steer davies gleave

SNC·LAVALIN

Hamilton Rapid Transit Preliminary Design and Feasibility Study

B-LINE

SIGNALING SYSTEM DESIGN BRIEF

Version:2.0

METROLINX

An agency of the Government of Ontario

RAPIDTransit
moving HAMILTON forward

Hamilton
Public Works

Hamilton Rapid Transit Preliminary Design and Feasibility Study

B-LINE

SIGNALING SYSTEM DESIGN BRIEF
Version:2.0

February 2012

An agency of the Government of Ontario

moving HAMILTON forward

Hamilton Public Works

Table of Contents

APPENDICES

1.0 Introduction

1.1 Study Objectives

This report describes the proposed signalling design for a typical signalized intersection with Transit Signal Priority (TSP) along the Light Rail Transit (LRT) B-Line route. The system design is based on the conceptual system architecture which is compatible with future plans for centralized traffic control system. The rest of the report discusses the set up and the operations for a typical intersection at the preliminary design level of detail.

Appendix A: discusses at a high level the requirements for LRT system control for (TSP)

Appendix B: shows the list of all the intersections along the corridor with traffic and timing assumption. Such information shall be considered when moving forward to the next stage of design.

1.2 Scope of Work

For a selected typical intersection, signals operations based on the forecasted traffic volumes were developed and criteria for priority plans for LRT vehicles (LRV) were established. In practice there may be other types of intersection layouts and associated TSP strategies.

The schematic layout of signalling system components is developed at the preliminary level, in accordance with this phase of preliminary design.

The priority plans are described in general and for selected typical cases.

SNC • LAVALIN

2.0 System Architecture and Operations

2.1 System Hardware

The current design configuration assumes a localized 2-loop detector system operation, with provisions for future implementation of a centralized control and wireless communication system. For illustration purposes, a typical signal layout was designed for the intersection of Main Street West and Longwood Road South and is shown in **Exhibit-1**.

The layout shows the LRT stops on the east side of the intersection serving both directions. The 2-loop (detector) system includes a Check-in detector and a Check-out detector. The 2-loop system may be implemented with a real time responsive programmable traffic controller with the Transit Signal Priority (TSP) function enabled. For the configuration in the eastbound direction, the Check-in detector is upstream of the intersection. For the westbound direction, the Check-in detector is upstream of the stop platform. In both directions, the Check-out detector is placed just downstream of the intersection to indicate passage of the LRV.

The wiring diagram for the signal control is shown in **Exhibit-2**. Furthermore, **Exhibit-3** shows more detail of the system. The diagram show location and sample of pedestrian push buttons used on similar system in Ontario (St. Clair LRT, Toronto). The pedestrian button is constantly emitting an audible signal to alert visually impaired patrons of the facility to prompt the signal controller. The tactile arrow direction alerts the patron of the direction of crossing once the audible chirps are activated. The final system configuration shall be designed in the next design phase.

2.2 System Operations

The LRV will generally follow the posted speed which is 50 km/h for a majority of the route.

The following signal parameters are also assumed for the preliminary design:

- All signals are fixed time actuated with TSP;
- Minimum Green for LRV= 7 sec;
- Clearance for LRV= 6 sec;
- TSP Priority Mode Options = Early Termination/Extension/Phase Omission (no phase omission for intersections with LRT stops; however advance left-turns can be skipped);
- Detection Type = Check-in/Check-out loop detectors;
- Cycle Times = 90 sec (majority of intersections);

Advance left-turn phases can be skipped if there are no calls. Side-street phase omission may also be considered as part of the TSP priority scheme for intersections with no LRT stops, for more efficient operations.

2.3 Transit Signal Priority

The purpose of the TSP is to achieve minimum run times for LRV through localized loop detection systems using **"Check-in"** and **"Check-out"** detectors. The system control is discussed in further detail in the attached memorandum in **Appendix A**.

In order to accommodate TSP, some changes were made to the existing intersections in terms of physical geometrics, traffic controls, and/or signal timings & phasings, as summarized in **Appendix-B**.

Transit Priority can be achieved through several methods; Extension of the through-green phase (along the LRT alignment) or Early Termination of the cross-street phase after the minimum green or clearance is served.

Phase omission can also be considered. Left-turn advance phases along the LRT alignment can be skipped if there are no calls. For intersections without LRT stops, cross-street phases can be skipped if there are no calls from vehicles or pedestrians.

Phase insertion, such as LRT-only phase can also be considered.

The exact strategy depends on the layout of the intersection and its interface with LRT alignment, and also the system in place.

The purpose of the Check-in detector is to prepare the signal for an incoming LRV. It sends a signal to the controller to start the track green phase within a specified arrival time period. The Check-in detector should be placed far enough upstream of the intersection to allow for travel time to the stop-line, and if the stop is upstream of the intersection, the detector should allow for the dwell time, so there is enough time for initiating the track green phase before the LRV arrives. The signal initiates the track green phase after a specified time.

In the case of intersections with LRV stops upstream of the intersection, as in the example provided in this report, the Check-in loop is placed upstream of the stop in the westbound direction. The exact dwell time for the stops will be calibrated in the field and will depend on the loading profile of the stop. Consequently, the Check-in detector will send the signal to the controller to start the track green phase after the dwell time and after all minimums and clearance times have been served.

A LRV maximum green should also be defined to limit track green extensions beyond a reasonable length of time.

Other considerations for TSP operations can include an “All-red” phase to account for when the LRV could be stalled across the intersection. Algorithm could be included in the single controller to identify such conditions, such as when the LRV clears the Check-in detector but does not reach the Check-out detector even after LRV maximum green (with extensions) is reached. A provision may be included to send an alarm to the control centre for such situations.

Emergency vehicle pre-emption may also be included in the system design.

TSP Scenarios

The TSP algorithm is based on LRV detection at the Check-in loop and the state of the signal at that instance. After an approaching LRV is detected, depending on the state of the signal, a priority is provided by either extending the through-green with the LRV green running concurrently, or the early termination of the cross-street green to provide LRV passage.

If there are no LRV stops at the intersection then the cross-street phase can also be skipped to provide priority if there are no priority calls on the cross-street by either cars or pedestrians.

