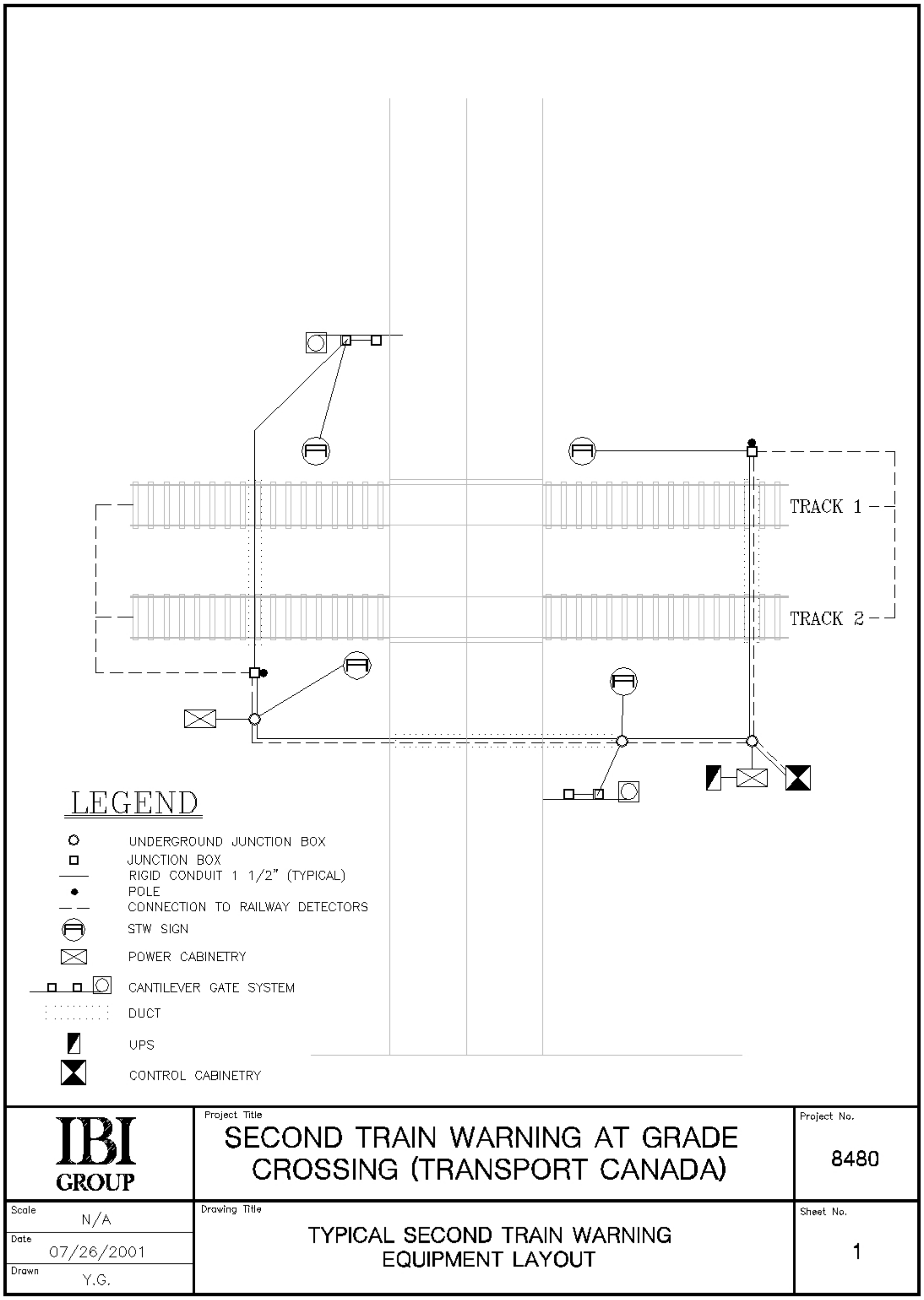


Figure 6-1 General Configuration of STW System Signs

6.2.3 Auxiliary Lights and Sounds

Based on discussions with the PSC, it was decided that auxiliary sound and lighting would not be required for the second train warning system, as described below:

- **Auxiliary sound** was previously incorporated in STW systems in England and was considered in the evaluation criteria. STW warning systems are no longer used in England as the existing warning systems were considered to provide sufficient warning of one or more trains at/approaching the crossing. It was suggested that an auxiliary sound device would need to displace the ambient noise levels emitted by the warning system bells and the passing/approaching train. In addition, a potential issue was identified with the use of an auxiliary sound at an RRI: an audible signal at a traffic signal indicates that the pedestrian has the right-of-way, not a warning of a potential hazard.
- **Auxiliary Lighting** such as a strobe light, has been used for one STW system installation to increase the conspicuousness of the sign. The primary reason for this supplemental device was that the location of the sign was offset from the direct path of the pedestrians travelling on the less frequently used sidewalk. It was determined that the number and location of signs would be such that each authorized pedestrian crossing would be provided with a sign in the pedestrian's field of view. Accordingly, auxiliary lighting was not considered necessary.

6.2.4 Bilingualism

Depending on the installation location, all text must messages would be provided in one of Canada's two official languages. Based on discussions with the PSC, it was determined that "Attention!" and "2 Trains" would qualify as bilingual statements. In addition, the Type 2 sign required a "When Flashing" tab. In Quebec the sign would include a "Quand Les Feux Clignotent" supplementary tab. All other components of the signs would be graphic in nature.

6.2.5 Fail-Safe Requirements

It is proposed that the STW system use the same power supply as is used by the train warning system. Second, in general, the fail-safe requirements provided by the train warning system should also apply to the STW system. Consequently, the STW system will remain deactivated until the train warning equipment provides a second train event notification.

In the event that the sign or its activation circuitry fail, the railway warning equipment will continue to provide appropriate warning for pedestrians and other road users. The STW system will automatically re-boot/restart following communications failures.

6.3 TYPE 1 – LED SIGNS

The following functional specifications are an aggregation of information collected through the identification of STW systems phase, input from the PSC, discussions with suppliers/manufacturers, a review of the *Manual of Uniform Traffic Control Devices* (Transportation Association of Canada, 1998) and field measurements relating to sign visibility.

6.3.1 Sign Content During Second Train Events

During activation, the LED sign will flash alternately between an image of two trains and letters that say "ATTENTION!", "2 TRAINS", as illustrated in **Figures 6-2** and **6-3**.

IBI GROUP	Project Title: SECOND TRAIN WARNING AT GRADE CROSSING (TRANSPORT CANADA)	Project No.: 8480
Scale: N/A Date: 07/26/2001 Drawn: Y.G.	Drawing Title: TYPE 1 STW SIGN - DISPLAY A	Sheet No.: 2

Figure 6-2 Type 1 Sign – Sign Content (Text)

IBI GROUP	Project Title SECOND TRAIN WARNING AT GRADE CROSSING (TRANSPORT CANADA)	Project No. 8480
Scale N/A Date 07/26/2001 Drawn Y.G.	Drawing Title TYPE 2 STW SIGN - DISPLAY B	Sheet No. 3

Figure 6-3 Type 1 Sign – Sign Content (Trains)

6.3.2 Sign Content During "Non-Second Train" Periods

Consideration was given to providing railway safety related messages on the LED display during "non-second train" periods. Messages could include such text as "Look both ways for trains", " Train Approaching" or "Cross with Care".

It is recommended that the LED sign be "dark" during times when a second train event is not taking place. This operation would provide pedestrians and other road users with a definitive message, as the active nature of the sign in itself will indicate that a second train event is occurring. Consequently, pedestrians will not be required to view the sign and decipher its message prior to making a decision regarding the level of safety at the crossing, since an active sign will only signify a second train event.

6.3.3 Sign Mounting and Location

The sign will be mounted at a height of approximately 2.5 m above the adjacent pedestrian travel surface and such that:

- The sign will be clearly legible from 30.5 m (100 ft.) to the most probable/designated pedestrian waiting areas; and
- The cone of vision will be 70º horizontal and 40º vertical.

6.3.4 Selection of Sign Dimensions

Based on the sign content and mounting locations/heights outlined in **Sections 6.2.1** to **6.3.3**, the sign characteristics were determined as follows:

- The sign face will be 76.2 cm (30 in.) wide and 38.1 cm (15 in.) high.
- High intensity amber LED technology with discrete character matrices of five by seven pixels with a letter size of 8.26 cm (3.25 in.) will be used. Light from the pixels will overflow so that there is no gap between pixels to the viewer.
- The sign will provide a full matrix display (32 x 64 pixels) with one LED per pixel.
- There will be a pixel size of 0.635 cm (0.25 in.) with a pitch of 1.21 cm (0.475 in.).
- The sign will incorporate a photo sensor system to provide automatic control of the display luminance as a function of the ambient illumination level, and the luminance will have a minimum of 15 levels to provide smooth transition between levels.

An illustration of the recommended mounting height is included in **Figure 6-4.**

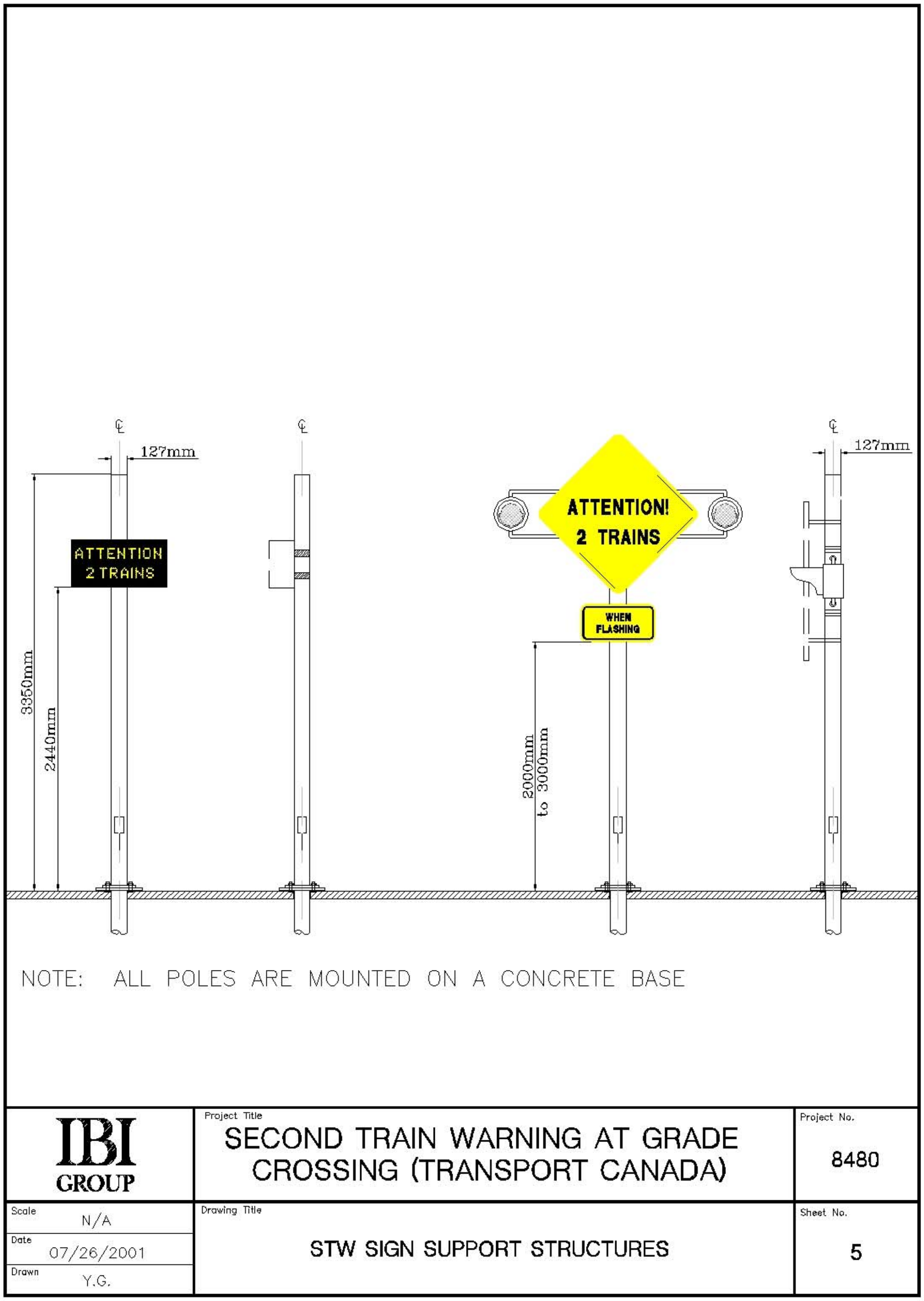


Figure 6-4 Sign Mounting Location

6.3.5 Manufacturing Costs

The cost of the Type 1 STW system sign is approximately $5,000 per sign. These preliminary costs were used to determine the preferred sign type for the pilot test site and for the ultimate deployment plan.

6.4 TYPE 2 - STATIC SIGN WITH FLASHING BEACONS

The following functional specifications are an aggregation of information collected through the identification of STW systems phase, discussions with vendors/manufacturers and a review of the *Manual of Uniform Traffic Control Devices.*

6.4.1 Sign Content and Activation

The static sign shall display the message "ATTENTION!", "2 TRAINS" with an information tab indicating either "Aux Feux Jaune" for applications in Quebec, or "When Flashing" for applications outside of Quebec, as illustrated in **Figure 6-5**. It should be noted that during the study process the French version of the supplementary tab was revised to "Quand les Feux Clignotent" to reflect standard Quebec sign content terminology (see **Section 17.4**).

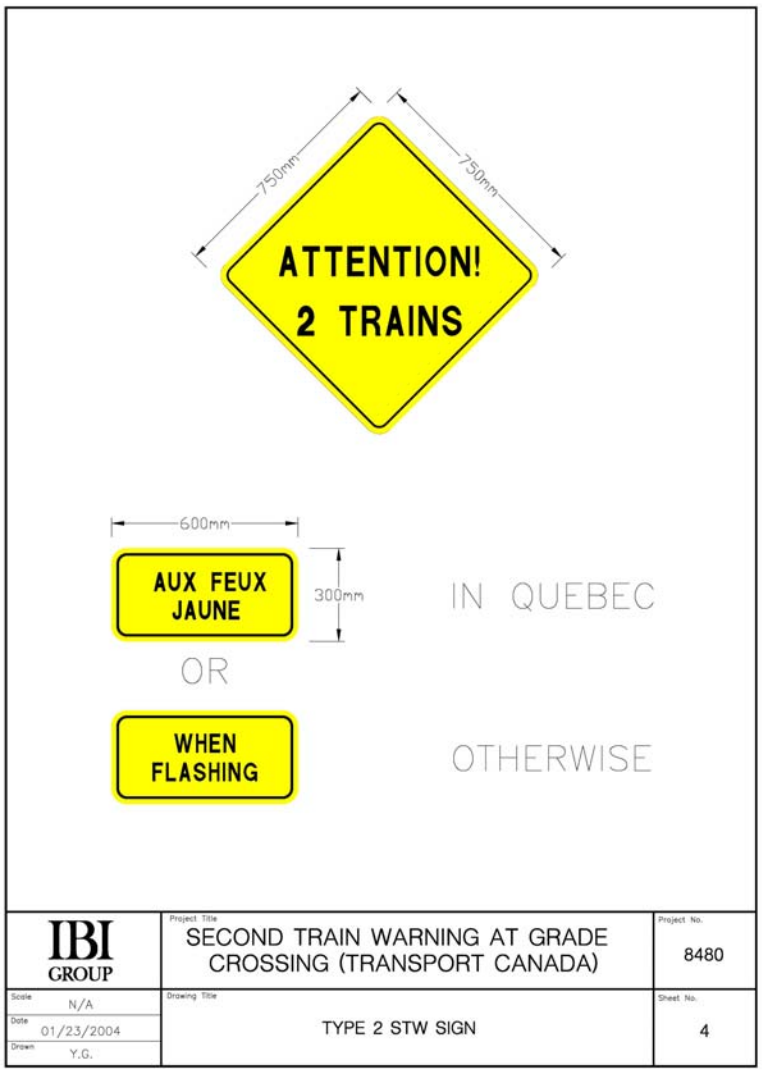


Figure 6-5 Type 2 Sign – Sign Content

The flasher units shall remain non-activated, except when activated by a second train event (i.e., the default setting is unenergized).

6.4.2 Sign Mounting and Location

The sign will be mounted at a height of approximately 2.0 to 3.0 m (6.5 to 10 ft.) above the adjacent pedestrian travel surface and such that:

- The sign will be clearly legible from 30.5 m (100 ft.) to the most probable/designated pedestrian waiting areas; and
- The cone of vision will be 70º horizontal and 40º vertical.

An illustration of the recommended mounting height is included in **Figure 6-4**.

6.4.3 Selection of Sign Dimensions and Beacons

To accommodate the sign content outlined in **Section 6.4.1**, the sign dimensions shall be 750 mm (30 in.) square for the main sign and 600 mm (24 in.) x 300 mm (12 in.) for the supplemental tab, with all character heights consistent with the *Metric Edition Standard Alphabets for Highway Signs and Pavement Markings* (U.S. Department of Transportation) and as per the Transportation Association of Canada (TAC) guidelines for warning signs.

The flashing beacons will be 200 mm (8 in.) in diameter and will be mounted as depicted in **Figure 6-4**. The flashers shall alternate with a frequency of 50 to 60 flashes per minute, as per the TAC guidelines for warning signs.

6.4.4 Manufacturing Costs

The cost of the Type 2 Warning System sign including the flashing beacons is approximately $390 per unit. This preliminary sign cost estimate was used, in part, in the decision to recommend the sign type to be used for the pilot test installation. The actual cost of the static signs and their installation for the pilot test site are included in **Section 14.5**.

7. RISK-MITIGATION COST-BENEFIT MODEL

7.1 COST-BENEFIT MODEL

The valuation of the overall benefits and costs is a critical factor in determining the net effectiveness of the implementation of STW systems. A detailed assessment of the risk reductions attributable to STW systems must be performed, thereby providing an estimate of their effectiveness. Using these results in conjunction with an analysis of the societal benefits and costs will lead to the establishment of a benefit/cost ratio for the effect of STW countermeasures for a range of study parameters. These indicators will provide key information in the decision-making process regarding the viability of STW systems as a cost-effective countermeasure for reducing second train collisions.

Usually, in developing a cost-benefit model both direct and indirect benefits and costs need to be identified and measured (quantitatively) in monetary terms. The costs and benefits of primary focus are the "societal" cost or benefit. **Table 7-1** includes a summary of the benefits and costs associated with the STW system countermeasure.

It should be recognized that a number of the costs and benefits attributable to the STW system installation are dependent on the STW system design and RRI operations at a particular site. Where possible, the costs and benefits independent of the design and project site have been quantified. A worked cost-benefit example has been included in **Section 7.7** to demonstrate the quantification of the site-specific benefits and costs.

Table 7-1 Benefits and Costs Associated with STW System Implementation

Benefits	Costs
• Reduction in second train collisions • Fewer fatalities • Reduced burden on emergency services • Reduced burden on health care system • Avoidance train/schedule delays • Increased profits to rail/train operators • Reduced litigation/insurance claims	• Capital costs • Operating costs • Maintenance costs • Administrative costs

7.1.1 Benefits

A societal benefit can be defined as a positive impact or outcome for society resulting from a certain activity or occurrence, which can be direct or indirect. Direct benefits are those that can be measured and attributed directly to the activity or occurrence. Indirect benefits cannot usually be quantified precisely nor attributed directly to the activity or occurrence, but are associated with the activity or occurrence.

The most critical direct benefit to be measured due to the implementation of STW systems is the expected reduction in second train collisions and the associated societal savings (e.g., resources that are not expended for healthcare, police/emergency services, train delays, insurance claims, litigation, etc.). The benefit of collision reduction is the avoidance of these societal costs. In essence, the avoidance of a second train collision results in the resources that would have been consumed being available elsewhere for the benefit of society.

7.1.2 Costs

A cost can be defined as an expenditure (e.g., resource, money) put out to obtain something required or needed. The costs of road/railway safety countermeasures (i.e., STW systems) are usually classified as direct or indirect. Direct costs can be measured and attributed directly to the activity or occurrence. Indirect costs cannot usually be quantified precisely nor attributed directly to the activity or occurrence, but are associated with the activity or occurrence and allocated using some type of qualitative basis.

Direct costs for STW systems include capital costs as well as ongoing maintenance, operating and administrative costs. These will constitute the major costs to be accounted for in a Cost-Benefit Model.

7.2 PURPOSE OF THE EVALUATION MODEL

The main purpose of the evaluation is to assess the net benefit of the STW system with respect to its performance in making improvements to the level of safety for pedestrians at RRIs where second train events occur. Risk analysis methods are implemented to compute performance measure indicators that provide the "knowledge" required for assessing the performance of the newly introduced STW system. That is, for second train incident occurrences:

- Are safety benefits being realized due to the implementation of the STW system?
- How effective is the STW system for improving safety, and if so to what extent?
- Have the risks for pedestrians at RRIs where second train events occur been reduced?

In order to answer these questions, the evaluation model will attempt to address the following four tasks:

1) Measurement of the effectiveness of the STW system with respect to its capacity to reduce pedestrian collisions at RRIs (**Sections 7.4** and **7.5**).
2) Estimation of the potential reductions of second train collisions that can be expected due to the implementation of the STW system (**Section 7.3**).
3) Estimation of the societal savings and costs of STW implementation (**Section 7.6**).
4) Estimation of the net benefits (benefit-cost ratio analysis) that can be expected due to the implementation of STW systems (**Section 7.7**).

7.3 SECOND TRAIN VIOLATIONS AND COLLISIONS

Ideally, an evaluation of the effectiveness of STW systems would involve a direct measurement of the reduction of second train collisions attributable to the STW systems; however, second train collisions are very rare events. In Canada, only 11 pedestrian fatalities over the period 1988-1998 resulted from collisions involving a second train. As a result, it is not possible to assess the effectiveness of STW systems based on collision data since it would take years to collect sufficient data in order to conduct a safety analysis. Therefore a surrogate measure is required. The surrogate criterion that will be used to measure the effectiveness of STW systems will be second train incidents.

7.4 RISK-MITIGATION STATISTICAL MODEL EVALUATION

In recent years, researchers have taken a more proactive approach to determining the safety of an entity, be it a driver, vehicle, road or railway location. Newer and improved methods are evolving that provide the capacity to measure the "true" effectiveness of treatments/countermeasures, as well as the capacity to identity high-risk "deviant" entities that may require remedial treatment(s).

Alternative methods to consider include:

- Comparison Group Method (C-G Method);
- Empirical Bayes (EB) Method; and
- Risk Analysis Method.

Sections 7.4.1 through 7.4.3 include a brief summary of these models. **Section 7.4.4** includes an outline of the rationale for choosing the preferred risk-mitigation model.

7.4.1 C-G Method

The Observational Before-After Comparison Group (C-G) Method is based on the following:

A group of entities are identified that are similar in traits and characteristics to the treated entities. This group is known as the comparison group and these entities remain untreated. The treated entities form the "treatment" group. The hope is that the system-wide or global changes in safety that occur from the "before" to the "after" periods for the comparison group is what the changes in safety would have been for the treatment group, had treatment not been applied to the treated group. In this manner, the net observed change in safety within the treatment group is revealed.

Although the C-G method has helped to improve our ability to estimate the effectiveness of treatments more accurately, it has limitations. It assumes that the numerous factors that affect safety have changed from the "before" to the "after" period in the same manner on both the treatment and the comparison group. Furthermore, it assumes that these changes in factors (unaccounted for) influence the safety of the treatment and comparison groups in the same way. Another restriction on the C-G method is the limitation of its applicability. The C-G method is useful for measuring the effectiveness of some treatment/countermeasure, but is not useful for identifying "deviant" or "high-risk" entities. To address these issues two other methods have evolved over the past few years, namely the Risk Analysis Method (Stewart, 1998) and the Empirical Bayes Method (Hauer, 1997).

7.4.2 Empirical Bayes (EB) Method

The idea behind the EB Method is that it uses two pieces of information that contain clues to the safety of an entity, namely,

- The collision history of the entity, and
- The collision history of other entities with similar traits and characteristics.

The EB method accounts for the regression-to-the-mean bias. This is a phenomenon whereby the collision counts for a particular entity will (over the longer term) regress to the average for entities with similar traits and characteristics. Also, the EB estimates are more precise than those produced by other traditional estimation methods.

The pivotal concept behind the EB approach is the availability of a large reference population similar in traits and characteristics to the entity of interest. This reference population is necessary for measuring “what the expected safety of the entity of interest is”. This is done mathematically by combining the collision history of the entity and the collision history/expected level of safety of the reference population entities.

7.4.3 The Risk Analysis Method

The concept behind the Risk Analysis Method is the combination of exposure (to risk) and consequence (fatality, injury, collision, violation) databases to compute road use risk performance measure indicators. These risk performance indicators can be compared in various ways, i.e., by computing relative risk ratios and relative risk odds-ratios. They can be used to measure the effectiveness of treatments in reducing road use risks as well as to identify deviant entities (e.g., road locations, road user groups, vehicle types, etc.).

Either the EB method or the Risk Analysis Method will permit a jurisdiction to objectively evaluate the effectiveness of treatments, and to identify which locations are most deviant (and requiring remedial measures). Then, through a process known as *network screening* the locations can be prioritized with respect to which locations deserve immediate attention.

7.4.4 Preferred Model and Structure for Evaluating STW Implementation

The scope of the study design does not include monitoring conditions at both a treated site and a series of similar untreated comparison sites. The purpose of including untreated comparison sites is to provide a measure of the global changes in safety that occurred from the “before” to the “after” periods of STW implementation. They effectively measure what the changes in safety would have been for the treatment (STW) group, had treatment not been applied to the treated group of RRIs. ***This limitation eliminates the C-G Method for evaluating the effectiveness of the STW systems.***

The EB Method requires large amounts of data for many locations in order to estimate what the expected number of consequences (fatalities, injuries, collisions, violations) would be if STW systems were not implemented. To put this in perspective, data is required from at least 60 RRIs over a minimum of a five-year period prior to implementing a STW system. This data is required to develop estimates of what the expected number of consequences would be if the STW systems were not implemented. ***Therefore, it is not possible to apply the EB Method for evaluating the effectiveness of the STW systems***.

The application of the Risk Analysis Method is recommended for evaluating the STW systems. Given the study design (i.e., no comparison sites being used as a means for measuring the relative changes in safety at the STW sites “before” and “after” STW system implementation) it is possible to estimate Relative Risk Performance Measure Indicators (RRs) to determine the changes in safety at railway grade crossings “before” and “after” the STW system implementation. The methodology and structure for estimating RRs is given in **Section 7.5**.

7.5 RISK ANALYSIS METHODS APPLIED TO SECOND TRAIN WARNING SYSTEMS

7.5.1 Basic Structure Behind the Road Use “Relative Risk” Performance Measure Indicator – RR^P

The concept behind the “road travel relative risk” estimator seeks to compare the risks of incident involvement for two (groups of) entities represented on the surface transportation systems. The key to the concept is in the term “relative”. In essence, a road use “basic risk” estimator is computed for each of the two (groups of) entities. Then, these two road use basic risk performance measure indicators are compared through the computation of a relative risk ratio (i.e., the division of the one basic risk estimator by the other). The resultant road use relative risk performance measure indicator is a measure of any differential in road use risk level(s) (i.e., level of safety) existing between the two (groups of) entities.

The following example will serve as an illustration. An equal number of drivers travel an equal distance along two different roads to reach the same destination. The first road is straight and flat, with ample lane and shoulder widths, clear roadsides and adequate traffic controls. The second is narrow and winding, with unprotected, sheer drop-offs and rock faces immediately beyond a narrow shoulder. There is risk associated with driving either road – risk is an inherent aspect of mobility. However, intuitively we know – and can measure – that driving the narrow, winding road is considerably riskier, all other things being equal. By dividing the "basic risk estimator" of one road by that of the other, we can determine the *relative risk* of travelling on one route as opposed to the other.

Appendix D includes a summary of the rationale behind the "Relative Risk" performance measure indicator. For a detailed explanation of the concept of this methodology, refer to Stewart (1998).

7.5.2 Estimation of RRP

The mathematical formulation for detecting any *road travel risk differential* existing between the two entity target groups, say "target group 1" – TG_1 , and "target group 2" – TG_2 , is given by equation (1).

$$RR^{P}(I|TG_{1:2}) = \frac{p(I|TG_1)}{p(E|TG_1)} \div \frac{p(I|TG_2)}{p(E|TG_2)} \qquad (1)$$

where,

$RR^{P}(I|TG_{1:2})$ is the ***proportional*** **road use *relative risk* performance measure estimator** of the **<u>differential in road use risk existing between entity groups TG_1 and TG_2</u>**

$p(I|TG_1)$ is the proportion of incidents (fatalities, injuries, collisions, violations) for target group 1,

$p(I|TG_2)$ is the proportion of incidents (fatalities, injuries, collisions, violations) for target group 2,

$p(E|TG_1)$ is the proportion of "exposure (to risk)" for target group 1,

$p(E|TG_2)$ is the proportion of "exposure (to risk)" for target group 2,

Target group 1 refers to the after period (i.e., after STW system implementation period),

Target group 2 refers to the before period (i.e., before STW system implementation period).

For details concerning the accuracy and interpretation of these relative risk performance measure indicators see Stewart (1998).

7.6 COST-BENEFIT MODEL INPUT VARIABLES

As previously indicated, there are a number of input variables required for measuring the effectiveness of STW systems, estimating the societal savings and costs of STW implementation, and estimating the final cost-benefit ratio.

In order to apply the methodology there are a number of parameters that must be inputted to the modelling equations, including: cost of STW system, cost of a collision including the value of a human life, cost of delay to individuals on passenger trains, rail costs associated with delay to freight trains, costs of providing alternative transportation services/compensation to rail passengers, lost revenue by commuter rail operators, emergency services costs, train crew "critical street consultation"/trauma, etc.

7.6.1 Cost of STW Warning System

The costs of implementing an STW system include:

- Capital cost (purchase price) of the STW system, including signs, bases and poles;
- Installation costs, including erection of the STW signs, bases and poles as well as the system components (electronic circuit and power provisions);
- Operating and maintenance costs over the "life" of the system. It is estimated that the system will have a maximum life of 15 years, given limited usage.

These site specific costs will be a function of the location, taking into account the:

- Geometry and configuration of the crossing;
- Local operating conditions, including the number of sidewalks provided/used;
- Number of STW signs required based on sidewalk availability/usage;
- Site-specific nature of the installation and labour costs.

For the above reasons, it is impossible to provide a cost estimate for a "typical" STW system installation. Included in **Section 7.8** is a worked example of the cost-benefit calculation for the proposed pilot test site: O'Brien Avenue, Ville Saint-Laurent, Quebec.

7.6.2 Societal Cost of "The Loss of a Human Life"

There are a number of values that can be used to assign a monetary value to the "loss of a human life", depending on the method used for its estimation (e.g., human capital approach, willingness-to-pay, and variations thereof) or the value adopted by an agency. For the purposes of Phase 1 of this study, the value of $1.5 million was used, which is the societal cost of the loss of a human life used by Transport Canada in the year 2001.

7.6.3 Delay to Passenger Trains

The following three commuter rail operators were surveyed to determine the "cost of delay" to a commuter/passenger train:

1) GO Transit;

2) Montrain – a division of CN; and
3) VIA Rail.

In general, a "typical" cost of a collision for a passenger train could not be provided, as these costs would be a function of the following:

- Time of day and duration of the train-pedestrian collision;
- Involvement of carrier train or not;
- Provision of "critical stress consultation" or "trauma time" for train crew (and availability of alternative train crew to continue on trip);
- Time required for the coroner to arrive and release the train;
- Over the course of the delay, the number of foregone passenger fares and/or the cost of providing alternative transportation to passengers; and/or
- Any "future discounts" or "freebies" that are provided to compensate for train delays.

GO Transit

The costs incurred by GO Transit as a result of a train collision causing the closure of an at-grade intersection are generally related to the loss of revenue. In many cases it is impractical to provide alternative transportation due to:

- The large volume of passengers on a train, which makes it impractical to arrange alternative service;
- The location of a train that has made an emergency stop, which will probably not be conducive to passengers safely leaving the train.

In most cases, GO Transit passengers are on the train until it is released. A "worst case" scenario, in terms of lost revenue/costs, would occur if train service were suspended such that GO Transit would not be able to provide service. Potential GO Transit riders would seek alternative forms of transportation. Depending on the time of the track closure, GO Transit could lose one or two-way fares from their "pay-as-you-go" passengers (representing about 55% of the riders). Monthly pass holders are not reimbursed in these cases.

Montrain

Montrain does not have a cost model developed in Montreal for the commuter train delays caused by a collision at a level crossing. Depending on the time of the collision, one or more commuter trains could be delayed, resulting in incurred costs from the following:

- Loss of revenue for commuters;
- Alternative bus service;
- Railway operations cost;
- Transit agency costs;
- Contract penalties (variable);
- Material damages (variable); and
- Police, ambulance, etc. (variable).

VIA Rail

VIA Rail incurs the following general costs when a train is delayed for short periods of time:

- If delay is less than one hour, then passengers are given free services such as food and drink to compensate for their inconvenience; or
- If delay is greater than one hour, then the passengers are given additional free services and are provided with a voucher for 50% off their next trip. Overtime for train crew is also incurred under this scenario.

If a VIA Rail train is involved, the following additional costs may also be incurred:

- Operator and crew may book “trauma time” and depart the collision site;
- An alternative crew is then required, including overtime and travel to the site; or
- Buses may be required, if the train is damaged and cannot proceed.

VIA Rail representatives indicated that statistics/data on such events are not typically compiled.

