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Hamilton Rapid Transit Preliminary Design and Feasibility Study

B-LINE

UTILITY RELOCATION STRATEGY GUIDELINES

Version:2.0

METROLINX

An agency of the Government of Ontario

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Hamilton
Public Works

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Table of Contents

1.0 Introduction

The Hamilton B-Line Rapid Transit project is the provision of light rail transit (LRT) between McMaster University and Eastgate Square along the Main Street/King Street corridor.

A review of the conflicts of the LRT system with the utilities and services along the B-Line corridor has been carried out and a relocation strategy has been developed to identify conflicts with municipal services and private utilities at the preliminary engineering level.

This work was performed as an iterative process. Once the major conflicts were identified and a new location was proposed, the configuration was analyzed for new conflicts at the new location. This was done until all utilities and services in the corridor were indicatively accommodated. During this process, the City of Hamilton was consulted, any concerns about the relocations were addressed and appropriate changes to the strategy were made.

The conflict identification was based on the present location of the utilities and services as shown on the base survey map provided by the City. Fire hydrant leads and catch basin leads are not shown on the City base information, however they were assumed to be connect to the closest watermain or sewer (combined or storm), and any changes in length or need for protection were quantified.

As this is a preliminary strategy, the main goal was to identify the conflicts and need for relocation. In the future, such strategy should be evaluated and updated based on further input from the City and all utility and service companies involved.

This report outlines the criteria used for identification of conflicts; guidelines used for the relocation strategy and how the relocation was quantified for cost estimation purposes.

This report also discusses alternative treatments evaluated in areas with constrained right of way.

All the utilities considered in the relocation strategy, drawings and quantity takes off are based on the existing network without consideration for improvements. At the end of the design, the City of Hamilton did identify sectors where upsizing of pipes will be required in the next design stage (Appendix A.3).

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2.0 Conflict Identification

2.1 Utility Free Zone Definition

Subsurface infrastructure along the corridor is comprised of watermains, sewers, gas lines, electrical utilities and communication infrastructure.

The introduction of an LRT system into a corridor with existing subsurface infrastructure creates conflicts, particularly since when subsurface infrastructure parallel to the tracks requires servicing, LRT service must be interrupted. Therefore, to minimize service interruptions and to ensure safety of workers, direct physical obstructions, such as maintenance holes in the right-of-way of the LRT should be eliminated. Infrastructure under the track, if not removed, will be exposed to the LRT vehicle's load and vibration forces as well as the potential of corrosion from stray currents along the track. To minimize these impacts, the subsurface infrastructure must be moved out of the transitway loading zone.

For the purpose of this review, the utility free zone was identified as 3 m to either side of the guideway (see Figure 2.1). Infrastructure which crosses perpendicular to the track is to be maintained, but must be protected from surface loads and stray current.

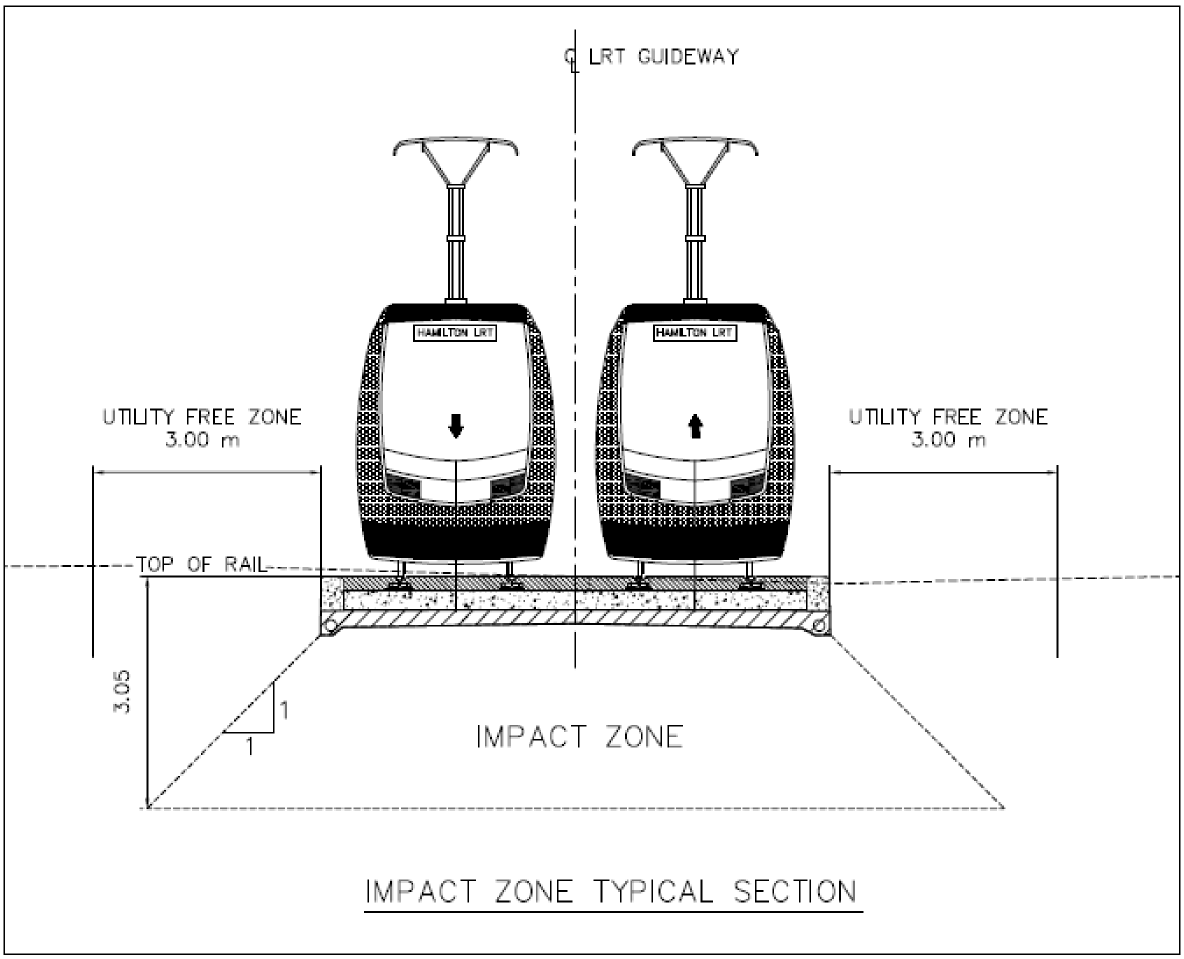

Figure 2.1 Utility Free Zone

2.2 Conflict Criteria

2.2.1 Watermains and Sewers

Watermains and sewers (combined, sanitary, and storm) running parallel within the utility free zone were identified as in conflict and requiring relocation. Watermains and sewers, including fire hydrant leads and catch basin leads, crossing the utility free zone perpendicularly, which need to be maintained in their location, were identified as requiring protection for the length in which they were within the LRT impact zone.

2.2.2 Gas lines, Hydro and Communication Ducts

Sufficient depth of cover for gas lines, hydro and communication ducts, under the track bed was assumed. As such, these utilities were not identified as in conflict. However, when existing access to these utilities (i.e. a maintenance hole) is located within the new guideway, this access was identified as in conflict. As a result, the utilities leading to the access were also in conflict and required relocation.

2.3 Conflict Criteria Summary

All the criteria under which utilities and services were identified as needing relocation are summarized in Table 2.1.