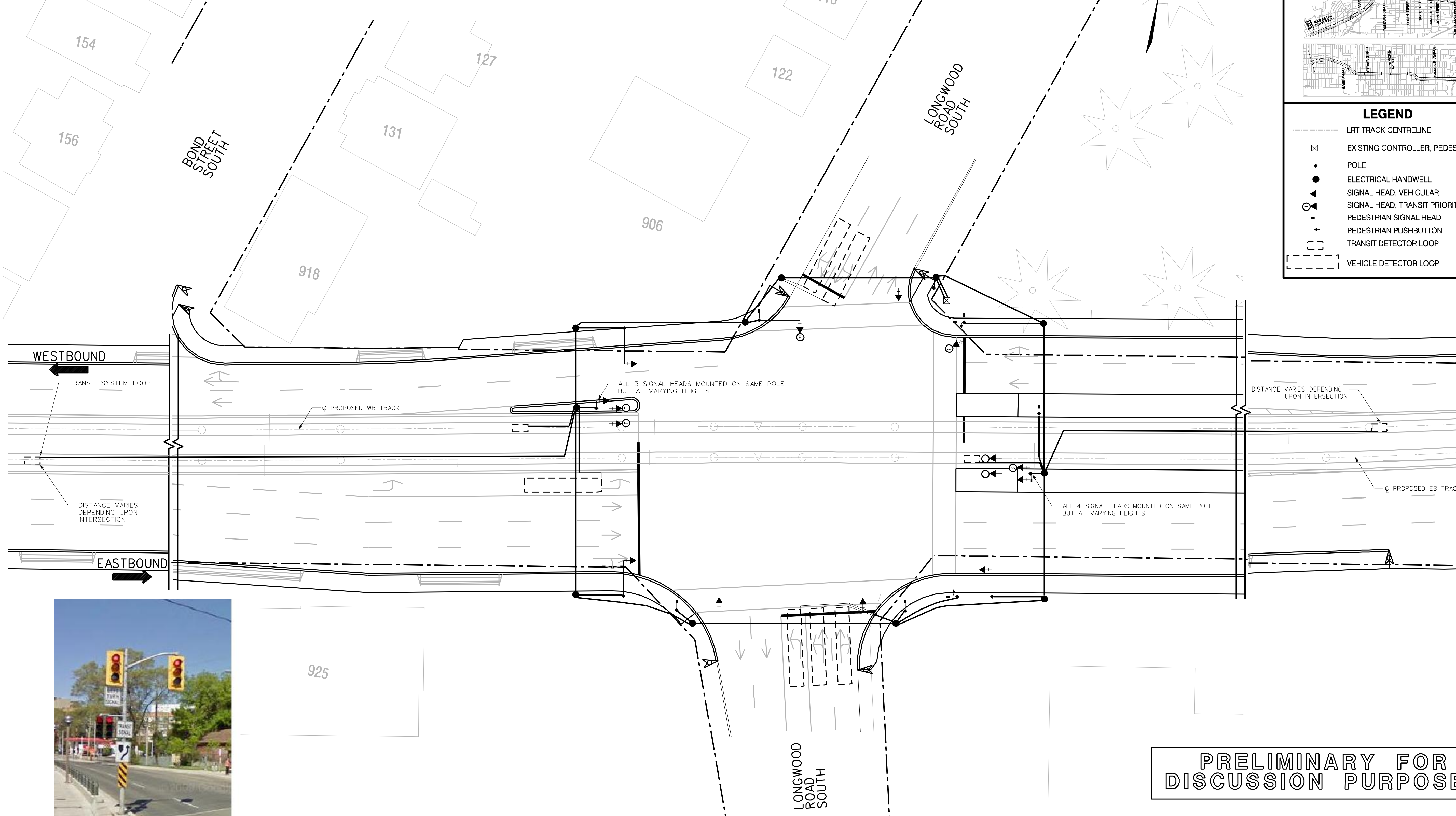
The exact sequence and timing depends on the mode and direction of arrival and whether the LRV stops at the upstream station (downstream station will have no impact on signal operations). These scenarios and their respective TSP strategies are summarized in the following two exhibits. **Exhibit-3** summarizes scenarios at intersections with LRT stops, such as the intersection of Main and Longwood which is illustrated here. **Exhbit-4** summarizes scenarios for intersections without LRT stops.

P:\503795\elec\Layout\TSignals\LRT-RD-ELEC0611.dgn
TRUOJ 2011-08-16 3:18:09 PM

MAIN STREET W

NOTE:

1. LAYOUT SHOWN FOR PROTECTED E/B LEFT TURN. SIMILAR LAYOUT CAN BE USED FOR U-TURN SCENARIO BY CHANGING TYPE 2 HEADS TO HIGHWAY TYPE HEADS.



FILE No.	CONTRACT No. PW 00-00 (-)	SHEET No. 1 OF 2

DIMENSIONS SHOWN ON THIS PLAN ARE IN METRES UNLESS OTHERWISE NOTED

LEGEND

- LRT TRACK CENTRELINE
- EXISTING CONTROLLER, PEDESTAL MOUNTED
- POLE
- ELECTRICAL HANDWELL
- SIGNAL HEAD, VEHICULAR
- SIGNAL HEAD, TRANSIT PRIORITY
- PEDESTRIAN SIGNAL HEAD
- PEDESTRIAN PUSHBUTTON
- TRANSIT DETECTOR LOOP
- VEHICLE DETECTOR LOOP

PRELIMINARY FOR DISCUSSION PURPOSES

EXHIBIT - 1

No.	REVISIONS	INITIAL	DATE

REFERENCE MATERIAL:
Surveyed By : COMPILED FBS AND SURVEY LRT.dgn (MAY 19, 2011) 0937HAMI0002_ALL_v8.dgn (OCTOBER 7, 2010)
Sewer Plans :
Water Plans :
Survey Plan :