7.6.4 Cost of Passenger Time

The “cost of time” for delay passengers is commonly used in toll road assessments and studies relating to the impact of transportation system congestion. This value takes into account lost “revenue potential” due to passenger delay. Typically, a value of ten to fifteen dollars per hour is afforded to an average person’s time, with the former generally being used in delay studies. For this reason, an estimate of ten dollars per hour is being assumed for the cost of an individual’s time.

7.6.5 Delay to Freight Trains

The project team contacted CN and CP representatives to determine whether either of the rail operators has compiled data on the costs associated with a collision at an at-grade crossing. The direct costs incurred by the railway have not been calculated mainly due to the fact that the impact of each collision has on the operating authority is a function of a number of characteristics, including:

- The time and duration of the at-grade crossing; and
- The number of trains being delayed, their overall trip length and the ability of the train to “make-up time” on the remainder of the trip.

CN indicated that, in a business case, the agency does not allow a claim of more than $350/hour/train. It was recognized that this value did not include many of the direct and indirect costs to the railway. Likewise, CP provided a figure of $37/engine/hour.

7.6.6 Emergency Services and Litigation Costs

No documentation of emergency services or litigation costs are readily available for collisions at RRIs. They have not been quantitatively included in the cost-benefit ratio.

7.7 COST-BENEFIT MODEL APPLICATION

7.7.1 Application of Risk Analysis Methodology and Cost-Benefit Analysis Model for Evaluating the Effectiveness of STW Systems

The Risk Analysis methodology can be applied for evaluating the effectiveness of STW systems. In order to apply the methods it is necessary to identify the data requirements.

7.7.2 Data Requirements

Consequence Data – Since collisions are extremely rare the consequence data will be "violations" by pedestrians. The total count of pedestrians violating the rail-grade crossing in both the "before" period (prior to STW implementation) and the "after" period (after STW implementation) are required.

Exposure (to risk) Data – The total count of pedestrians at the railway grade crossing (both violators and non-violators) in both the "before" period and the "after" period are required. This value, minus the violators, yields the non-violators.

7.7.3 Measurement of the Relative Risk Performance Measure Indicator

The above data is input into the risk estimation equations (described in **Section 7.5.2**) in order to compute the relative risk performance measure indicators.

7.7.4 Effectiveness of STW Systems

The effectiveness estimators of the STW system are computed using the relative risk performance measure indicators. This is computed as:

$$\text{EFF (STW)} = (1 - RR^{P}) \times 100\%$$

where,

EFF (STW) is the effectiveness of the STW system in reducing violations; and

RR^{P} is the relative risk performance measure indicator (refer to **Section 7.5.1.**).

7.7.5 Cost-Benefit Analysis

Cost-benefit analyses will be carried out to determine whether the STW system offers a potentially cost-beneficial countermeasure for reducing the risk of a collision between a pedestrian and a second on-coming train.

An assumption will be made that the effectiveness of reducing collisions is directly proportional to the effectiveness of the STW system in reducing violations. In other words, the relationship will be assumed to be linear, that is, an "X" percent reduction in violations translates into an "X" percent reduction in collisions.

Using the EFF (STW) estimates, the number of collisions that can be prevented per year will be estimated. A further assumption will be made that all collisions are expected to be fatal. By combining estimates of the number of collisions avoidable, the societal costs of a "lost human life", and collision cost savings, the total societal savings due to reductions in collisions as a result of STW system implementation are estimated. These estimators are then compared to the costs of STW system installation (i.e., capital, operating and maintenance costs) by computing a benefit/cost ratio. Mathematically,

$$\text{Benefit/Cost Ratio} = \frac{\text{Total societal savings from reduced collisions}}{\text{STW capital costs + STW operating costs + STW maintenance costs}}$$

With the above estimates computed, it may be possible to derive estimates of the expected length of time at which the benefits exceed the costs of STW system installation. This should provide the information necessary for making an informed decision on the overall effectiveness of STW systems as a viable countermeasure for reducing second train collisions.

7.8 A WORKED EXAMPLE

The following calculation is a worked example of the cost-benefit of a second train warning system implementation on a commuter line such as the Deux-Montagnes Subdivision in Quebec. This calculation is provided for illustrative purposes only. For the actual cost-benefit calculation for the pilot test installation, please refer to **Section 14**.

7.8.1 Measurement of the Relative Risk Performance Measure Indicator

The relative risk performance measure indicator (RR^P) would normally be estimated using data collected prior to STW implementation and after STW implementation. The RR^P provides the information necessary for estimating the effectiveness of an STW system in reducing violations at a particular RRI. Since this empirical data is still to be collected at a Canadian test site, for the purposes of this example the RR^P estimator will be based on the findings from two studies completed in the United States:

- "Second Train Coming Warning Sign Demonstration Project" (MMTA and Sabra Wang & Associates, 1999)
- "Second Train Coming Warning Sign Demonstration Project" (Khawani, undated)

The RR^P values for the 0-30 and 31-60 day periods after STW installation in Maryland were 0.44 and 0.00 respectively. Taking the average of these results (0.22), this means that the potential risk that a pedestrian will violate the RRI track area during a second train event without an STW system in place is about five times greater than if an STW system was present. Similarly, the findings from the Los Angeles study revealed that the potential risk of a pedestrian violating the RRI track area on a non-STW RRI was also approximately five times greater than an RRI with an STW system ($RR^P = 0.22$). Since both of these studies (which were conducted in different U.S. states) yielded consistent results, this provides confidence for using an **RR^P estimator of 0.22 in this example**.

7.8.2 Effectiveness of STW Systems

With an estimator of the RR^P derived it is now possible to derive a measure of the effectiveness of the STW systems. It is computed as follows:

$$\begin{aligned} EFF\ (STW) &= (1 - RR^P) \times 100\% \\ &= (1 - 0.22) \times 100\% \\ &= 78\%. \end{aligned}$$

Therefore, the effectiveness of STW systems is estimated to be about 78%, or in other words "it is expected that pedestrian violations at RRIs can be reduced by 78% through the implementation of STW systems".

7.8.3 Cost-Benefit Analysis

It is now possible to determine whether STW systems offer a potentially cost-beneficial countermeasure for reducing the risk of a collision between a pedestrian and a second on-coming train.

Assumption: It is assumed that the effectiveness of STW systems in reducing violations is directly proportional to their effectiveness in reducing collisions. That is, a 78% reduction in violations will translate into a 78% reduction in collisions – the relationship between violation and collision reduction is assumed to be linear.

a) <u>Estimator of Second Train Collisions Avoidable</u>

Using the EFF(STW) estimator of 78%, an estimator of the "expected number of second train collision pedestrian fatalities that can be avoided per RRI per year" (CA/RRI/year) can be derived.

Only fatality reductions are being considered in this example since it is expected that most, if not all, collisions will result in death to the pedestrian. Also, since the societal costs assigned to a fatality ($1.5 million) are about 130 times larger than that of an injury ($11,800), the omission of injury incidents from the analysis is not expected to have a significant effect on the final results.

As indicated in **Section 7.3** of this report there have been 11 recorded pedestrian fatalities in Canada over the eleven year period 1988-1998 resulting from collisions involving a second train. There are about 255 RRIs in Canada where a second train collision could potentially occur. This means that there have been:

11/ 255 = 0.043 fatalities per RRI over a 11 year period, or

0.043 / 11 = **0.004 fatalities per RRI per year.**

Since the EFF(STW) estimator is 78%, that means that the number of pedestrian-train collisions that can be prevented per RRI per year (CA/RRI/year) due to STW system implementation is given by:

CA/RRI/year = 0.78 * 0.004
= **0.003 collisions per RRI per year**.

b) <u>Societal Cost Savings</u>

Using a value of $1.5 million for the societal cost of a human life, this results in a Societal Cost Savings (SCS) of:

SCS = 0.003 * $1,500,000
= **$4,500 per RRI per year**.

c) <u>Collision Cost Savings</u>

There are a number of factors to consider in the direct costs of a pedestrian-train collision. In the absence of a "general" cost of collision data, it was determined that the following would be used as an example of a collision at the O'Brien Avenue crossing:

- A collision impacting the movement and schedule of 10,000 commuters (equivalent to 10 commuter trains;
- Assume that passengers/potential passengers are delayed for one hour. This hour represents the extra time required for individuals to find an alternative means of transportation or the extra time required for the commuter rail provider to arrange alternative transportation ($10/hour * 10,000 = $100,000);
- The costs incurred by the commuter rail as a result of losing paying passengers or provision of buses to accommodate remaining passengers. Assume $10 per passenger to provide alternative bus service or "lost wages". ($100,000)
- Emergency services (variable);
- Cost of crew "trauma" and alternative crew provisions (variable); and
- Contract penalties and material damages (variable).

As illustrated in the bullet points above there are potentially many factors to be considered in estimating the total costs involved in a pedestrian-train collision. The above costs are only suggested and estimated to demonstrate the steps involved in applying the cost-benefit model. Should other costs and more accurate dollar values be identified, these would be included in the total collision costs as well.

With the collision cost categories identified and respective dollar values assigned, they are added to arrive at an estimated total collision cost (TCC) per second train collision. In this example, for the data above, we have:

TCC = $100,000 + $100,000
= **$200,000 per second train collision**

Since the total number of collisions per RRI per year that are expected to be avoided due to STW implementation is 0.003, therefore the total collision cost savings (TCCS) is estimated as:

TCCS = CA/RRI/year * TCC
= 0.003 * $200,000
≈ **$600 per RRI per year**

d) <u>Total Societal Savings due to Reduced Collisions</u>

By adding the societal cost savings (SCS) and the total collision cost savings (TCCS) in b) and c) above, an estimate of the total societal savings (TSS) due to reduced collisions is estimated as follows:

TSS = SCS + TCCS
= $4,500 + $600
= **$5,100 per RRI per year**

e) <u>Capital Cost of STW System</u>

The major initial cost for implementing an STW system at an RRI is the purchase price of the STW system signs. It has been estimated that four Type 1 and Type 2 STW signs (including the poles and bases) could be purchased for about **$27,000 and $7,700 per RRI**, respectively.

f) Installation Cost of STW System

A second major cost incurred is the cost of installing (IC) the STW system. This includes not only the erection of the four STW signs at an RRI, but also the system components (poles and bases) and electronic circuit and power provisions. The estimated total **IC is $50,000 per RRI.**

g) Operation and Maintenance Costs of STW System

In order to ensure that the STW system is well maintained and operating efficiently at all times it is expected that one routine maintenance and one emergency maintenance event per year will be required. It is estimated that the cost for each of these maintenance events will be approximately $1,000. Therefore, the total operation and maintenance costs (MC) are expected to be approximately $2,000 per RRI per year.

h) Total Costs for STW Installation, Operation and Maintenance

Based on conversations with sign suppliers/manufacturers, it is anticipated that the "functional life" of the STW system will be approximately 15 years. An analysis period of 15 years was selected for this reason.

To arrive at the total costs of installing, operating and maintaining an STW system (TCSTW) for the first year of implementation, the costs included in e), f) and g) above are summed, resulting in the values shown in **Table 7-2**.

Table 7-2 Type 1 and Type 2 STW Costs

Costs	STW System – Type 1		STW System – Type 2	
	Year 1	Year 2 through 15	Year 1	Year 2 through 15
Equipment	$27,000	$0	$7,700	$0
Installation	$50,000	$0	$50,000	$0
Maintenance	$2,000	$2,000	$2,000	$2,000

i) Benefit/Cost Ratio (TSS/TCSTW)

With all the societal cost savings (due to expected reductions in collisions as a result of STW implementation) and costs for implementing an STW system identified and estimated, the benefits can now be compared to the costs of installing the system. The benefit/cost ratio of the system is computed by converting all yearly costs and benefits into present values (PV) using a 6% discount rate:

$$B/C = PV_{benefits}/PV_{costs}$$

Table 7-3 includes a summary of the present value costs and benefits and the benefit-to-cost ratio for each STW sign type.

Table 7-3 Calculation of Benefit/Cost Ratio for Example STW System Implementation		
Value	**Type 1 STW System**	**Type 2 STW System**
PV of costs	$92,065	$73,860
PV of benefits	$49,530	$49,530
Benefit-to-Cost Ratio	0.54	0.67

Based on the analysis provided for the above scenario, benefit/cost ratio is less than 1.0 for the implementation of either of the STW systems. In order to achieve a benefit/cost ratio greater than 1.0, the benefits (in addition to the $1.5 million "cost of life" estimate and the $200,000 "cost of collision" estimate) would have to increase by:

- $800,000 for Type 1 signs; or
- $1,500,000 for Type 2 signs.

Note: The above calculation and results are provided for illustrative purposes only. For the actual cost-benefit calculation for the pilot test installation, please refer to Section 14.

8. PILOT TEST SITE LOCATION BACKGROUND

8.1 PILOT TEST SITE LOCATION

The Phase 1 recommendations included as the pilot project the installation of static second train warning signs and flashing beacons (referred to at Type 2 signs) at the O'Brien Avenue crossing of the Deux-Montagnes line.

The O'Brien Avenue / Deux-Montagnes RRI consists of a four-lane roadway crossing two sets of electrified tracks. Sidewalks are present on both sides of O'Brien Avenue and accommodate approximately 400 pedestrians in the eight peak hours of the day. Although pedestrians use both sidewalks, the majority (approximately 75%) cross on the west side of the roadway.

Pedestrians were present at the RRI during 15 of the 31 train arrivals recorded during the eight-hour survey. **Table 8-1** includes a summary of the violations.

Table 8-1 Violation Summary – O'Brien Avenue / Deux-Montagnes RRI
August 9, 2001 (8 hour survey)

Time	Train Direction	ST Event	Violation Type
8:01 a.m.	EB	No	Pedestrian crossed during activation
8:04 a.m.	WB	No	Pedestrian crossed during activation
11:06 a.m.	EB	No	Cyclist crossed during activation
1:22 p.m.	EB	No	Cyclist crossed during activation

The Deux-Montagnes commuter line accommodates approximately 56 trains per day. During the eight hour pedestrian and train activity count undertaken on August 9, 2001, no second train events were observed; however, the train schedule and "near second train events" during the field observations suggests that the site could experience an average of one to three second train events per day.

8.2 SIGN CONTENT AND PLACEMENT

At the conclusion of Phase 1, it was recommended that the sign content be finalized, as necessary, based on a sign comprehension survey to be completed by rail users. IBI Group staff, in conjunction with Transport Canada staff, conducted a one-day survey to establish suitable sign content. The design and results of the sign comprehension survey are included in **Section 10**.

Given that the pedestrians cross on the east and west sides of the RRI, it was proposed that four signs be installed to be viewed from all four quadrants of the intersection.

8.3 MONITORING SYSTEM

The monitoring system was designed to consist of two camera assemblies located east and west of the RRI within the railway right-of-way. The cameras will be situated and configured to observe pedestrian actions within the four waiting areas approaching the rail line. The proposed layout for the O'Brien system is shown in **Figure 8-1**.

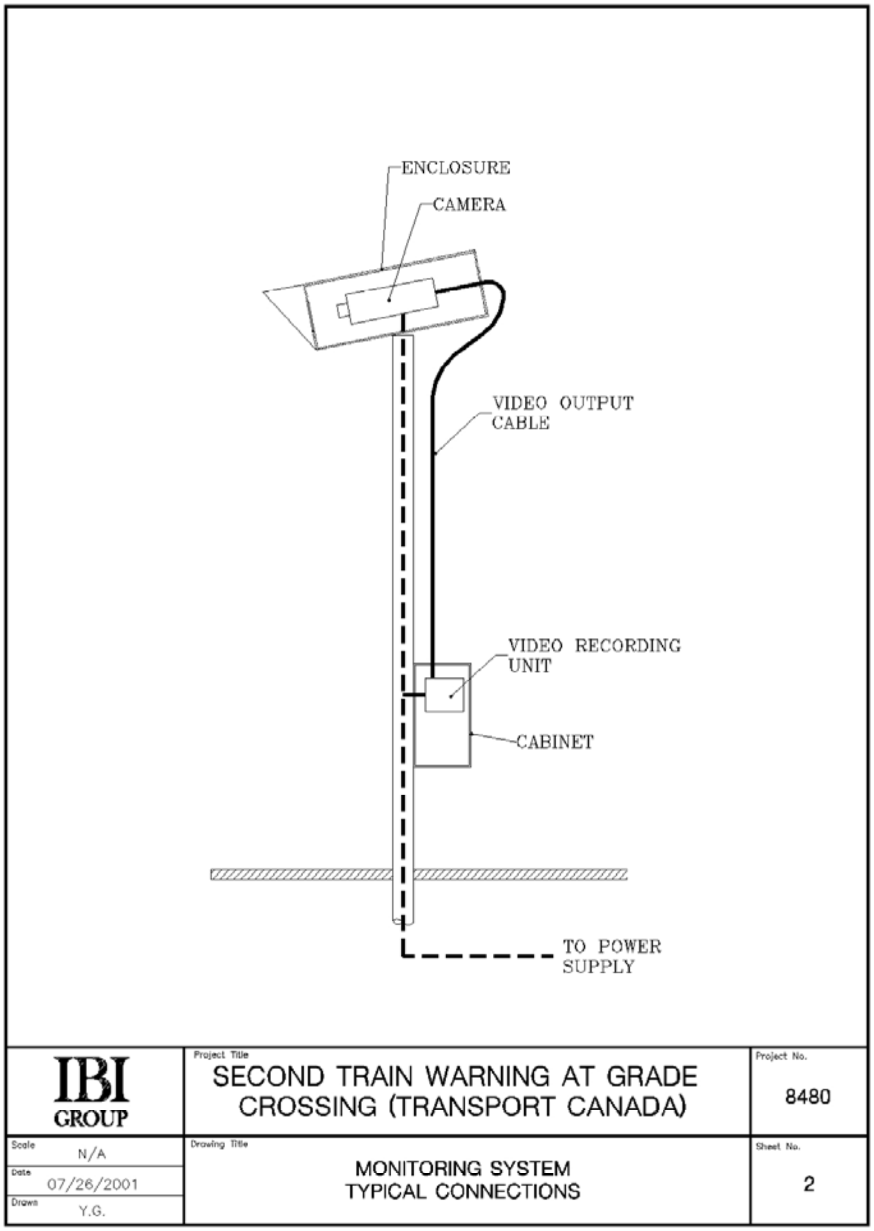


Figure 8-1 O'Brien Avenue Pilot Test – Sign Layout

8.4 STAKEHOLDERS

Three stakeholders were identified for the pilot test installation at the O'Brien Avenue site:

8.4.1 Rail Authority

CN is the railway operating authority of the Deux-Montagnes line. Approvals were required for the installation of STW system equipment within the railway right-of-way, including duct work, poles, cabinets, power/video and grounding cables. CN staff prepared signal circuit drawings, through consultation with IBI Group, to identify communication requirements between the STW system and the railway detection equipment.

In addition, CN staff conducted the full installation of the STW warning system, including the monitoring equipment. The installation and commissioning of the system is summarized in **Section 11**.

8.4.2 Commuter Rail Service

Montrain, a division of CN, operates the commuter rail service. The pilot test installation was not located in close proximity to a commuter rail station and it was not anticipated that the system installation or operations would affect the rail service at the O'Brien Avenue crossing. Notwithstanding these facts, IBI Group maintained liaison with Montrain throughout the pilot project.

8.4.3 Road Authority

Ville Saint-Laurent is the municipality having jurisdiction over O'Brien Avenue. The municipality required encroachment permits/approvals for the following activities:

- STW system components suspended above or installed with the City road right-of-way. Specific requests relating to the right-of-way were submitted to Dominique Brault at the Ville Saint-Laurent Public Works Department;
- Road or lane closures for the installation and maintenance activities. For the road closure approvals, a letter was submitted to the Direction Generale of Ville Saint-Laurent, outlining the:
  - Nature of the work to be completed;
  - Impact the work will have on the roadway; and
  - Type of closure to be used.
- The City confirmed that it had no issue with respect to pedestrian and motorist privacy given the nature/location of the video monitoring equipment to be installed and the information that was to be recorded during the review of the tape by the consultant team. The Executive Committee resolution from the Ville Saint-Laurent is included in Appendix E.

8.5 BEFORE DATA COLLECTION

8.5.1 Data Requirements

As noted in **Section 7**, train collisions – and specifically second train collisions – are relatively rare occurrences when compared to other forms of travel modes, i.e., vehicular collisions at a roadway intersection. Recognizing this low frequency, it is not expected that statistically significant results could be generated from the "before" and "after" periods of the STW system during this study.

It is suggested that a surrogate for collisions would be the **collision potential** resulting from risky behaviour by pedestrians during second train events. Specific definitions for "risky behaviour" were established for the "before" and "after" studies and are outlined in **Sections 12** and **13**.

8.5.2 "Before" and "After" Data Collection Period

The previous STW studies undertaken in Maryland and Los Angeles provided an overall benefit of an approximately 78% reduction in violations. It was assumed that similar violation reductions would be attained at the subject site.

Given the existing violation rate of 26.7% and the anticipated reduction in violations of 78%, **Table 8-2** includes a summary of the required observations to determine the effectiveness of the STW system with a 85th, 90th and 95th confidence level. The values presented in **Table 8-2** assume that the resultant violation rate range is within 15% of the difference between the "before" and "after", that is, the first row suggests one would require 988 total observations to be 95% confident that violations were reduced from 26.7% to 5.8% +/- 3.1%. The 3.1% range is calculated by taking 15% of (26.7% - 5.8%).

Table 8-2 Before and After Observation Requirements

Confidence Level	Total Number of Observations Required	Number of Observations Required in Each of the Before and After Periods
95% confidence	988	494
90% confidence	700	350
85% confidence	533	267

The 95 percent confidence limit was considered acceptable for a reliable pilot test of this nature.

9. PHASE 2 SCOPE

Phase 2 of the study included the installation and assessment of the effectiveness of a second train warning system at a pilot test site. The following is a brief summary of the activities completed as part of Phase 2 of the study.

- **Sign Comprehension Survey** – A survey of pedestrians to establish that the majority of the public would understand the proposed STW static sign design.
- **STW System Installation, Commissioning and Activation** – Installation of the STW system, including the signs, beacons and video surveillance equipment at the pilot test location, namely, the O'Brien Avenue crossing of Deux-Montagnes CN line.
- **"Before" Data Collection and Analysis** – Collection of the required number of person-train observations to determine the "before" violation rate.
- **"After" Data Collection and Analisis** – Collection of the required number of person-train observations to determine the "after" violation rate.
- **Risk-Mitigation Cost-Benefit Evaluation of STW System** – Draw conclusions from the risk-mitigation cost-benefit evaluation of the effectiveness of STW system.

A summary of each of these components is provided in **Sections 10** through **14**.

10. SIGN COMPREHENSION SURVEY

10.1 SURVEY DESIGN

A survey was conducted to establish that the majority of the public would understand the proposed STW static sign design. A survey area was set up in Central Station in Montreal. The following were presented at the survey location in both official languages:

- Board "A" – A short introductory board indicating that the survey is for Transport Canada, for a rail safety initiative and inviting participants to complete a two minute questionnaire.
- Board "B" – A board with an enlargement of a photograph of a typical railway crossing with the second train warning sign present. The respondent was asked to "imagine" he/she is a pedestrian attempting to cross the at-grade crossing. A train has just passed through the crossing and the railway warning system is still active.

IBI/Transport Canada staff asked respondents the following questions:

1) "If you were a pedestrian at the crossing shown on Board 'B' and the lights on the warning sign were flashing, what situation would you expect to occur?"
2) If the response to Question #1 does not relate to a second train approaching/crossing the at-grade crossing, then the surveyor will tell the respondent what the sign is intended to mean. The follow-up question will be: "What changes would you make to the sign content to help alert pedestrians with regard to the occurrence of a second train?"

IBI Group/Transportation Canada staff recorded the participants' responses.

10.2 SURVEY EXECUTION

The sign comprehension survey was undertaken in Montreal on April 25, 2002. In addition to response to the second train survey scenario outlined in section 10.1, IBI Group/Transport Canada staff recorded general demographic information regarding the participant's gender, approximate age and language most used.

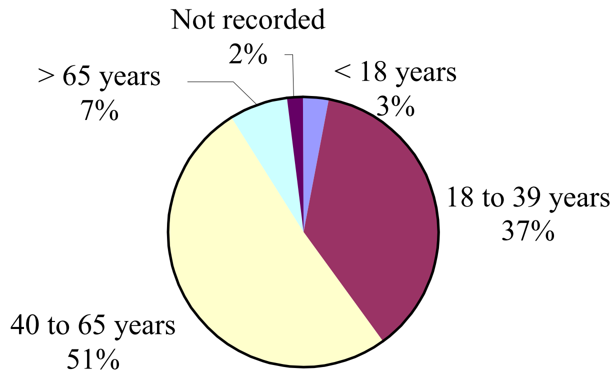
10.3 SURVEY RESULTS

Figure 10-1 is a summary of the demographic and comprehension responses provided by the survey respondents.

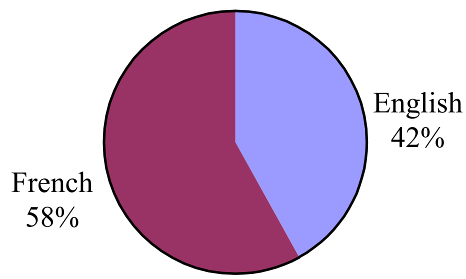
The two primary comments received from those participants that did not understand the sign were:

1) The flashing lights should be red as opposed to yellow. Red generally designates a "stop" or prohibitive situation; and
2) Arms or gates should be used.

Approximate Age of Participants



Language Most Used



Sign Comprehension

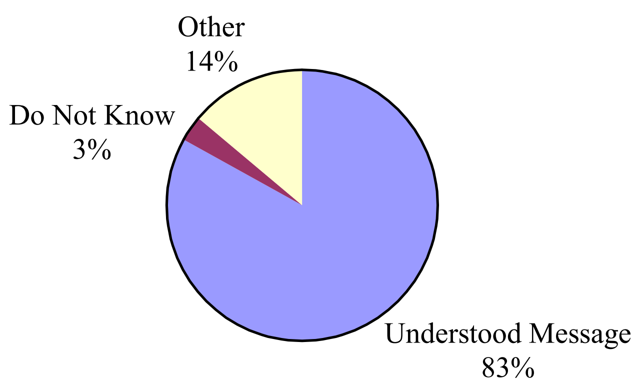


Figure 10-1 Survey Responses

The survey clearly demonstrated that the proposed STW display was appropriate for the pilot installation at the O'Brien Avenue crossing. The recommendations from those participants that did not understand the sign were not carried forward for the following reasons:

- The STW system is not intended to be a regulatory device, but a supplementary warning device. In this case, the yellow flashing beacons are appropriate; and
- A physical barrier such as an arm or a gate for pedestrians would not provide the pedestrians with the additional information that a second train is arriving at the crossings, i.e., it would not provide any additional warning that is not already provided by the rail warning system.

11. STW SYSTEM INSTALLATION, COMMISSIONING AND ACTIVATION

11.1 SYSTEM INSTALLATION

The STW system, including the signs, beacons and video logging equipment, was installed in October and early November 2002. CN Rail staff undertook the complete installation under contract with IBI Group. Provided in **Figure 11-1** is a brief photographic summary of the STW system installation.

Pole Installation

Cable Installation

Beacon Installation

Video Surveillance Equipment Installed

Figure 11-1 STW System Installation

11.2 SYSTEM COMMISSIONING

The STW system was commissioned on November 21, 2002, at the O'Brien Avenue crossing of the Deux-Montagnes CN Line in Ville Saint-Laurent, Quebec.

The following is a list of individuals present at the site during the commissioning:

1) Anthony Napoli – Transportation Development Centre, Transport Canada;
2) René Turgeon – Surface Branch, Quebec Region, Transport Canada;
3) Gaetan Provost – CN;

4) A work crew of two individuals from CN; and
5) Ian Nelson – IBI Group.

Included in **Table 11-1** is a summary of the activities undertaken during the commissioning.

Table 11-1 STW Commissioning Summary

Activity	Description
Camera adjustments	The 4 cameras were adjusted in order to view all pedestrian crossing points.
Lens adjustments	The focal lengths of the lenses were adjusted in order to optimally observe pedestrian movements.
VCR – time lapse	It was determined that once the recording begins, a 2 minute recording time would be a conservative choice to allow plenty of time to view pedestrians before and after a train crosses.
VCR – recording speed	The recording speed was set to 18 hours. This speed allows for greater recording time while maintaining a quality recording.
VCR – time and date stamp	Time and date stamping has been set up to record on all videotapes.
Functionality	A simulated train crossing was performed with the signs, flashers, cameras, and VCRs active. All equipment worked successfully. Although a 2-train incident was not simulated, CN staff ensured that it was successfully tested on Tuesday, November 12, 2002.
Videotape delivery	12 Sony T-160 videotapes were delivered by IBI Group and received by Anthony Napoli.
STW sign storage	Verified that all aluminum signs are stored safely in the CN bungalow.
Designated personnel	Anthony Napoli agreed to change the videotapes. Gaetan Provost of CN will be the contact person if any equipment adjustments need to be made.

The video logging system was set up to activate during the presence of one or more trains to record observations and violations for the "before" analysis period. The rationale for this activation logic is outlined in **Section 12**.

11.3 SYSTEM ACTIVATION

The STW system was fully activated in March 2003 subsequent to the "before" data collection activities. The warning signs were installed and flashing beacons were uncovered. The activation sequence was modified to trigger the signs and the video logging system to capture only second train events. The results of the "after" study are outlined in **Section 13**.

12. BEFORE DATA COLLECTION AND ANALYSIS

12.1 BACKGROUND

The "before" data was collected through videotaping of the crossing during the two-month time period November 21, 2002 to January 19, 2003. Subsequently, the tapes were reviewed and "pedestrian-train incidents" were identified. A "pedestrian-train incident" occurred when "one train (although sometimes it could be two[1]) passed through the O'Brien Avenue crossing of the Deux-Montagnes CN line during the activation period, with at least one pedestrian within the warning system area".

A detailed review was conducted of a total of 20 videotapes covering the period November 21, 2002 to January 19, 2003. The objective of the review was to identify and document the total number of "violations" and "non-violations" that were committed by pedestrians and cyclists at the O'Brien Avenue crossing during a "pedestrian-train incident".

12.2 ANALYTICAL APPROACH

12.2.1 Definitions

Each "pedestrian-train incident" identified on the tapes was carefully reviewed to determine whether the pedestrian (or cyclist) "violated" the crossing or not. The videotapes permit us to identify and document the following:

- Whether an observation should be included in the final analysis; and
- Whether the person(s) "violated" or "did not violate" the crossing while the warning system device was activated.

For the purposes of the before data analysis the following definitions were established:

- **Observation** – A person that is included in the analysis for subsequently determining whether he/she "violated" or "did not violate" the crossing is defined as "A person who has reached the arms of the warning system gates while the warning system is activated".
- **Violation** – Is defined as "A person who encroaches upon the railway right-of-way (i.e., entire area between the warning system gates) prior to the completion of the warning system device activation".

12.2.2 Data Recording Procedures

An ACCESS database was created to record and analyze the data. In order to document all the violation and non-violation counts, a column was created for recording the violation information. Whether a person is a violator or non-violator is determined using the definitions of an "observation" and "violation" as given above. The 1,870 observations currently in the ACCESS database are coded as:

- **"V"** – indicating that a violation occurred;
- **"NV"** – indicating that no violation occurred; or

[1] It should be noted that this approach of recording observations when either one or two trains pass through the crossing area during the activation period was used to shorten the before data collection period. This will not affect the final estimators of effectiveness derived for the second train warning systems because pedestrians and cyclists do not have the information necessary to determine whether one or two trains are present without a specific second train warning system installed.

- **“N/A”** – indicating that the observation is not a “pedestrian-train incident”.

It should also be noted that there were a number of cyclists observed during the videotape analysis. It was therefore decided to record whether the observation was a pedestrian or cyclist. This information was captured by recording the type of observation in the comments section of the data record.

There were also some observations where it was not possible to determine whether the person violated the crossing or not, e.g., poor view on the videotape, not sufficient video capture to determine, etc. All observations where it was not possible to definitively determine whether the person violated the crossing or not were recorded as “**N/A”** and will be left out of the final analysis when merging this “before” data with the “after” data results in order to measure the effectiveness estimates for the STW signs.

A few decisions had to be made as to whether an observation is to be regarded as a violation, in addition to the main criteria specified above. For example, a child may be well ahead of an adult and violates the crossing. Another type of instance involves a child holding the hand of an adult or being pushed in a child stroller/carriage by an adult who violates the crossing. A decision had to be made whether these conditions implied two violations or just one. In order to decide upon these many types of situations that occurred the following criterion was adopted:

“A person is counted as an observation if it is apparent that he/she has the freedom to make his/her own ‘choice’ or decision to comply at the crossing”.

Finally, it should be pointed out that some data records contain more than one observation (i.e., more than one person that has been documented). In many instances there could be two, three or more people (observations) to record the results for. In these instances, the number of violators and non-violators are noted. The counts for all violators and non-violators are recorded in brackets under the “Violation” column that was created in the ACCESS database.

Using the above data recording process the total number of “violations” and “non-violations” for pedestrians and cyclists separately was determined at the O’Brien Avenue crossing between November 21, 2002 and January 19, 2003.

12.3 RESULTS

Provided in **Tables 12-1**, **12-2** and **12-3** is a summary of the results of the review carried out on videotapes 1 to 20 covering the period November 21, 2002 to January 19, 2003. Results were generated for pedestrians and cyclists separately, as well as for these two groups of road users combined.

12.3.1 Pedestrian Violations

Pedestrian violations are shown in **Table 12-1**. There were a total of 1,813 pedestrians observed on the videotapes.