Table 2.1: Conflict Criteria

Utility/Service:	Relocation required if:
Bell Ducts	• On top of alignment of new Watermain or Sewer • Bell Maintenance Hole relocated
Bell Maintenance Holes	• In conflict with: o Guideway o New Curb o New utility location (i.e. Watermain)
Coaxial Cables	• On top of alignment of new Watermain or Sewer • Cable Pedestal relocated • Depth of cover changed
Cable Pedestals	• In conflict with: o Guideway o New Curb o New Sidewalk
Gasmains	• On top of alignment of new Watermain or Sewer • Depth of cover changed
Hydro Ducts	• On top of alignment of new Watermain or Sewer • Hydro Maintenance Hole relocated • Depth of cover changed
Hydro Maintenance Holes	• In conflict with: o Guideway o New Curb o New utility location (i.e. Watermain)
Sewers (Combined, Sanitary, Storm)	• In the Utility Free Zone
Watermains	• In the Utility Free Zone

Table 2.1: Conflict Criteria (Continued)

Utility/Service:	Relocation required if:
Catch Basins	• Not in line with new curb
Catch Basin Leads	• Catch Basin relocated
Fire Hydrants	• Less than 600 mm from edge of curb • In conflict with the new sidewalk • In conflict with new stop structure • New Fire Hydrant Lead less than 1 m in length
Fire Hydrant Leads	• Fire Hydrant relocated
Concrete/Wooden Hydro Poles	• Less than 600 mm from edge of curb • In conflict with the new sidewalk • In location of new Sewer or Watermain
Utility Light Standards	• Less than 600 mm from edge of curb • In conflict with the new sidewalk • In location of new Sewer or Watermain • Utility Light Standard not relocated in new platform locations
Traffic Utilities *Includes: Traffic Light Posts, Controllers, Junction Boxes, Vehicle and Pedestrian Signal Heads, and Road Signs*	• In conflict with: o Guideway o New Roadway o New Curb o New utility location (ie Watermain)

3.0 Relocation Strategy

3.1 Utility Clearance Guidelines

A relocation strategy was developed for the utilities and services found to be in conflict.

Clearance guidelines were compiled using information from the City of Hamilton and guidelines from the Ministry of Environment. The required spacing between services is summarized in Table 3.1.

Table 3.1: Minimum Spacing between Services

	Property Line	Combined/ Storm/ Sanitary Sewer (outer edge)	Watermain (outer edge)
Combined/ Storm/ Sanitary Sewer (outer edge)	3 m	0.5 m minimum	2.5 m minimum; if less, must have 0.5 m vertical clearance
Watermain (outer edge)	3 m	2.5 m minimum; if less, must have 0.5 m vertical clearance	–
Hydro Ducts	1.75 m	–	–
Gas Main	0.75 m	–	–
Bell Ducts	1.75 m	–	–

In the information provided by the city, it was identified that the profile view was provided for the sewer infrastructure but not for other utilities. Watermains were assumed to have 1.6 m of cover and this was used to assess the criteria of 0.5 m vertical clearance from sewers.

These guidelines were used wherever possible; however in some places along the corridor, the right-of-way was too narrow to accommodate the requirements. These situations were examined in more detail, taking into account length of conflict and risk of a lower clearance in each individual case. Upon examination, minimum spacing was lowered in situations where it was appropriate.

3.2 Watermain Clearance

Clearance between parallel watermains was based on the space required for installation and compaction of backfill. This was assumed to be 0.3 m.

3.3 Crossing Utilities

Watermains and sewers, including fire hydrant leads and catch basin leads, crossing the utility free zone perpendicularly have to be maintained in that location. They were identified as requiring protection from the surface loading and stray current. This protection was assumed to be installed for the length of the utility within the utility free zone.

3.4 Traffic Utilities

Traffic utilities, including traffic light posts, controllers, junction boxes, vehicle and pedestrian signal heads, and road signs, that have been identified as in conflict, a relocation strategy is not defined at this stage, although they have been included in the cost estimate.

3.5 Gas lines, Hydro and Communication Ducts

Gas lines, hydro and communication ducts were identified as needing relocation when there was a change in depth of cover. This occurs when the original utility is under the existing sidewalk but is to be located under the new roadway in the new design. Relocation is required to under the new sidewalk as depth of cover is compromised. As discussed in Section 2.2.2, ducts that remain or are relocated to beneath the LRT guideway are considered to have sufficient depth of cover, and do not pose a structural risk to the structure of the guideway. In fact, the system itself has a system-wide ductbank under the guideway for exclusive system use.

3.6 Utility Tunnel

In sections where the clearance requirements could not be met or, upon a detailed examination, lowered without risk, the strategy of a utility tunnel was developed. The initial tunnel concept would house the subsurface utilities in the corridor, arranged to be easily identified and accessible for maintenance. The utilities and services inside the tunnel vary by section. A typical cross section of the initial tunnel concept can be seen in Figure 3.1.

The main advantage of the initial tunnel concept is to house all utilities into a single structure with a unified access point at locations not in conflict with the LRT. The tunnel will isolate loadings and mitigate stray current risks.

The original tunnel concept was presented to the City of Hamilton and the following main comments were made:

1. Jointly housing watermains and hydro cables poses a risk.
2. Separation of combined sewer to watermains and coexistence within the structure should be further evaluated, especially in regard to potential comments by the Ministry of the Environment (MOE).
3. Risk of gases from combined sewer accumulating inside the tunnel.
4. City would rather separate hydro and communications into a joint use trench.

As a result of the inputs at the meeting SNC-Lavalin developed a new tunnel concept as can be observed in Figure 3.2.

The new tunnel only houses municipal infrastructure as they pose the biggest risk to the stability of the LRT guideway.

Hydro and communications would be accommodated into a separate joint use trench. Figure 3.3 shows the conceptual arrangement and indicative dimensions, as obtained by the City of Hamilton. Further design efforts can also evaluate the potential use of a dual chamber utility tunnel to separate hydro and communications from municipal infrastructure. Figure 3.4 shows an example of a dual chamber arrangement.

The City of Hamilton should further liaise with MOE to finalize the tunnel concept, especially in relation to the location of the combined sewer. The use of ventilation pipes can be evaluated in further design efforts, to mitigate the risk of gases from the sewer from filling the tunnel chamber.

Two different construction methods for the proposed tunnel concept were evaluated – slip form and cast-in-place. SNC-Lavalin met with a slip-form manufacturer and through discussions discovered that the slip form equipment was too large to have next to the tunnel construction and still have one active lane for emergency vehicles. Therefore, based on the constrained right of way, the cast in place was chosen as the most time-effective construction option.