Geodetic Bench Mark Index Elevation=
Borehole Report -

SCALES
0 5m 10m
HORIZONTAL 1:250
0 1m 2m
VERTICAL 1:50

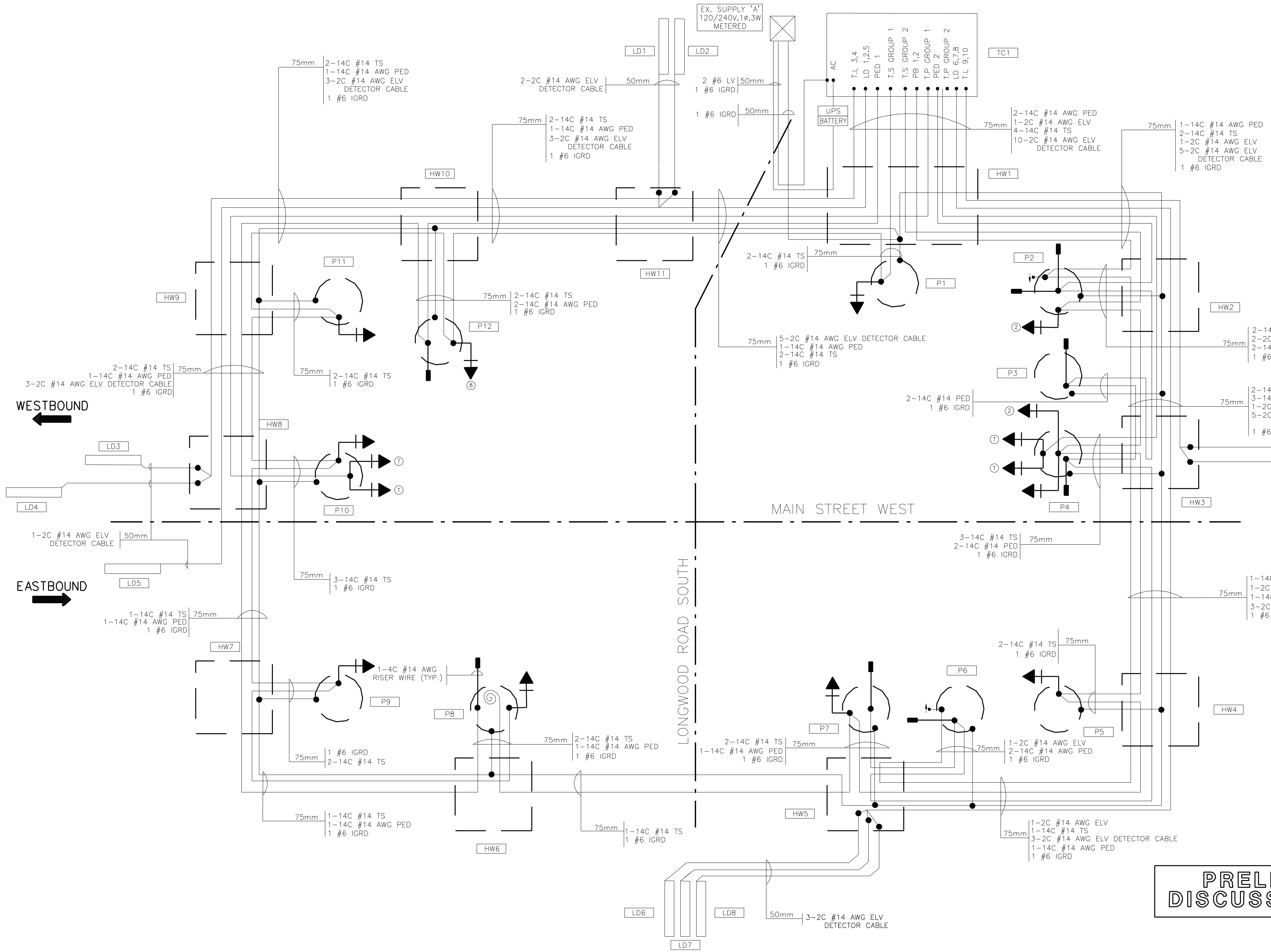
Project Manager (Design)
NAME
Manager of Design
NAME

SNC·LAVALIN steer davies gleave DIALOG

DRAWN REETY JAGGI RATRA
CHECKED MARIO BUCCI
APPROVED

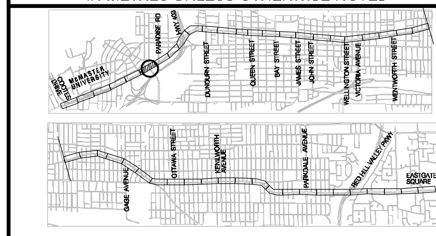
Hamilton Public Works
RAPIDTransit moving HAMILTON forward
METROLINX An agency of the Government of Ontario

HAMILTON LRT 'B' LINE TRAFFIC SIGNAL LAYOUT



FILE No.	CONTRACT No. PW 00-00 (-)	SHEET No.

DIMENSIONS SHOWN ON THIS PLAN ARE IN METRES UNLESS OTHERWISE NOTED



LEGEND

P	—	POLE
T.L	—	TRANSIT LOOP DETECTOR
LD	—	VEHICLE LOOP DETECTOR
T.S	—	TRAFFIC DETECTOR SIGNAL
PB	—	PUSH BUTTON
T.P	—	TRANSIT PRIORITY SIGNAL
PED	—	PEDESTRIAN SIGNAL
HW	—	ELECTRICAL HANDWELL
TC	—	TRAFFIC CONTROLLER

PRELIMINARY FOR DISCUSSION PURPOSES

EXHIBIT - 2

P:\503795\elec\Layout\TSignals\LRT_WIRING_ELEC(1).dgn
2011-08-16 2:09:41 PM
TRUOJ

No.	REVISIONS	INITIAL	DATE

REFERENCE MATERIAL:
Surveyed By : CO
Sewer Plans :
Water Plans :
Survey Plan :
Geodetic Bench Mark Index Elevation=
Borehole Report -

SCALE
N.T.S.