Table 12-1 Pedestrian Observations		
Pedestrian Observations	**Count**	**Percentage**
Violators	**1,500**	**82.7**%
Non-Violators	247	13.6%
Non-Applicable Observations	66	3.7%
Total Pedestrian Observed	**1,813**	**100.0**%

Sixty-six (or 3.7%) were not "pedestrian-train incident" observations and therefore should be disregarded when combining this "before" STW system implementation data with the "after" STW system implementation data to measure the effectiveness of the STW system.

The major finding is that 82.7% of the pedestrians violated the crossing during a "pedestrian-train incident", with only 13.6% observing and complying with the existing warning system. If the 66 observations that are not "pedestrian-train incident" observations are omitted from the analysis then the final estimate for the number of pedestrians violating the crossing during a "pedestrian-train incident" is 86.1%.

12.3.2 Cyclist Violations

Table 12-2 provides the results of the cyclist violations. There were a total of 57 "cyclist-train incident" observations.

Table 12-2 Cyclist Observations		
Cyclist Observations	**Count**	**Percentage**
Violators	**53**	**93.0%**
Non-Violators	4	7.0%
Non-Applicable Observations	0	0.0%
Total Cyclists Observed	**57**	**100.0**%

Ninety-three percent (93%) of the cyclists violated the existing warning system.

12.3.3 Total Violations

The total number of "person-train incident" observations (including pedestrians and cyclists) videotaped between November 21, 2002 and January 19, 2003 at the O'Brien Avenue crossing are given in
Table 12-3.

Table 12-3 Total Observations (Cyclists and Pedestrians)		
Road User Observations	**Count**	**Percentage**
Violators	**1,553**	**83.1%**
Non-Violators	251	13.4%
Non-Applicable Observations	66	3.5%
Total Observations	**1,870**	**100.0**%

There were a total of 1,870 observations recorded on the videotapes. Of these, 66 were determined not to be “person-train incidents”, resulting in 1,804 valid “person-train incidents” that were recorded.

The total number of violators was 1,553 out of 1,804 (or 86.1%). This value represents the final estimate for the total number of “before” period violations that will be used for evaluating the effectiveness of the STW system.

The 95% confidence limits surrounding this estimator are (84.5%, 87.7%), meaning that the percentage of violators is expected to be between 84.5% and 87.7% for 95 samples out of every 100 taken, that have at least 1,804 “person-train incident” videotaped events.

13. AFTER DATA COLLECTION AND ANALYSIS

As noted in **Section 11.3,** the STW system was commissioned at the O'Brien Avenue crossing of the Deux-Montagnes CN Line in March 2003. The "after" analysis phase included the period when the warning system was fully functional and included observations between March 21, 2003 and October 2, 2003.

The data was collected through videotaping of the second train events at the crossing during this six and a half month time period. Subsequently, the tapes were reviewed and "pedestrian-train incidents" were identified. A "pedestrian-train incident" occurred when "two trains passed through the O'Brien Avenue crossing from opposite directions during the STW system activation period, with at least one pedestrian within the warning system area".

A detailed review was conducted of a total of 24 videotapes covering the above "after" observation period. The objective of the review was to identify and document the total number of "violations" and "non-violations" that were committed by pedestrians and cyclists at the O'Brien Avenue crossing during a "pedestrian-train incident".

13.1 ANALYTICAL APPROACH

The analytical approach for determining whether a pedestrian (or cyclist) "violated" the crossing during the STW system activation period is identical to that employed for conducting the "before" data evaluation outlined in **Section 12**.

As in the case of the "before" data analysis, each "pedestrian-train incident" identified on the tapes was carefully reviewed to determine whether the pedestrian (or cyclist) "violated" the crossing.

13.2 RESULTS

Included in **Tables 13-1, 13-2** and **13-3** is a summary of the results of the "after" data review carried out on videotapes #25 to #48 covering the period March 21, 2003 to October 2, 2003. Also included in these tables are the results of the "before"data analysis outlined in **Section 12** for comparison purposes.

13.2.1 Pedestrian Violations

Pedestrian violations are shown in **Table 13-1**. There were a total of 448 pedestrians observed during the "after" data period.

Table 13-1 Summary of Pedestrian Observations and Violations

Observations	Before Observations		After Observations	
	Count	Percentage	Count	Percentage
Violators	1,500	82.7%	137	30.6%
Non-Violators	247	13.6%	311	69.4%
Non-Applicable Observations	66	3.7%	0	0.0%
Total Pedestrians Observed	1,813	100.0%	448	100.0%

The major finding is that 30.6% of the pedestrians violated the crossing during a "pedestrian-train incident" with the STW system in place, which is a significant improvement over the 86.1% of the pedestrians that violated the crossing during the "before" data period without the STW system in place.

This represents over a 64% decrease in pedestrian violations in the "after" period (with the STW system in place) compared to the "before" period (without the STW system in place).

13.2.2 Cyclist Violations

Table 13-2 provides the results of the cyclist violations. There were a total of 61 "cyclist-train incident" observations during the "after" data period.

Table 13-2 Summary of Cyclist Observations and Violations

Observations	Before Observations		After Observations	
	Count	Percentage	Count	Percentage
Violators	53	93.0%	20	32.8%
Non-Violators	4	7.0%	41	67.2%
Non-Applicable Observations	0	0.0%	0	0.0%
Total Cyclists Observed	57	100.0%	61	100.0%

Only 32.8% of the cyclists violated the crossing with the STW system in place compared to 93.0% of all cyclists violating the crossing without the STW system in place.

This represents over a 64% decrease in cyclist violations in the "after" period (with the STW system in place) compared to the "before" period (without the STW system in place).

13.2.3 Total Violations

The total number of "person-train incident" observations (including pedestrians and cyclists) videotaped in the "after" analysis period are provided in **Table 13-3**.

Table 13-3 Summary of Total Observations and Violations

Observations	Before Observations		After Observations	
	Count	Percentage	Count	Percentage
Violators	1,553	83.1%	157	30.8%
Non-Violators	251	13.4%	352	69.2%
Non-Applicable Observations	66	3.5%	0	0.0%
Total	1,870	100.0%	509	100.0%

The total number of violators was 157 out of 509 (or 30.8%) with the STW system in place, compared to 1,553 violators out of 1,804 (excluding the 66 non-applicable observations) or 86.1% without the STW system in place (as seen in the "before" data results).

There were a total of 509 “after” data observations recorded on the videotapes with the STW system in place.

The 95% confidence limits surrounding these estimators are:

- **(26.8%, 34.8%)** for the “after” data, meaning that the percentage of violators is expected to be between 26.8% and 34.8% for 95 samples out of every 100 taken, that have at least 509 “person-train incident” videotaped events, and
- **(84.5%, 87.7%)** for the “before” data, meaning that the percentage of violators is expected to be between 84.5% and 87.7% for 95 samples out of every 100 taken, that have at least 1,804 “person-train incident” videotaped events.

The 95% confidence limits for the estimators derived from the “before” and “after” data provide conclusive evidence that the percentage of violations with an STW system in place is significantly lower statistically than without an STW system in place.

These results translate into **over a 64% decrease in total violations** (including pedestrians and cyclists) with the STW system in place.

14. RISK-MITIGATION COST-BENEFIT EVALUATION OF STW SYSTEM

The main purpose of the risk-mitigation cost-benefit (B/C) evaluation is to assess the net benefit of the STW system with respect to its performance in making improvements to the level of safety for pedestrians at RRIs where second train events occur.

Having established the effectiveness of the STW system at the O'Brien Avenue pilot location, attention was then turned to the cost-benefit analysis of installing such systems at other RRI locations, assuming similar safety performance effects.

14.1 BENEFITS AND COSTS

Usually, in developing a B/C model both direct and indirect benefits and costs of a treatment need to be identified and measured (quantitatively) in monetary terms. The benefits and costs of primary focus are the "societal" benefits and costs. **Table 14-1** includes a summary of the benefits and costs associated with the STW system countermeasure.

Table 14-1 Benefits and Costs Associated with STW System Implementation

Benefits	Costs
• Reduction in second train collisions • Fewer fatalities • Reduced burden on emergency services • Reduced burden on health care system • Avoidance of train/schedule delays • Increased profits to rail/train operators • Reduced litigation/insurance claims	• Capital costs • Operating costs • Maintenance costs • Administrative costs

14.2 ESTIMATION OF COLLISION COSTS

The **direct costs** of a second train type collision will be dependant on many variables. The following is a partial list of items that would be included in a cost calculation:

- Level of associated property damage;
- Medical costs;
- Emergency services costs;
- Travel delay to freight, train passengers and road users (a function of the nature of the rail line interrupted); and
- Administrative and legal costs.

In addition to these direct costs, a **comprehensive cost estimate** would include lost earnings, lost household production, pain and lost quality of life.

14.2.1 Assumptions

In *The Economics of Railroad Safety* (Savage, 1998), it is estimated that the average total societal cost of a train-vehicle fatality in the United States is US$3.15 million. This value is a 1998 estimate factored from an average 1988 comprehensive societal cost of a fatal collision of US$2.39 million noted in *The Costs of Highway Crashes* (Miller et al., 1991).

Transport Canada assumes a societal cost of a fatal collision is CAN$2.0 million in 2003. This is the value that has been used for the following benefit-cost calculation. To this value we have assumed an additional $230,000 of direct costs associated with passenger delay, service operator costs and emergency services. The relative scale of the value is consistent with the "average" direct costs of US$128,495 (in 1988 dollars) noted in *The Costs of Highway Crashes*.

14.2.2 Other Considerations in Cost Calculation

Included in **Section 14.4** is an estimation of the total societal cost savings associated with the prevention of a second train collision, potentially resulting in a fatality, on a primary commuter rail line. Other considerations that may be included in the direct costs at other sites may include, but not be limited to:

- Delay to highway users should the collision occur on a heavily used highway or arterial roadway;
- Freight delay costs associated with delay to a primary freight line; and/or
- Other costs associated with the movement or delay of hazardous materials.

14.3 ESTIMATOR OF SECOND TRAIN COLLISIONS AVOIDABLE

Using the EFF(STW) estimator of 64.38% an estimator of the "expected number of second train collision pedestrian fatalities that can be avoided per RRI per year" (CA/RRI/year) can be derived. The 95% confidence limits for the STW effectiveness are 49.06% (lower) and 75.10% (upper).

Based on the assumptions outlined in **Section 7.8.3**, only fatality reductions are being considered in the calculation since it is expected that all collisions involving a pedestrian and train will result in death to the pedestrian. In addition, the societal costs assigned to a fatality are many times greater than that of an injury; therefore, the omission of injury incidents from the analysis is not expected to have a significant effect on the final results.

As indicated in **Section 7.3**, there have been 11 recorded pedestrian fatalities in Canada over the 11-year period 1988-1998 resulting from collisions involving a second train. There are about 255 RRIs in Canada where a second train collision could potentially occur. This means that there have been 0.043 fatalities per RRI over an 11-year period (11 fatalities/255 sites) or **0.004 fatalities per RRI per year (**0.043 fatalities per RRI/11 years).

Since upper and lower confidence limits of the EFF(STW) estimator are 49.06% and 75.10%, respectively, this means that the number of pedestrian-train collisions that can be prevented per RRI per year (CA/RRI/year) due to STW system implementation is given by:

$$0.4906 * 0.004 < \textbf{Estimated CA/RRI/year} > 0.7510 * 0.004, \text{ or}$$

$$0.00192 < \text{Estimated CA/RRI/year} > 0.00295$$

14.4 TOTAL SOCIETAL COST SAVINGS

The total societal cost savings is the sum of the societal cost savings of "human life" and the estimated direct cost savings due to pedestrian-train collisions that are prevented. Included in **Table 14-2** is a summary of the estimated costs for a "typical" pedestrian-train collision at an RRI that would impact the movement and schedule of 10,000 commuters (which is equivalent to 10 commuter trains), and the estimated societal cost savings per RRI per year.

Table 14-2 Total Societal Cost Savings of Prevented Collision				
Cost Savings	**Description**	**Estimate**	**Societal Cost Savings Per RRI Per Year** [1]	
			Lower 95% Confidence Estimate	**Upper 95% Confidence Estimate**
Societal Cost Savings of "Human Life"	$2.0 million per death[2]	$2.0 million	**$3,847.84**	**$5890.20**
Commuter Delay	10,000 passengers are delayed one hour at $10/hour	$100,000		
Commuter Rail Operations	Provision of alternative transportation at $10/passenger	$100,000		
Emergency Services	Variable – assume $10,000 per collision	$10,000		
Crew "Trauma" and Alternative Crew Provision	Variable – assume $10,000 per collision	$10,000		
Contract Penalties and Material Damages	Variable – assume $10,000 per collision	$10,000		
	Subtotal	$230,000	**$442.50**	**$677.37**
		Total Societal Cost Savings per RRI per Year	***$4,290.35***	***$6,567.57***

Note:

(1) Based on unit costs of one typical collision at an RRI multiplied by the number of pedestrian-train collisions that can be prevented by the STW system at an RRI each year, as calculated in **Section 14.3**.

(2) The Societal Cost Savings of "human life" value has been updated from the Phase 1 analysis (previously $1.5 million per fatality) to reflect current values assigned by Transport Canada in 2003.

14.5 CAPITAL COST OF STW SYSTEM

Based on the costs incurred at the O'Brien Avenue pilot project site, the capital costs associated with a general second train warning installation were estimated.

The cost of materials for the pilot test site was $20,519.34 and the labour costs were $44,273.41, for a total installation cost of $64,792.75. Maintenance costs are estimated to be approximately $2000.00 per year. These costs do not reflect the supply and installation of the video surveillance equipment, which would not be included at a general installation of an STW warning system. Included in **Table 14-3** is a summary of the initial and annual costs associated with the static sign warning system.

Table 14-3 STW System Capital Costs		
Item	**Year 1**	**Year 2 through 15**
Equipment	$20,519.34	$0
Installation	$44,273.41	$0
Maintenance	$2,000	$2,000
Note: Assumes the Type 2 static sign installation		

14.6 BENEFIT/COST RATIO

With all the societal cost savings per RRI per year (due to expected reductions in collisions as a result of STW implementation) and costs for implementing an STW system identified and estimated, the benefits can now be compared to the costs of installing and maintaining the system. The benefit/cost ratio of the system is computed by converting all yearly costs and benefits into present values (PV) using a 6% discount rate:

$$B/C = PV_{benefits}/PV_{costs}$$

Table 14-4 includes a summary of the present value (PV) costs and benefits and the benefit/cost ratio for the Type 2 STW static sign type.

Table 14-4 Benefit/Cost Ratio for STW System Implementation		
Type 2 Static Sign	**Estimated Value for 15 Year Life Cycle**	
	Lower 95% Confidence Limit	**Upper 95% Confidence Limit**
PV of Costs	$80,549.73	$80,549.73
PV of Benefits	$41,668.90	$63,785.86
Benefit-to-Cost Ratio	0.52	0.79

Based on the analysis provided for the above scenario, benefit/cost ratio is less than 1.0 for the implementation of STW system. In order to achieve a benefit/cost ratio of approximately 1.0, one of the following would need to be realized:

- The costs associated with supply and installation would need to be reduced to less than $47,000 (NOTE: The “upper bound” of the societal benefits was used for determining the $47,000 value, rather than the exact point estimator); or
- The total societal cost savings (or economic benefits) per RRI per year would have to increase by approximately $Y. To achieve this additional $Y in societal cost savings per RRI per year would require that the total cost of a human life and a typical collision at an RRI would have to increase to approximately $2.82 million from the current estimate of $2.23 million (i.e., $2.0 million cost of a “human life” plus $230,000 operational and person-delay costs due to a typical collision at an RRI). (NOTE: The “upper bound” of the societal

benefits was used for determining the $2.82 million value, rather than the exact point estimator).

14.7 MODEL APPLICATION

The risk-mitigation cost-benefit model can be applied in a number of cases to review the relative costs and benefits anticipated from an STW installation. The "total societal cost savings of collision" values can be modified to reflect the railway operating conditions at a specific grade crossing or a series of grade crossings along a specific subdivision. From this site-specific modification, the relative benefits of an STW system installation at one site can be compared to other sites. The anticipated benefits could be an additional decision factor in the overall ranking process, should a number of sites attain similar priority rankings in the recommended priority ranking process.

15. PHASE 3 SCOPE

Phase 3 of the study included the following components:

1) Compare the results from the Phase 2 pilot deployment with those obtained from similar installations in North America.
2) Review the functional specification produced for the pilot installation and determine whether any modifications are required for application to general deployments.

Provide cost and schedule estimates for deployment of STW systems to priority list grade crossings.

16. SECOND TRAIN WARNING EFFECTIVENESS

During Phase 1 of the project, three active second train warning systems were identified in North America, two of which had before and after studies undertaken to determine the effectiveness of the system. The two sites that were evaluated were the Timonium Road crossing on the Baltimore CLRL in Maryland and the Vernon Avenue grade crossing on the Metro Blue Line operated by the LACMTA. Provided in **Sections 16.1** and **16.2** is a summary of the effectiveness of these systems, followed by a comparison of the results (**Section 16.3**) obtained at the subject study pilot site. Further information regarding the location, installation and operation of these North American systems is provided in **Section 3.3**.

16.1 TIMONIUM ROAD CROSSING RESULTS

During the 90-day observation period following the installation of the STW system at the Timonium crossing, the frequency of illegal pedestrian movements and the incidents of "risky behaviour" associated with second train events were reduced by 80 percent. Based on the road user's survey undertaken as part of this project, the STW sign was well received and understood by motorists.

16.2 VERNON AVENUE CROSSING RESULTS

This demonstration project found that the STW system was effective in reducing risky behaviour by pedestrians at the Vernon Avenue crossing. Included in **Table 16.1** is a summary of the before and after results. In addition, intercept surveys were undertaken and indicated that most pedestrians were aware of the signs and were of the opinion that the STW signs improved safety at the Vernon Avenue crossing.

Table 16-1 STW Effectiveness – Vernon Avenue Crossing

Measure	Reduction in Risky Behaviour
Pedestrians crossing LRT tracks 15 seconds or less in front of approaching train	14%
Pedestrians crossing LRT tracks 6 seconds or less in front of approaching train	32 %
Pedestrians crossing LRT tracks 4 seconds or less in front of approaching train	73%

16.3 COMPARISON OF RESULTS

To provide some indication of the relative effectiveness or "success" of the STW pilot installation at the O'Brien Avenue crossing in Montreal, the system's effectiveness in reducing risky behaviour was compared to those noted above.

At the O'Brien Avenue pilot test site the percentage of violators with the STW system in place was 30.8% compared to 86.1% without the STW system in place. The 95% confidence limits surrounding this estimator are:

- **(26.8%, 34.8%)** for the "after" data, meaning that the percentage of violators is expected to be between 26.8% and 34.8% for 95 samples out of every 100 taken, that have at least 509 "person-train incident" videotaped events, and
- **(84.5%, 87.7%)** for the "before" data, meaning that the percentage of violators is expected to be between 84.5% and 87.7% for 95 samples out of every 100 taken, that have at least 1,804 "person-train incident" videotaped events.

The 95% confidence limits for the estimators derived from the "before" and "after" data provide conclusive evidence that the percentage of violations with an STW system in place is significantly lower statistically than without an STW system in place.

These results translate into over a 64% decrease in total violations with the STW system in place.

By making comparisons between the existing North American STW systems, it is not the intention to infer that they are similar systems, nor installed at locations with like operating characteristics. In fact, the warning systems and their installation location and reporting mechanisms are quite dissimilar. Specifically, it should be recognized that:

- The Timonium installation was primarily directed at evaluating the impact on vehicular traffic;
- The Vernon Avenue and Timonium sites were located in close proximity to stations, which may promote greater violations associated with individuals hurrying to catch a train or individuals being less prudent regarding track activity when one train is already stopped at the station;
- The definitions of "risky behaviour" for the before and after analysis for the various projects were not the same; and
- A static sign installation was employed at the pilot project at the O'Brien Avenue crossing, whereas the other two systems involved variable message signs.

Notwithstanding the above, the Maryland and Los Angeles STW system installations represent the *best available* comparison sites for the O'Brien Avenue STW system.

Table 16-2 Comparison of STW Installation Effectiveness Results

Site Installation	Effectiveness Reported
Timonium Crossing – Maryland	80%
Vernon Avenue Crossing – Los Angeles	14% to 73% [1]
O'Brien Avenue Crossing – Montreal	64%

Note:
(1) The range represents the effectiveness observed for the different definitions of risky behaviour that were outlined in **Section 16.2**.

In summary, the results obtained at the O'Brien Avenue pilot project test site appear to be consistent with those achieved at other STW pilot program locations in North America.

17. FUNCTIONAL SPECIFICATION – GENERAL DEPLOYMENT

The functional specification produced during Phase 1 of the study included an evaluation of the general requirements of an STW system and the specific requirements for a limited-state, pre-programmed LED sign (Type 1 sign) and a static warning sign with flashing beacons (Type 2 sign). The following items were included in the evaluation:

- Warning system activation and logic;
- Sign location and number;
- Auxiliary lighting and sound;
- Bilingualism;
- Fail-safe requirements;
- Sign content during second train events;
- Sign content during "non-second train" periods (LED signs);
- Sign mounting and location; and
- Sign dimensions.

Section 6 includes a discussion of the general functional specification requirements of an STW system and the specific functional requirements for each type of STW sign. **Appendix F** includes the functional specification produced for the pilot test site at the O'Brien Avenue crossing, which called for the Type 2 static signs.

The functional specification was revisited to determine whether any refinements were required for general deployment applications. Following is a summary of this assessment.

17.1 SIGN TYPE

The Type 2 static sign was installed and evaluated at the O'Brien Avenue pilot test site. Based on the comparison of the effectiveness of the pilot installation to STW systems employing "active" LED signs outlined in **Section 16**, it appears that the static sign system proves to provide comparable reductions in risky behaviour as the active signs. Combining this finding with the fact that the capital and maintenance costs associated with the static sign are less than the LED signs, it is recommended that STW system deployment in Canada be the Type 2 signs.

While not tested in this field during the subject study, the LED signs may provide some benefits over the static sign and beacon system:

- The "active" display may provide a better means of gaining the attention of pedestrians; and
- The sign content can be adjusted to provide a range of messages.

Depending on the number of deployment locations and the second train collision potential at these locations, consideration should be given to providing LED signs for the STW system.

17.2 ACTIVATION LOGIC

The activation logic included in the functional specification for the pilot installation was general and will suffice for the functional specification of a typical STW. There may be complicating factors such as a two-stage crossing or adjacent traffic signal operations that may require modifications to the activation logic; however, these can only be determined on a site-by-site basis.

17.3 SIGN LOCATION AND NUMBER

The STW system is solely targeted for pedestrians; therefore, it was determined in Phase 1 that signs should be located immediately adjacent to the pedestrian crossings. In addition, the signs should be directly visible at all legal pedestrian crossing points. The pilot test installation included "near side" sign placement whereby a pedestrian would look to the near side of the crossing to view the warning device.

The results of the pilot test installation appear to indicate the "near side" sign installations were successful in gaining the pedestrian's attention and providing the additional warning for which they were intended. It is recommended that the general deployment include near side sign installations unless site-specific geometrics or operating conditions do not permit such an installation or would not provide sufficient warning at the typical pedestrian wait areas.

17.4 SIGN CONTENT AND ACTIVATION

The pilot installation displayed the message "ATTENTION!", "2 TRAINS" with an information tab indicating "Aux Feux Jaunes". Based on subsequent discussions with transportation practitioners in Quebec, it is our understanding that the French version of the sign tab typically recommended on a flashing beacon assembly is "Quand Les Feux Clignotent", which generally translates to "when lights are flashing".

Accordingly, it is recommended that the static sign display the message "ATTENTION!", "2 TRAINS" with an information tab indicating either "Quand Les Feux Clignotent" for applications in Quebec, or "When Flashing" for applications outside of Quebec, as illustrated in **Figure 17-1**. Based on the sign comprehension survey and the results of the pilot test installation, it is apparent that there is an adequate sign comprehension of the sign content.

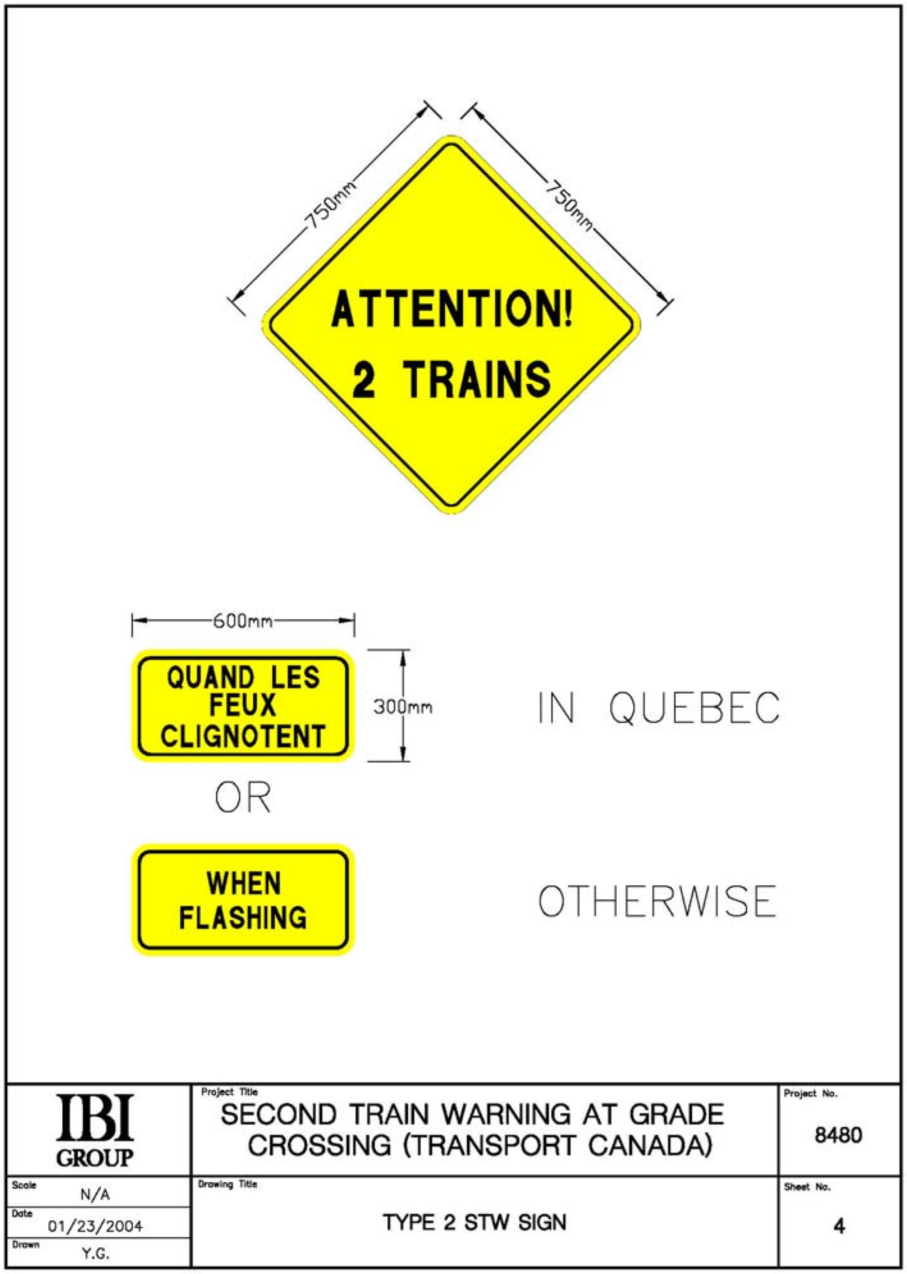


Figure 17-1 Recommended Sign Content

In some cases it may be beneficial to provide the information tab in both official languages, should local pedestrian demographics warrant.

The flasher units shall remain non-activated except when activated by a second train event (i.e., the default setting is unenergized).

17.5 AUXILIARY SOUND OR LIGHTS

The results of the pilot test installation appear to indicate that the static sign and flashing beacons were successful in gaining pedestrians' attention and providing the additional warning for which they were intended. Based on these results, supplementary lights and/or sounds are not recommended as part of a standard deployment of an STW system. It should be recognized that the O'Brien Avenue crossing pilot installation represented a relatively straightforward installation in that it involved a two-track crossing in a relatively open roadside environment.

There may be cases where the STW sign cannot be placed in the preferred locations due to geometric or operational constraints. In addition, there may be installation locations with roadside environments that may make it challenging for pedestrians to detect the STW indication. In these two cases, supplementary sounds or lights may be required to attract pedestrian's attention. The following are opportunities that should be pursued, as necessary:

- **Warning System Bell** – There may be an opportunity to deactivate the warning system bell once the first train no longer occupies the actual crossing (but is still in the crossing activation area) and re-activate it when the second train is detected;
- **Supplemental Warning Beacons** – During the pilot installation it was determined that the beacon hood obscured the beacon from the pedestrians while they were standing in close proximity or past the sign. It was determined by the PSC that supplementary beacons positioned on the backside of the recommended beacon location may rectify this situation.

These requirements can only be determined on a site-by-site basis and have not been included in the general deployment specification.

17.6 SIGN MOUNTING AND LOCATION

The results of the pilot test installation appear to indicate that the signs were located such that the supplemental warning was visible from the pedestrian waiting areas; however, the ultimate sign location will be a function of the site-specific characteristics. The signs should be located as close as possible laterally to the pedestrian sidewalk/waiting area, taking into consideration the safe passage of all road users. Signs should be mounted as low as safely possible to place them within a pedestrian's cone of vision.

During the pilot test installation it was noted that the STW signs were wavering in moderate to high winds. At one point one of the pilot test signs was dislocated from the pole. For future deployments, the sign mounting hardware should be improved to reduce wavering and the potential dislodging of the sign.

An illustration of the recommended mounting height is included in **Figure 17-2**.

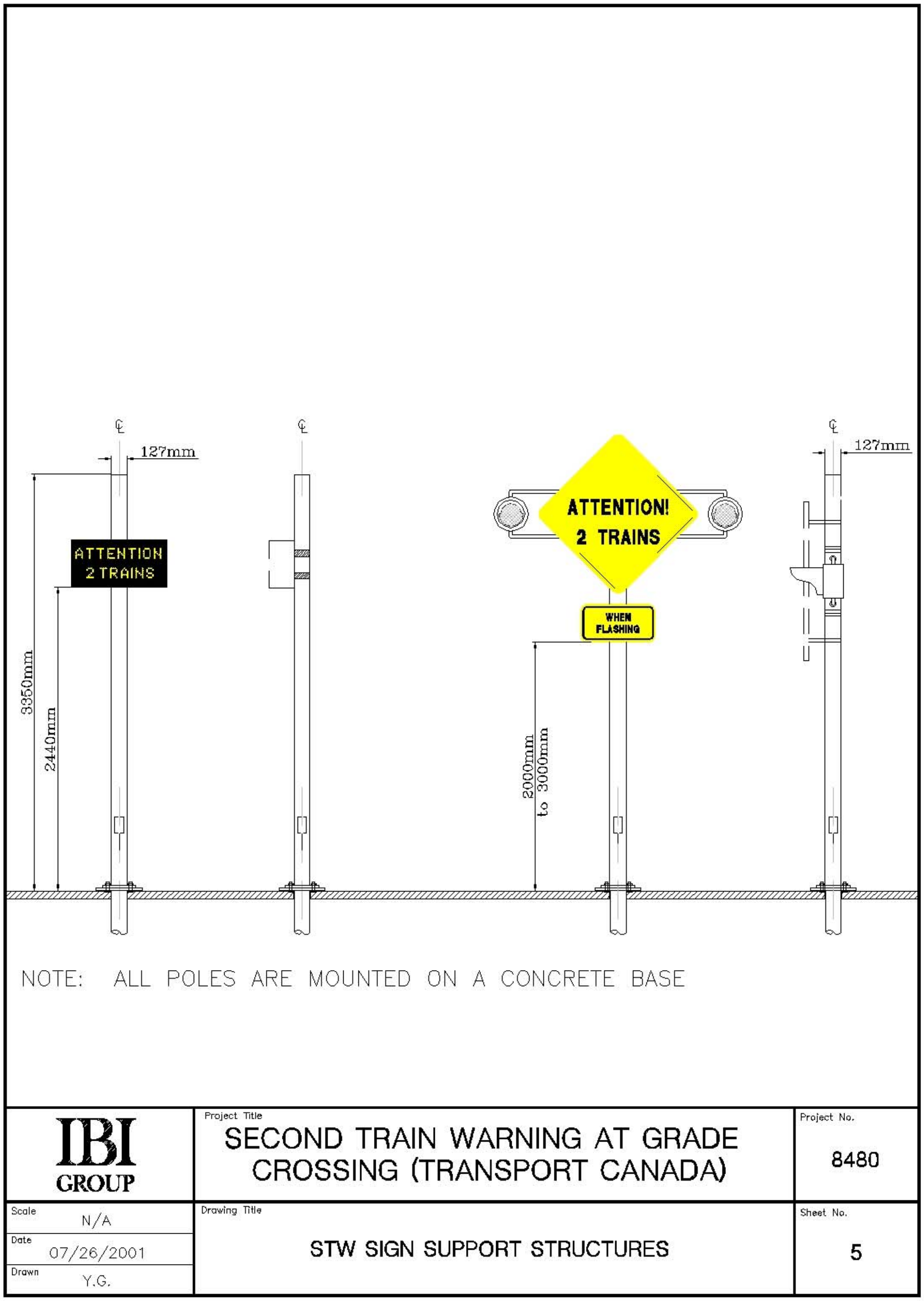


Figure 17-2 Recommended Sign Mounting Location

17.7 SIGN DIMENSIONS AND BEACONS

The results of the pilot test installation appear to indicate that the size and layout of the signs and beacons were such that the supplemental warning was visible from the pedestrian waiting areas. No changes are recommended to the sign or beacon size or arrangement for a standard installation. At some installation sites, beacon visibility may be hindered by sunlight, ambient lighting or a busy roadside environment. In these cases it may be beneficial to provide backboards on the beacons to improve visibility. This requirement should be determined on a site-by-site basis.