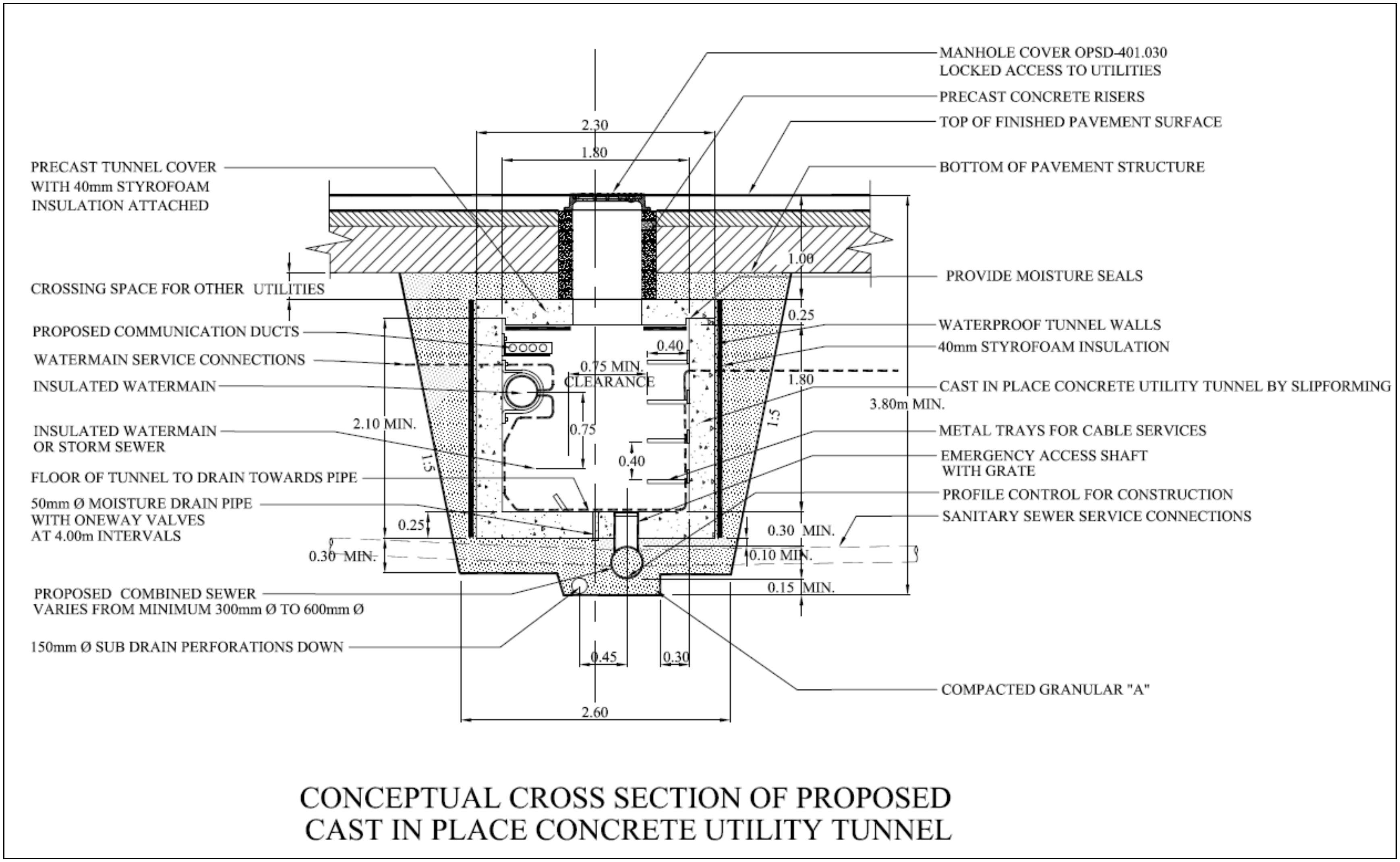

Figure 3.1 Initial Utility Tunnel Concept

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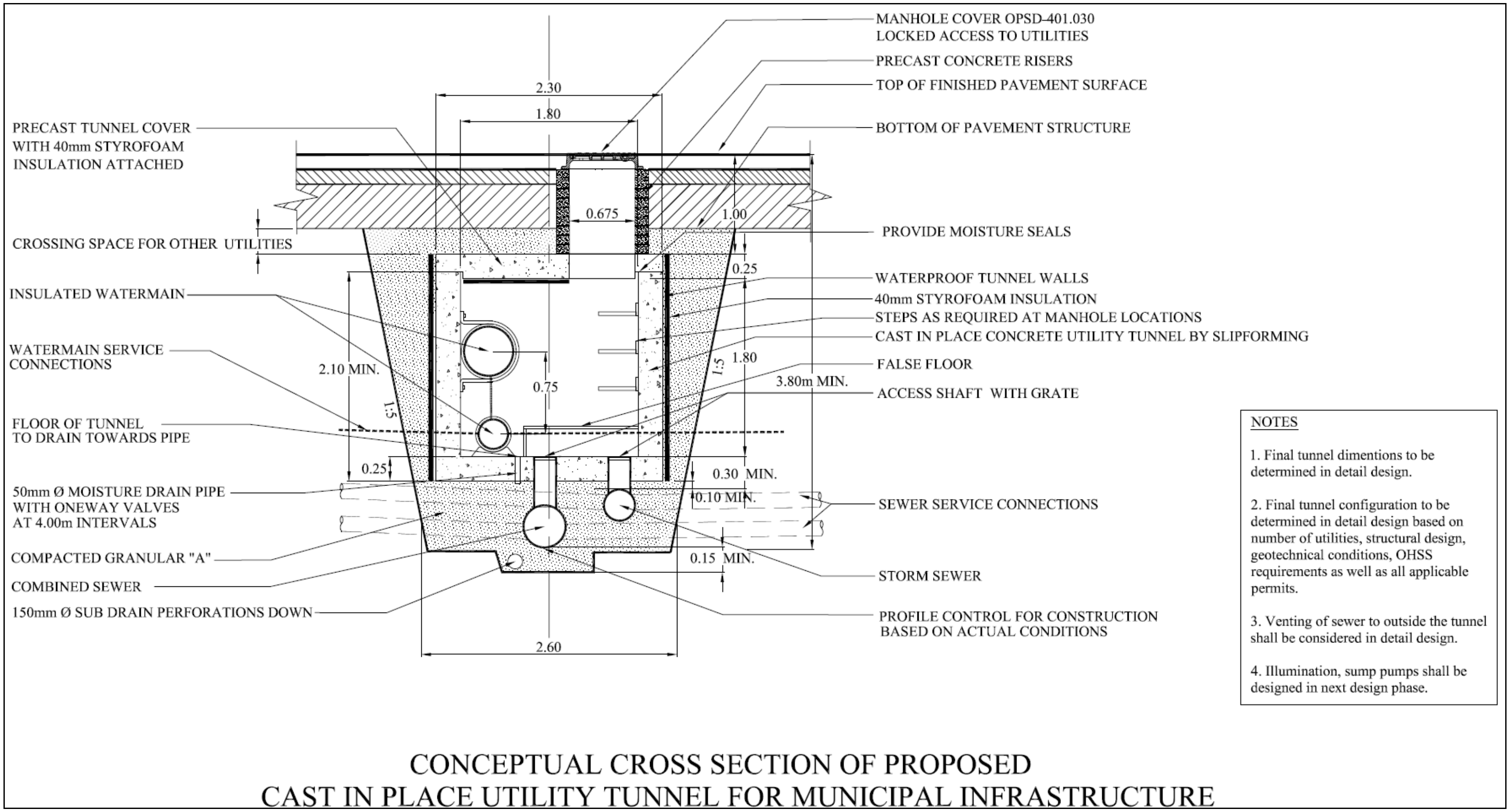