Project Manager (Design)
NAME
Manager of Design
NAME

SNC·LAVALIN steer davies gleave DIALOG

DRAWN JAMES TRUONG
CHECKED MARIO BUCCI
APPROVED

Hamilton Public Works
RAPIDTransit moving HAMILTON forward
METROLINX An agency of the Government of Ontario

HAMILTON LRT 'B' LINE TRAFFIC SIGNAL WIRING DIAGRAM

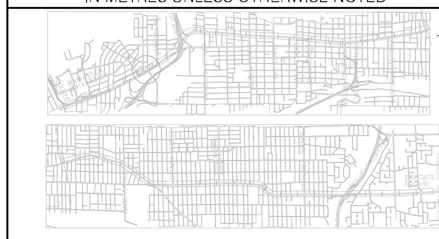
MAIN STREET W

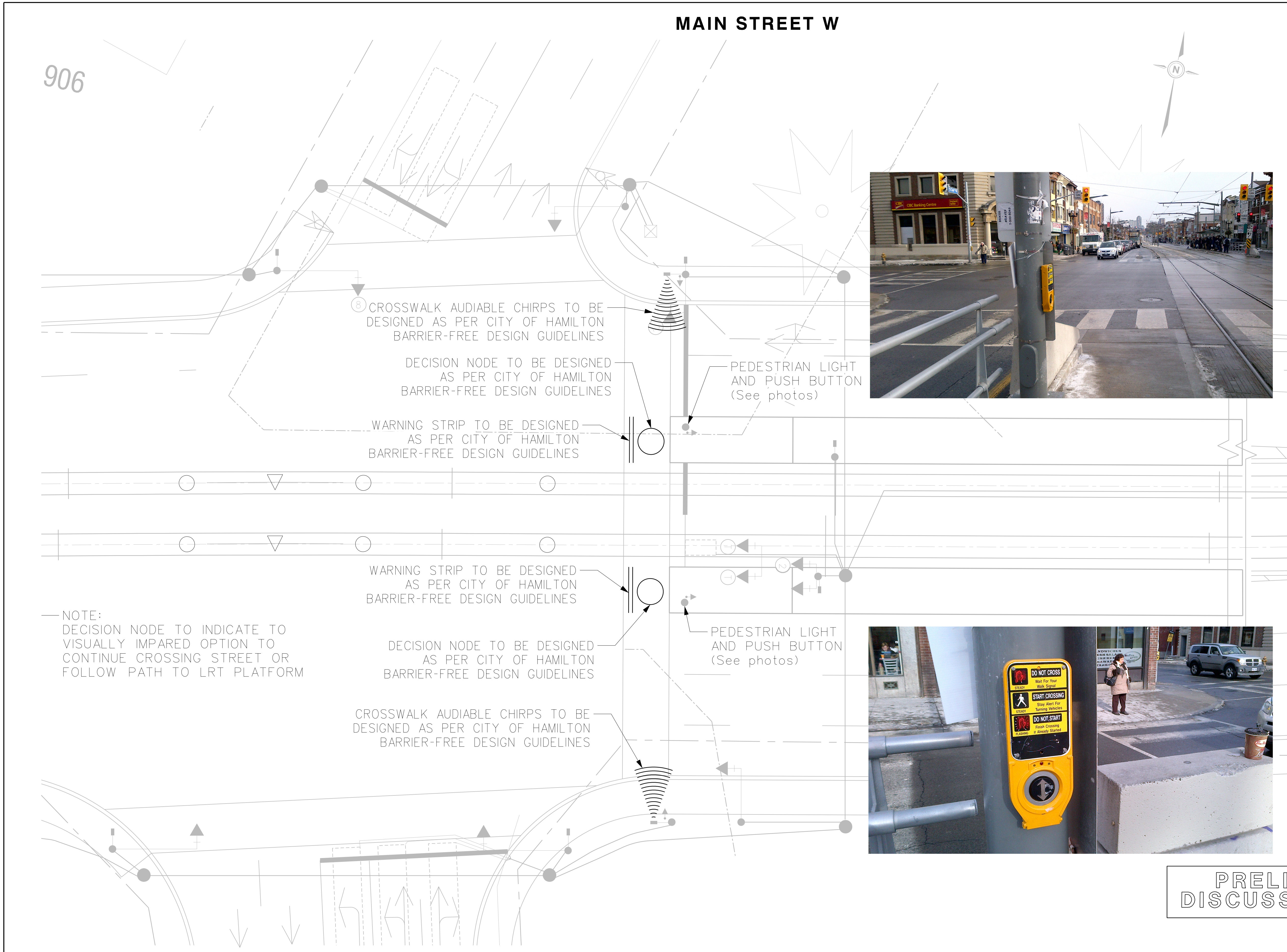
09-H-00 (1)

J:\503795\30 PM\37 Reports\01 ATMS\Train Control and Signalling\LRT-RD-PEDESTIAN SIGNAL 2.dgn
WONGE4 2012-01-30 9:58:25 AM

FILE No.	CONTRACT No. PW 00-00 (-)	SHEET No.

DIMENSIONS SHOWN ON THIS PLAN ARE IN METRES UNLESS OTHERWISE NOTED





LEGEND

- LRT TRACK CENTRELINE
- EXISTING CONTROLLER, PEDESTAL MOUNTED
- POLE
- ELECTRICAL HANDWELL
- SIGNAL HEAD, VEHICULAR
- SIGNAL HEAD, TRANSIT PRIORITY
- PEDESTRIAN SIGNAL HEAD
- PEDESTRIAN PUSHBUTTON
- TRANSIT DETECTOR LOOP
- VEHICLE DETECTOR LOOP

PRELIMINARY FOR DISCUSSION PURPOSES

EXHIBIT - 3

No.	REVISIONS	INITIAL	DATE

REFERENCE MATERIAL:
Surveyed By : COMPILED FBS AND SURVEY LRT.dgn (MAY 19, 2011)
0937HAMI0002_ALL_v8.dgn (OCTOBER 7, 2010)
Sewer Plans :
Water Plans :
Survey Plan :

Geodetic Bench Mark Index Elevation=
Borehole Report -

SCALES
0 5m 10m
HORIZONTAL 1:250
0 1m 2m
VERTICAL 1:50

Project Manager (Design)
NAME
Manager of Design
NAME

SNC·LAVALIN steer davies gleave DIALOG

Hamilton Public Works RAPIDTransit moving HAMILTON forward METROLINX An agency of the Government of Ontario