The character heights are consistent with the *Metric Edition Standard Alphabets for Highway Signs and Pavement Markings* (U.S. Department of Transportation, 2000) and as per TAC guidelines for warning signs. The flasher frequency is consistent with the TAC guidelines for warning signs.

17.8 FAIL-SAFE REQUIREMENTS

Power supply backup and "critical" or essential activation components were not deemed necessary for the pilot installation. This decision was based on the fact that the STW system represented a supplementary warning to the primary train warning system and that the costs for the activation equipment would be less for the pilot test. Should STW systems become part of a widespread deployment plan, it is recommended that consideration be given to providing appropriate battery backup and including "critical" activation components.

17.9 SUMMARY

The above requirements are documented in the recommended STW system functional specification for a typical two-track crossing location (see **Appendix H)**.

18. SYSTEM IMPLEMENTATION COST

18.1 COST ESTIMATE

The costs provided in **Section 14.5** represented those that were incurred for the pilot test installation minus the equipment and installation costs associated with the monitoring equipment. These are summarized in **Table 18-1**.

Table 18-1 STW System Costs

Materials	**Actual Cost**
Signs	$704.83
UPS	$292.09
Aluminium poles, anchors and brackets	$3,095.80
Beacons and flashers	$880.84
Relay materials	$15,545.78
Materials Subtotal	**$20,519.34**
Labour	
Design	$5,000.00
Construction	$37,273.41
Commissioning	$2,000.00
Labour Subtotal	**$44,273.41**
TOTAL	**$64,792.75**

To develop a cost estimate for full deployment of a standard or "typical" installation, the following must be recognized:

- The O'Brien Avenue crossing pilot test site represented a relatively straightforward installation in that it involved a two-track crossing in a relatively open roadside environment. STW system installation at other sites may include, but not be limited to, the following challenges:
  - Three or more sets of track with multiple jurisdictions;
  - Interconnection with and consideration of nearby traffic signal controls; and
  - Roadside/trackside infrastructure or stations that prevent sign placement on a standard pole adjacent to the nearside sidewalk.
- The costs associated with the design of the track circuit logic may be reduced as more STW systems are designed and implemented.
- The installation costs represent approximately two thirds of the overall cost of the system and may be reduced with future installations and experience.
- The O'Brien Avenue STW system was a retrofit installation. Should the STW system be installed in conjunction with a crossing upgrade or as part of a new at-grade crossing, the costs of installation may be lower. The materials costs would likely not be lower, but the labour and installation equipment costs may be lower as a result of economies of scale.

18.2 OTHER CONSIDERATIONS FOR IMPLEMENTATION COSTS

18.2.1 Critical Component Designation

To reduce the cost of the pilot test installation, "non-critical" components were used in the relays to activate the STW system and video monitoring devices. The rationale for the use of these components was that the rail warning system represented the primary warning mechanism and the STW system provided additional and supplementary information, but did not "overrule" the primary warning system. Should an STW system failure occur, the device would not activate during a second train event; however, a properly operating warning system would continue to provide sufficient warning to motorists and pedestrians.

Should the operating rail agency choose to incorporate "critical" components into its standard STW system installation, the costs would be greater than those outlined above.

18.2.2 Wire/Cable Connections

The installation cost for the pilot test site reflected the installation of the required cabling below grade; however, it was not to a typical depth that would be required for a general deployment. The cost of burying the cable without the presence of ducts would be higher than that experienced at the pilot test site.

18.2.3 General Specification and Circuit Design

The cost of installation of future STW systems may be reduced with the preparation of a general specification and circuit design for various configurations. The former is included in **Section 17**, but may require further refinement based on specific rail authority preferences or requirements. The latter does not form part of this project, but could be established for a number of basic layouts, i.e., three and four track crossings, traffic signal pre-emption location, etc.

18.2.4 Retrofit, Upgrade or New Installation

As with many construction-related costs, "economies of scale" have the potential to reduce both equipment and installation costs. The following should be recognized:

- The installation of STW systems at numerous sites may permit a bulk purchase of equipment, which may reduce the unit costs of the individual components.
- Installation time and costs may be reduced as more experience is gained from each subsequent installation.
- The labour costs may be reduced if the STW system is installed in conjunction with a crossing upgrade or a new rail warning system installation.

19. SITE INSTALLATION PRIORITIZATION

19.1 GENERAL APPROACH

In order to develop a program for full deployment of STW systems across Canada, it is necessary to develop criteria and an approach for identifying locations that have a high risk of second train events. This process involves the following steps:

- Establish location criteria for identifying RRI types that have the greatest probability or likelihood of second train collisions;
- Develop a site location prioritization model;
- Identify data requirements for implementing the site selection prioritization model.

19.2 SELECTION OF LOCATION CRITERIA

A preliminary selection of location criteria was undertaken in Phase 1 of the study based on:

- The existing body of literature on STW systems and their implementation; and
- Input from individuals on the PSC and in the rail industry.

Included in **Section 4.2** is a summary and description of the preliminary location criteria established in the Phase 1 activities. The appropriateness of this list was revisited to determine whether there were any criteria that should be incorporated or removed. It was determined that all criteria should be carried forward for consideration in the prioritization model. Included in **Table 19-1** is a summary of the location criteria, their potential applicability (quantitative or qualitative) and the availability of data/information at potential sites.

19.3 SITE LOCATION PRIORITIZATION METHODS

Having established appropriate location criteria, attention is turned to developing a simple and efficient model that can be applied across Canada to prioritize STW installations.

There are approximately 255 at-grade RRI locations across Canada that have two or more tracks that have been identified as potential high-risk locations, from general observation, that have the potential for second train collisions involving pedestrians. The best criteria to use in developing a site location prioritization model are those that provide a **quantitative basis for estimating and comparing the risks of a second train collision** occurring at all sites being considered. With these risks computed, it would then be possible to prioritize the site locations with respect to the requirement for a STW system.

Ideally, the number of second train events per day at each site, along with the number of pedestrians at each site, would prove to be good indicators of the relative risks of a second train collision. Based on the data collection efforts undertaken during Phase 1 of this project, and as noted in **Table 19-1**, this level of information is not readily available for many of the multi-track grade crossings in Canada.

Accordingly, formal pedestrian counts and train activity logs (specifically second train events) would need to be collected for many of the multi-track grade crossings in Canada to generate a complete quantitative prioritization of RRIs with the potential for second train collisions.

Through discussions with the PSC, and based on the field investigations undertaken as part of the pilot project site selection, there are locations with lower probabilities of a second train incident due to the nature of their location or operations. These would include crossings with:

- Little or no pedestrian traffic (multi-track grade crossing in a rural or remote area);
- Low train volumes and/or probability of second train events; and/or
- Low probability for second train events to coincide with pedestrian activity.

Consequently, it is recommended that a qualitative model be developed with the data, surrogate data and/or site characteristics that are readily available to generate a short list of "higher risk" sites. Subsequently, detailed quantitative data would be compiled and/or collected for the short list of locations for input into a quantitative ranking or "Exposure to Risk" model. Included in **Sections 19.3.1** and **19.3.2** is a description of the recommended qualitative screening model and quantitative priority ranking models, respectively.

Table 19-1 Location Criteria

Location Criteria	**Quantitative Criteria**	**Qualitative Criteria**	**Comments**
Multiple Track RRI	X		• Mandatory criterion • Information readily available
Collision History/Potential		X	• Collision history available • Requires violation or conflict data
High Pedestrian Volume	X	X	• Quantitative data available for some, but not all sites • Qualitative assessment by region
Number of Second Train Events	X		• Quantitative data is not readily available
High Train Volumes in Both Directions	X	X	• Quantitative data available for some, but not all sites • Qualitative assessment by region
Whistle Prohibition		X	• Prohibition status available for all crossings
Visibility		X	• Visibility characteristics not readily available
Train Operating Speeds		X	• Maximum train speeds available • Speed differentials could be estimated by region
Existing Warning System		X	• Existing warning system type readily available • Exact crossing configuration/layout not readily available

19.3.1 Qualitative Screening

The objective of the qualitative screening model is to obtain a short list of RRI locations with a "higher risk" of second train collisions, using readily available data. Based on a review of the potential qualitative location criteria in **Table 19-1**, it was determined that the criteria listed in **Table 19-2** should be included in the qualitative model for assessment of all potential installation locations.

Table 19-2 Qualitative Model Location Criteria	
Qualitative Location Criteria	**Measure Description**
Pedestrian Volume	Low, medium and high activity
Train Volumes	Estimated number of trains per day
Whistle Prohibition	Prohibited/no prohibition
Train Operating Speeds/Speed Differential	Low, medium and high speeds/speed differentials

These qualitative location criteria were weighted by "weighting factors" to differentiate among the levels of importance to be assigned to each criterion. Based on the information obtained through previous research, discussions with the PSC and activities completed in this study, preliminary weighting factors were generated and provided to the PSC members for review and comment. Included in **Table 19-3** are the weighting factors proposed for the qualitative screening evaluation.

Table 19-3 Qualitative Screening Process			
Criteria	**Index**	**Weight**	**Total**
Pedestrian Volumes	Pedestrian Volume Index ❑ 1 = Low activity ❑ 3 = Medium activity ❑ 5 = High activity	0.40	
Train Volumes	Train Volume Index ❑ 1 = 1-80 trains per day ❑ 2 = 81-160 trains per day ❑ 3 = 161-240 trains per day ❑ 4 = 241-320 trains per day ❑ 5 = > 320 trains per day	0.30	
Whistle Prohibition	Whistle Prohibition Index ❑ 1 = Whistling not prohibited ❑ 5 = Whistling prohibited	0.10	
Train Operating Speeds/Speed Differentials	Train Operating Speed Index ❑ 1 = Low operating speeds/differentials ❑ 3 = Medium operating speeds/ differentials ❑ 5 = High operating speeds/differentials	0.20	
Total Score		1.00	

An application of this qualitative screening model is provided in **Appendix I.** The model includes a ranking of the 47 Canadian multi-track at-grade crossings where sufficient data was readily available as provided by the PSC members. It should be recognized that the crossing characteristic data in Appendix I represents the best summary of readily available data on multiple track locations; however, some of the values included may not be representative of existing operating conditions at the locations specified.

19.3.2 Quantitative Screening – "Exposure to Risk" Model

After all RRIs are ranked using the qualitative screening model, the highest-risk sites with the greatest potential for a second train collision occurrence will be selected for further detailed investigation. This more rigorous process is to be carried out using a quantitative model. In order to implement the quantitative model, it will be necessary to collect relevant quantitative data for the short-listed sites and to conduct on-site audits to record/document the site-specific criteria such as visibility and warning system configuration. The two basic types of data required at each of the RRIs in order to compare and prioritize them on a quantitative basis are:

1) Daily pedestrian volume counts, in one hour increments, for a typical day; and
2) Daily second train event counts, in one-hour increments, under typical railway operations.

If these data were available, this would permit the ability to develop an "Exposure to Risk" Index for prioritizing sites for STW system installation.

<u>**Exposure (to risk) Index**</u>

The Exposure (to risk) Index (hereafter referred to as the "exposure index"), or train "meets" occurring with pedestrian presence, is the best quantitative criterion to use for prioritizing site locations. Using the relative proportion of pedestrian daily crossing counts at an RRI (the proportion is computed for each RRI being considered) in conjunction with the expected number of train "meets" per day at an RRI, an index measuring the exposure to risk (the likelihood of train "meets" and pedestrian presence) can be estimated. The exposure index is calculated with the following equation:

$$EX = PX/PT * STX$$

where:

E_X = Exposure index at site RRI_X
P_X = Pedestrian volume at RRI_X
P_T = Total pedestrian volume at all short-listed sites
ST_X = Number of second train events at RRI_X

For example, if the relative proportion of RRI_A pedestrian volume is 0.1 (or 10% of the pedestrian volume for all RRIs being considered) and the expected number of train "meets" is 10, then the exposure index is 0.1 times 10, which equals 1.0. For RRI_B, if the relative proportion of pedestrian volume is 0.05 (or 5% of the pedestrian volume for all RRIs being considered) and the expected number of train "meets" is 12 then the exposure index is 0.05 times 12, which equals 0.6. Therefore RRI_A would be preferred, even though it has less train "meets" then RRI_B, because the pedestrian volume is double that of RRI_B.

Using this type of comparison method for all RRIs would provide an exposure index as a criterion for ranking the RRIs for STW system implementation.

Data Requirements

The ability to effectively develop an accurate, quantitative exposure index for each RRI is totally dependent on the amount and detailed level of data available, particularly "pedestrian volume" data and "train volume/second train incident" data.

Pedestrian Volume Data Collection

It is not possible to implement the above prioritization methods without obtaining further pedestrian volume data. As noted earlier, only 47 out of 255 sites in the preliminary list of potential sites have pedestrian counts available. It is therefore recommended that pedestrian volume counts be conducted at all short-listed sites. The counts should be conducted for the eight-hour peak period of the day (e.g., 6-9 a.m., 11 a.m. - 1 p.m., 3-6 p.m.). The counts should be undertaken for a one-week period. If this is not possible, at least a typical count during a weekday and a weekend count should be obtained. It is important that a typical one-week pedestrian count is available so that it can be correlated with train volume/second train incidents data.

This data, once available, will serve as part of the information for developing the exposure index. The counts not only serve as a needed input for prioritizing sites for STW implementation consideration, but will also help in the evaluation of the STW system's effectiveness later.

Train Volume/Second Train Incidents Data Collection

It is imperative that a prediction of the likelihood of second trains coming together at each RRI is computed. This provides the second part of the data necessary for computing the exposure indexes. There are different approaches/methods that could be considered for obtaining this data. Each one offers a different level of detail, resulting in varying levels of accuracy and precision with respect to the ability to predict the expected frequency of a pedestrian presence with a second train incident event.

The most basic method would be to obtain train schedules from the train scheduling department(s) of the respective rail operators for all trains passing the RRI by time of day. With this information, it may be possible to estimate the expected number of train "meets" per day at the RRI, thereby making it possible to predict potential "second train incidents" occurrence. This method is not expected to provide sufficient information for computing accurate estimates of second train incidents due to the fact that schedules can change or vary, and are subject to random changes due to various reasons, e.g., delays, etc. Therefore, scheduling information could be used, but is considered unreliable for the prediction of second train incidents.

The preferred method would be to count (directly) the number of second train incidents that occur over a specified period of time. This information could be collected at the short-listed sites through manual counts or rail monitoring equipment installed at a limited number of sites across Canada. As with the pedestrian volumes, it is suggested that one week of data (eight hours per day) be collected. Furthermore, the exact time of the second train incidents could be recorded as well. With this information available, it would be possible to correlate it with the pedestrian volume count distributions (by day of week, if available) to predict the total amount of pedestrian presence with second train incidents occurrences with a high level of precision and accuracy. This would then provide the needed data inputs into the Prioritization Modelling Methods for predicting the highest risk site locations based on exposure.

Summary

Detailed pedestrian volume counts and second train incidents counts are currently not available for most RRIs. In order to prioritize the RRIs fairly using a common set of Site Location Criteria and generic Prioritization Modelling Methods, it is essential that counts for these two key criteria are available for all RRIs being considered for STW implementation. With the availability of pedestrian daily crossing counts at an RRI (as a percentage of all pedestrian daily crossings at the sites in Canada), in conjunction with the expected number of train events per day at an RRI (i.e., number of second train events per day), an index measuring the “exposure to risk” can be estimated for each RRI. Using this type of comparison method for all RRIs would provide a direct quantitative “Exposure to Risk” Index as the major criterion for ranking the RRIs for STW system implementation.

Once the “Exposure to Risk” Index is calculated, the sites would be ranked in ascending order. This index could be supplemented with the other qualitative criteria discussed in **Section 19.2** in order to arrive at a final prioritization index for each RRI.

20. FINDINGS

1. Location criteria were developed through the course of the Phase 1 study and reflected physical and operational characteristics that could be used to identify locations that have a high risk of a second train collision. Through the research undertaken regarding second train systems and events, supplemented by discussions with the PSC, the following location criteria were developed for application in Phase 1:

   - Multiple track roadway-rail intersection;
   - Collision history;
   - High pedestrian volumes;
   - Number of second train events;
   - High train volumes in both directions;
   - Whistle prohibition;
   - Visibility;
   - Train operating speeds;
   - Train warning system in use.

2. Three Toronto area sites and six Montreal area sites were identified by the PSC as potential pilot project sites for the second train warning system. Site audits were undertaken at all the short-listed sites. Based on a review of the site suitability and an evaluation of the candidate sites using the location criteria, the O'Brien Avenue crossing of the Deux-Montagnes Line in Ville Saint-Laurent, Quebec, was identified as the preferred candidate site. CN required that its staff would be responsible for the design, installation and maintenance of the second train warning and monitoring systems associated with the pilot project.

3. General specifications for the STW system were developed. It was determined that the following details should be addressed in the specification:

   - Activation logic;
   - Sign location and number;
   - Auxiliary lights and sounds;
   - Bilingualism;
   - Fail-safe requirements;
   - Sign content during second train events;
   - Sign content during "non-second train" periods (LED signs);
   - Sign mounting and location;
   - Sign dimensions; and
   - Manufacturing costs.

4. Two types of warning systems were evaluated. Type 1 signs were LED signs, which would display two alternating messages/displays upon detection of a second train event. The first display would be an image of two trains and the second image would be the words " Attention!" and "2 Trains". The Type 2 signs would be static warning signs with a tab sign. Flashing beacons, mounted on either side of the sign, would be activated upon a second train event. The sign would state "Attention! 2 Trains" and the tab would indicate "When Flashing" (English) or "Quand Les Feux Clignotent" (French). Based on an evaluation of the two signs it was determined that the Type 2 static signs would be installed at the pilot test site.

5. A risk-mitigation cost-benefit model was developed to determine the net benefits of providing a second train warning system at a crossing in Canada. The following characteristics and facts were incorporated into the model:

   – Cost of the second train warning system;
   – Societal cost of "The Loss of a Human Life";
   – Delay to passenger trains resulting from a second train collision;
   – Cost of passenger time;
   – Delay to freight trains resulting from a second train collision; and
   – Anticipated effectiveness of a second train warning system.

6. The sign comprehension survey undertaken in April 2002 at Montreal's Central Station indicated that there was a good understanding of the content of the STW warning sign. Approximately 83% of the respondents understood the sign content.

7. The STW system, including the STW warning signs, beacons and the video logging equipment, was installed without issue at the O'Brien Avenue crossing of the Deux-Montagnes CN line.

8. The total number of "before" and "after" observations at the STW pilot test site was 1,804 and 509, respectively. Comparing the "before" and "after" violation rates, the STW system appears to have decreased the violation rate by approximately 64%. Provided in **Table 20-1** is a summary of the violation rates for the various road users.

Table 20-1 Comparison of "Before" and "After" Violation Rates at Pilot Test Site

Road User Type	Before Violation Percentage	After Violation Percentage	Percent Decrease
Pedestrian	82.7%	30.6%	- 64%
Cyclist	93.0%	32.8%	- 64%
All	86.1%	30.8%	- 64%

9. The 95% confidence limits surrounding this estimator are:

10. (**26.8%, 34.8%**) for the "after" data, meaning that the percentage of violators is expected to be between 26.8% and 34.8% for 95 samples out of every 100 taken, that have at least 509 "person-train incident" videotaped events, and

11. (**84.5%, 87.7%**) for the "before" data, meaning that the percentage of violators is expected to be between 84.5% and 87.7% for 95 samples out of every 100 taken, that have at least 1,804 "person-train incident" videotaped events.

12. The 95% confidence limits for the estimators derived from the "before" and "after" data provide conclusive evidence that the percentage of violations with an STW system in place is significantly lower statistically than without an STW system in place.

13. From the results of the Before and After Effectiveness Evaluation conducted using the data collected at the O'Brien Avenue RRI, the Type 2 Static Sign STW system was found to be very effective at reducing pedestrian (as well as cyclist) violations. Taking the sample sizes

and the sampling errors into account, it is expected that pedestrian violations will be reduced anywhere between 49% and 75% by the implementation of a Type 2 STW system.

14. The Type 2 Static Sign STW system is not cost beneficial over a 15-year service life period. The cost-benefit ratio is anywhere between 0.52 and 0.79 for a 15-year service life period (the upper 95% confidence limit of 0.79 is less than 1.0). Based on a review of other STW installations in North America, the static sign STW installation at the pilot test site was as effective in reducing risky behaviour by pedestrians as the active LED STW systems.

15. As the cost of the Type 1 (active LED) signs is greater than that of the Type 2 static signs, the cost-benefit ratio for the Type 1 signs would be less than that reported in item 12.

16. The cost of materials for the pilot test site was approximately $14,685, including taxes, and the labour costs were approximately $77,175, for a total installation cost of $91,860. These costs reflect the supply and installation of the video surveillance equipment, which would not be included in a general installation of an STW system.

17. It is estimated that a general deployment of an STW system would cost approximately $64,790 including materials ($20,519.34) and labour ($44,273.41). The installation costs represent approximately two thirds of the cost of installation. It is anticipated that the cost of installation would be less if the STW system were installed as part of new at-grade crossing construction or crossing upgrade.

18. The cost of an STW deployment will be a function of the following:

    – Site location and configuration, including number of tracks;
    – Roadside environment and constraints;
    – Installation rates;
    – Type of installation, i.e., retrofit, upgrade or new installation; and
    – Number of installations deployed.

19. Based on a review of the effectiveness and installation of the static sign STW system at the O'Brien Avenue crossing, the initial functional specification developed in Phase 1 was refined for general deployment and includes:

    – Activation logic;
    – Sign location and number;
    – Auxiliary lights and sounds;
    – Bilingualism;
    – Fail-safe requirements;
    – Sign content during second train events;
    – Sign content during "non-second train" periods (LED signs);
    – Sign mounting and location; and
    – Sign dimensions.

20. It was determined that a quantitative priority ranking model, supplemented by qualitative location criteria, would be the best method for ranking the at-grade crossings in Canada with the potential for second train collisions.

21. Based on a review of the location criteria developed in Phase 1 and the availability of data, it was determined that a qualitative model would be used to generate a short list of sites that

have a higher potential of second train events. The qualitative model would be based on a weighted index of the following site attributes:

- Pedestrian volumes;
- Train volumes;
- Whistle prohibition; and
- Train operating speeds and/or speed differentials.

22. Data/information collection efforts will be required by the various operating agencies to develop the qualitative model; however, local knowledge of the crossing locations would generate the majority of the information required to build the model.

23. Subsequent to the qualitative screening process, data collection efforts will be required at the short-listed sites to collect the following information to develop the quantitative ranking model:

- Daily pedestrian volumes; and
- Daily second train event volumes.

21. RECOMMENDATIONS

Based on the findings of Phases 1 through 3 of the project, the following are recommended:

1. STW warning systems should be pursued at sites with a high risk of second train incidents/collisions.

2. Data collection efforts should be undertaken to complete the qualitative screening process. The qualitative model included in Appendix I should be updated to provide a complete qualitative assessment of all RRIs in Canada with the potential to have second train collisions.

3. Once completed, the results of the qualitative screening should be used to establish a short list of sites to complete full site audits and data collection efforts to develop the quantitative priority ranking model.

4. Studies should be conducted to continuously monitor locations after the installation of STW systems and measure the long-term effectiveness of the STW systems.

5. As pedestrian and train volumes (i.e., “exposure to risk”) as well as operational and environmental characteristics at the various RRIs are expected to change over time, it is imperative that recommendations 1 through 4 are repeated on a regular basis. This will ensure that resources and funds are used as efficiently as possible in order to maximize the safety benefits.

REFERENCES

Hauer, E., *Observational Before-After Studies in Road Safety*, Pergamon, Oxford, U.K., 1997.

Khawani V., *Second Train Coming Warning Sign Demonstration Project*, Paper No. 01-2590, LACMTA Office of System Safety and Security, Los Angeles, (undated).

Korve H., et al., *Pedestrian Control Systems for Light-Rail Transit Operations in Metropolitan Environments*, Seventh National Conference on Light Rail Transit, 1995.

Manual of Uniform Traffic Control Devices, Transportation Association of Canada, 1998.

Miller, T.R., Viner J., Rossman S., Pindus N., Gellert, W., Douglass, J., Dillingham, A., Blomquist, G., *The Cost of Highway Crashes*, FHWA, 1991.

Savage, I., *The Economics of Railroad Safety*, Kluwer Academic Publishers, 1998.

Second Train Coming Warning Sign Demonstration Project, TCRP Project No. A-5A(2), MMTA and Sabra Wang & Associates, Baltimore, 1999.

Standard Alphabets for Highway Signs and Pavement Markings, U.S. Department of Transportation, FHWA, 2000.

Standard Highway Signs Metric Edition, U.S. Department of Transportation, FHWA, 2002.

Stewart, D. E., *Methodological Approaches for the Estimation, Evaluation, Interpretation and Accuracy Assessment of Road Travel 'Basic Risk', 'Relative Risk' and 'Relative Risk Odds-Ratio' Performance Measure Indicators: A 'Risk Analysis and Evaluation System Model' for Measuring, Monitoring, Comparing and Evaluating the Level(s) of Safety on Canada's Roads and Highways*, Road Safety, Transport Canada, Transport Canada Publication # TP 13238, Ottawa, Ontario, 1998.

Van Houten R., and Malenfant L., *ITS Animated LED Signals Alert Drivers to Pedestrian Threats*, ITE Journal, 2001.

APPENDIX A

LITERATURE REVIEW SUMMARY

Provided in Table A-1 is a summary of the references used for the literature review for the second train warning project. Following Table A-1 is a description of each reference.

Table A-1 Second Train Warning Publications Summary

Document	Key Components
1. Terms of Reference for Study of a Second Train Warning System at Road Crossings for Pedestrians, Transport Canada, July 1998	Incident reports, candidate sites, example projects, technologies and evaluations.
2. Identification of Second-Train Warning Systems for Pedestrians, TP 13018, Transportation Development Centre, Transport Canada, May 1997	Candidate Second Train Warning systems.
3. Session 8 – Light Rail Transit Systems, Hartsock, V., Grade Crossing Technologies – The New Millennium, Texas Transportation Institute, October 1999	Site selection, sign development, activation logic and circuitry for a number of North American projects (Los Angeles, Massachusetts, Portland etc.)
4. New Technologies for Improving Light-Rail Grade Crossing Safety, Meadow, L. and Curry, J., Seventh National Conference on Light Rail Transit, November 1995	Safety and enforcement issues, grade crossing new technology review, demonstration projects
5. Pedestrian Control Systems for Light-Rail Transit Operations in Metropolitan Environments, Korve H. et al, Seventh National Conference on Light Rail Transit, November 1995	Rail-pedestrian crossing environment, existing pedestrian control devices, static and dynamic second train warning signs, other pedestrian safety measures and pedestrian crossing design considerations.
6. Integration of Light Rail Transit into City Streets, Korve H. et al, Seventh National Conference on Light Rail Transit, November 1995	Pedestrian crossing treatment including STW systems
7. Second Train Coming Warning Sign Demonstration Project, Maryland Mass Transit Administration, February 1999	Sign selection and specifications, sign selection survey, signal control specifications, data collection activities/methods and before & after study results
8. Proceedings of the Second Workshop on Rail-Highway Grade Crossing Research, TP 13536, Transportation Development Centre, Transport Canada, November 2000	Incident reporting, data collection and integrity, collision analysis, human factors, current research initiative including STW systems.
9. Study of a Second Train Warning System at Road Crossings for Pedestrians – Transport Canada Meeting Minutes, September 1998	Second train incident characteristics, human factors and other STW project initiatives.
10. Second Train Coming Warning Sign Demonstration Project, Maryland Mass Transit Administration and Sabra, Wang & Associates, February 2001	This document is an updated report on the Maryland test site discussed in References #3 and #7. The STC warning sign demonstrated favourable results during the 30-day "after" period where illegal pedestrian and risky driver behaviour was reduced by 80%. The STW system was well received and understood.

Table A-1 Second Train Warning Publications Summary	
Document	**Key Components**
11. Second Train Coming Warning Sign Demonstration Project, Khawani V., Los Angeles County Metropolitan Transportation Authority	Site selection criteria, sign specifications and operations, data collection and evaluation and before and after studies.
12. Pedestrian Warning and Control Devices, Guidelines and Case Studies, Siques J., Korve Engineering Inc.	Discussion of various pedestrian safety treatments at rail-highway intersections including passive and active warnings.
13. Use of Animation in LED Pedestrian Signals to Improve Pedestrian Safety, Van Houten, R., et al., ITE Journal, February 1999	A review of pedestrian behaviour (primarily the observation of turning vehicles) before and after the installation of the "animated eyes" display on standard pedestrian heads.
14. ITS Animated LED Signals Alert Drivers to Pedestrian Threats, Van Houten, R., and Malenfant, L., ITE Journal, July 2001	A study of two applications of the "animated eyes" at a mid-block traffic signal and in a parking structure exit. The study focused on the changes to driver and pedestrian behaviour relating to watching for and yielding to one another at these critical locations.
15. The Economics of Railroad Safety, Savage, I., Kluwer Academic Publishers, 1998	The main part of the publication includes a discussion of the economics of rail safety including: The level of care taken by the rail operator, its employees and the public; Encouraging a higher level of care within the rail right-of-way by all parties; and The associated costs of a rail collision to each party.
16. The Cost of Highway Crashes, Miller et al., FHWA, 1991	The documents outlines the three measures of crash costs for highway collisions: Comprehensive Years lost plus direct costs; and Human capital
17. Grade Crossing Safety in the Chicago Area: An Environmental Analysis of the Potential Noise Impacts from the Swift Rail Development Act's Locomotive Horn Sounding Requirement, Laffey, S., Transportation Quarterly, Eno Transportation Foundation Inc., Volume 54, Number 1, Winter 2000	A study to review the number of residents and institutions impacted by train whistle blowing in Northeastern Illinois. The paper provides an overview of the spatial analysis undertaken to determine the implications of the horn-sounding requirement of the Swift Rail Development Act of 1994. In addition, a brief summary is provided from other sources of the collision potential of at-grade crossings with and without whistle-blowing restrictions.
18. Second Train Warning – Project Implementation Plan, Transportation Development Centre, Transport Canada, July 2000	The Project Implementation Plan included a summary of the second train warning project objective, background (including Transport Canada and other STW initiatives), study implementation approach and work processes and estimated schedule.

Reference #1

Document Title: Terms of Reference for Study of a Second Train Warning System at Road Crossings for Pedestrians

Author/Source: Transport Canada

Date: July 1998

The document contains:

- Transportation Safety Board of Canada occurrence investigation that took place in 1995 and involved two trains (R95D005). The second train incident resulted in the fatal injury of two high school students.
- A list of fatal collisions involving trains from 1988-1998. The table lists the subdivision, types of injury, province, time, type of train, speed, and whether or not a second train was involved. It also contains some comments regarding the collision (i.e. victim and train actions prior to collision).
- List of pedestrian collisions involving a second train between 1988-1998. These are more detailed than the previous list.
- List of crossings with a potential for second train collisions including number of tracks, maximum train speed, number of pedestrians, vehicle volume, whistling prohibition status and type of warning system.

Reference #2

Document Title: Identification of Second-Train Warning Systems for Pedestrians

Author/Source: Transport Canada

Date: May 1997

This document presents the findings involved in a search to identify technologies that are already in use to alert pedestrians at a railway crossing when a second train is approaching. The warning systems covered are located in the U.S., European Union, and Japan. The report explains in detail the sign, the technology behind the sign (lights, bells etc.), the criteria for installation as well as information regarding whether or not any collisions have occurred since the installation.

Reference #3

Document Title: Session 8 – Light Rail Transit Systems

Author/Source: Vern Hartsock

Event/Date: Grade Crossing Technologies – The New Millennium, October 1999

The Federal Transit Administration issued a grant to the Maryland MTA to design, build and study the effectiveness of a prototype second train warning (STW) sign for use at light rail highway grade crossings. In September of 1998, the Maryland MTA activated the prototype.

The Maryland MTA test site chosen was the Timonium Road Grade Crossing. Warning devices used are a bell, flashing lights and crossing gates. All these are activated when a train is approaching. At this particular site, two trains at close to the same time frequently activate the grade crossing equipment.

Two scenarios were tested when a second train incident was triggered. In the first scenario, the crossing gates would remain horizontal after the first train had gone through and stay that way until the second train had completely passed. Under the second scenario, the gates would begin to rise after the passing of the first train. This would only last a few seconds whereby the crossing gates would go down again due to the approach of the second train. The factor that determines which scenario occurs is totally dependant on the meeting point of the two trains.

As for the sign selection, variable message LED signs were chosen for the STC sign. Amber strobe lights that attract the motorists' attention were installed near each STC sign and are activated at the same time as the STC signs. The LED signs consist of three parts:

1) **WARNING** for a period of 2 seconds;
2) **2nd Train Coming** for a period of 2 seconds; and
3) 5 second animation showing two trains moving in the opposite direction.

This process repeats until both trains have completely passed.

Another component of the project involved the installation of four WALK/DON'T WALK signals to govern the pedestrian movements across the tracks. It displays WALK all the time and changes to a FLASHING DON'T WALK for 13 seconds followed by DON'T WALK until the trains have cleared and gates are in the upward position.

A study revealed that the first scenario caused a decrease of occurrences (risky behaviour) by 86% while the second scenario (where the gates rise for a while before the second train arrives) caused a decrease of 26%.