Figure 3.2 Revised Utility Tunnel Concept

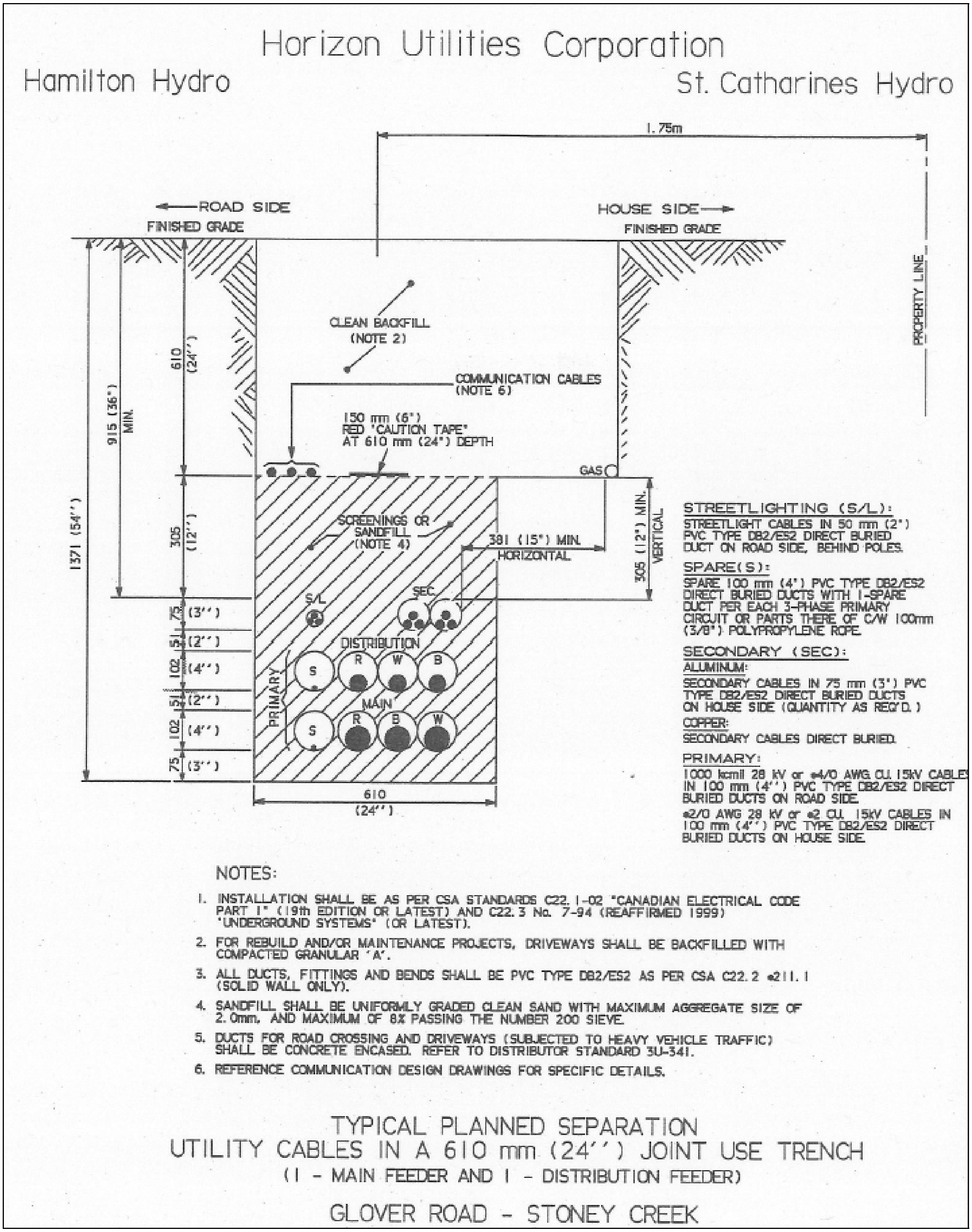

Figure 3.3 Joint Use Trench

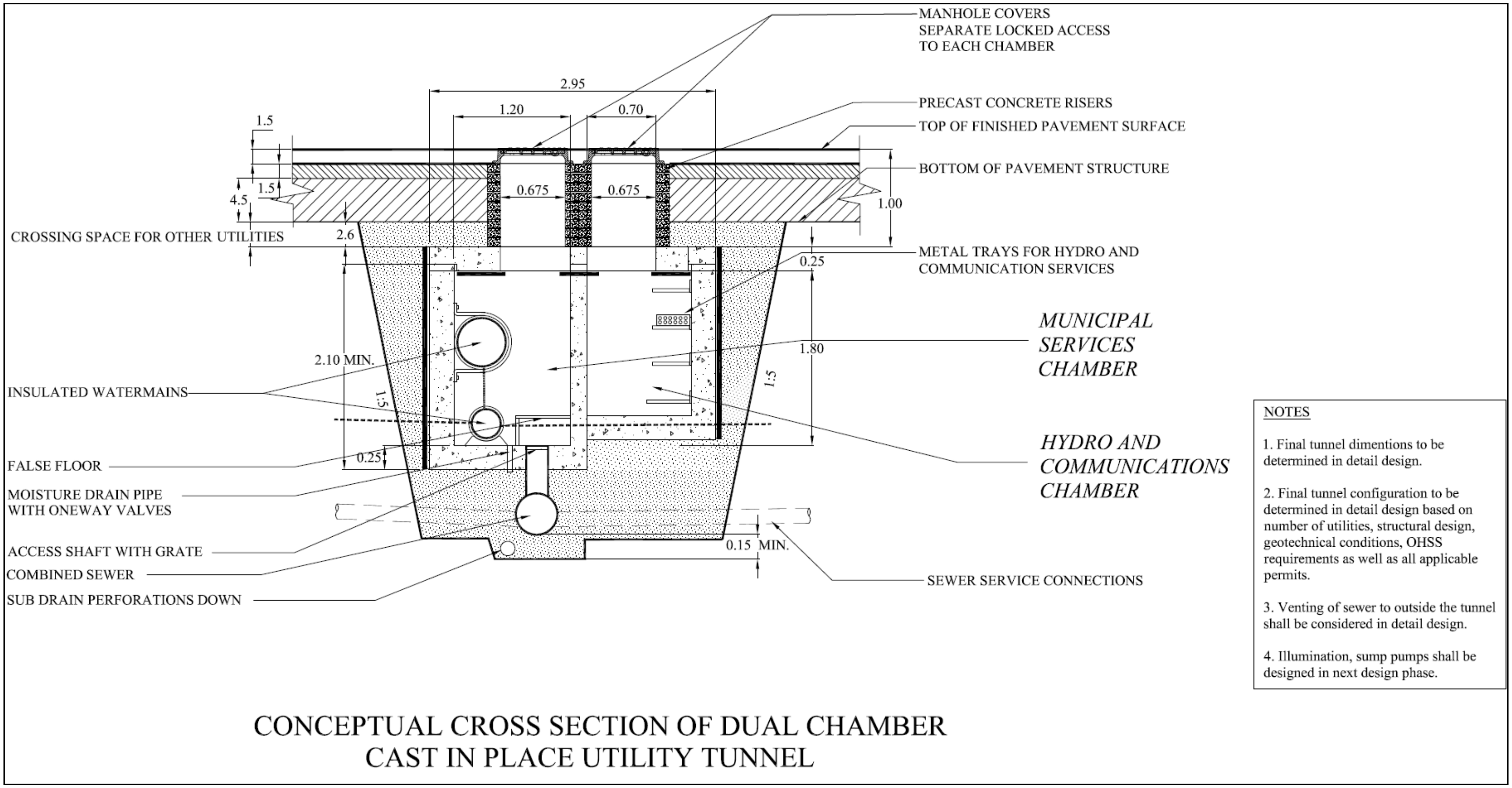

Figure 3.4 Dual Chamber Utility Tunnel Concept

3.6.1 Proposed Tunnel Section

The proposed tunnel concept is approximately 2.5 km in length and runs parallel to the LRT guideway. It starts at Sta. E5+890 just east of Ashley St. and continues until Sta. E8+375, just east of Kensington Ave. The utilities and services inside the tunnel vary by section, depending on the existing utilities in the area. Generally, changes in utility and services characteristics, such as change in pipe size, occur at roadway intersections.