HAMILTON LRT 'B' LINE PEDESTRIAN SIGNAL LAYOUT

***Exhibit-3: Example of TSP Scenarios for the Main/Longwood Stops*[1]** *(e.g. far side stops)*

LRV Arrival Mode	Scenario	Longwood Road (Cross-street) Call Status	Signal State at LRV Arrival			TSP Priority Options	
			Longwood Rd (Cross-street)	Main St Through (Along LRT)	LRT	Road vehicle - Through Traffic phase	LRT Phase
LRV approaches from the west on Main St (no LRT Stop)	1	Cars waiting	Red	Green	Red	Extend Green	Start LRT Green
	2	No Cars waiting	Red	Green	Red	Extend Green do not skip Cross-street Phase	Start LRT Green
	3	Cars waiting	Green	Red	Red	Early termination of Cross-street Green after pedestrian clearance time	Start LRT Green after Cross-street Clearance
	4	Cars waiting	Red	Green	Green	Extend Green	Extend LRT Green
	5	No Cars waiting	Red	Green	Green	Extend Green and Skip Cross-street Phase	Extend LRT Green
LRV approaches from the east on Main St and stops at the Stop for at least 25 seconds before crossing the intersection	6	Cars waiting	Red	Green	Red	Extend Green after 25 seconds delay	Start LRT Green after 25 seconds delay
	7	No Cars waiting	Red	Green	Red	Extend Green after 25 seconds delay and do not skip Cross-street Phase	Start LRT Green after 25 seconds delay
	8	Cars waiting	Green	Red	Red	Call for early termination of Cross-street Green within a 25 seconds delay and pedestrian clearance time	Start LRT Green after 25 seconds delay plus Cross-street clearance time
	9	Cars waiting	Red	Green	Green	Extend Green after 25 seconds delay	Extend LRT Green after 25 seconds delay
	10	No Cars waiting	Red	Green	Green	Extend Green after 25 seconds delay and do not skip Cross-street Phase	Extend LRT Green after 25 seconds delay

Notes:

1. ***Advance left-turn phase along LRT alignment can be skipped if there is no call***
2. ***LRT phases are operated concurrently with through traffic***
3. ***LRT phase terminates when Check-out detector is tripped***
4. ***For early terminations, the minimum green and clearance times will be served before termination (such as pedestrian clearance time)***
5. ***For purpose of illustration, it is assumed here that the LRV dwell time at the stop is 25 seconds. This time will be calibrated in the field and will depend on the loading profile at the Stop***

SNC·LAVALIN

Exhibit-4: TSP Scenarios for Intersections without LRT Stops

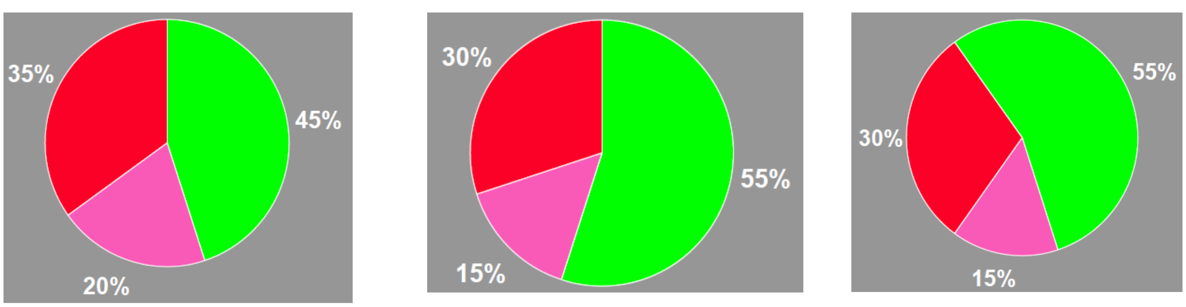
LRV Arrival Mode	Scenario	Cross-street Call Status	Signal State at LRV Arrival			TSP Priority Options	
			Cross-street (across LRT)	Through Traffic (along LRT)	LRT	Through Non-LRT Phase	LRT Phase
LRV approaches from either side (no LRT Stop)	1	Cars waiting	Red	Green	Red	Extend Green	Start LRT Green
	2	No Cars waiting	Red	Green	Red	Extend Green; and skip Cross-street Phase	Start LRT Green
	3	Cars waiting	Green	Red	Red	Early termination of Cross-street Green after pedestrian clearance time	Start LRT Green after Cross-street Clearance time
	4	Cars waiting	Red	Green	Green	Extend Green	Extend LRT Green
	5	No Cars waiting	Red	Green	Green	Extend Green; and skip Cross-street Phase	Extend LRT Green

Notes:

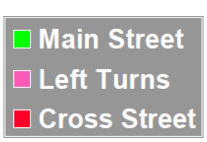
1. *Advance left-turn phase along LRT alignment can be skipped if there is no call*
2. *LRT phases are operated concurrently with through traffic*
3. *LRT phase terminates when Check-out detector is tripped*
4. *For early terminations, the minimum green and clearance times will be served before termination (such as pedestrian clearance time)*

The following **Exhibit-5** illustrates two possible impacts of TSP on normal signal cycle.

Exhibit-5 Impacts of TSP on Signal Cycle



Normal Cycle (without TSP) **Early Green Cycle (along LRT)** **Early Termination (for Cross-Street)**



Source: "Light Rail Signal Priority", Skehan, S, LADOT, 2004

3.0 Recommendations

3.1 Recommendations

For intersections with no LRT stops, it is recommended that cross-street phases be skipped if required to adhere to LRV schedule, to allow for more efficient LRV priority and easier recovery to normal cycle.

It should be noted that the current, initial, set-up does not distinguish between an LRV running on or behind schedule. This may be implemented in future.

As mentioned previously, an all-red phase may be considered to alert the central office in case of LRV stalling across the intersection. This may be activated when an LRV does not reach the downstream check-out detector even after the maximum green (with extensions) is reached or after communications between the operator and central control to report the condition.

It is suggested pedestrian detection systems be considered at intersections, especially at stop locations, to facilitate pedestrian crossings even when the pedestrian calls do not get activated for any reason. This will facilitate patrons of the system to arrive at the stop platform in a timely fashion.

Emergency vehicle pre-empt can also be included in the system design.