Reference #4

Document Title: New Technologies for Improving Light-Rail Grade Crossing Safety

Author/Source: Linda J. Meadow, James P. Curry

Event/Date: Seventh National Conference on Light Rail Transit, November 1995

LRT most critical areas of concern:

- Motorists' disobedience of traffic laws;
- Motorists' confusion over traffic signals; and/or
- Pedestrian inattention or confusion.

The Metro Blue Line (MBL) in Los Angeles experienced a high number of fatalities. The Maryland Mass Transit Administration is applying a variety of solutions. The safety program includes four elements:

- Enforcement of traffic regulations using police officers and photographic systems;
- Engineering improvements i.e. ITS, warning devices, and signal improvements;
- Legislation for higher fines as well as safety educational programs; and
- Bilingual public information.

ITS technologies include the installation and operation of photographic enforcement systems, trial installation of a four-quadrant crossing gate system, use of dynamic displays, and automated wayside horns. All these technologies except for the dynamic displays are described in the project.

Photographic enforcement had been completed on five demonstration projects and 17 crossings were underway. The system consists of high-resolution cameras that take pictures of violators. These violators are in turn handed citations. All results point to a significant decrease in the amount of violations, as well as the number of collisions.

Some factors to consider for the system installation:

- Efficient placement of cameras;
- Detector loops placement; and
- Citation processing details with required authorities.

The four-quadrant crossing gate system is designed to minimize or possibly eliminate grade crossing collisions without the high cost (four quadrants are formed by the rail tracks and the street). The gates at both entrances and exits (all 4 directions) completely close off the crossing. The system can potentially decrease the number of collisions caused by motorists driving around closed crossing gates from the crossing street and who are hit by a second train as it passes through the crossing. The report also lists the existing North American four-quadrant gate installations as well as the design approach and assumptions.

Reference #5

Document Title: Pedestrian Control Systems for Light-Rail Transit Operations in Metropolitan Environments

Author/Source: Hans W. Korve, Jose I. Farran, Douglas M. Mansel

Event/Date: Seventh National Conference on Light Rail Transit, November 1995

The aim of this research project was to expand on the potential methodology for selecting one or more pedestrian crossing control treatments for installation at a given pedestrian location.

The document discusses the following:

- Pedestrian crossing environments and characteristics;
- Recommended pedestrian control devices;
- Pedestrian design considerations; and
- Types of pedestrian crossing control treatments.

The following pedestrian crossing treatments are reviewed/discussed:

- Automatic gates;
- Swing gates;
- Z-crossings; and
- Bedstead barriers.

Reference #6

Document Title: Integration of Light Rail Transit into City Streets

Author/Source: Hans W. Korve, Jose I. Farran, and Douglas M. Mansel

Event/Date: Seventh National Conference on Light Rail Transit, November 1995

This document has the same authors as *Pedestrian Control Systems for Light-Rail Transit Operations in Metropolitan Environments* and generally includes a discussion of the same material.

Reference #7

Document Title: Second Train Coming Warning Sign Demonstration Project

Author/Source: Maryland Mass Transit Administration

Date: February 1999

This report is a more detailed documentation of the study included in Vern Hartsock's report at the "Grade Crossing Technologies – The New Millennium" conference.

Some relevant information includes:

- Selecting sign size, messages and displays;
- The use of closed circuit television cameras for data collection; and
- A definition of risky behaviour.

Reference #8

Document Title: Proceedings of the Second Workshop on Rail-Highway Grade Crossing Research

Author/Source: Transportation Development Centre, Transport Canada

Date: November 2000

A compilation of the following presentations:

- Rail-Highway Grade Crossing Research Program – Update;
- U.S. Directions in Research and the Expectations;
- Grade Crossing Accidents: Investigating the Aftermath;
- Occurrence Data: an Integrated Approach to Data Integrity and Accessibility;
- Analysis of Collision Data: Expectations and Reality;
- A Human Factors Analysis of Rail-Highway Grade Crossing Accidents;
- Database of Operation Lifesaver Information (DOLI);
- FRA Safety Web Page;
- Grade Crossing Regulations;
- Trespassing and Suicide: Dealing with Human Tragedy;
- Low-Cost Active Warning System at Low-Volume Crossings – The Answer for the Lonely Crossbuck?;
- Automated Horn System Study;
- Motor Carrier Safety Ratings and Grade Crossing Safety Contraventions;
- Second Train Warning Signs for Light Rail;
- A Video Sensor for Automated Enforcement and Safety Monitoring of Grade Crossings; and
- Wheel Counters for North American Signalling Systems.

Reference #9

Document Title: Study of a Second Train Warning System at Road Crossings for Pedestrians

Author/Source: Transport Canada Meeting minutes

Date: September 1998

This is a summary of a September 23, 1998 meeting in Toronto to discuss the issue of second train collisions. Discussions at the meeting included:

- Collision characteristics of second train incidents in Canada between 1988 and 1998;
- Human behaviour at second train incidents;
- Existing second train warning systems in North America; and
- Transport Canada's research project.

Reference #10

Document Title: Second Train Coming Warning Sign Demonstration Project

Author/Source: Maryland Mass Transit Administration and Sabra, Wang & Associates

Date: February 2001

This document is an updated report on the Maryland test site discussed in References #3 and #7.

The STC warning sign demonstrated favourable results during the 30-day "after" period where illegal pedestrian and risky driver behaviour was reduced by 80%. The STW system was well received and understood.

Reference #11

Document Title: Second Train Coming Warning Sign Demonstration Project

Author/Source: Vijay Khawani, Los Angeles County Metropolitan Transportation Authority

Date: N/A

This document is a summary of the second train warning system demonstration project undertaken on Los Angeles County Metropolitan Transportation Authority's Metro Blue Line.

The key aspects included in this report include:

- Site selection criteria;
- Selection and evaluation of a warning sign;
- Activation criteria;
- Public information plans;
- Data collection and evaluation methodologies; and
- Before and after studies.

Reference #12

Document Title: Pedestrian Warning and Control Devices, Guidelines and Case Studies

Author/Source: Joaquin Siques, Korve Engineering Inc.

Date: N/A

The contents of this document generally follows the information/discussions provided in References #5 and #6.

Reference #13

Document Title: Use of Animation in LED Pedestrian Signals to Improve Pedestrian Safety

Author/Source: Ron Van Houten, Richard Retting, Joy Van Houten, Charles Farmer and Louis Malenfant, ITE Journal

Date: February 1999

The "animated eyes" display includes a LED panel with a pair of eyes which, when activated, look from side to side. In this particular study the animated eyes display was incorporated into a standard LED pedestrian head with the "WALK" and "DON'T WALK" symbols. The purpose of the "eyes" is to remind pedestrians to look both ways for turning traffic while they are crossing.

A number of variations were tested to determine the pedestrian's reactions to the "eyes" and the time at which they were activated/maintained in relation to the "WALK" signal. It was determined that the optimal time to activate the eye animation was concurrent with the "WALK" indication.

In the "before" observations, the number of pedestrians that did not look for turning vehicles ranged from 26 to 32 percent between the two study locations. With the installation of the animated eyes display, the number of pedestrians that did not look for these conflicts was reduced to 5 to 10 percent.

Overall, the pilot test demonstrated a sizeable decrease in the percentage number of pedestrians not looking for turning vehicles. This change in behaviour reduced the number of the pedestrian-vehicle conflicts.

Reference #14

Document Title: ITS Animated LED Signals Alert Drivers to Pedestrian Threats

Author/Source: Ron Van Houten and Louis Malenfant, ITE Journal

Date: July 2001

This study focused on the same type of LED display outlined in Reference #13. The study focused on the installation of the "animated eyes" LED sign at a parking garage exit and a mid-block signal. The two primary measures of effectiveness included the number of drivers looking in the direction of the approaching pedestrian and the number of motorists yielding to these pedestrians. The "before" and "after" observations suggested that the LED display produced a minimum 50% improvement in the number of motorists looking for pedestrians at the two critical locations. In addition, the number of motorists yielding to the approaching pedestrian increased by approximately the same magnitude.

Reference #15

Document Title: The Economics of Railroad Safety

Author/Source: Ian Savage, Kluwer Academic Publishers

Date: 1998

The first section of the book outlines the railroad safety issue including the types of collisions, the nature of the fatality/injury, fatality rates, warning system use at collision sites and reported collision cause. Following this introduction is a discussion of historical and current safety regulations in the rail industry and how railroad risks compare to other hazards in society.

The main part of the publication includes a discussion of the economics of rail safety including:

- The level of care taken by the rail operator, its employees and the public;
- Encouraging a higher level of care within the rail right-of-way by all parties; and
- The associated costs of a rail collision to each party.

Finally, the latter part of the publication includes an evaluation of the existing regulations and possible improvements for the safety regulation strategies in the rail industry.

Reference #16

Document Title: The Cost of Highway Crashes

Author/Source: Miller T.R., Viner J., Rossman S., Pindus N., Gellert, W., Douglass, J., Dillingham, A., and Blomquist, G., FHWA

Date: 1991

The documents outlines the three measures of crash costs for highway collisions:

- Comprehensive
- Years lost plus direct costs; and
- Human capital

The first three sections of the book outline the cost components and values that are used to establish the three methods of cost calculation noted above. The remainder of the document provides insight into societal safety priorities, the responsibility for crash costs and a number of worked examples of collision costs.

Reference #17

Document Title: Grade Crossing Safety in the Chicago Area: An Environmental Analysis of the Potential Noise Impacts from the Swift Rail Development Act's Locomotive Horn Sounding Requirement

Author/Source: Stephen C. Laffey, Transportation Quarterly, Eno Transportation Foundation Inc., Volume 54, Number 1

Date: Winter 2000

This report includes a summary of the spatial analysis undertaken to determine the number of residents and other land uses that would be affected by the train horn blowing stipulations specified by the Swift Rail Development Act of 1994 in northeastern Illinois. Current operating practice in northeastern Illinois is for the train operator to not sound the horn when approaching approximately 890 of their 1,950 at-grade crossings. A GIS-based system was used to look at the noise impacts if horn sounding was undertaken at all the crossings in this region. The author refers to a number of Federal Railroad Association (FRA) studies to outline the safety impacts of horn blowing restrictions.

Reference #18

Document Title: Second Train Warning – Project Implementation Plan

Author/Source: Transportation Development Centre, Transport Canada

Date: July 2000

The Project Implementation Plan included a summary of the following as they related to the Second Train Warning at Grade Crossing project:

- Project objective;
- STW background including Transport Canada and other STW initiatives;
- Study implementation approach and work processes; and
- Estimated study duration.

APPENDIX B

SITE AUDIT FORM

Second Train Warning
Site Audit Prompt List

Site Visit Information	
Study Location/Intersecting Roadway:	
Railway Authority(s):	
Subdivision:	
Mileage:	
Municipality/Road Authority:	
Date:	
Time:	
Reviewed By:	
Weather/Road Conditions:	

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		
Visibility	Are there any fixed objects that could create visibility restrictions for the train operator?		
Trains	What types of trains operate on this line?		
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		
Second train events	Did you observe any second train events while you were at the site?		
Second train incidents	Did you observe any second train incidents while you were at the site?		
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		
	Is there a train station in close proximity to the RRI?		
	Where are the parking lot locations in comparison to the RRI?		
	What are the primary generators of vehicles, pedestrians and/or cyclists?		
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		
	Are there any opportunities to improve the active warning systems at the site?		
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		
Passive devices	Are there any passive warning devices other than “crossbucks” installed at the RRI? Are they in good condition?		
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		
	Are there any opportunities to improve the passive devices at the site?		
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		

Item	Issue to Be Considered	√	Comments
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		
	Are they in good condition?		
	What are the widths of the sidewalk/walkways?		
	Are the pedestrian movements primarily on one side versus the other?		
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		
	How would you describe the level of pedestrian activity during your site visit? (low, medium, high)		
	Were pedestrians observed within the RRI while the rail warning devices are activated?		
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		
	What is the estimated AADT of the roadway in the vicinity of the RRI?		
Lanes	How many lanes is the roadway in the vicinity of the RRI?		
Operating speed	Based on visual observations, what is the prevalent operating speed?		
Access	What level of land access is provided in proximity to the RRI?		
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		

Item	Issue to Be Considered	√	Comments
General operations	Are there any site specific roadway operating conditions that should be noted?		

APPENDIX C

COMPLETED SITE AUDITS

MONTREAL AND TORONTO SITES

Second Train Warning – Site Audit Prompt List
Tannery Street – Mississauga, Ontario

Site Visit Information	
Study Location/Intersecting Roadway:	Tannery Street
Railway Authority (s):	CP Rail
Subdivision:	Galt
Mileage:	20.85
Municipality/Road Authority:	City of Mississauga
Date:	April 23, 2001
Time:	11:30 a.m.
Reviewed By:	R. Brownlee, R. Stewart
Weather/Road Conditions:	Clear, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		2 mainline tracks
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Generally straight
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Fair – some trees and poles on sight triangles
Trains	What types of trains operate on this line?		Go Transit – three in the AM and three in the PM peak Freight – approx. 18 per day
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		Unknown
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		Not apparent
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Residential and school to the west Commercial, high-rise residential to the east
	Is there a train station in close proximity to the RRI?		Greater than 300 metres to the south
	Where are the parking lot locations in comparison to the RRI?		N/A
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Mixed uses including school
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		School arrival and departure Noon hour between the school and commercial area
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Sidewalk is located outside the gates
	Are there any opportunities to improve the active warning systems at the site?		Stop pedestrians from walking around gates Move gates behind sidewalk
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		Teenaged pedestrians “playing” with gate arm while down Pedestrians walked across before gate was fully up and bells stopped
Passive devices	Are there any passive warning devices other than “crossbucks” installed at the RRI? Are they in good condition?		Yes – “Warning Double Rail Tracks – Wait for Gates to Rise”
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Both approaches of the RRI – to the right of the sidewalk
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event

Item	Issue to Be Considered	√	Comments
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Both sides
	Are they in good condition?		Sidewalks are not well defined
	What are the widths of the sidewalk/walkways?		Approx. 1.5 metres
	Are the pedestrian movements primarily on one side versus the other?		Mainly on north side
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		A number of poles, vegetation and cabinet on northwest corner. Visibility from pedestrian perspective is good
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Very high – mainly school related traffic and some local residential traffic
	Were pedestrians observed within the rail warning devices while they are activated?		Yes
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Collector
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lanes
Operating speed	Based on visual observations, what is the prevalent operating speed?		Slow – approximately 40 km/h Rough crossing
Access	What level of land access is provided in proximity to the RRI?		Approximately 80 metres to the east is a north-south roadway

Item	Issue to Be Considered	√	Comments
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Rough crossing

Tannery Street Crossing – Westbound

Tannery Street Crossing – Eastbound

Second Train Warning – Site Audit Prompt List
Queen Street – Mississauga, Ontario

Site Visit Information	
Study Location/Intersecting Roadway:	Queen Street
Railway Authority (s):	CP Rail
Subdivision:	Galt
Mileage:	20.12
Municipality/Road Authority:	City of Mississauga
Date:	April 23, 2001
Time:	1:00 p.m.
Reviewed By:	R. Brownlee, R. Stewart
Weather/Road Conditions:	Clear, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		2 mainline tracks Spur line to the east, industrial access
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Rail line curved and super-elevated through RRI Super-elevated on the south
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Fair – some trees, poles and cabinet on sight triangles
Trains	What types of trains operate on this line?		Go Transit – three in the AM and three in the PM peak Freight – approx. 18 per day
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		Unknown
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		None apparent
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		High-rise residential to the northeast Service station to the immediate northeast Open field to southeast House on southwest corner Residential to the north and south, further from the RRI Commercial, high-rise residential to the east
	Is there a train station in close proximity to the RRI?		Greater than 300 metres to the northwest
	Where are the parking lot locations in comparison to the RRI?		N/A
	What are the primary generators of vehicles, pedestrians and/or cyclists?		High rise and other residential
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		No
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Sidewalk is located outside the gates
	Are there any opportunities to improve the active warning systems at the site?		Move gates behind sidewalk
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No
Passive devices	Are there any passive warning devices other than "crossbucks" installed at the RRI? Are they in good condition?		Yes – "Warning Double Rail Tracks – Wait for Gates to Rise" Maze barrier on the southeast sidewalk

Item	Issue to Be Considered	√	Comments
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Both approaches of the RRI – to the right of the sidewalk
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Only one pedestrian observed during visit
	Are they in good condition?		Discontinuous – No sidewalk is provided on the southwest corner of the RRI
	What are the widths of the sidewalk/walkways?		Approx. 1.5 metres
	Are the pedestrian movements primarily on one side versus the other?		Could not assess – only one pedestrian observed during visit
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Alignment of track reduces visibility
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Low
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Arterial
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lanes

Item	Issue to Be Considered	√	Comments
Operating speed	Based on visual observations, what is the prevalent operating speed?		Approximately 50 km/h Uneven crossing due to super-elevation
Access	What level of land access is provided in proximity to the RRI?		Driveway access for residential and service station. East-west roadway located approximately 50 metres to the north of the RRI. Truck traffic.
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Super-elevated crossing

Queen Street Crossing – Northbound

Queen Street Crossing – Southbound

Second Train Warning – Site Audit Prompt List
Brampton GO Station/Mill Street – Brampton, Ontario

Site Visit Information	
Study Location/Intersecting Roadway:	Mill Street
Railway Authority (s):	CN Rail
Subdivision:	Halton
Mileage:	15.4
Municipality/Road Authority:	City of Brampton
Date:	April 23, 2001
Time:	2:00 p.m.
Reviewed By:	R. Brownlee, R. Stewart
Weather/Road Conditions:	Clear, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		2 mainline tracks
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Cabinet on the SW corner
Trains	What types of trains operate on this line?		GO Transit Freight
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		Unknown
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		None apparent
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Manufacturing on SW and NW corners Car repair and residential to the SE Residential north and south – further from RRI
	Is there a train station in close proximity to the RRI?		Yes – east of RRI
	Where are the parking lot locations in comparison to the RRI?		Parking is located adjacent to station on north side of tracks Overflow parking for GO Station is located on SW of the RRI
	What are the primary generators of vehicles, pedestrians and/or cyclists?		GO Station and residential to the north
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		AM and PM peak periods (GO Station commuters)
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Sidewalk is located outside the gates
	Are there any opportunities to improve the active warning systems at the site?		Move gates behind sidewalk
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Northbound motorist approach the RRI on a curve
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No
Passive devices	Are there any passive warning devices other than "crossbucks" installed at the RRI? Are they in good condition?		*Yes – "Danger do not cross the tracks while the train is in the station"* *Signs are located along the walkway between the GO Station and the RRI*

Item	Issue to Be Considered	√	Comments
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		See above
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event while train is in station
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Sidewalks on both sides
	Are they in good condition?		Poor condition
	What are the widths of the sidewalk/walkways?		Approx. 1.5 metres
	Are the pedestrian movements primarily on one side versus the other?		Primarily on east side
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Supports for overhead signal structure
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Low to medium
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Major collector
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lanes
Operating speed	Based on visual observations, what is the prevalent operating speed?		Approximately 50 km/h

Item	Issue to Be Considered	√	Comments
Access	What level of land access is provided in proximity to the RRI?		Driveway access for GO located north of RRI East-west roadway (Railroad Street) located just south of RRI
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Horizontal curves approaching RRI on Mill Street

Mill Street Crossing – Northbound

Mill Street Crossing – Southbound

Warning Sign at Brampton GO Station

Second Train Warning – Site Audit Prompt List
3^{e} Avenue – Île Perrot, Quebec

Site Visit Information	
Study Location/Intersecting Roadway:	3^{e} Avenue
Railway Authority (s):	CN and CP Rail
Subdivision:	18.07 Vaudreuil (CP) and 23.57 Kingston (CN)
Mileage:	See above
Municipality/Road Authority:	Île Perrot
Date:	May 28, 2001
Time:	10:30 a.m.
Reviewed By:	R. Brownlee, R. Begin
Weather/Road Conditions:	Overcast, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		4 tracks (2 CN and 2 CP) approx. 15 metres in between two sets
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight alignment to the west and horizontal curve to the east
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Cabinets
Trains	What types of trains operate on this line?		Freight (24/day) and commuter (26/day) trains on CP Line Freight (32/day) and VIA (18/day) trains on CN Line
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		90 –105 km/h (freight) 100-150 km/h (passenger)
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		None apparent
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Retail, residential and light industrial north of the RRI Retail south of the RRI across the freeway
	Is there a train station in close proximity to the RRI?		Yes – approximately 200 metres to the west
	Where are the parking lot locations in comparison to the RRI?		Parking is located next to the station and does not impact on the operations of the RRI
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Residential and retail interactions
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		None apparent
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates No intermediate gates were present between the two sets of tracks.
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		No formal sidewalk areas through the RRI
	Are there any opportunities to improve the active warning systems at the site?		Pedestrian gates or intermediate gates
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		Yes. The warning system remained activated for a considerable time after a freight train passed through the RRI. Approximately 5 vehicles were observed to drive around the gates.
Passive devices	Are there any passive warning devices other than “crossbucks” installed at the RRI? Are they in good condition?		No
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		N/A

Item	Issue to Be Considered	√	Comments
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event.
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		No sidewalks provided through RRI, pedestrians walk on paved surface or gravel shoulder
	Are they in good condition?		N/A
	What are the widths of the sidewalk/walkways?		N/A
	Are the pedestrian movements primarily on one side versus the other?		Primarily on west side
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Some vegetation
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Medium – mid-day site visit
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Minor arterial
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lanes
Operating speed	Based on visual observations, what is the prevalent operating speed?		Approximately 50 km/h
Access	What level of land access is provided in proximity to the RRI?		Roadway intersections exist immediately north and south of the RRI

Item	Issue to Be Considered	√	Comments
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Roadway is on a skewed angle to the rail line

3^{e} Avenue – Northbound

3^{e} Avenue – Southbound

3^e^ Avenue – Southbound Looking East Along North Tracks

3^e^ Avenue – Southbound Looking West Along North Tracks

Second Train Warning – Site Audit Prompt List
Woodland Avenue – Beaconsfield, Quebec

Site Visit Information	
Study Location/Intersecting Roadway:	Woodland Avenue
Railway Authority (s):	CN and CP Rail
Subdivision:	12.15 Vaudreuil (CP) and 17.52 Kingston (CN)
Mileage:	See above
Municipality/Road Authority:	Beaconsfield
Date:	May 28, 2001
Time:	9:25 a.m.
Reviewed By:	R. Brownlee, R. Begin
Weather/Road Conditions:	Overcast, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		4 tracks (2 CN and 2 CP) approx. 15 metres in between two sets
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight alignment
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Cabinets Station to the west
Trains	What types of trains operate on this line?		Freight (24/day) and commuter (26/day) trains on CP Line Freight (32/day) and VIA (18/day) trains on CN Line
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		90 –105 km/h (freight) 100-150 km/h (passenger)
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		Interconnected signalized intersection north and south of the RRI
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Residential to the south North rural with some subdivision under development
	Is there a train station in close proximity to the RRI?		Yes – west of pedestrian crossing
	Where are the parking lot locations in comparison to the RRI?		Parking is located next to the station and does not impact on the operations of the RRI. "Kiss and Ride" area
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Residential and train station interactions
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		AM and PM commuter peaks
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates Intermediate pedestrian gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Gates behind the sidewalk on west side of roadway
	Are there any opportunities to improve the active warning systems at the site?		
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No
Passive devices	Are there any passive warning devices other than "crossbucks" installed at the RRI? Are they in good condition?		Yes, double track signs – refer to photos
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		To the right side of the walkways, some posted low

Item	Issue to Be Considered	√	Comments
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event. Post at a standard height
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		West side only
	Are they in good condition?		Yes
	What are the widths of the sidewalk/walkways?		2.0 metres
	Are the pedestrian movements primarily on one side versus the other?		Primarily on west side
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Station infrastructure and utility vaults
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Low – morning site visit
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Collector
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lanes at RRI 4 lanes just south of RRI
Operating speed	Based on visual observations, what is the prevalent operating speed?		Less than 50 km/h

Item	Issue to Be Considered	√	Comments
Access	What level of land access is provided in proximity to the RRI?		Roadway intersections exist immediately north and south of the RRI
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Signals interconnected to rail equipment

Woodland Avenue – Northbound

Woodland Avenue – Southbound

Woodland Avenue – Northbound East Sidewalk Area

Woodland Avenue – Southbound West Sidewalk

Woodland Avenue – Northbound Looking East

Woodland Avenue – Northbound Looking West

Second Train Warning – Site Audit Prompt List
Wilderton Avenue – Montreal, Quebec

Site Visit Information	
Study Location/Intersecting Roadway:	Wilderton Avenue
Railway Authority (s):	CP
Subdivision:	Adirondack
Mileage:	48.81
Municipality/Road Authority:	Montreal
Date:	May 28, 2001
Time:	1:00 p.m.
Reviewed By:	R. Brownlee, R. Begin
Weather/Road Conditions:	Overcast, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		2 mainline tracks and one siding
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight alignment to the west and horizontal curve to the east
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Signs and signal hardware
Trains	What types of trains operate on this line?		Passenger (10 trains/day) and freight (20 trains/day)
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		50 km/h (freight) 80 km/h (passenger)
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		Roadway intersections in close proximity north and south of the RRI
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Residential – combination of row-houses, single family and high-rise Some office uses Canora Station (passenger rail on CN electrified line) located just northwest of RRI
	Is there a train station in close proximity to the RRI?		Not on this line; however, refer to the above
	Where are the parking lot locations in comparison to the RRI?		N/A
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Residential
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		AM and PM peak
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Behind the sidewalks
	Are there any opportunities to improve the active warning systems at the site?		
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No.
Passive devices	Are there any passive warning devices other than "crossbucks" installed at the RRI? Are they in good condition?		No
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		N/A

Item	Issue to Be Considered	√	Comments
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		N/A
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Both sides of RRI
	Are they in good condition?		Yes
	What are the widths of the sidewalk/walkways?		1.5 metres
	Are the pedestrian movements primarily on one side versus the other?		No
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Few
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Low – mid-day site visit
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Arterial
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		4 lanes
Operating speed	Based on visual observations, what is the prevalent operating speed?		Slow due to the adjacent intersections
Access	What level of land access is provided in proximity to the RRI?		High

Item	Issue to Be Considered	√	Comments
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Signal interconnection

Wilderton Avenue – Northbound

Wilderton Avenue – Southbound

Wilderton Avenue – Northbound Looking West Along Tracks

Second Train Warning – Site Audit Prompt List
O'Brien Avenue – Ville Saint-Laurent, Quebec

Site Visit Information	
Study Location/Intersecting Roadway:	O'Brien Avenue
Railway Authority (s):	CN
Subdivision:	Deux-Montagnes
Mileage:	7.57
Municipality/Road Authority:	Ville Saint-Laurent
Date:	May 28, 2001
Time:	2:00 p.m.
Reviewed By:	R. Brownlee, R. Begin
Weather/Road Conditions:	Overcast, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		2 electrified mainline tracks
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight alignment to the west and horizontal curve to the east
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Utility poles
Trains	What types of trains operate on this line?		Commuter (50 trains/day) and freight
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		65 km/h (freight) 100 km/h (passenger)
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		Switching area to the west
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Residential and commercial
	Is there a train station in close proximity to the RRI?		No
	Where are the parking lot locations in comparison to the RRI?		N/A
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Residential and retail interactions
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		None apparent
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		In front of the sidewalks
	Are there any opportunities to improve the active warning systems at the site?		Move gates to the outside of the sidewalks
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No.
Passive devices	Are there any passive warning devices other than “crossbucks” installed at the RRI? Are they in good condition?		No
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		N/A
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		N/A

Item	Issue to Be Considered	√	Comments
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Both sides of RRI
	Are they in good condition?		Yes
	What are the widths of the sidewalk/walkways?		2.0 metres
	Are the pedestrian movements primarily on one side versus the other?		No
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		No
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		Medium – mid-day site visit
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Arterial
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lanes
Operating speed	Based on visual observations, what is the prevalent operating speed?		Approximately 50 km/h
Access	What level of land access is provided in proximity to the RRI?		High
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit

Item	Issue to Be Considered	√	Comments
General operations	Are there any site specific roadway operating conditions that should be noted?		None apparent

O'Brien Avenue – Northbound

O'Brien Avenue – Southbound

O'Brien Avenue – Southbound Looking West Along Tracks

O'Brien Avenue – Southbound, West Sidewalk

Second Train Warning – Site Audit Prompt List
Westminster Avenue/Elmhurst Street – Montreal, Quebec

Site Visit Information	
Study Location/Intersecting Roadway:	Westminster Avenue/Elmhurst Street
Railway Authority (s):	CP
Subdivision:	0.04 Vaudreuil and 4.48 Westmount
Mileage:	See above
Municipality/Road Authority:	Montreal
Date:	May 28, 2001
Time:	12:00 p.m.
Reviewed By:	R. Brownlee, R. Begin
Weather/Road Conditions:	Overcast, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		3 mainline tracks Montreal West Station
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight alignment to the east Horizontal curve to the west approaching Westminster
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Elmhurst – trees, fences, signs and train station Westminster – fences, trees, poles
Trains	What types of trains operate on this line?		Commuter (36 trains/day), ten of which do not stop at the station
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		0 to 30 km/h
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		No
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes

Item	Issue to Be Considered	√	Comments
Uses	What are the adjacent land uses?		Elmhurst – high and medium rise residential, park Westminster – commercial, office, residential
Adjacent Land Uses			
	Is there a train station in close proximity to the RRI?		Montreal West Station is between the Elmhurst and Westminster at-grade crossings
	Where are the parking lot locations in comparison to the RRI?		Parking area to the south of Elmhurst
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Residential
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		AM and PM peak
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Elmhurst – bells and gates Westminster – bells and gates, one pedestrian arm on the southwest sidewalk
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		Behind the sidewalks at Elmhurst Pedestrian arm on SW corner at Westminster
	Are there any opportunities to improve the active warning systems at the site?		Gates on both sides at Elmhurst
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No.
Passive devices	Are there any passive warning devices other than "crossbucks" installed at the RRI? Are they in good condition?		*Yes – Elmhurst* *No – Westminster*
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		

Item	Issue to Be Considered	√	Comments
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Both sides both locations
	Are they in good condition?		Yes
	What are the widths of the sidewalk/walkways?		Approximately 1.5 metres
	Are the pedestrian movements primarily on one side versus the other?		No
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Poles, fences and stations at both locations
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		High at both locations
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		Arterials
	What is the estimated AADT of the roadway in the vicinity of the RRI?		Not available
Lanes	How many lanes is the roadway in the vicinity of the RRI?		2 lane roadways
Operating speed	Based on visual observations, what is the prevalent operating speed?		40-50 km/h – Elmhurst 50 km/h – Westminster

Item	Issue to Be Considered	√	Comments
Access	What level of land access is provided in proximity to the RRI?		High – roads, park access, properties and office
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		Roadways slightly skewed to rail Police officers patrol tracks at Elmhurst to prevent pedestrians from entering track area during activation period.