The utility tunnel is a well arranged system that allows centralized operational control for all utilities during and after construction, resulting in savings of time and cost. It also extends the lifetime of utilities by mitigating interference with earthworks during construction and maintenance operations, thus reducing environmental impacts.

In certain instances, more than one pipe for each system is to be constructed in the utility tunnel. For example, from Proctor Boulevard (STA E6+740) to St. Clair Avenue (STA E6+815) on King Street East, a 500 mm watermain pipe is aligned with 150 mm watermain pipe. Beyond St. Clair Avenue, the 150 mm watermain pipe continues at an enlarged diameter of 300 mm.

3.7 Relocation Criteria Summary

New location of utilities and services were determined by the criteria summarized in Table 3.2.

Table 3.2: Relocation Criteria

Utility/Service	New Location Criteria
Bell Ducts	• Maintaining minimum clearance • Not on top of alignment of new Sewers or Watermain • Connecting to relocated or existing Bell Maintenance Holes
Coaxial Cables	• Maintaining minimum clearance • Connecting to relocated or existing Cable Pedestals
Gasmains	• Maintaining minimum clearance
Hydro Ducts	• Maintaining minimum clearance • Connecting to relocated or existing Hydro Maintenance Holes
Sewers (Combined, Sanitary, Storm)	• Maintaining minimum clearance • Cased for protection when crossing the Utility Free Zone sleeved
Sewer Maintenance Holes	• Relocated, keeping the same spacing • Not relocated in sections where Sewers are in Utility Tunnel • Some new added for new connections
Watermains	• Maintaining minimum clearance • Sleeved for protection when crossing the Utility Free Zone sleeved • Valve Chambers, Valve Boxes and Tee Connections replaced, keeping the spacing • Valve Chambers and Boxes Not relocated in sections where Watermains are in Utility Tunnel
Catch Basins	• Relocated to new edge of curb • Spacing between Catch Basins generally not modified, except at stop platform locations
Catch Basin Leads	• Cased when crossing Utility Free Zone • Extended or reduced to new location
Fire Hydrants	• Relocated to 600 mm from edge of curb • Relocated to opposite side of street when in conflict with new stop structure
Fire Hydrant Leads	• Assumed 150 mm pipe • Sleeved when crossing Utility Free Zone • Minimum length of 1 m
Concrete/Wooden Hydro Poles	• Relocated to 600 mm from edge of curb
Utility Light Standards	• Relocated to 600 mm from edge of curb • ULS not relocated in new platform locations
Traffic Utilities	• Conflicts identified; no new location shown on drawings

4.0 Quantity Take-off Assumptions

4.1 Abandonment and Removal

Watermains and sewers (combined, sanitary and storm) requiring relocation would be either abandoned or removed after the new pipe is installed. Since it is less costly to abandon the pipe by filling and plugging, than excavating and removing it, pipes were assumed to be removed only when it was necessary to make space for a new pipe.

Since sewers are buried deeper than watermains, an existing sewer running parallel to a new watermain installation can be simply abandoned. However, in the case of a new sewer being installed in that location, the existing sewer would have to be removed. Existing watermains in the location of new watermain or sewer installation would have to be removed.

For the purposes of the cost estimate, existing watermains within 1 m of the location of a new watermain or sewer were quantified as removed. Existing sewers within 1 m of the location of a new sewer were quantified as removed. All others were quantified as abandoned.

4.2 Maintenance Holes

Maintenance holes for sewers, hydro and communication ducts, must be reset to the new elevation when there is a change in the depth of cover. This occurs when the original utility is under the existing sidewalk but is to be located under the new roadway in the new design, or it is under the existing roadway but is to be located under the new sidewalk in the new design. Number of maintenance holes which require to be reset was quantified.

In the case where a relocated sewer pipe requires connection to an existing maintenance hole, this maintenance hole requires reconfiguration. The number of maintenance holes which require reconfiguration was quantified.

4.3 Hydro Ducts

In some cases, the surface plan view did not show hydro ducts leading to the Utility Light Standards. These sections were cross referenced with aerial images and Google Streetview and if no overhead lines were found, buried hydro ducts were assumed. If the Utility Light Standards were relocated, lengths of extension of the hydro ducts to the new locations were quantified.

Since the contents of the hydro duct banks is unknown (length and type of wires), only the length of the new ducts was quantified at this stage and not the wires.

4.4 Property Connections

The relocation of a watermain or sewer (combined and sanitary) would require the replacement of the service connections to the property. At this stage, no information was available about the size and length of individual property service connections. One connection per property, to the nearest watermain and sewer (combined or sanitary) was assumed. The number of connections requiring replacement was quantified without specific length or size.

4.5 Utility Tunnel

The subsurface infrastructure crossing the utility tunnel must be removed during the construction of the utility tunnel. Length of each utility within 2 m of the tunnel was assumed to require replacement. Watermains and sewers, including fire hydrant and catch basin leads, connecting to the utilities within the tunnel, were assumed to require 2 m of connection length.

Subsurface infrastructure that is running parallel to the location of the utility tunnel would need to be removed for the construction of the tunnel. Since the new services would only be installed inside the tunnel, after the construction, the installation of temporary services before removing existing ones was accounted for.

4.6 Utility Protection

During construction and installation of new watermains and sewers, crossing gas lines, hydro and communication ducts must be protected. The length of the protection was quantified as the length of the utility within the excavation area as shown in Figure 4.1.