The following shall be considered in the detail design phase; pedestrian signals with call buttons for pedestrian coming out of the LRT stops toward the intersection cross walk should be considered at the boundary of the stop platform and the ramp to keep pedestrians from reaching the crosswalks until a walk signal on the crosswalk is activated. This walk signal will be synchronized with the crossing street walk signal. The purpose of this device is to force system patron alighting at the stop to wait on the stop platform rather than at the cross-walk in an unprotected environment. These additional pedestrian signals should not have audible chirps to avoid confusion with the crosswalk chirps.

Crosswalk widths near LRT stops shall be revised in the next design phase in light of expected passenger volume loading at peak hour for pedestrian safety.

Adaptive controllers can be considered for corridor-wide or system-wide optimization with the ability to re-order phase sequence.

It is recommended to initiate a comprehensive before and after study to measure benefits of TSP on different levels of coverage, at local, corridor level and system level. It would also be important to choose appropriate Measures of Effectiveness (MOEs). For example it is recommended that delay be measured per person rather than per vehicle to measure benefits of LRT. Before and after collisions should also be monitored.

Disclaimer

This document contains the expression of the professional opinion of Steer Davies Gleave North America Inc. and/or its sub-consultants (hereinafter referred to collectively as "the consultant team") as to the matters set out herein, using their professional judgment and reasonable care. It is to be read in the context of the agreement (the "Agreement") between Steer Davies Gleave North America Inc. and the City of Hamilton (the "Client") for the Rapid Transit Preliminary Design and Feasibility Study (reference C11-12-10), and the methodology, procedures, techniques and assumptions used, and the circumstances and constraints under which its mandate was performed. This document is written solely for the purpose stated in the Agreement, and for the sole and exclusive benefit of the Client, whose remedies are limited to those set out in the Agreement. This document is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context.

The consultant team has, in preparing the Agreement outputs, followed methodology and procedures, and exercised due care consistent with the intended level of accuracy, using professional judgment and reasonable care.

However, no warranty should be implied as to the accuracy of the Agreement outputs, forecasts and estimates. This analysis is based on data supplied by the client/collected by third parties. This has been checked whenever possible; however the consultant team cannot guarantee the accuracy of such data and does not take responsibility for estimates in so far as they are based on such data.

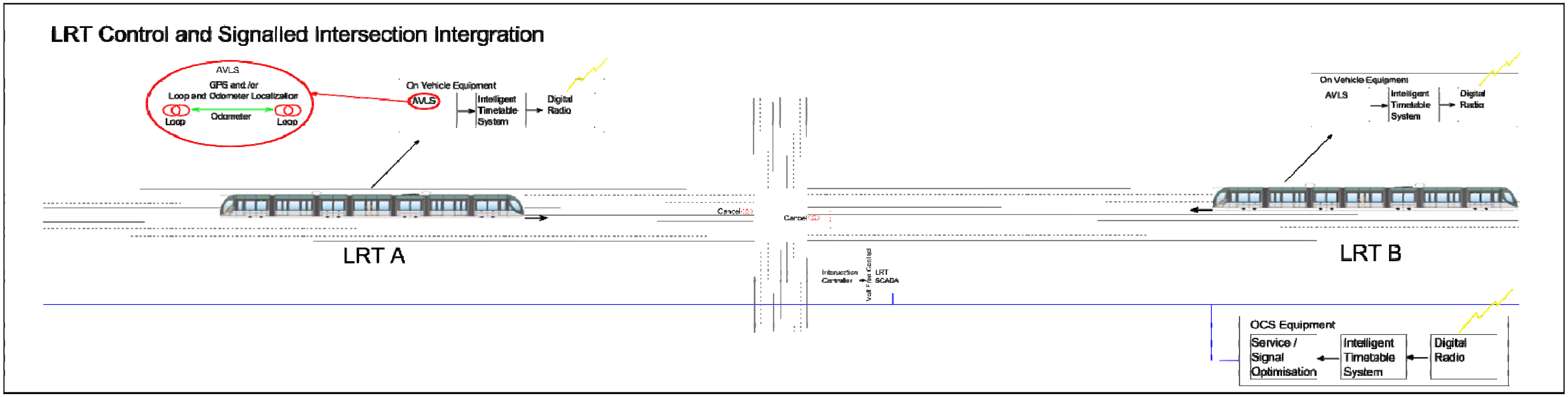
Steer Davies Gleave North America Inc. disclaims any liability to the Client and to third parties in respect of the publication, reference, quoting, or distribution of this report or any of its contents to and reliance thereon by any third party.

Appendix A

Concept of LRT system control for TSP

LRT System Control

1.1 The following diagram provides an overview of the systems employed to control an urban LRT system and the interfaces with traffic intersections. The system shows an arrangement using centralised control. In place of centralised control, loop detection can be used using “Prepare”, “Advance” and “Limit Line” loops feeding into the LRT control system with local volt free contacts to the signal controller.



1.2 The following table details some of the scenarios that can be employed. Multiple scenarios can be used to provide different levels of priority at different times of the day.

TABLE 1 PRIORITY SCENARIOS

Scenario	Vehicle	Intersection
1	Vehicle A is identified approaching intersection, running on or behind schedule.	LRT priority is requested from signal controller Signal phases are extended or cut short as appropriate (depending on travel time/distance of LRT from intersection) Signal controller can run clearance moves (where

		left turns are on LRT track) LRT movement signalled, with priority given to LRT Signal controller compensates for lost time as required
2	Vehicle A is identified approaching intersection, running ahead of schedule.	LRT Vehicle presence given to signal controller Signal phases are not extended or cut short Depending on point in signal cycle and desired programming, LRT receives standard LRT phase within the normal phase timing sequence. Signal controller can run clearance moves (where left turns are on LRT track) LRT movement signalled, LRT vehicle served in normal signal sequence, level of LRT delay therefore related to arrival point in signal cycle
3	Vehicle A is identified approaching intersection, running on or behind schedule. Vehicle B is identified on longer approach to intersection running on or behind schedule, with peak movement priority. Vehicle A's presence is not provided to Intersection if Vehicle B is detected within wider area When Vehicle B reached virtual loop, priority call placed for both LRT movements.	LRT priority is requested from signal controller Signal phases are extended or cut short as appropriate (depending on travel time/distance of LRT from intersection) Signal controller can run clearance moves (where left turns are on LRT track) Both LRT movements signalled, with vehicle B given priority and vehicle A varying priority, depending on signal sequence (i.e. should the LRT movements be non-conflicting, then vehicle A could receive signal phase prior to vehicle B, or at least concurrently) Signal controller compensates for lost time as required
4	Vehicle A is identified approaching	Vehicle A presence passed to signal controller