Elmhurst Street – Northbound

Elmhurst Street – Southbound

Elmhurst Street – Northbound Looking East Along Tracks

Westminster Avenue – Northbound Looking West Along Tracks

Westminster Avenue – Northbound Looking East Along Tracks

Westminster Avenue – Southbound Looking East Along Tracks

Second Train Warning – Site Audit Prompt List
Baie d'Urfé Station – Baie d'Urfé, Quebec

Site Visit Information	
Study Location/Intersecting Roadway:	Baie d'Ufré Station Pedestrian Crossing
Railway Authority (s):	CN and CP Rail
Subdivision:	13.8 Vaudreuil (CP) and 19.21 Kingston (CN)
Mileage:	See above
Municipality/Road Authority:	Baie d'Urfé
Date:	May 28, 2001
Time:	10:00 a.m.
Reviewed By:	R. Brownlee, R. Begin
Weather/Road Conditions:	Overcast, dry

Item	Issue to Be Considered	√	Comments
Railway Function/Alignment			
Track configuration	How many tracks exist at the site? Are they mainline, siding, service, etc. tracks?		4 tracks (2 CN and 2 CP) approx. 15 metres in between two sets
Alignment	Describe the alignment of the tracks in the vicinity of the RRI.		Straight alignment
Visibility	Are there any fixed objects that could create sight visibility restrictions for the train operator?		Cabinets Station facilities to the east Some trees
Trains	What types of trains operate on this line?		Freight (24/day) and commuter (26/day) trains on CP Line Freight (32/day) and VIA (18/day) trains on CN Line
Operating speeds	What are the typical operating speeds for the various types of trains at the RRI location?		90 –105 km/h (freight) 100-150 km/h (passenger)
Operations	Are there any unusual or noteworthy operations in the vicinity of the crossing? (nearby switching, train car parking/storage)		Pedestrian crossing only
Second train events	Did you observe any second train events while you were at the site?		No
Second train incidents	Did you observe any second train incidents while you were at the site?		No

Item	Issue to Be Considered	√	Comments
Whistle blowing	Is a whistle blowing prohibition in effect at this location?		Yes
Adjacent Land Uses			
Uses	What are the adjacent land uses?		Residential to the south Freeway immediately to the south North rural with walkway to industrial area
	Is there a train station in close proximity to the RRI?		Yes – east of RRI
	Where are the parking lot locations in comparison to the RRI?		No parking
	What are the primary generators of vehicles, pedestrians and/or cyclists?		Residential and train station interactions
Operations	Are there any times of the day when pedestrian volumes will be significantly impacted by the operations at the adjacent land uses, i.e., passenger train arrivals, shift changes, school arrival/departure, etc.?		AM and PM commuter peaks
Warning Systems			
Existing installations	What forms of active warning devices are present at the RRI?		Flashing bells and gates Partial intermediate pedestrian gates
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		N/A
	Are there any opportunities to improve the active warning systems at the site?		Full arms
	Are the active warning systems clearly visible to motorists, pedestrians and other road users?		Yes – pedestrians
Operations	Did you observe vehicles/pedestrians within the functional area of the RRI while the warning systems were activated?		No
Passive devices	Are there any passive warning devices other than “crossbucks” installed at the RRI? Are they in good condition?		Yes, double track signs – refer to photos

Item	Issue to Be Considered	√	Comments
	Where are they located in relation to the roadway and the pedestrian sidewalks/walkways?		To the right side of the walkways, some posted low
	Are there any opportunities to improve the passive devices at the site?		Indicate the possibility of a second train event. Post at a standard height. Add signs on south side.
	Are the passive devices clearly visible to motorists, pedestrians and other road users?		Yes
Pedestrian Facilities and Warning Devices			
Pedestrians	Are sidewalks, crosswalks or pedestrian related facilities present at the RRI? One side? Both sides?		Pedestrian walkway
	Are they in good condition?		Yes
	What are the widths of the sidewalk/walkways?		3 to 4 metres
	Are the pedestrian movements primarily on one side versus the other?		No
	Are there fixed objects that would restrict pedestrian visibility of approaching trains from either direction?		Station infrastructure and utility vaults
	How would you describe the level of pedestrian activity during the your site visit? (low, medium, high)		None – morning site visit
	Were pedestrians observed within the rail warning devices while they are activated?		No
Warning devices	Are there opportunities to improve a higher form of pedestrian warning at the RRI?		Passive second train signs
Intersecting Roadway Function			
Function	What is the function of the roadway (local, arterial, highway, etc) in the vicinity of the RRI?		N/A
	What is the estimated AADT of the roadway in the vicinity of the RRI?		N/A
Lanes	How many lanes is the roadway in the vicinity of the RRI?		N/A

Item	Issue to Be Considered	√	Comments
Operating speed	Based on visual observations, what is the prevalent operating speed?		N/A
Access	What level of land access is provided in proximity to the RRI?		N/A
Signing	Are any of the RRI related signs inaccurate, confusing or unreadable?		No
	Are the signs effective/visible in all likely conditions, including day, night, rain, lighting conditions, etc.?		Daytime site visit
General operations	Are there any site specific roadway operating conditions that should be noted?		N/A

Baie d’Urfé – Northbound

Baie d’Urfé – Southbound

Baie d'Urfé – Walkway to the North

Baie d'Urfé – Posted Signs

Baie d'Urfé – Southbound Looking East

Baie d'Urfé – Southbound Looking West

Baie d'Urfé – Southbound Looking West

Baie d'Urfé – Pedestrian Tunnel to Street Level on South Side

APPENDIX D

A SUMMARY OF THE

RELATIVE RISK METHODOLOGY

Introduction

The following is a summary of the basic concept behind "relative risk" performance measure indicator and its application to measuring the effectiveness of remedial measures and countermeasures. For a full understanding of the concepts behind the Relative Risk Performance Indicator, please refer to Methodological Approaches for the Estimation, Evaluation, Interpretation and Accuracy Assessment of Road Travel 'Basic Risk', 'Relative Risk' and 'Relative Risk Odds-Ratio' Performance Measure Indicators: A 'Risk Analysis and Evaluation System Model' for Measuring, Monitoring, Comparing and Evaluating the Level(s) of Safety on Canada's Roads and Highways (see Stewart, 1998, in references section of main report).

For simplicity, the description provided below is formulated from a road use example; however, it should be recognized that these concepts can be applied to many real world situations.

Basic Concept Behind the Road Use 'Relative Risk' Performance Measure Indicator (RR^P)

The concept behind the 'road travel *relative risk*' estimator seeks to compare the *risks of incident involvement* for two (groups of) entities represented on the roads and highway systems. In essence, a *road use 'basic risk' estimator* is computed for both (groups of) entities. Then, these two *road use basic risk performance measure indicators* are then compared through the computation of a *relative risk ratio* (i.e., the division of the one *basic risk* estimator by the other). The resultant *road use relative risk performance measure indicator* is a measure of any *differential in road use risk level(s) (i.e., level(s) of safety) existing between the two (groups of) entities*.

Estimation of RR^P

The mathematical formulation for detecting any *road travel risk differential* existing between the two entity target groups, say 'target group 1' (TG_1) and 'target group 2' (TG_2), is given by equation (1).

$$RR^P(I|TG_{1:2}) = \frac{p(I|TG_1)}{p(E|TG_1)} \div \frac{p(I|TG_2)}{p(E|TG_2)} \qquad \text{(D-1)}$$

where,

$RR^P(I\|TG_{1:2})$	is the proportional road use relative risk performance measure estimator of the differential in road use risk existing between entity groups TG_1 and TG_2
$p(I\|TG_1)$	is the proportion of incidents (fatalities, injuries, collisions, violations) for target group 1,
$p(I\|TG_2)$	is the proportion of incidents (fatalities, injuries, collisions, violations) for target group 2,
$p(E\|TG_1)$	is the proportion of 'exposure (to risk)' for target group 1,
$p(E\|TG_2)$	is the proportion of 'exposure (to risk)' for target group 2,

Target group 1 refers to the after period (i.e., after remedial measure implementation period),

Target group 2 refers to the before period (i.e., before remedial measure implementation period).

The Accuracy of *RR^P*

The lower and upper 95% confidence limits for the $RR^P(I|TG_{1:2})$ estimator are given in equations (2) and (3) respectively.

$$RR^P(I|TG_{1:2})_{[L,95\%]} = e^{\{In_e[RR^P(I|TG_{1:2})] - 1.96 * \sigma(In_e[RR^P(I|TG_{1:2})])\}} \quad \text{(D-2)}$$

$$RR^P(I|TG_{1:2})_{[U,95\%]} = e^{\{In_e[RR^P(I|TG_{1:2})] + 1.96 * \sigma(In_e[RR^P(I|TG_{1:2})])\}} \quad \text{(D-3)}$$

where,

$$\sigma\left(In_e\left[RR^P\left(I|TG_{1:2}\right)\right]\right) = \sqrt{\sigma^2\left(In_e\left[RR^P\left(I|TG_{1:2}\right)\right]\right)} \quad \text{(D-4)}$$

$$\sigma^2\left(In_e\left[RR^P\left(I|TG_{1:2}\right)\right]\right) = \sum_{k=1}^{2}\left\{\left[1/p(I|TG_k)\right]^2 * \sigma^2\left(p\left(I|TG_k\right)\right)\right\} + \sum_{k=1}^{2}\left\{\left[1/p(E|TG_k)\right]^2 * \sigma^2\left(p\left(E|TG_k\right)\right)\right\} \quad \text{(D-5)}$$

Note: It is not essential that the reader fully comprehend the derivation of the above confidence limits; but it is essential to understand their importance in interpreting the accuracy of the results. Provided below is further explanation and examples of the application of the methodology confidence limits.

The Interpretation of RR^P

ASSUMPTIONS

There are no assumptions that need to be made for justifying or interpreting the resultant values of the *proportional road use relative risk estimator*.

LIMITATIONS / RESTRICTIONS

No limitations or restrictions affect the interpretation of *the proportional road use relative risk estimator*. Natural logarithms (to the base e) are used in its computation thereby ensuring that the RR^P can always be measured, has a logical upper bound and the confidence limits measuring its accuracy are 'near symmetrical' around RR^P and have a logical upper bound as well.

ANALYTICAL PROPERTIES

The proportions of incidents and *exposure (to risk)* for both groups TG_1 and TG_2 must be greater than zero for meaningful *relative risk estimation and comparisons*, i.e.,

$p(I|TG_1) > 0, p(I|TG_2) > 0, p(E|TG_1) > 0, p(E|TG_2) > 0$

$RR^P(I|TG_{1:2})$ are unit free, i.e., dimensionless, ensuring that comparisons of RR^Ps are valid and meaningful.

$0 < RR^P(I|TG_{1:2}) < \infty$. The value of the *proportional road travel relative risk estimator* is always greater than zero and has a logical 'upper bound'.

The 95% lower and upper confidence bounds, $RR^P(I|TG_{1:2})_{[L,95\%]}$ and $RR^P(I|TG_{1:2})_{[U,95\%]}$, are 'near' symmetrical around $RR^P(I|TG_{1:2})$ and have logical lower and upper bounds as well.

$RR^{P}(I|TG_{1:2})_{[EXPECTED]} = 1$. The **expected value** of a *proportional road use relative risk estimator* is '1' with the **value of '1'** meaning that the road use risk level of incident encounter of type I is potentially **equivalent** for both target entity groups TG_1 and TG_2. This 'expected value' of 1 implies that if the ratio of the representation of entity group TG_1 in incident involvement to its *exposure (to risk) representation* on the roads is equivalent to target entity group TG_2's incident involvement to *exposure (to risk) representation ratio*, then *the road use risk level* for the two target entity groups is *'relatively' the same*. In other words, the *level of safety* being experienced by the two groups of entities is equivalent. However, the *proportional road use relative risk estimators* must only be interpreted by taking into account their accuracy levels, i.e., 95% C.L.s.

INTERPRETATION(S)

If $RR^{P}(I|TG_{1:2}) < 1 \Rightarrow$ Then the ***road use risk level of incident encounter of type I*** is **potentially** ***'lower'*** for the **target** entity or **group** of entities, $\mathbf{TG_1}$, then it is for **target** entity **group** $\mathbf{TG_2}$;

If $RR^{P}(I|TG_{1:2}) > 1 \Rightarrow$ Then the ***road use risk level of incident encounter of type I*** is **potentially** ***'higher'*** for the **target** entity or **group** of entities, $\mathbf{TG_1}$, then it is for **target** entity **group** $\mathbf{TG_2}$;

If $RR^{P}(I|TG_{1:2}) = 1 \Rightarrow$ Then the ***road use risk level of incident encounter of type I*** is **potentially** ***'equivalent'*** for **target** entity groups $\mathbf{TG_1}$ and $\mathbf{TG_2}$.

The above decision rules provide the basic guidelines for *interpreting the relative risk estimators*, but their results cannot be fully interpreted without taking into account their accuracy assessment measurements. The hypothetical examples given in **Figure D-1** demonstrate the care that must be taken for properly interpreting the resultant *proportional road use relative risk estimators*.

Note: It is not essential that the reader fully comprehend the derivation of the above confidence limits; but it is essential to understand their importance in interpreting the accuracy of the results. Provided below is further explanation and examples of the application of the methodology confidence limits.

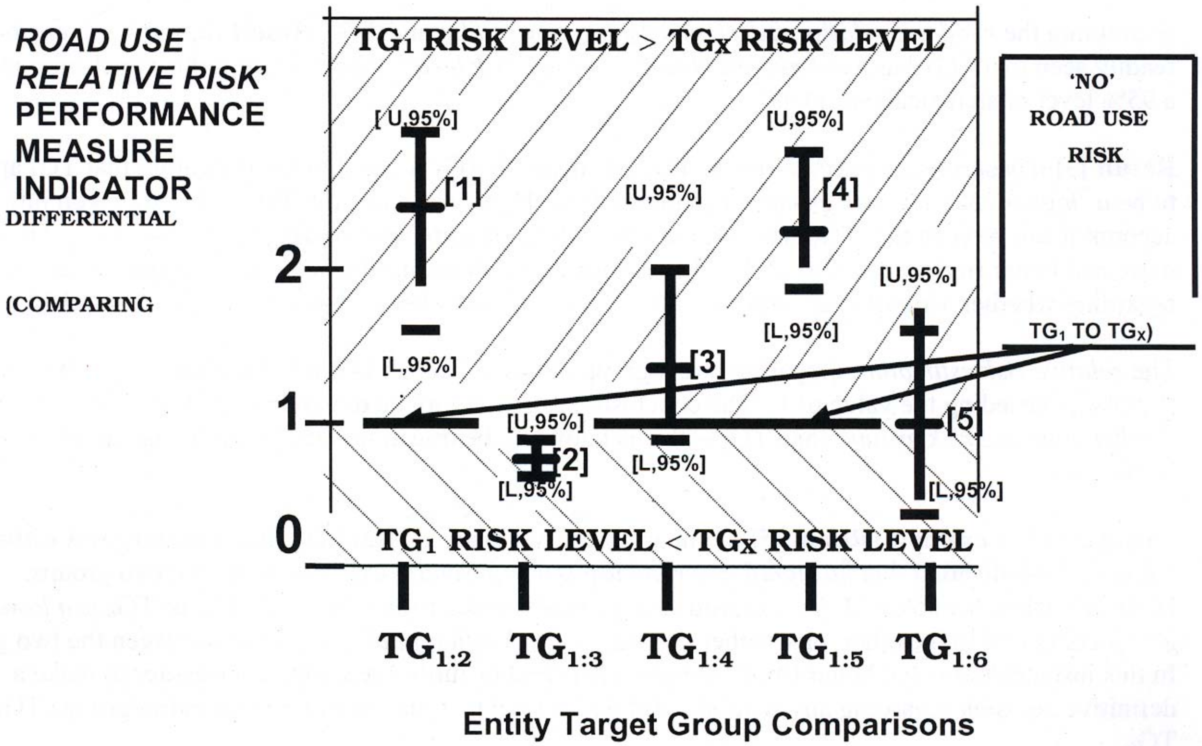


Figure D-1 Interpretation of the '*Proportional Road Use Relative Risk*' Performance Measure Indicators

Five target group *relative risk comparisons* estimating the differential in *road use risk* between target group 1 (TG_1) and target groups TG_2, TG_3, TG_4, TG_5 and TG_6 are illustrated in Figure D-1.

Result [1] shows an RR^P value of about 2.25 comparing entity target groups 1 and 2, implying that target group 1 has a *road use risk level* that is about 2.25 times higher than that of target group 2. Even when the 95% C.L. error bounds for the *relative risk estimator* are taken into account it can be concluded that target group 1 is *a 'higher road use risk' group* than entity group TG_2.

Examining the *road use relative risk comparison* between TG_1 and TG_3 , **Result [2]** = 0.75, it can be readily seen that TG1 has a *definitively 'lower road use risk level'* than TG_3, and this conclusion is true at a 95% level of statistical confidence.

Result [3] measuring the *relative risk* of TG_1 compared to TG_4 is equal to 1.4 indicating that TG_1 appears to be *a 'higher road use risk group'* than group TG_4. However, when the 95% C.L.s are taken into account it can be seen that TG_1 is not a *(statistically significant) 'higher risk group'* than TG_4. Therefore, more and better (more accurate) data and/or further research are needed to make a definitive decision regarding whether a *significant road use risk differential* exists between entity groups TG_1 and TG_4.

The *relative risk estimator* comparing target groups 1 and 5, **Result [4]**, is 2.3 with the lower 95% C.L., [L,95%], exceeding the value of 1. The conclusion can therefore be drawn that TG1 is *definitively a 'higher road use risk group'* than TG_5 – this is known to be true at the 95% level of statistical confidence.

Finally, the last example (**Result [5]**) comparing entity groups TG_1 and TG_6 has *a relative risk estimator* value of 1.0 indicating that *no significant road use risk differential* exists between the two groups. However, when the 95% C.L.s are considered it cannot be determined whether TG_1 or TG_6 is *a lower risk group* compared to the other, or whether *no road use risk differential* really exists between the two groups. In this instance more and better (more accurate) data and/or further research is necessary to make a definitive decision regarding any *road use risk differential* that may exist between entity groups TG_1 and TG_6.

The above analyses and interpretations of the *resultant proportional road use relative risk performance measure estimators* have focused on decision-making using a 'fixed' level of statistical confidence, i.e., 95% C.L.s. An alternate approach for identifying the level of statistical confidence at which one can draw a definitive conclusion regarding the *relative risk differential* existing between two entity target groups could be used to provide support for decision-making. This procedure would permit one to interpret all road use *relative risk* performance measure indicators as:

" IT CAN BE CONCLUDED THAT, AT THE X% LEVEL OF STATISTICAL CONFIDENCE, TARGET ENTITY GROUP TG_X IS A *'HIGHER' (OR 'LOWER'/'EQUIVALENT')* *ROAD USE RISK GROUP* IN COMPARISON TO GROUP TG_Y".

APPENDIX E

VILLE SAINT-LAURENT

EXECUTIVE COMMITTEE RESOLUTION REGARDING PRIVACY

RÉSOLUTION NUMÉRO CE 20011212-29 Demande d'autorisation de procéder à des enregistrements vidéos du passage des piétons au croisement du train Deux-Montagnes du CN et de l'avenue O'Brien, dans le cadre de l'installation d'un système d'avertissement de l'arrivée de trains, présentée par IBI Group.

ATTENDU la lettre de monsieur Russell Brownlee datée du 28 novembre 2001;

ATTENDU que IBI Group, mandaté par Transport Canada, projette d'installer un système de signaux visuels au croisement du train Deux-Montagnes et de l'avenue O'Brien afin d'avertir les piétons de l'arrivée simultanée de deux trains;

ATTENDU que suite à l'installation du système de signaux visuels, la firme désire installer des caméras vidéos afin d'enregistrer l'activité piétonnière uniquement lors de l'activation du système d'avertissement de l'arrivée de trains;

ATTENDU que Transport Canada désire s'assurer de l'accord de la Ville à l'enregistrement des usagers de route, en regard du droit à la vie privée;

IL EST RÉSOLU À L'UNANIMITÉ d'autoriser les enregistrements vidéos de l'activité piétonnière au croisement du train Deux-Montagnes et de l'avenue O'Brien.

Le directeur adjoint - circulation du service des travaux publics avisera la firme.

ADOPTÉ.

APPENDIX F

SECOND TRAIN WARNING SYSTEM

AND MONITORING SYSTEM

FUNCTIONAL SPECIFICATIONS FOR PILOT PROJECT

1. GENERAL DESCRIPTION

The Second Train Warning System incorporates an automated warning system that will detect a 'second train event', and provide clear warning messages for pedestrians at a Roadway-Rail Intersection (RRI). A 'second train event' is defined here as a point in time when two trains move through a RRI, one after the other, within the same warning system activation period (i.e. a single gate and/or flasher activation for the two arrivals).

The Second Train Warning System is comprised of the following elements:

- Second Train Warning Sign (STW Sign) – limited state, pre-programmed light emitting diode (LED) sign. LED activated by a second train event;
- Sign support structure – this will comprise a roadside pole-mount with an 2.45m (8') clearance;
- Sign Activation Equipment – a second train warning logic relay wired to railway circuitry interfacing with the current equipment; and
- Power Connection to Sign – associated wiring and disconnect switch.

Alternatively, the STW Sign may be a static warning sign with alternating amber flashing (wig-wag) beacons. Within this specification, the LED and static sign approaches are referred to as Type 1 and Type 2 STW Signs, respectively.

2. FUNCTIONAL REQUIREMENTS

2.1 Equipment Layout

The STW Signs shall typically be located as indicated in Figure F-1 of Attachment 1 of this specification. The actual location plans for the subject installation(s) shall be provided by Transport Canada as part of a Specific Requirements package to accompany this General Requirements package.

A STW sign shall be installed at a position conspicuous from each pedestrian access to a pedestrian rail crossing area (up to 4 distinct sites per RRI). This will typically be on the near side of the rail tracks facing the nearside pedestrian waiting area.

In all instances, the STW Signs shall be designed and placed to maximize legibility for pedestrians using the designated crossing areas of the RRI.

The STW signs shall be free of visual obstruction from roadside sources such as trees, signing, poles, etc.

2.2 STW Sign Functionality

Type 1 STW Signs

These limited state LED STW signs shall be capable of fulfilling the following functionality:

- the sign should be capable of displaying any one of three predefined messages, including a 'blank-out' state where applicable;
- the sign will be 'dark', or non-activated, except when activated by second train event (i.e. the default setting is 'blank');
- the sign will include a 'watchdog timer' circuit that will initiate the following two strategies:
  a) reset the sign if the sign becomes 'stuck' on the 'activated' display after the clearance period; and
  b) display the 'active' message in the event that no detection (activation) occurs after a user-specified period elapses.

Type 2 STW Signs

These static sign and flasher systems shall be capable of fulfilling the following functionality:

- the static sign shall display an appropriate warning message (see Section 3.1.1);
- the flasher units shall remain non-activated, except when activated by a second train event (i.e. the default setting is unenergized).

2.3 Detection and Clearance

The railway authority will provide all train detection circuitry, including signals indicating the detection of the arrival of any train into the RRI 'detection zone', and the clearance of this train from the RRI 'detection zone'. The Second Train Warning System shall include the following features:

- a logic circuit that will activate the STW Sign only upon the receipt of a specific combination of detection signals (interpreted as a command) from the railway detection circuits;
- the logic circuit will only provide an activation signal for the STW Sign if the rail detection circuitry detects a train entering the RRI 'detection zone' AND a second train entering the same RRI 'detection zone' (regardless of the number of tracks) prior to the clearance of the first train from the RRI 'detection zone'; and
- the logic circuit will maintain an activation signal for the STW Sign until both trains clear the RRI 'detection zone'.

3. MATERIAL REQUIREMENTS

3.1 Warning Sign

3.1.1 Display

Type 1 STW Signs

The LED Warning Sign will have the following characteristics:

- the sign will flash alternately between an image of 2 trains and letters that say "ATTENTION!", "2 TRAINS", as illustrated in Figures F-2 and F-3 of Attachment 1;
- a full matrix display (32 x 64) pixels with one LED per pixel;
- a pixel size of 0.635 cm (0.25 inch) with a pitch of 1.21 cm (0.475 inch);
- high intensity amber LED technology with discrete character matrices of five (5) by seven (7) pixels with a letter size of 8.26 cm (3.25 inch). Light from the pixel will overflow so that there is no gap between pixels to the viewer;
- the sign face will be 76.2 cm (30 inches) wide and 38.1 cm (15 inches) high;
- the sign will incorporate a photo sensor system to provide automatic control of the display luminance as a function of the ambient illumination level, and the luminance will have a minimum of 15 levels to provide smooth transition between levels;
- sign will be clearly legible from 30.5 m (100 feet);
- the cone of vision will be 70 degrees horizontal and 40 degrees vertical.
- the installation will automatically re-boot following power or communications failures; and
- the sign shall be powered from the rail system power supply and back-up supply to ensure continuous power availability.

Type 2 STW Signs

- the static sign shall display the message “ATTENTION!”, “2 TRAINS” with an information tab indicating either “Quand les feux clignotent” for applications in Quebec, or “When Flashing” for applications outside of Quebec, as illustrated in Figure F-4 of Attachment 1;
- the sign face shall be made of high reflectivity sheeting;
- the sign dimensions shall be 750 mm square for the main sign, 600 mm x 300 mm for the supplemental tab, with all character heights consistent with the *Metric Edition Standard Alphabets for Highway Signs and Pavement Markings* (U.S. Department of Transportation), as illustrated in Figure F-4 of Attachment 1, and as per the TAC guidelines for warning signs;
- the flashers shall alternate with a frequency sign of 50-60 flashes per minute, per the TAC guidelines for warning signs; and
- the sign shall be clearly legible from 30.5 m (100 feet).

3.1.2 Sign Case for Type 1 STW Signs

The maximum dimensions of the Type 1 STW Signs shall be as follows:

- Maximum overall height = 50.8 cm (20 inches) high
- Maximum overall width = 88.9 cm (35 inches) wide
- Maximum overall depth = 8.26 cm (3.25 inches) deep
- Maximum gross unit weight = 9.07 kg (20 lbs);

The minimum distance from the bottom of STW Sign to ground level when in display mode shall be 2.5 metres.

The sign case (enclosure) shall have the following characteristics:

- The display elements and associated electronics will be housed in a weather-tight aluminium housing, designed to provide protection from solar radiation, water, dust, dirt and salt spray.
- The sign face shall be constructed of non-glare, scratch resistant, high impact, ultraviolet radiation stabilized, polycarbonate sheeting.
- The polycarbonate sheets shall be hinged and prop rod secured to allow easy access to internal sign components for service and repair.
- The box will be painted light (<50%) grey.
- The sign case shall have appropriate mounting accommodations to allow the sign case to be attached to a pole with the use of metal strapping, or via U-bolt connections.
- The sign case enclosure shall be able to be securely locked. Three (3) sets of master keys are to be provided with the supply of the sign case.

3.2 Sign Support Structure

As illustrated in Figure F-5 of Attachment 1, the structural support for the STW Sign shall include the following features:

- the sign will be mounted on a galvanized 3.35 m (11 foot) round aluminium pole with a 12.7 cm (5 inch) outer diameter;
- the pole will be installed within the rail right-of-way;
- the pole will be mounted on an appropriate concrete pole base;
- the pole base and pole will be installed to provide an approximate 50 cm (20 inch) clearance (parallel to the tracks) between the pole and edge of the sidewalk;
- the pole base and pole will be installed to provide a minimum clearance (perpendicular to the tracks) between the pole and the nearest rail track. This minimum distance will be defined by the railway owner/operator;

- the sign will be centre-mounted on the pole with a u-bracket and banding (or other appropriate fastener) with a sign clearance of 250 cm (98 inches);
- the supporting pole will act as the conduit for the power supply to the sign.

The above-noted pole installation directions shall be followed as closely as possible. Should any variation be required at time of installation, minor modifications may be possible subject to the approval of Transport Canada, or its Representative. In these circumstances, emphasis shall be placed on maintaining adequate visibility of the sign for pedestrians.

Where available, the STW Signs may be mounted on existing structures. The Contractor shall be responsible for obtaining any necessary approvals for such a mounting configuration. The Contractor must confirm that the proposed existing structure is structurally adequate for the proposed use. A qualified Professional Engineer (for the applicable Province) must certify this adequacy.

3.3 Interface Requirements for Sign Activation

For sites selected, Transport Canada will provide detection and cancellation circuitry defining the 'detection zone'. This circuitry will terminate within a cabinet to be supplied by Transport Canada.

The contractor shall supply a logic circuit that will interpret the existing rail detection inputs to activate the STW signs per Section 2.3. Transport Canada will allow the Contractor access to the existing grade crossing control cabinetry for the purposes of installing the logic circuits that will activate the STW Sign. The logic circuits will make use of the current railway circuitry to activate the sign or beacon, based on the combination of detection inputs described above. Figure F-6 in Attachment 1 provides a general schematic for this arrangement.

3.4 Electrical System

Power will be supplied either by an aerial drop or by underground conduit, as is suitable for the specific site. The Contractor shall be responsible for all coordination with the applicable electrical utility to secure approvals and complete electrical hook-up of the STW Sign and all related field components.

All electrical/electronic components shall be of modular, interchangeable, plug-in type fabrication and shall be standard manufacturers' components and CSA certified, where possible. If no CSA standards are available for a proposed component, other standards organization certification may be substituted with the approval of Transport Canada, or its Representative.

All electrical safety requirements will be followed.

All components used shall be fully weatherproofed and capable of operating under any of the environmental conditions found locally at the proposed site. Prior to commencing the project, the Contractor shall confirm the required range of environmental operating conditions with Transport Canada, or its Representative.

All components shall be treated so that no corrosion occurs for a period of 3 years from the time of delivery.

All connectors and components shall be fully Code compliant, readily available and ruggedized.

4. INSTALLATION REQUIREMENTS

All aspects of the installation, including traffic control, installation methods, equipment, and attachment hardware are subject to approval by Transport Canada, or its Representative.

All power and activation circuitry cables shall be formed of continuous unspliced lengths from source to destination. No cable splices shall be permitted.

4.1 Precautions

Care must be taken to avoid damaging equipment during transportation and installation. If equipment supplied is damaged, altering the characteristics of the equipment, the equipment will be repaired by the Contractor (to the satisfaction of Transport Canada, or its Representative) or replaced at the Contractor's expense.

In all instances, appropriate precautions shall be taken to protect all equipment and related cabling and connections from the potentially harmful effects of weather.

4.2 Traffic Control

The Contractor shall be responsible for developing traffic control plan suitable for the installation processes being proposed. The Contractor must obtain the latest standards in roadway / roadside work operations from Transport Canada.

All traffic control plans must be submitted to Transport Canada and the relevant road authority (or authorities) for approval. Approval must be obtained from Transport Canada, or its Representative, at least three working days before work can commence.

4.3 Sign Placement

The STW Signs shall be mounted on the poles as described in Section 3.2. The signs shall be levelled and aimed at the associated pedestrian waiting area, or as designated by Transport Canada, or their Representative.

Power cables and activation circuitry shall be protected by a watertight conduit. A Professional Engineer licensed to practice in the Province where the installation is being conducted shall attest the method of installation of such cables.

The Contractor is required to co-ordinate its activities with Transport Canada, or its Representative, to ensure that all required electrical power supplies, and activation circuitry are available prior to the installation of the STW Signs.

4.4 Connection between Detection Circuit and STW Sign

The Contractor is responsible for establishing and maintaining the connection between the rail detection circuit and the sign.

A logic circuit shall be installed within the existing grade crossing control (gate) cabinetry, as described in Section 3.3.

5. QUALITY CONTROL

The Contractor is responsible for all testing and documentation required to establish approval and acceptance of the installation and operation of the STW Signs. The following identifies the specific quality control requirements for this item.

The Contractor shall develop testing procedure and perform testing for a Pre-Installation Test and a Proof of Performance Test. Testing procedures and final test results are subject to the approval of Transport Canada, or its Representative.

Transport Canada, or its Representative, may witness all tests. The Contractor shall give Transport Canada, or its Representative, 48 hours notice of when tests are to be performed.

The Contractor shall submit to Transport Canada (for approval) detailed test procedures no later than two (2) weeks after award of the Contract, based on the performance requirements described in these specifications. The test procedures shall illustrate the nature of the test activities to be performed. The Contractor shall submit a total of one electronic copy and four hard copies of the test procedures once the test procedures have been accepted prior to the commencement of testing.

For the above-noted tests, the Contractor shall record on a suitable test certificate the site reference, the device reference, the date of the test, the prevailing weather conditions, ambient temperature, the measure of acceptable performance, and the actual performance of the devices during the test.

All test results shall be submitted to Transport Canada, or its Representative, for approval. These test results shall be submitted no later than two weeks following completion of testing. The Contractor shall, as directed by Transport Canada or its Representative, correct or replace any materials that fail the above tests.

5.1 Shop Drawings

The Contractor shall submit shop drawings for the signcase, mounting hardware, pole installation, electrical connection, detection connections (including a logic diagram and wiring diagram) no later than two (2) weeks after award of the Contract.

5.2 Pre-Installation Testing

The Contractor shall carry out pre-installation testing to ensure that the STW Signs exhibit error free operation:

- The Contractor shall demonstrate brightness levels, colour uniformity by visual assessment, activation of all pixels and legibility distance.

The Contractor shall demonstrate proper operation of the STW Signs by ‘locally’ selecting the full range of messaging (i.e. without the need for a ‘live’ detection).

5.3 Proof of Performance (POP) Testing

The Contractor shall carry out proof of performance testing to ensure that the STW Signs exhibit error free on-site operation. Each of the functions outlined in Section 2 of this specification shall be demonstrated.

The Contractor shall complete the POP testing in co-ordination with Transport Canada, or its Representative.

All POP tests on the STW Signs shall be performed within five (5) working days of installation.

6. MAINTENANCE REQUIREMENTS

The Contractor shall be prepared to enter into a maintenance contract with Transport Canada for a period of one year, with optional extensions of one year, not exceeding a total of three years.

The Terms of the maintenance contract are negotiable, and the Contractor proponents shall submit an estimate and details of their proposed maintenance program with their cost estimates.

7. MEASUREMENT FOR PAYMENT

Measurement of the Second Train Warning Signs is by Plan Quantity and may be revised by Adjusted Plan Quantity. The unit of measure is ‘each’. Each unit shall include the installation, testing and documentation of the STW Signs, and all related power and control features.

A separate annual payment for the maintenance of this equipment will be negotiated, as described in Section 6.

8. BASIS OF PAYMENT

Payment at the Contract Item Price shall be full compensation or all labour, equipment and material required to do the work including the supply, testing, and the production of documentation and test results.

ATTACHMENT 1 – SPECIAL PROVISIONS PACKAGE

JULY 2001

1. GENERAL DESCRIPTION

This special provision specification covers the installation and testing of a Second Train Warning (STW) system and monitoring camera at the at-grade road-rail intersection (RRI) on O'Brien Avenue in St. Laurent/Montreal, Quebec. The specification will include:

the installation (including related mounting equipment and poles if required) and maintenance of:

1. The installation of a STW System (sign and related detection equipment).

2. The installation of a monitoring system (CCTV camera, enclosure, triggering and recording equipment).

3. All related video interface cabling, power supply, cabinetry, and wiring necessary to operate the STW Sign system.

4. The monitoring, recording set-up, retrieval and forwarding of video tapes from the recording equipment.

2. SIGN INSTALLATION

It is proposed to install a STW System at the RRI on O'Brien Avenue in the municipality of St. Laurent/Montreal. A sketch of the intersection layout is provided.

The functional specification for STW system has been described in 'Functional Requirements for Second Train Warning System – General Specifications Package' (Appenix H). The installation of the STW System shall comply with the requirements of this specification.

The contractor shall be responsible for the acquiring the necessary scaled plans, detailed wiring diagrams, duct routes, power supply details and detection system details from CN Rail and St. Laurent/Montreal. The contractor shall be responsible for acquiring all municipal, utility, or other permits, clearances or approvals required to complete the work.

The contractor shall be responsible for the delivery of a working STW system as defined within the General Specifications Package, and the maintenance of this system, as defined herein.

3. MONITORING SYSTEM INSTALLATION

The monitoring system includes a weather proof video recording system, to be placed on site at the O'Brien Avenue crossing for the duration of the study period. The video system will be activated and record during the presence of two trains in crossing during the same activation period.