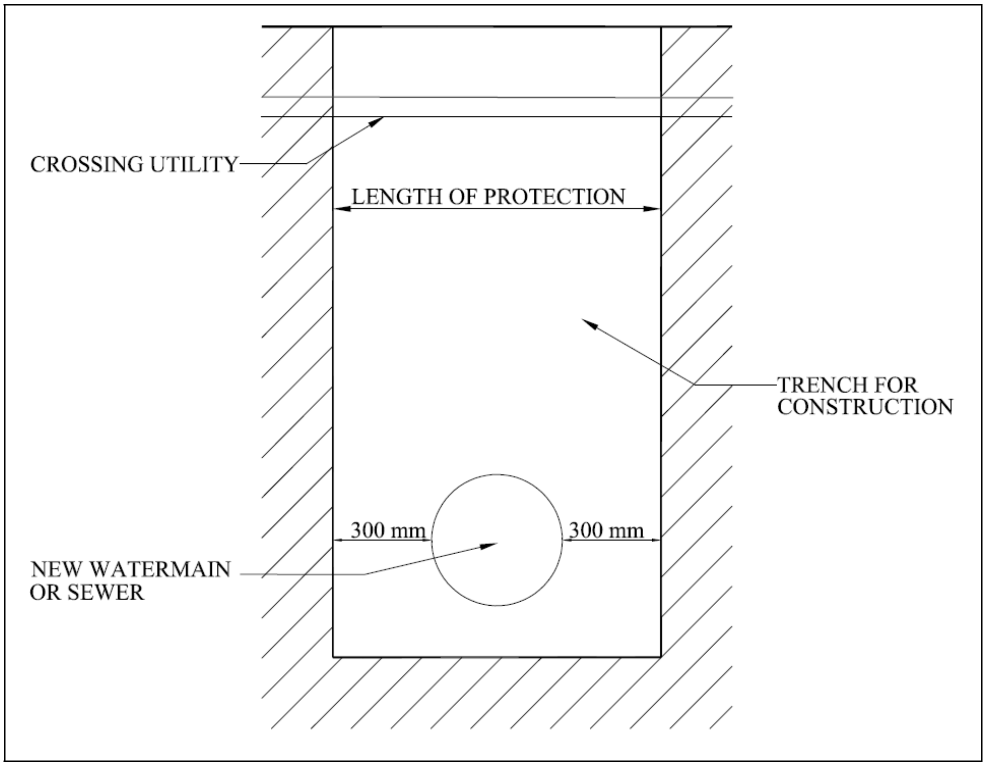

Figure 4.1 Length of Protection for Crossing Utility

4.7 Quantity Take Off Criteria Summary

Items for the cost estimation were quantified as summarized in Table 4.1.

Table 4.1: Quantity Take Off Criteria

Utility/Service	Items Quantified
Bell Ducts	• Length of new ducts • Length of protection when works need to be undertaken below it
Bell Maintenance Holes	• Number of Maintenance Holes relocated • Number of Maintenance Holes Reset
Coaxial Cables and Pedestals	• Length of new cable • Length of protection when works need to be undertaken below it • Number of Pedestals relocated
Gasmains	• Length of new gasmain • Length of protection when works need to be undertaken below it

Table 4.1: Quantity Take Off Criteria (Continued)

Utility/Service	Items Quantified
Hydro Ducts	• Length of new ducts • Length of protection when works need to be undertaken below it
Hydro Maintenance Holes	• Number of Maintenance Holes Relocated • Number of Maintenance Holes Reset
Sewers (Combined, Sanitary, Storm)	• Length of new Sewer • Length of Casing for Sewer crossing the Utility Free Zone • Number of Property Service Connections • Sewer quantified as Removed when within 1 m of location of new Sewer installation, otherwise it is quantified as Abandoned
Sewer Maintenance Holes	• Number of Maintenance Holes Relocated • Number of Maintenance Holes Reset • Number of Maintenance Holes Reconfigured
Watermains	• Length of new Watermain • Length of Sleeve for Watermain crossing the Utility Free Zone • Number of Property Service Connections • Number of Valve Chambers, Valve Boxes and Tee Connections Relocated • Number of Elbows Installed (not shown on drawing) • Watermain quantified as Removed when within 1 m of location of new Watermain or Sewer installation, otherwise it is quantified as Abandoned
Traffic Utilities	• Number of Traffic Light Posts and Hand Wells Relocated • Number of Controllers Relocated • Number of Junction Boxes Relocated • Number of Vehicle and Pedestrian Signal Heads Relocated • Number of Road Signs Relocated
Utility Tunnel	
Subsurface Infrastructure Crossing Tunnel	• Length of utility within 2 m of the tunnel Replaced
Watermains and Sewers (including Fire Hydrant and Catch Basin leads)	• 2 m of connection length within the tunnel assumed

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.

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DOCUMENT END

APPENDIX A: UTILITY TUNNEL CASE STUDIES

A.1 University of Toronto Utility Tunnel Network

The University of Toronto is located near Queen's Park in Toronto, with the campus buildings denoted in blue in Figure A.1.1 below.

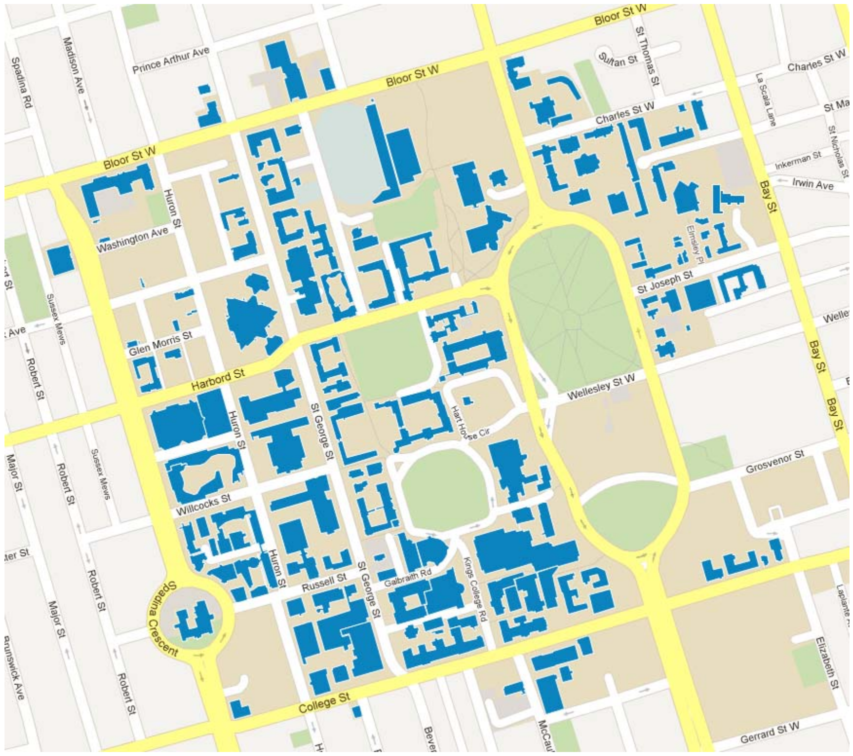

Figure A.1.1 University of Toronto Building Index Thematic Map

As shown in Figure A.1.1 above, the campus buildings are scattered between non-university buildings and properties. As the University required uninterruptible services to its buildings, it had to acquire a large network of utility tunnels in order to achieve this level of service.

These tunnels carry mainly high-pressure steam pipes, water pipes and sewer pipes as well as electrical power cable and cable bundles for data, telecommunication, and fiber-optic networks. Some utility tunnels consist of multiple chambers or galleries to separate utilities which can generate heat, in order to minimize the risk of heating up the water pipes. Figure 1.2 shows the chamber consisting of steam pipes and electrical power cables that is considered as the main source of heat transfer to some of the building systems.

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Figure A.1.2 Steam Pipes

As shown in the upper left corner of Figure A.1.3, rather than using open pipe racks, pipe cabinets are installed to house the telecommunication cable bundles for added security and lower maintenance operation requirements. This approach also protects the contents from effects of flooding or high moisture.

Figure A.1.3 Utilities housed within University of Toronto Utility Tunnel

Information on the construction method for the tunnels is not available. However, based on other utility tunnel networks of other institutions in urban environments, the open trench construction was more likely the preferred method, undertaken in conjunction with the construction of new campus buildings, or as part of campus development plans.

A.2 Utility Tunnels in the Czech Republic

The Czech Republic is a country located in Central Europe, has and has hot summers characterized by rain and storms, and cold, cloudy, and snowy winters similar to Southern Ontario.