	intersection, running **on or behind schedule**. Vehicle B is identified on longer approach to intersection running ahead of schedule, with peak movement priority.	Vehicle B presence passed to signal controller (when it reaches virtual loop) Signal phases are not extended or cut short Depending on point in signal cycle and desired programming, LRT receives standard LRT phase within the normal phase timing sequence. Signal controller can run clearance moves (where left turns are on LRT track) LRT movement signalled, LRT vehicle served in normal signal sequence, level of LRT delay therefore related to arrival point in signal cycle If LRT Vehicle B is within a certain pre-set distance (or travel time), and the LRT movements are non-conflicting, the LRT Vehicle A signal would be extended to provide LRT Vehicle B a signal too If Vehicle B misses Vehicle A move, separate signalled move provided (as in Scenario 1 above).

Signal Controller Logic

The centralized control would provide inputs to the signal controller (via the LRT controller) – therefore the centralized controller is making the decisions on when to pass inputs to the signal controller, essentially making the decisions on how to treat late-running versus early-running LRT vehicles, and any peak direction bias. As noted above, this function could also be provided by "prepare", "advance" and "limit line" detector loops, although in this case, treatment of late-running versus early-running and peak directional bias would not be possible.

The signal controller would therefore still carry out all functions of providing intersection control, including for LRT phases. The normal model of LRT operation would be to use the standard RBC controller, with LRT priority provided through the "transit priority" function within the intersection controller.

For a typical intersection operation, as noted in the 4 scenarios above, LRT signal phases would be provided by the intersection controller by either:

- Using the transit priority function to extend/curtail/skip phases in order to minimise LRT delay
- Using the normal phase sequence

In both cases, the length of LRT phase would be controlled by the "cancel" loop, with the LRT phase only terminated once the cancel loop has detected the LRT vehicle

Within the "transit priority" operation, certain parameters would be set at each intersection (on an individual intersection basis) to enable the maximum level of LRT priority to be provided, whilst maintaining a suitable level of intersection capacity for all other movements (this clearly includes the maintaining of all minimum green split and clearance periods). In this way, the normal sequence of phase appearance will generally be maintained, except for the potential skipping of less critical left-turn permitted phases – phase green splits could vary each cycle depending on the appearance (or not) of LRT vehicles, but the intersection cycle time will generally be maintained over a number of cycles (where fixed cycle time operation is required for co-ordination with adjacent intersections).

At a few particular intersections, the RBC "pre-empt" function could be used as an alternative to "transit priority". In this case, LRT phases would be inserted at the next available opportunity (i.e. as soon as the current running timing period is able to terminate, subject to minima), rather than within the normal timing sequence. Within an urban environment, where the LRT alignment is street-running, the number of intersections that operate "pre-empt" LRT priority will be minimal, due to the considerations of maintaining co-ordination between adjacent intersections and ensuring pedestrian crossing movements are served when expected.

System Integration

The loops and vehicle detectors associated with the LRT system, including those used for the traffic signal system are in the majority of systems connected to the LRT control system. The LRT system provided voltage free feeds to the individual intersection controllers, usually from an adjacent equipment cabinet.

All the signal heads, traffic and LRT are controlled from the intersection controller.

Appendix–B

Summary list of Intersections with traffic and timing assumptions along the corridor

(Geometrics, Control and/or Signal Timings & Phasing)