3.1 Materials To Be Supplied

3.1.1 CCTV Camera and Lens

The camera and lens shall form an operational unit.

.1 Functional

The CCTV camera shall meet, or exceed, the following functional requirements:

- the camera shall make use of a 1/2" Black & White, inter-line transfer, solid state CCD image sensor with a minimum of 768 (H) x 494 (V) active pixels;
- the camera shall be designed for use at low light levels and shall have a wide dynamic range and minimal blooming and transfer smear characteristics;
- the camera shall be capable of providing a bright to high contrast colour picture with a full video output at a minimum illumination of 13 lux and a useable picture at a minimum of 0.95 lux, both at F1.2;
- the camera shall provide a minimum of 470 lines horizontal resolution;
- automatic light range circuits shall be included to provide compensation for variations in scene brightness.
- the camera shall incorporate AGC circuitry to provide for compensation at low light levels;
- the camera shall operate from a TIA standard RS-170 sync as provided by an internal integrated sync generator and phased locked loop circuit to synchronize camera to power line zero crossing;
- the camera shall allow vertical phase adjustment;
- the camera shall have an output impedance of 75 ohms and shall provide a standard colour NTSC composite video signal output;
- the weighted signal to noise ratio shall be greater than 48 dB at 1.0 V p-p (AGC off).
- The resolution of the camera should be such that pedestrian head rotation movements, in the pedestrian waiting areas, can be easily distinguishable from the intended camera location.

The lens shall meet the following functional requirements:

- the lens shall be a 1/3" format, "C" mount, zoom lens with automatic iris and spot filter;
- the lens shall provide a minimum focal length range of 6-90 mm and shall be manually adjusted on-site at the time of installation;
- the automatic iris shall include a neutral density spot filter providing a minimum total aperture adjustment of f/1.2 to f/720;
- the default state of the camera shall be powered;
- power interruption protection shall be provided to close the lens iris in case of power loss;
- the lens shall be held closed by a delay circuit for a minimum of 5 seconds when power start-up (after a power loss) occurs;
- the lens shall be designed to prevent bright light "flare" caused by indirect sunlight outside the angle of view of the lens affecting the viewed scene.

.2 Physical

The CCTV camera shall meet, or exceed, the following physical requirements:

- camera dimensions shall not exceed 70 mm H x 70 mm W x 170 mm L;
- externally accessible controls shall be kept to a minimum in order to prevent incorrect adjustment;
- the camera shall be suitable for mounting of a standard "C" mount lens;
- standard 6 mm (1/4")-20 tapped thread mount holes shall be provided at the base of the camera/lens assembly for balanced mounting;
- a quick disconnect BNC connector shall be provided for video output (to the recording device) on the rear panel of the camera.

The lens shall meet the following physical requirements:

- lens dimensions shall not exceed 60 mm H x 67 mm W x 132 mm L.

The camera assembly (camera and lens) shall have a maximum weight of 1.5 kg.

.3 Electrical

The CCTV camera shall meet, or exceed, the following electrical requirements:

- the camera shall include any required power supply/adaptor equipment to allow operation from an input voltage of 24 VAC ±10%, 60 Hz ±5% via screw terminals. If an external power supply is required to accommodate this voltage, it shall be included in the price for this item; and
- The maximum power consumption of the camera and lens shall not exceed 10 W.

.4 Environmental

The CCTV camera and lens shall meet, or exceed, the following environmental requirements:

- as a minimum, the operating temperature range shall be -12°C to +50°C.

3.1.2 <u>Environmental Enclosure</u>

The environmental enclosure shall include a thermostatically controlled blower and heater for environmental control.

.1 Functional

The environmental enclosure shall meet, or exceed, the following functional requirements:

- the enclosure shall be of a size suitable for housing the CCTV camera, lens, ventilation fan and heater;
- access to the environmental enclosures shall be provided by a hinged top cover, secured by a minimum of four (4) quick release latches;

- a finished sunshield shall be mounted to the environmental enclosure to protect from heat due to direct solar radiation, while permitting air flow over the housing exterior without interfering with cover operation;
- provision shall be made to securely mount the CCTV camera and lens to the base of the environmental enclosure;
- provision shall be made to securely fasten the environmental enclosure to the mounting equipment attached to the pole;
- the ventilation fan shall provide an internal positive pressure;
- the enclosures shall allow for waterproof entry and easy removal of all external cable.

.2 Physical

The environmental enclosure shall meet, or exceed, the following physical requirements:

- the environmental enclosure should have minimum useable internal dimensions of 90 mm H x 80 mm W x 460 mm L;
- the weight of the environmental enclosure including sunshield, ventilation fan and heater accessories shall not exceed 4.5 kg.

.3 Electrical

The environmental enclosure shall meet, or exceed, the following electrical requirements:

- the ventilation fan shall require a maximum power consumption of 20 W at 115 VAC ±15%, 60 Hz ±5%;
- the thermostat equipped heaters should operate on an input voltage of 115 VAC ±15%, 60 Hz ±5% to generate a total of 150 watts (2 ´ 75) of heat energy;
- an additional two 75 watt heaters shall be provided as spares and turned over to Transport Canada, or its Representative;
- the environmental enclosure shall have a grounded duplex receptacle providing 115 VAC ±15%;
- the environmental enclosure shall provide a suitable electrical supply for the operation of the CCTV camera.

.4 Environmental

The environmental enclosure shall meet, or exceed, the following environmental requirements:

- the heater shall be provided complete with thermostat control to maintain internal enclosure temperatures above +4°C with an external temperature of -35°C;
- heaters with thermostat control shall activate at temperatures less than or equal to +4°C and shall turn off when temperatures are above +10°C;
- the thermostat control shall activate a ventilation fan at temperatures above +33°C and automatically turn off when temperatures fall below +26°C.

3.1.3 Pole and Mounting Hardware

A 15 metre wooden pole shall be supplied for the purposes of mounting the camera assembly (camera/lens and enclosure) and the video recording unit/cabinet.

Suitable mounting hardware shall be employed to securely fasten the camera assembly to the top of the pole in such a way that does not prevent manual adjustment to the camera assembly aiming.

3.1.4 Video Interface Cable

.1 Wiring

A video output cable is required to connect the output from the camera to the input on the video recording unit. It shall meet, or exceed, the following requirements:

- The cable shall have a black PVC jacket and its outer diameter shall be 6.15 mm.
- The outer conductor shall be bare copper mesh of no less than 95% shield coverage.
- The centre conductor shall be 22 AWG consisting of 7-30 AWG bare copper strands.
- The dielectric shall be cellular polyethylene.
- The nominal impedance shall be 75 ohms and the d.c. loop resistance shall be 49.2 ohms/km.
- The cable shall be labelled in accordance with Transport Canada labelling convention (to be supplied by Transport Canada).

.2 Connectors

Connectors shall be BNC Amphenol RG-59, crimp-crimp termination (Electrosonic) or equivalent.

3.1.5 Cabinet

The cabinet shall meet, or exceed, the following requirements:

.1 General

- The cabinet shall house the video recording unit, its communications and power supply equipment and operating manuals, for the monitoring system.

.2 Fabrication

- The cabinet shall be fabricated from sheet aluminum at least 3mm thick and shall be adequately reinforced by welded aluminum members. All construction shall be free of dents, scratches, weld burn through and abrasions harmful to the strength and general appearance. All seams shall be of continuously welded construction. All exterior welds shall be ground smooth. All edges shall be smooth and free of burrs.
- The roof of the cabinet shall be designed such to assist in water drainage and to prevent any accumulation of standing water. Further drainage

shall be provided by means of a rain gutter mounted on the front of the cabinet only.

.3 Cabinet Finish

- The cabinet shall be properly degreased and cleaned before application of paint finish. An Iron Phosphate conversion coating shall be applied to aluminum parts using immersion of power spray methods of application;
- Cabinets shall be finished inside and out with gloss polyester thermosetting powder paint min 76 μm thick. All coating shall be commercially smooth, substantially free of flow lines, paint washout, streaks, blisters, and other defects that would impair serviceability or detract from general appearance;
- The inside walls, door and ceiling of the cabinet shall be painted the same as the outside finish;
- A certificate of compliance shall be furnished by the manufacturer certifying that the coating system furnished complies in all respects with the above requirements.

.4 Cabinet Components

- The cabinet shall have a single front hinged door equipped with a lock. When the door is closed and latched, the door shall automatically lock and a firm seal between the neoprene door gasket and the cabinet doorframe will exist, making the cabinet dust and moisture tight.
- The cabinet shall be insulated with 12.5mm of expanded polystyrene insulation or acceptable equivalent material with the same insulation capabilities.
- The cabinet door frame shall be double-flanged out on all four sides and shall be provided with strikers to hold tension on and form a firm seal between door gasketing and cabinet door frame. The flange width shall be a minimum of 25 mm.
- The latching handles shall have provision for padlocking in the closed position and shall be constructed of cast aluminum or steel. The handle assembly shall be zinc plated and coated with the paint of the same colour as used for the cabinet paint finish.
- Each door hinge shall be a single continuous hinge with a fixed pin. The hinges shall be bolted to the cabinet using stainless steel hardware.
- Door hinge, pin and bolts shall be made of stainless steel. Flat head bolts shall be used in attaching the hinge to the door and to the cabinet shell. The hinge pin and bolts shall not be accessible from the outside when the door is closed. Pop rivets shall not be used in attaching the hinge to either the door or the cabinet shell.
- The front doors shall be provided with automatic self-engaging catches to hold the door open at both 90° and 180° (±10°). The catches shall be plated steel rods. The catch system shall be capable of holding the door open at 90° in a 60mph wind at an angle perpendicular to the plane of the door. The catch holders shall be welded or bolted to the cabinet door and chassis. Stainless steel nuts and bolts shall be used.
- A standard rack shall be installed inside the cabinet for mounting the video recording unit and associated power supply and activating equipment. The mounting location and configuration of the video recording device shall allow for proper operation of the unit and easy access to the unit's input cables, panel controls and video tape door.

- Each cabinet shall have rails, racks or shelves that shall swing horizontally in order to reach the cabinet components mounted in the back of the cabinet. There shall be a mechanism to lock the racks in place.
- A trouble lamp with basket protection shall be mounted near the top of the door. The trouble lamp shall be mounted securely to the door without the use of screws, etc. and shall be capable of being removed from its holder for inspection purposes, without the use of tools. The wiring for the trouble lamp shall be provided for easy removal of the lamp, but shall be protected in the door open area and from the heater. A minimum of 2.44m of wiring shall be provided with the trouble lamp. The trouble lamp fixture shall also have a manual switch.
- The trouble lamp will operate off the power supply provided for the video recording equipment.

.5 Operating Environment

- Heater and fans shall be provided to provide temperature and humidity control adequate for the proper operation of the video recording unit and other components to be housed in the cabinet.
- The fan(s) shall be of adequate size and power to circulate air in the cabinet and be controlled by an adjustable thermostat.
- The fans shall be thermostatically controlled. The thermostat shall be user configurable for different degrees of internal cabinet air temperature.
- The fans shall operate from the power supply provided inside the cabinet.
- The fan shall be covered with a protective mesh for safe operation to prevent accidental insertion of fingers.
- The bottom filter bracket shall be formed into a waterproof sump with drain holes to the outside. The louvered vents shall be designed and constructed such that a stream of water from pressure head, such as a sprinkler, will not enter the cabinet. The louvered area shall be slightly less than the filtered area.
- A vent cover shall be provided for reducing the size of the vent opening in the winter. The cover shall have a 25mm diameter hole in the centre and shall fit into the filter bracket without removing the air filter. The cover shall be made from material identical to the cabinet and shall be finished in the same manner.
- Each cabinet shall be equipped with a forced air heater. The heater assembly shall consist of the heater and fan, a handle and a mounting bracket. The assembly shall fit in and be mounted within the cabinet. The heater shall be thermostatically controlled.
- The heater shall be operated from the power supply provided inside the cabinet.

.6 Cabinet Wiring Diagram

- Two sets of non-fading cabinet wiring diagrams shall be supplied with each cabinet. The diagrams shall be non-proprietary. They shall identify all circuits in such a manner as to be readily interpreted. The diagrams shall be stored in the cabinet.
- Detailed equipment layout scale drawings and wiring diagrams of all equipment installed in the cabinet shall be submitted for approval.

.7 Mounting and Enclosure

- The cabinet is to be mounted to the monitoring system pole as identified in 3.1.3.
- Mounting hardware is to be supplied.
- The mounting equipment shall be fabricated from the same material and shall be finished in the same manner as the cabinet.

3.1.6 <u>Video Recording Unit</u>

- The video recording unit shall utilize a standard VHS tape for recording;
- The video recording unit shall have the capacity to record 6 hours of video on a standard VHS tape at a horizontal resolution compatible with the video camera;
- A built-in alarm feature shall be included in the video unit to facilitate the triggering of the record mode during second train events;
- The alarm feature must have a “manual” triggering mechanism to facilitate a variable recording period for each alarm call;
- The video and alarm input connectors must be compatible and function with the remainder of the monitoring system;
- Upon power failure, the video recording system should have the ability to continue to record alarm events including time and date stamping, once power is restored (i.e. the system should not require a manual reset of system programming for time, date, alarm settings, etc.).

3.2 Method

3.2.1 <u>CCTV Camera and Lens</u>

- The camera and lens shall be firmly attached at the ‘C’-mount to form one operational unit;
- the CCTV camera and lens shall be securely mounted to the base of the environmental enclosure;
- the enclosure shall be secured to the mounting hardware atop the pole;
- the camera shall be mounted within the enclosure such that lens and window separation is kept to a minimum when the lens is fully extended;
- any external power supplies shall be securely mounted within the enclosure;
- the camera shall be supported within the enclosure in a manner that ensures that the weight of the camera does not rest on the lens mount. The Contractor is responsible for supplying and installing required hardware including mounting spacers between the enclosure and camera to ensure that balanced mounting is achieved.

3.2.2 <u>Environmental Enclosure</u>

- The environmental enclosure including camera, lens, heaters and ventilation equipment shall be secured to mounting hardware, which in turn will be attached to a pole; and
- The Contractor shall ensure that the entire pole top assembly is grounded via a ground wire to the controller cabinet.

3.2.3 Pole and Mounting Hardware

- A 10 metre direct-buried wood pole will be used to mount the camera;
- The pole is to be installed on CN right-of-way;
- the pole will be installed to provide an approximate 1200 cm (472 inch) clearance (parallel to the tracks) between the pole and edge of the sidewalk;
- the pole will be installed to provide an approximate 100 cm (39 inch) clearance (perpendicular to the tracks) in addition to the clearance provided between the STW sign and the nearest rail track (e.g. if the STW sign is provided a 200 cm clearance, the CCTV pole shall be provided a 300 cm clearance, subject to the above-noted right-of-way restriction); and
- the above-noted pole installation directions shall be followed as closely as possible. Should any variation be required at the time of installation, minor modifications may be possible subject to the approval of Transport Canada, or its Representative. In these circumstances, the pole is to be positioned such that the camera will be afforded an unobstructed view for the two pedestrian waiting areas on the nearside of the RRI (i.e. either side of the road) without the need for a Pan-Tilt-Zoom unit.

3.2.4 Wiring

.1 General

- Interface cable and connectors shall be installed to make the monitoring system completely operational.
- Wiring shall run continuous from source to destination. No splices shall be accepted.
- Wiring shall be neatly tagged at both terminations to indicate source and destination and function. All cables shall be labelled in accordance with Transport Canada labelling convention (to be supplied by Transport Canada).
- Sufficient slack shall be provided for maintenance purposes.
- All cabling shall be secured and protected as necessary to the satisfaction of Transport Canada or its Representative.
- All electrical cable shall meet the requirements of the Canadian Electrical Code and shall be acceptable to the Local Hydro Authority.
- All wiring and connectors shall conform with industry standard and shall be approved by Transport Canada, or its Representative.

3.2.5 Cabinet

The cabinet shall be secured to the pole at a height that allows easy access to the video recording unit and for maintenance.

The cabinet assembly must be appropriately grounded.

3.2.6 Video Recording Unit

The video recording unit shall be housed and secured in the cabinet, and shall be connected as follows:

- The camera output will be connected to the recorder input.
- The detection circuit lead shall be connected to the alarm circuits of the recorder.

3.2.7 <u>Power Connections</u>

All components of the monitoring system shall be appropriately powered. As noted earlier, the contractor is responsible for arranging for this power connection.

4. OPERATION OF THE MONITORING SYSTEM

The Contractor shall be responsible for monitoring the status of the video recording unit. Weekly, the Contractor shall inspect the unit to ensure that:

- The trigger alarm function begins a recording;
- The recording lasts until the detection zone is cleared;
- There are no problems with the video tape; and
- All connections are secure and operational.

The Contractor shall be responsible for the retrieval of video tapes from the video recording unit. Specifically, on a weekly basis, the Contractor shall:

- Confirm that the video tape is less that 80% 'full' of recorded material. In this circumstance, the video tape in use will be left in the recording unit. The Contractor shall return the video recording unit to its normal state of "record-standby" operation. The video tape usage will be checked again in one week's time; or
- Retrieve the video tape and forward the tape to Transport Canada by courier. In this circumstance, a new, clean video tape will be used to replace the used tape. The Contractor shall return the video recording unit to its normal state of 'record-standby' operation.

5. QUALITY CONTROL

The quality control testing on the STW System is described in the General Specifications Package. This section describes the Quality Control process for the STW monitoring system.

5.1 Pre-Installation Testing

Functional testing shall be based on manufacturers standard testing procedures as well as the requirements detailed herein. Functional tests shall include at least the following:

5.1.1 <u>CCTV Camera and Lens</u>

- proper operation of automatic light compensation circuitry shall be verified;
- operation of back focus, power, AGC, focus and zoom controls shall be verified;
- automatic black level clamp circuits shall be set;
- the horizontal resolution shall be confirmed;
- the camera signal-to-noise ratio shall be measured at various light levels and confirmed to satisfy the requirements established herein. Testing shall be conducted as per the manufacturer's specified measurement procedure;
- video output shall be set to 1 volt p-p from sync tip to peak white and the variance measured to ensure compliance with the requirements of this specification;
- bright light lens flare causing uneven light levels on the video image shall be eliminated.

5.1.2 Environmental Enclosure

- internal circuitry, heaters and fans shall be confirmed operational.

5.2 Proof of Performance Testing

The Contractor shall conduct Proof of Performance Testing at each camera location that includes the following:

- video output level at the field cabinet shall be measured and recorded;
- proper operation of automatic light compensation circuitry shall be verified;
- proper operation of manual zoom (in/out), iris and focus functions shall be demonstrated;
- The Contractor shall demonstrate that the video signals arrive at the recording unit within the cabinet;
- Demonstration that the field of view includes applicable pedestrian wait areas.
- Demonstration that the image resolution is adequate to observe pedestrian behaviour.

5.3 System Integration Testing

The Contractor shall carry out system integration testing to ensure that the CCTV camera, lens and enclosure perform to the specified standards when used in operation with all other devices (i.e. detection circuit).

6. MEASUREMENT FOR PAYMENT

The unit of measurement is lump sum, based on the description above.

7. BASIS OF PAYMENT

Payment at the contract price shall be full compensation for all labour, equipment and materials required to do the work including delivery, installation, testing and the production of all drawings, documentation and test results.

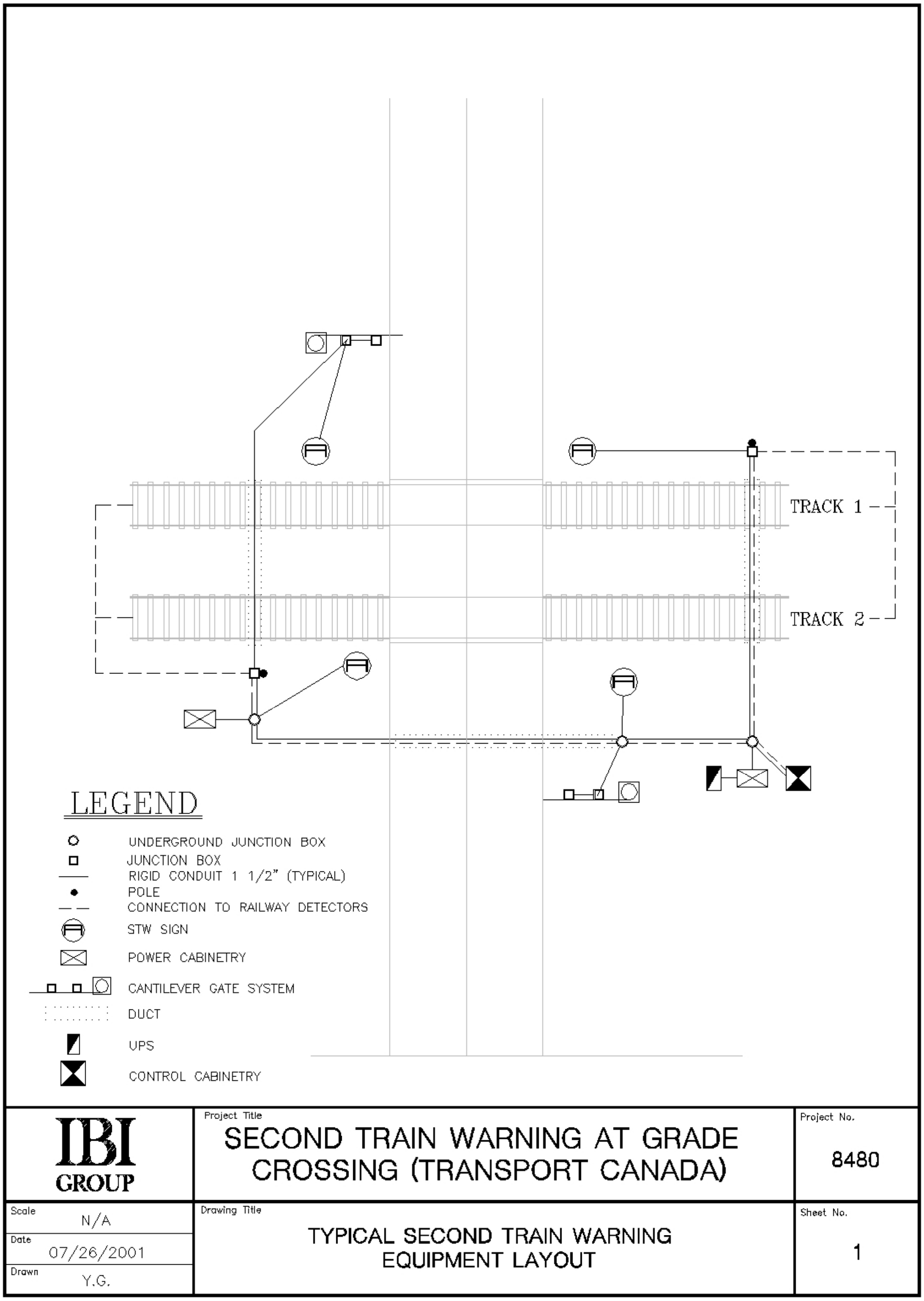


Figure F-1 General Configuration of STW System Signs

IBI GROUP	Project Title: SECOND TRAIN WARNING AT GRADE CROSSING (TRANSPORT CANADA)	Project No.: 8480
Scale: N/A Date: 07/26/2001 Drawn: Y.G.	Drawing Title: TYPE 1 STW SIGN - DISPLAY A	Sheet No.: 2

Figure F-2 Type 1 Sign – Sign Content (Text)

IBI GROUP	Project Title: SECOND TRAIN WARNING AT GRADE CROSSING (TRANSPORT CANADA)	Project No. 8480
Scale: N/A Date: 07/26/2001 Drawn: Y.G.	Drawing Title: TYPE 2 STW SIGN - DISPLAY B	Sheet No. 3

Figure F-3 Type 1 Sign – Sign Content (Trains)

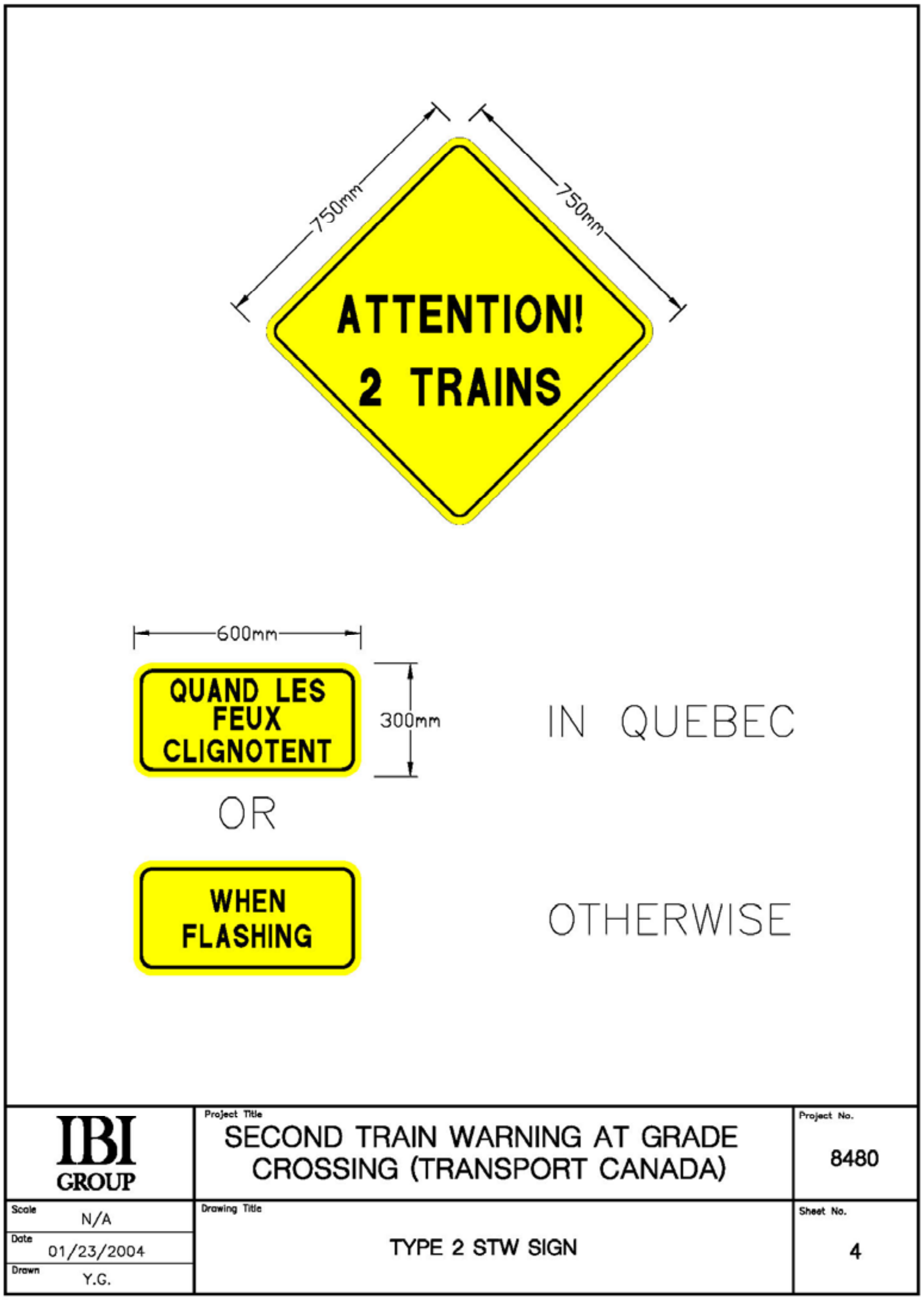
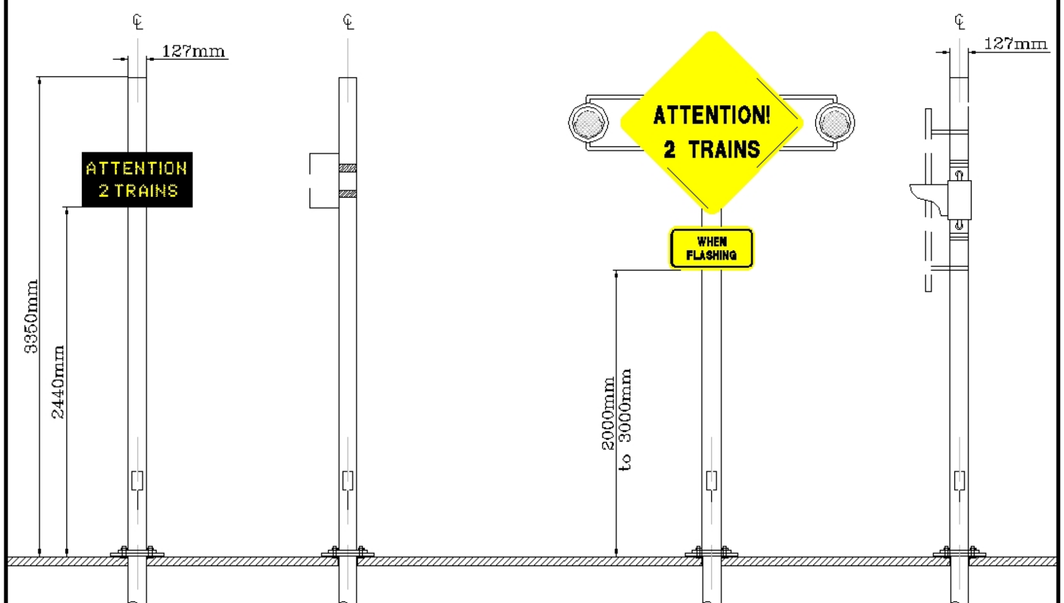


Figure F-4 Type 2 Sign – Sign Content



NOTE: ALL POLES ARE MOUNTED ON A CONCRETE BASE

IBI GROUP	Project Title SECOND TRAIN WARNING AT GRADE CROSSING (TRANSPORT CANADA)	Project No. 8480
Scale N/A Date 07/26/2001 Drawn Y.G.	Drawing Title STW SIGN SUPPORT STRUCTURES	Sheet No. 5

Figure F-5 Sign Mounting Location

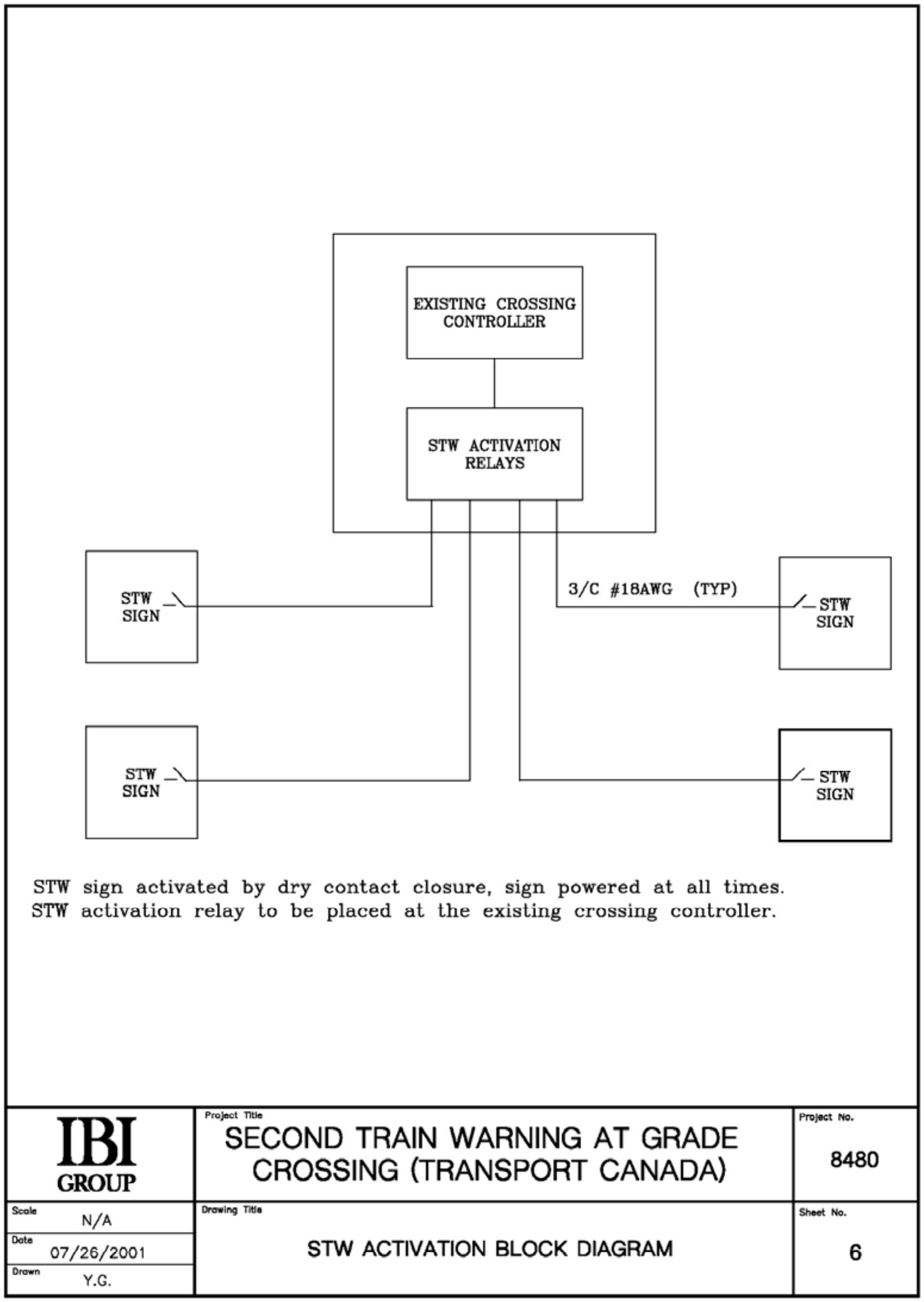


Figure F-6 Activation Block Diagram

APPENDIX G

SIGN CONTENT SURVEY FORM

Second Train Warning Project
Transportation Canada

Sign Content Survey
Central Station, Montreal, Quebec
April 18, 2002

Demographics:

Language of Preference	English	❐	French	❐
Approximate Age	<18 ❐	18 to 39 ❐	40 to 65 ❐	65 > ❐

Preamble:

"Imagine you are walking up to the railroad crossing shown in the picture. A train has just passed, the warning arms are down, railway lights are still flashing and the bells are ringing."