Utility tunnels have been developed in the Czech Republic widely since the 1970s in historic areas and large urban centres such as in Prague, Brno, Ostrava, Tabor, and Jihlava as a part of the city development. For example, an extensive network of utility tunnels with a total length over 90 km is currently in operation in Prague. Even though the government restricts any construction activities as part of the “Historic Prague Reserve” mandate, the government allows the construction of utility tunnels within restricted areas to accommodate required connections. The general layout of the network in Prague can be found in Figure A.2.1.

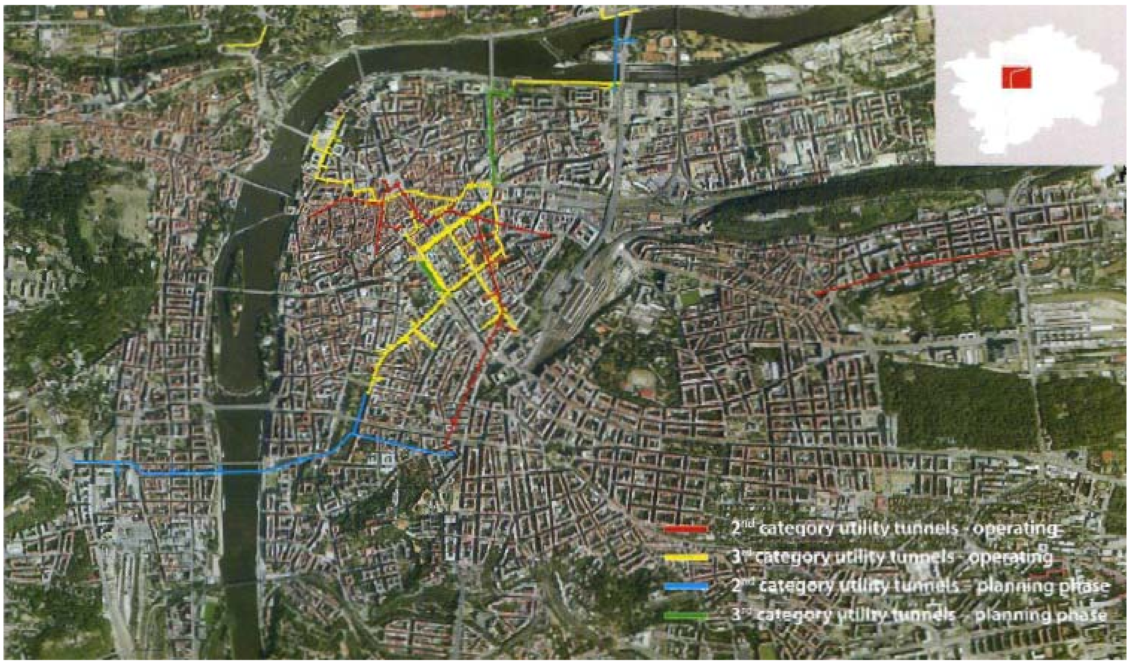

Figure A.2.1 General Layout of Utility Tunnels in the Central Part of Prague

Many sections in the network are overlaid by the public street car system called the Prague Tram. The vertical alignment of the tunnels is at varying depths per geological conditions after detailed geotechnical investigations. When hard bedrock exists, the typical depth of the tunnel is between 22 m to 30 m below the ground surface, ensuring minimum effects on existing buildings and utility networks not located in the tunnels.

During the preliminary design stage, it was concluded that building the utility tunnels can save overall construction and installation time for several utility networks. The pipe networks comprise of watermain pipelines of various pressure ranges and a gas pipeline. The cable networks comprise of high voltage cables, traction mains, telecommunication cables, information cables, data distribution weak-current cable and a tubular post distribution line.

In general, the construction method adopted was tunnel boring. When direct access from properties to the tunnel was required, the tunnel was built using open trench construction in order to be close to the points of consumption. Figure A.2.2 is a typical cross section of the utility tunnel as constructed under the Prague Tram, which provides direct services to adjacent buildings. It also shows a sewage pipe underneath the tunnel which collects sewage from the surrounding buildings.

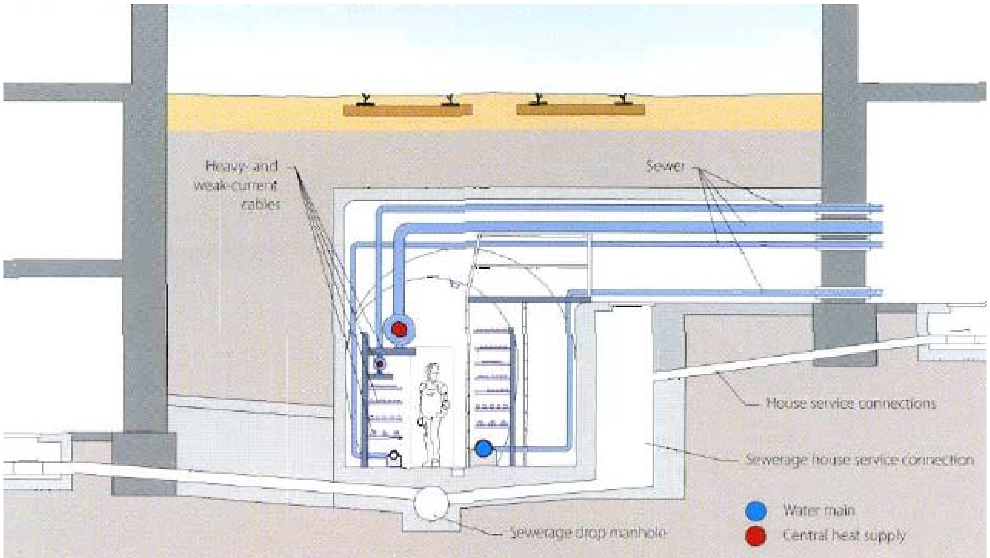

Figure A.2.2 Cross Section of the Utility Tunnel and Connection to the Buildings

As in the case of the utility tunnels of the University of Toronto, the gasmain pipe is isolated from the watermain pipes since there is a risk of heating the watermain pipes. The yellow circle in the schematic below in Figure A.2.3 and the corresponding yellow pipe in the actual photograph depict the gas main, while the blue dots depict the watermain. The drainage pipe is situated below the tunnel, towards the centre of the tunnel floor.