Node #	New?	Main Street	Cross Street	Geometric Assumptions	Physical Signal Changes?	Traffic and Timing Assumptions
On LRT Alignment "Online"						
41		Main	Emerson		No	No changes to phasing (offline)
600a	Yes	Main	Tram Stop Xing Ebnd		Yes	Simple 2-phase, LRT with main road
600b	Yes	Main	Tram Stop Xing Wbnd		Yes	Simple 2-phase, LRT with main road
42		Main	Bowman		Yes	No changes to phasing, LRT with main road
43		Main	Dalewood		Yes	No changes to phasing, LRT with main road
44		Main	Haddon		Yes	No changes to phasing, LRT with main road
45		Main	Highway 403		Yes	No changes to phasing, LRT with main road
46		Main	Paisley	No SBLT, No EBLT	Yes	No changes to phasing, LRT with main road
47		Main	Longwood		Yes	No changes to phasing, LRT with main road
498	Yes	Main	Paradise		Yes	Simple 2-phase, LRT with main road
48		Main	Macklin	No EBLT	Yes	Simple 2-phase, LRT with main road
113		King	Dundurn	Extra free SBRT	Yes	Phase1 WBLT, Phase2 LRT, Phase3 NBLT, Phase4 SB, Phase6 WB, Phase8 NB
114		King	Strathcona	No WBLT	Yes	No changes to phasing, LRT with main road
115		King	Locke		Yes	No changes to phasing, LRT with main road
1075	Yes	King	Pearl (No signal)	No WBLT	Yes	Simple 2-phase, LRT with main road
117		King	Queen		Yes	Phase1 LRT, Phase2 WB, Phase4 SB
118		King	Hess		Yes	No changes to phasing, LRT with main road
119		King	Caroline	No WBLT	Yes	No changes to phasing, LRT with main road
120		King	Bay		Yes	No changes to phasing, LRT with main road
121		King	Summers Xing		Yes	No changes to phasing, LRT with main road
122		King	MacNab	Bus only WBLT	Yes	Simple 2-phase, LRT with main road, Buses WBLT yield to LRT
8		King	James	Bus only WBLT	Yes	No changes to phasing, LRT with main road, Buses WBLT yield to LRT
123		King	Hughson		Yes	No changes to phasing, LRT with main road
124		King	John		Yes	No changes to phasing, LRT with main road
125		King	Catharine		Yes	Phase1 LRT, Phase2 WB, Phase4 SB
126		King	Mary		-	Traffic Signals Removed
127		King	Walnut		-	Traffic Signals Removed
128		King	Ferguson Xing		-	Traffic Signals Removed
129		King	Jarvis Xing		-	Traffic Signals Removed
130		King	Wellington		Yes	Phase1 LRT and EB, Phase2 WB, Phase4 SB
603	Yes	King	West		Yes	Simple 2-phase, LRT with main road
131		King	Victoria		Yes	No changes to phasing, LRT with main road
604	Yes	King	East	No WBLT	Yes	Simple 2-phase, LRT with main road
132		King	Emerald		Yes	Phase1 LRT and NSXing, Phase2 WB, (Phase 3 LRT alternative), Phase4 SB+NB
133		King	Tisdale		Yes	Phase1 LRT and NSXing, Phase2 WB, (Phase 3 LRT alternative), Phase4 SB+NB
134		King	Wentworth		Yes	Phase1 LRT and NSXing, Phase2 WB, (Phase 3 LRT alternative), Phase4 SB
135		King	Sanford		Yes	No changes to phasing, LRT with main road
136		King	Holton		Yes	Phase1 LRT and NSXing, Phase2 WB, (Phase 3 LRT alternative), Phase4 SB+NB
137		King	Sherman		Yes	Phase2 WB, Phase3 LRT and NSXing, Phase4 SB+NB
605	Yes	King	Barnesdale		Yes	Phase2 WB, Phase3 LRT and NSXing, Phase4 SB+NB
138		King	Melrose		Yes	Phase2 WB, Phase3 LRT and NSXing, Phase4 SB+NB
606	Yes	King	Balsam		Yes	Phase2 WB, Phase3 LRT and NSXing, Phase4 SB+NB
139		King	Gage	No WBLT	Yes	No changes to phasing, LRT with main road
607	Yes	King	Dunsmore		Yes	Simple 2-phase, LRT with main road
140		King	Glendale	No WBLT	Yes	No changes to phasing, LRT with main road
72		King	Main		Yes	Phase1 NB, Phase2 WB+LRT, Phase3 West Xing, Phase4 EBUT
74		King	Balmoral Xing	No WBLT	Yes	No changes to phasing, LRT with main road
608	Yes	King	Grosvenor		Yes	Phase1 LRT and NSXing, Phase2 WB, (Phase 3 LRT alternative), Phase4 SB+NB
75		King	Ottawa		Yes	Phase1 WBLT, Phase2 LRT, Phase4 NB, Phase6 WB, Phase8 SB
76		King	Graham		Yes	Phase1 LRT and NSXing, Phase2 WB, (Phase 3 LRT alternative), Phase4 SB+NB
609	Yes	King	Tuxedo	No WBLT	Yes	Simple 2-phase, LRT with main road
77		King	Kenilworth		Yes	Phase1 WBLT, Phase2 LRT, Phase4 NB, Phase6 WB, Phase8 SB
78		King	Cameron Xing	No WBLT	Yes	No changes to phasing, LRT with main road
79		King	Cope		Yes	No changes to phasing, LRT with main road
80		King	Fairfield Xing		Yes	Simple 2-phase, LRT with main road
495	Yes	King	Queenston		Yes	Phase1 LRT, Phase2 SB Circulatory, Phase4 NB, Phase6 WB
82		Queenston	Cochrane		Yes	Phase1 WBLT, Phase2 LRT, Phase4 NB, Phase6 WB
83		Queenston	Walter	No WBLT, No EBLT	Yes	Simple 2-phase, LRT with main road
84		Queenston	Parkdale		Yes	Phase1 WBLT+EBLT, Phase2 EB+WB+LRT, Phase4 NB+SB
85		Queenston	Reid	No WBLT, No EBLT	Yes	Simple 2-phase, LRT with main road
86		Queenston	RHVPWest		Yes	Phase1 EBLT, Phase2 EB+LRT, Phase4 SB, Phase6 EB
87		Queenston	RHVP East		Yes	Phase1 EBLT, Phase2 EB+LRT, Phase4 NB, Phase6 EB
88		Queenston	Woodman		Yes	Phase1 WBLT+EBLT, Phase2 EB+WB+LRT, Phase4 NB+SB
710		Queenston	Queenston 575 Xing		Yes	Simple 2-phase, LRT with main road
89		Queenston	Nash		Yes	Phase1 WBLT+EBLT, Phase2 EB+WB+LRT, Phase3 NBLT, Phase4 SB, Phase7 SBLT, Phase NB. Increase cycle time to 100" in AM+PM
90		Queenston	Greenford		Yes	Phase1 WBLT+EBLT, Phase2 EB+WB+LRT, Phase4 NB+SB. Increase cycle time to 100" in AM+PM
611a	Yes	Queenston	Tram Stop Xing Ebnd		Yes	Simple 2-phase, LRT with main road, Set cycle time to 100" in AM+PM
611b	Yes	Queenston	Tram Stop Xing Wbnd		Yes	Simple 2-phase, LRT with main road, Set cycle time to 100" in AM+PM
91		Queenston	Eastgate Mall		No	No changes to phasing (offline). Increase cycle time to 100" in AM+PM
Off LRT Alignment ("Offline")						
220		York	Dundurn	Extra WBLT lane	Yes	No changes to phasing (offline)
149		King	Parkdale		Yes	Cycle time increase to 120" in PM
1043	Yes	Parkdale	Britannia		Yes	New traffic signal intersection. Simple 2-phase
-		Britannia	Tragina		No	Stop signs only on side roads (currently 4-way Stop)
-		Britannia	Fairfield		No	Stop signs only on side roads (currently 4-way Stop)
-		Britannia	Normanhurst		No	Stop signs only on side roads (currently 4-way Stop)
-		Britannia	Walter		No	Stop signs only on side roads (currently 4-way Stop)

Notes
1." Phase 3 LRT alternative" - stage only operates if LRT present, thus allowing an LRT phase to be inserted either before or after both main and side road timing periods
2. All LT phases on main road of LRT alignment (phases #1 and #5) are always protected (and not permitted)
3. All LT movements across the LRT at intersections are protected (and not permitted) and do not operate simultaneously with the LRT - with the exception of nodes 122 and 8 where buses can yield