Question 1:

If you are a pedestrian at the crossing at this moment and the lights on the yellow warning sign began to flash, what situation would you expect to occur?

Another train approaching/watch for another train. ❐

Two trains in the crossing. ❐

Do not know. ❐

Other ❐ Please specify: ______________________________

Question 2:

If the response to Question #1 does not relate to a second train approaching/crossing the at-grade crossing, then explain to the individual: *"The sign is intended to warning pedestrians regarding a second train approaching the railroad crossing while the warning system has already been activated for the first train."*

What would you change about the sign to warning pedestrians about this danger?

____

____

____

APPENDIX H

FUNCTIONAL REQUIREMENTS FOR SECOND TRAIN WARNING SYSTEM

GENERAL SPECIFICATIONS PACKAGE

1. GENERAL DESCRIPTION

The Second Train Warning System incorporates an automated warning system that will detect a 'second train event', and provide clear warning messages for pedestrians at a Roadway-Rail Intersection (RRI). A 'second train event' is defined here as a point in time when two trains move through a RRI, one after the other, within the same warning system activation period (i.e. a single gate and/or flasher activation for the two arrivals).

The Second Train Warning System is comprised of the following elements:

- Second Train Warning Sign (STW Sign) – static warning sign with alternating amber flashing (wig-wag) beacons[1];
- Sign support structure – this will comprise a roadside pole-mount with an 2.45m (8') clearance;
- Sign Activation Equipment – a second train warning logic relay wired to railway circuitry interfacing with the current equipment; and
- Power Connection to Sign – associated wiring and disconnect switch.

Alternatively, the STW Sign may be a limited state, pre-programmed light emitting diode (LED) sign. LED activated by a second train event.

Note: (1) Based on actual site conditions, sign mounting location and anticipated pedestrian waiting areas, supplementary beacons mounted behind and facing in the opposite direction to the primary beacons may be required to permit waiting pedestrians to be notified of the STW system activation.

2. FUNCTIONAL REQUIREMENTS

2.1 Equipment Layout

The STW Signs shall typically be located as indicated in Figure H-1. The actual location plans for the subject installation(s) shall be provided by Transport Canada as part of a Specific Requirements package to accompany this General Requirements package.

A STW sign shall be installed at a position conspicuous from each pedestrian access to a pedestrian rail crossing area (up to 4 distinct sites per RRI). This will typically be on the near side of the rail tracks facing the nearside pedestrian waiting area.

In all instances, the STW Signs shall be designed and placed to maximize legibility for pedestrians using the designated crossing areas of the RRI.

The STW signs shall be free of visual obstruction from roadside sources such as trees, signing, poles, etc.

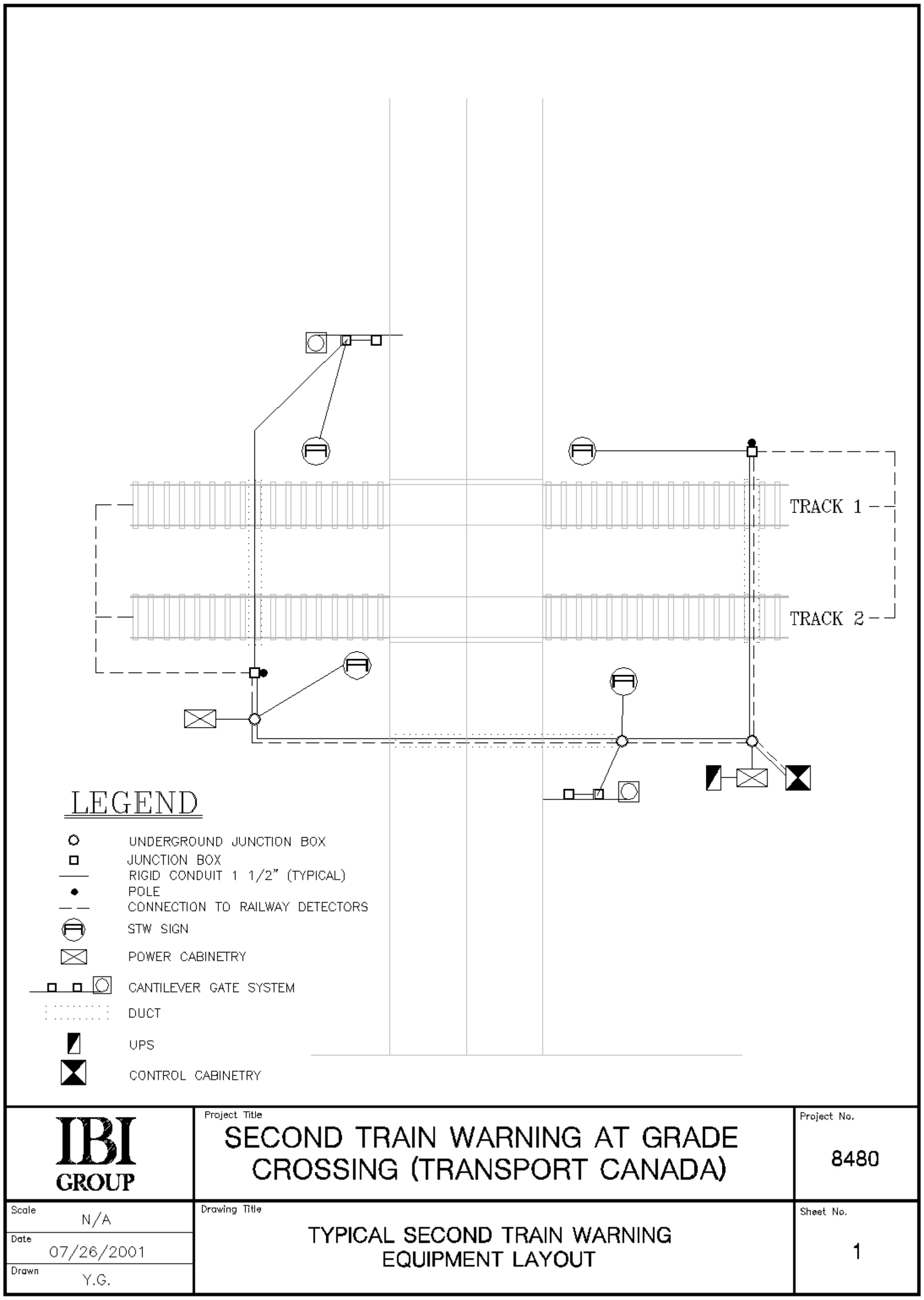


Figure H-1 General Configuration of STW System Signs

2.2 STW Sign Functionality

These static sign and flasher systems shall be capable of fulfilling the following functionality:

- the static sign shall display an appropriate warning message (see Section 3.1.1);
- the flasher units shall remain non-activated, except when activated by a second train event (i.e. the default setting is unenergized).

2.3 Detection and Clearance

The railway authority will provide all train detection circuitry, including signals indicating the detection of the arrival of any train into the RRI ‘detection zone’, and the clearance of this train from the RRI ‘detection zone’. The Second Train Warning System shall include the following features:

- a logic circuit that will activate the STW Sign only upon the receipt of a specific combination of detection signals (interpreted as a command) from the railway detection circuits;
- the logic circuit will only provide an activation signal for the STW Sign if the rail detection circuitry detects a train entering the RRI ‘detection zone’ AND a second train entering the same RRI ‘detection zone’ (regardless of the number of tracks) prior to the clearance of the first train from the RRI ‘detection zone’; and
- the logic circuit will maintain an activation signal for the STW Sign until both trains clear the RRI ‘detection zone’.

3. MATERIAL REQUIREMENTS

3.1 Warning Sign

3.1.1 Display

- the static sign shall display the message “ATTENTION!”, “2 TRAINS” with an information tab indicating either “Quand les feux clignotent” for applications in Quebec, or “When Flashing” for applications outside of Quebec, as illustrated in Figure H-2;
- the sign face shall be made of high reflectivity sheeting;
- the sign dimensions shall be 750 mm square for the main sign, 600 mm x 300 mm for the supplemental tab, with all character heights consistent with the Metric Edition Standard Alphabets for Highway Signs and Pavement Markings (U.S. Department of Transportation), as illustrated in Figure H-2, and as per the TAC guidelines for warning signs;
- the flashers shall alternate with a frequency sign of 50-60 flashes per minute, per the TAC guidelines for warning signs; and
- the sign shall be clearly legible from 30.5 m (100 feet).

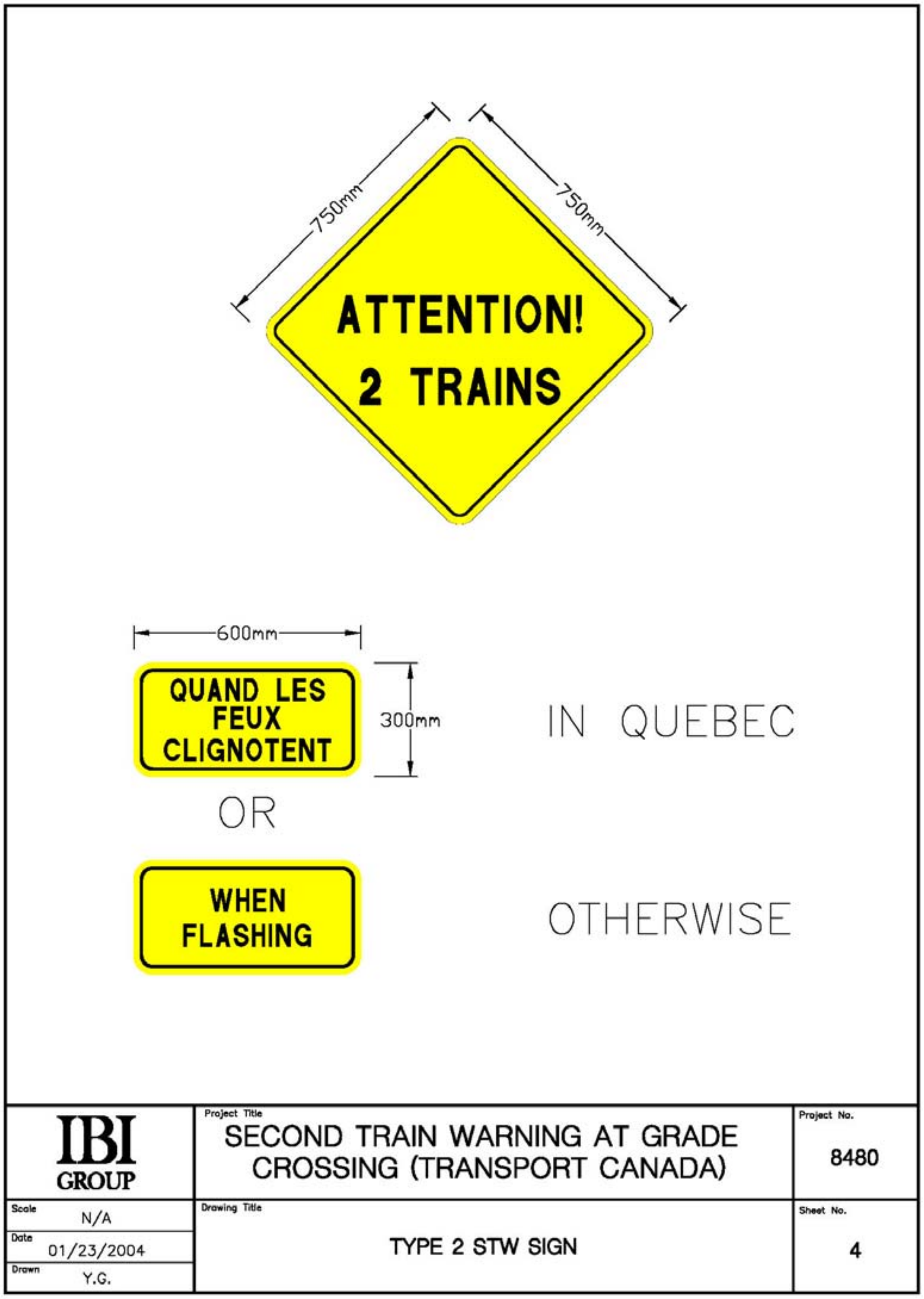


Figure H-2 Type 2 Sign – Sign Content

3.2 Sign Support Structure

As illustrated in Figure H-3, the structural support for the STW Sign shall include the following features:

- the sign will be mounted on a galvanized 3.35 m (11 foot) round aluminium pole with a 12.7 cm (5 inch) outer diameter;
- the pole will be installed within the rail right-of-way;
- the pole will be mounted on an appropriate concrete pole base;
- the pole base and pole will be installed to provide an approximate 50 cm (20 inch) clearance (parallel to the tracks) between the pole and edge of the sidewalk;
- the pole base and pole will be installed to provide a minimum clearance (perpendicular to the tracks) between the pole and the nearest rail track. This minimum distance will be defined by the railway owner/operator;
- the sign will be centre-mounted on the pole with a u-bracket and banding (or other appropriate fastener) with a sign clearance of 250 cm (98 inches). [The mounting equipment should be of sufficient strength to minimize wavering or dislodging for the site specific conditions;]
- the supporting pole will act as the conduit for the power supply to the sign.

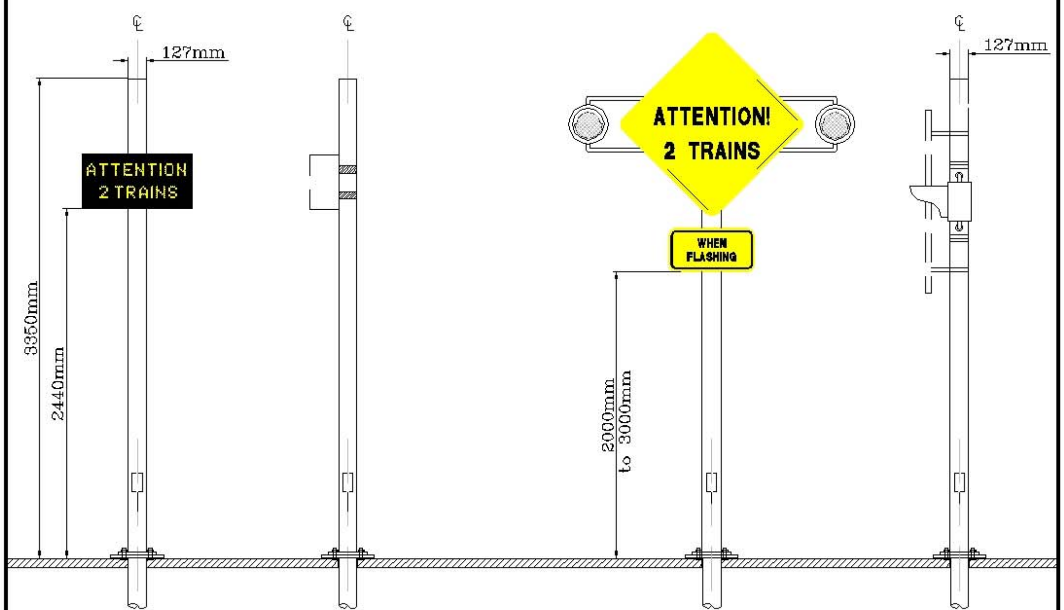
The above-noted pole installation directions shall be followed as closely as possible. Should any variation be required at time of installation, minor modifications may be possible subject to the approval of Transport Canada, or its Representative. In these circumstances, emphasis shall be placed on maintaining adequate visibility of the sign for pedestrians.

Where available, the STW Signs may be mounted on existing structures. The Contractor shall be responsible for obtaining any necessary approvals for such a mounting configuration. The Contractor must confirm that the proposed existing structure is structurally adequate for the proposed use. A qualified Professional Engineer (for the applicable Province) must certify this adequacy.

3.3 Interface Requirements for Sign Activation

For sites selected, Transport Canada will provide detection and cancellation circuitry defining the ‘detection zone’. This circuitry will terminate within a cabinet to be supplied by Transport Canada.

The contractor shall supply a logic circuit that will interpret the existing rail detection inputs to activate the STW signs per Section 2.3. Transport Canada will allow the Contractor access to the existing grade crossing control cabinetry for the purposes of installing the logic circuits that will activate the STW Sign. The logic circuits will make use of the current railway circuitry to activate the sign or beacon, based on the combination of detection inputs described above. Figure H-4 provides a general schematic for this arrangement.



NOTE: ALL POLES ARE MOUNTED ON A CONCRETE BASE

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Figure H-3 Sign Mounting Location

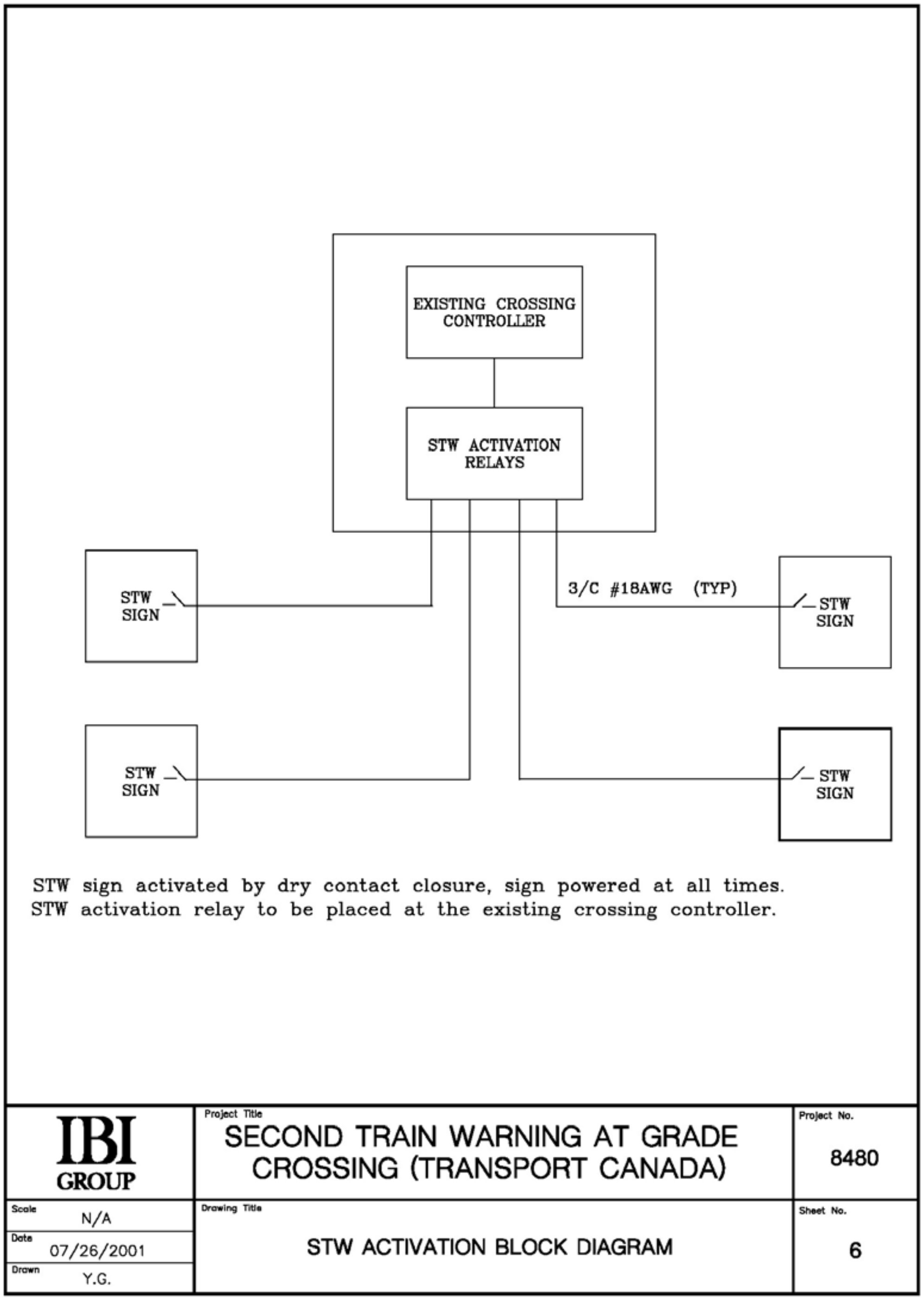

Figure H-4 Activation Block Diagram

3.4 Electrical System

Power will be supplied either by an aerial drop or by underground conduit, as is suitable for the specific site. The Contractor shall be responsible for all coordination with the applicable electrical utility to secure approvals and complete electrical hook-up of the STW Sign and all related field components.

All electrical/electronic components shall be of modular, interchangeable, plug-in type fabrication and shall be standard manufacturers' components and CSA certified, where possible. If no CSA standards are available for a proposed component, other standards organization certification may be substituted with the approval of Transport Canada, or its Representative.

All electrical safety requirements will be followed.

All components used shall be fully weatherproofed and capable of operating under any of the environmental conditions found locally at the proposed site. Prior to commencing the project, the Contractor shall confirm the required range of environmental operating conditions with Transport Canada, or its Representative.

All components shall be treated so that no corrosion occurs for a period of 3 years from the time of delivery.

All connectors and components shall be fully Code compliant, readily available and ruggedized.

4. INSTALLATION REQUIREMENTS

All aspects of the installation, including traffic control, installation methods, equipment, and attachment hardware are subject to approval by Transport Canada, or its Representative.

All power and activation circuitry cables shall be formed of continuous unspliced lengths from source to destination. No cable splices shall be permitted.

4.1 Precautions

Care must be taken to avoid damaging equipment during transportation and installation. If equipment supplied is damaged, altering the characteristics of the equipment, the equipment will be repaired by the Contractor (to the satisfaction of Transport Canada, or its Representative) or replaced at the Contractor's expense.

In all instances, appropriate precautions shall be taken to protect all equipment and related cabling and connections from the potentially harmful effects of weather.

4.2 Traffic Control

The Contractor shall be responsible for developing traffic control plan suitable for the installation processes being proposed. The Contractor must obtain the latest standards in roadway / roadside work operations from Transport Canada.

All traffic control plans must be submitted to Transport Canada and the relevant road authority (or authorities) for approval. Approval must be obtained from Transport Canada, or its Representative, at least three working days before work can commence.

4.3 Sign Placement

The STW Signs shall be mounted on the poles as described in Section 3.2. The signs shall be levelled and aimed at the associated pedestrian waiting area, or as designated by Transport Canada, or their Representative.

Power cables and activation circuitry shall be protected by a watertight conduit. A Professional Engineer licensed to practice in the Province where the installation is being conducted shall attest the method of installation of such cables.

The Contractor is required to co-ordinate its activities with Transport Canada, or its Representative, to ensure that all required electrical power supplies, and activation circuitry are available prior to the installation of the STW Signs.

4.4 Connection between Detection Circuit and STW Sign

The Contractor is responsible for establishing and maintaining the connection between the rail detection circuit and the sign.

A logic circuit shall be installed within the existing grade crossing control (gate) cabinetry, as described in Section 3.3.

5. QUALITY CONTROL

The Contractor is responsible for all testing and documentation required to establish approval and acceptance of the installation and operation of the STW Signs. The following identifies the specific quality control requirements for this item.

The Contractor shall develop testing procedure and perform testing for a Pre-Installation Test and a Proof of Performance Test. Testing procedures and final test results are subject to the approval of Transport Canada, or its Representative.

Transport Canada, or its Representative, may witness all tests. The Contractor shall give Transport Canada, or its Representative, 48 hours notice of when tests are to be performed.

The Contractor shall submit to Transport Canada (for approval) detailed test procedures no later than two (2) weeks after award of the Contract, based on the performance requirements described in these specifications. The test procedures shall illustrate the nature of the test activities to be performed. The Contractor shall submit a total of one electronic copy and four hard copies of the test procedures once the test procedures have been accepted prior to the commencement of testing.

For the above-noted tests, the Contractor shall record on a suitable test certificate the site reference, the device reference, the date of the test, the prevailing weather conditions, ambient temperature, the measure of acceptable performance, and the actual performance of the devices during the test.

All test results shall be submitted to Transport Canada, or its Representative, for approval. These test results shall be submitted no later than two weeks following completion of testing. The Contractor shall, as directed by Transport Canada or its Representative, correct or replace any materials that fail the above tests.

5.1 Shop Drawings

The Contractor shall submit shop drawings for the signcase, mounting hardware, pole installation, electrical connection, detection connections (including a logic diagram and wiring diagram) no later than two (2) weeks after award of the Contract.

5.2 Pre-Installation Testing

The Contractor shall carry out pre-installation testing to ensure that the STW Signs exhibit error free operation:

5.3 Proof of Performance (POP) Testing

The Contractor shall carry out proof of performance testing to ensure that the STW Signs exhibit error free on-site operation. Each of the functions outlined in Section 2 of this specification shall be demonstrated.

The Contractor shall complete the POP testing in co-ordination with Transport Canada, or its Representative.

All POP tests on the STW Signs shall be performed within five (5) working days of installation.

6. MAINTENANCE REQUIREMENTS

The Contractor shall be prepared to enter into a maintenance contract with Transport Canada for a period of one year, with optional extensions of one year, not exceeding a total of three years.

The Terms of the maintenance contract are negotiable, and the Contractor proponents shall submit an estimate and details of their proposed maintenance program with their cost estimates.

7. MEASUREMENT FOR PAYMENT

Measurement of the Second Train Warning Signs is by Plan Quantity and may be revised by Adjusted Plan Quantity. The unit of measure is ‘each’. Each unit shall include the installation, testing and documentation of the STW Signs, and all related power and control features.

A separate annual payment for the maintenance of this equipment will be negotiated, as described in Section 6.

8. BASIS OF PAYMENT

Payment at the Contract Item Price shall be full compensation or all labour, equipment and material required to do the work including the supply, testing, and the production of documentation and test results.

APPENDIX I

QUALITATIVE SCREENING RESULTS

							Measures				Weighted Measures				TOTAL
Province	Railway	Mile	Subdivision	Highway	Municipality	# of Tracks	Maximum Train Speed	Total # of Trains	# of Pedestrians	Whistle Blowing Prohibition	Maximum Train Speed	Total # of Trains	# of Pedestrians	Whistle Blowing Prohibition	Total Ranking
Ont	CP	77.02	Cartier	Bellevue Avenue	Sudbury	2	75	14	50	No	0.2	0.3	0.4	0.1	1
Que	CP	6.39	Adirondack	Rue St-Alphonse	Farnham	3	20	10	50	No	0.2	0.3	0.4	0.1	1
BC	CN	102.85	Yale	Church Street	Langley	2	50	22	100	No	0.4	0.3	0.4	0.1	1.2
Ont	CP	76.68	Cartier	Portage Avenue	Sudbury	2	40	31	50	No	0.4	0.3	0.4	0.1	1.2
BC	CP	112.8	Cascade	Westwood Street	Port Coquitlam	2	60	36	100	Yes	0.4	0.3	0.4	0.5	1.6
BC	CN	102.92	Yale	Glover Road	Langley	2	50	22	100	Yes	0.4	0.3	0.4	0.5	1.6
Man	CN	3.89	Rivers	Waverley	Winnipeg	3	40	54	50	Yes	0.4	0.3	0.4	0.5	1.6
Ont	CN	20.18	BALA	Hillview Drive	Richmond Hill	2	60	27	100	Yes	0.4	0.3	0.4	0.5	1.6
Que	CP	36.53	Adirondack	Petit Rang St-Régis Sud	St-Constant	2	50	15	10	Yes	0.4	0.3	0.4	0.5	1.6
Que	CN	2.94	Montreal	Rue St-Ambroise	Montreal	4	45	60	70	Yes	0.4	0.3	0.4	0.5	1.6
Man	CP	4.6	La Riviere	Grant Avenue	Winnipeg	2	10	6	200	No	0.2	0.3	1.2	0.1	1.8
Que	CP	6.35	Adirondack	Rue St-André	Farnham	3	20	10	200	No	0.2	0.3	1.2	0.1	1.8
Que	CN	17.52	Kingston	Avenue Woodland	Beaconsfield	2	100	51	20	Yes	0.6	0.3	0.4	0.5	1.8
Que	CN	19.21	Kingston	Rue Morgan	Baie-d'Urfé	2	100	50	100	Yes	0.6	0.3	0.4	0.5	1.8
Que	CN	59.36	St-Hyacinthe	Rue Robert	St-Basile-le-Grand	3	95	34	100	Yes	0.6	0.3	0.4	0.5	1.8
Que	CN	62.33	St-Hyacinthe	Rue de la Rabastalière	St-Bruno-de-Montarville	2	95	28	100	Yes	0.6	0.3	0.4	0.5	1.8
Que	CP	12.15	Vaudreuil	Avenue Woodland	Beaconsfield	2	70	44	20	Yes	0.6	0.3	0.4	0.5	1.8
Que	CP	13.8	Vaudreuil	Rue Morgan	Baie-d'Urfé	2	70	44	100	Yes	0.6	0.3	0.4	0.5	1.8
BC	CP	106.2	Cascade	Maple-Meadows Way	Maple Ridge	2	60	41	200	No	0.4	0.3	1.2	0.1	2
Que	CN	12.21	Bridge	Passage pour piétons	Vanier	2	75	10	200	No	0.6	0.3	1.2	0.1	2.2
BC	CN	1.82	Ashcroft	Singh Street	Kamloops	2	50	25	250	Yes	0.4	0.3	1.2	0.5	2.4
BC	CP	58.9	Cascade	Hwy#9	Kent	3	55	33	200	Yes	0.4	0.3	1.2	0.5	2.4
BC	BN	153.82	New Westminster	Kaslo Street	Vancouver	3	40	15	200	Yes	0.4	0.3	1.2	0.5	2.4
BC	CP	119.92	Shuswap	Pat Road	Kamloops	2	60	33	200	Yes	0.4	0.3	1.2	0.5	2.4
Que	CN	7.57	Deux-Montagnes	Avenue O'Brien	St-Laurent/Montreal	2	65	44	250	Yes	0.4	0.3	1.2	0.5	2.4
Que	CN	69.51	St-Hyacinthe	Rue St-Georges	Lemoyne	4	38	60	200	Yes	0.4	0.3	1.2	0.5	2.4
Ont	CN	49.05	Dundas	Norwich Avenue	Woodstock	4	80	34	300	No	0.6	0.3	1.2	0.5	2.6
Ont	CN	58.89	Dundas	Themes Street	Ingersoll	2	70	34	250	Yes	0.6	0.3	1.2	0.5	2.6
Que	CN	11.75	Bridge	Boul. du Père-Lelièvre	Vanier	2	75	10	150	Yes	0.6	0.3	1.2	0.5	2.6
Que	CN	53.55	St-Hyacinthe	Rue Ste-Anne	Mont St-Hilaire	2	95	33	130	Yes	0.6	0.3	1.2	0.5	2.6
Ont	CN	10.85	Oakville	Ogden Avenue	Mississauga	3	80	116	125	Yes	0.6	0.6	1.2	0.5	2.9
Ont	CN	16.09	Oakville	Clarkson Road	Mississauga	4	80	110	209	Yes	0.6	0.6	1.2	0.5	2.9
Que	CN	3.6	Montreal	Rue de Courcelles	Montreal	6	20	70	1 000	Yes	0.2	0.3	2	0.5	3
Que	CP	0.04	Vaudreuil	Avenue Westminster	Montreal	3	25	26	370	Yes	0.2	0.3	2	0.5	3
BC	BN	153.7	New Westminster	Renfrew Street	Vancouver	2	40	15	1 000	Yes	0.4	0.3	2	0.5	3.2
BC	BN	153.2	New Westminster	Rupert Street	Vancouver	2	40	17	500	Yes	0.4	0.3	2	0.5	3.2
BC	CP	107.35	Cascade	Harris Road	Pitt Meadows	2	60	37	400	Yes	0.4	0.3	2	0.5	3.2
Que	CN	4.89	Deux-Montagnes	Passage pour piétons	Mont-Royal	2	65	42	400	Yes	0.4	0.3	2	0.5	3.2
Que	CP	7.25	Lachute	Passage pour piétons	Montreal	2	40	14	500	Yes	0.4	0.3	2	0.5	3.2
Que	CP	10.21	Lachute	Boulevard des Prairies	Laval	2	45	14	400	Yes	0.4	0.3	2	0.5	3.2
Alta	CP	2.56	Macleod	50 Avenue SE	Calgary	3	30	338	150	Yes	0.2	1.5	1.2	0.5	3.4
Que	CN	12.4	Bridge	Passage pour piétons	Vanier	2	75	10	990	Yes	0.6	0.3	2	0.5	3.4
Alta	CP	3.06	Macleod	58 Avenue SE	Calgary	3	50	336	250	Yes	0.4	1.5	1.2	0.5	3.6
Alta	CP	3.31	Macleod	61 Avenue SE	Calgary	3	50	336	200	Yes	0.4	1.5	1.2	0.5	3.6
Ont	CN	11.03	Oakville	Alexandra Avenue	Mississauga	3	80	116	304	Yes	0.6	0.6	2	0.5	3.7
Alta	CN	127.21	Vegreville	129 Avenue E 62 Street	Edmonton	3	20	262	1 200	Yes	0.2	1.2	2	0.5	3.9
Alta	CP	4.63	Macleod	Heritage Drive	Calgary	3	50	336	500	Yes	0.4	1.5	2	0.5	4.4

Transportation Development Centre

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