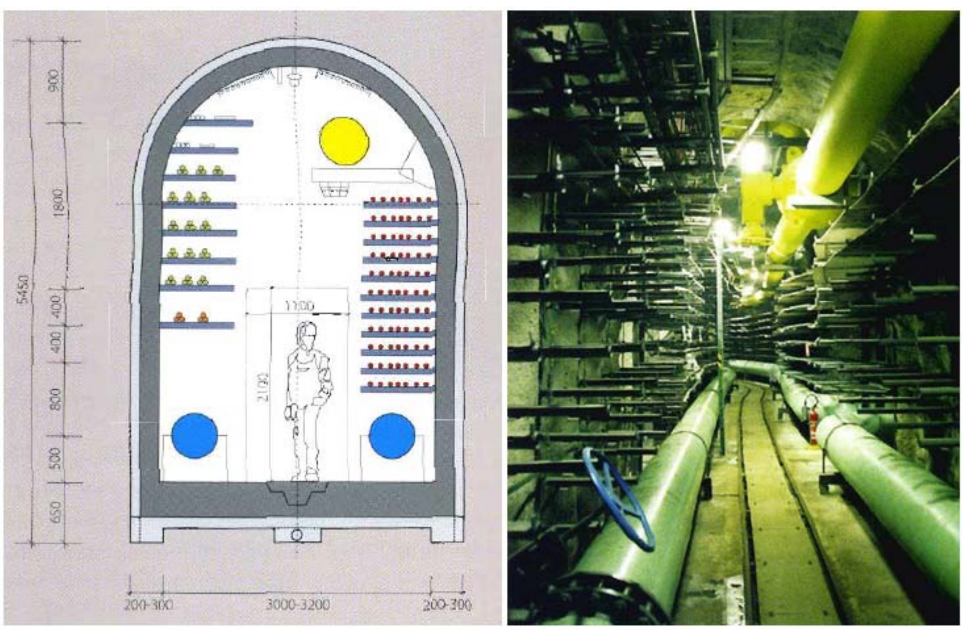

Figure A.2.3 Detailed Design and Tunnel after the Construction in Prague

The steel rebars on the side walls are installed to provide utility support system. Depending on the capacity of the pipes, the rebars can be used as pipe racks, or brackets can be added for rigid, heaver utility pipes. The capacity of the utility tunnel can be increased by adding further pipe racks or by reconfiguring the inside of the tunnel, thus reducing construction costs and schedule.

A.3 Utility betterment requirements

The following comments, related to preliminary requirements for watermain upsize/downsize recommendations, were received as mark ups from the City of Hamilton, such are based on the review of the Utility relocation drawings submitted by the consultant dated September 20, 2011. The mark-ups were formatted in a table format by the consultant to ensure they are considered in the following design phase.

The column page refers to the sequence of page numbers of the submission dated September 20, 2011.

Project:	Hamilton LRT 'B' Line
Contract No.:	C11-12-10
Drawings Title:	Preliminary Utility Relocation Strategy
Drawings Submitted Date:	November 1, 2011

Page	Type	Station	Issue
2	WM	0+350	Upsize to 200mm W/M is recommended
2	WM	0+600	Upsize to 200mm W/M is required
2	WM	0+785	Upsize to 200mm is required
3	WM	0+930	Upsize to 200mm is required
3	WM	1+170	Upsize to 200mm is required
3	WM	1+280	Upsize to 300mm is required
3	WM	1+280	500mm W/M missing from drawing and encasement needed under LRT
4	WM	1+580	Upsize to 200mm is required
4	WM	1+640	Missing stretch of 300mm W/M in drawing
5	WM	2+325	Missing stretch of 300mm W/M in drawing
5	WM	2+660	Upsize to 200mm is required
6	WM	2+930	Proposed W/M size should be 400mm
6	WM	3+060	Upsize to 400mm
6	WM	3+110	Proposed W/M size should be 450mm
6	WM	3+190	Upsize to 200mm
6	WM	3+230	Proposed W/M size should be 400mm
6	WM	3+375	Proposed W/M size should be 400mm
7	WM	3+430	Proposed W/M size should be 400mm
7	WM	3+530	Proposed W/M size should be 400mm
7	WM	3+585	Upsize to 200mm
7	WM	3+680	Proposed W/M size should be 400mm
7	WM	3+735	Upsize to 200mm
7	WM	3+830	Proposed W/M size should be 400mm
7	WM	3+910	Missing encasement for 300mm W/M
8	WM	4+060	Proposed W/M size should be 400mm
8	WM	4+175	Upsize to 200mm
8	WM	4+235	Proposed W/M size should be 400mm
9	WM	4+785	Parallel W/M arrangement
9	WM	4+835	W/M is 200mm instead of 150mm
9	WM	5+095	Upsize to 150mm is required
10	WM	5+225	Proposed W/M size should be 300mm

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Page	Type	Station	Issue
10	WM	5+275	Missing encasement for 750mm trunk-main
10	WM	5+335	Proposed W/M size should be 300mm
10	WM	5+380	Upsize to 300mm is required
10	WM	5+445	Proposed W/M size should be 200mm
10	WM	5+490	Upsize to 200mm is required
10	WM	5+550	Proposed W/M size should be 200mm
10	WM	5+590	Upsize to 200mm
10	WM	5+670	Proposed W/M size should be 300mm
10	WM	5+700	Upsize to 200mm
10	WM	5+745	Proposed W/M size should be 300mm
11	WM	5+800	Proposed W/M size should be 300mm
11	WM	5+950	Upsize to 200mm
11	WM	5+950	Proposed W/M size should be 300mm
11	WM	6+030	Upsize to 200mm
11	WM	6+100	Proposed W/M size should be 300mm
11	WM	6+245	Connection to new 300mm W/M
11	WM	6+295	Proposed W/M size should be 300mm
12	WM	6+480	Proposed W/M size should be 300mm
12	WM	6+600	Proposed W/M size should be 300mm
12	WM	6+640	Upsize to 200mm W/M is required
12	WM	6+745	300mm W/M is required
12	WM	6+885	300mm W/M is required
13	WM	7+080	300mm W/M is required
13	WM	7+150	Upsize to 200mm is required
13	WM	7+230	Proposed W/M size should be 300mm
13	WM	7+395	200mm W/M is required
13	WM	7+440	300mm W/M is required
14	WM	7+575	new 300mm W/M is required
14	WM	7+640	200mm W/M is required
14	WM	7+960	200mm W/M is required
14	WM	7+975	300mm W/M is required
14	WM	8+145	200mm W/M is required
15	WM	8+255	Proposed W/M size should be 300mm
15	WM	8+350	Should 500mm W/M be relocated northerly
15	WM	8+570	Proposed W/M size should be 300mm
15	WM	8+600	200mm W/M is required
16	WM	8+730	300mm W/M is required
16	WM	8+815	Existing 150mm W/M should be 300mm W/M
16	WM	8+865	Existing 150mm W/M should be 200mm W/M
16	WM	8+990	Proposed 150mm W/M should be 300mm W/M
16	WM	9+030	200mm W/M is required
16	WM	9+150	Proposed 150mm W/M should be 300mm W/M
16	WM	9+200	200mm W/M is required
17	WM	9+325	Proposed 150mm W/M should be 300mm W/M
17	WM	9+365	200mm W/M is required
17	WM	9+775	200mm W/M is required
18	WM	9+925	200mm W/M is required

Page	Type	Station	Issue
18	WM	10+075	200mm W/M is required
18	WM	10+120	200mm W/M is required
19			Section Name: Queenston Road
19	WM	10+630	200mm W/M is required
19	WM	10+780	200mm W/M is required
20			Section Name: Queenston Road
20	WM	11+365	200mm W/M is required
21			Section Name: Queenston Road
21	WM	11+660	300mm to be implemented if supported by Hydraulic analysis
22			Section Name: Queenston Road
22	WM	12+070	300mm to be implemented if supported by Hydraulic analysis
22	WM	12+115	200mm W/M is required
22	WM	12+165	200mm W/M is required
23			Section Name: Queenston Road
24			Section Name: Queenston Road
24	WM	12+285	200mm W/M is required

Clarifications and justifications of some of the mark-ups:

- **Generally, upsize to 200mm of existing 150mm crossing watermains is recommended to improve fire flow capacity, hydraulic performance and to accommodate future intensification around b-line. Some of them are proposed in order to be consistent with previous provision done in capital works program.**
- **The provision for upsize to 300mm (pg.3, station1+280) of existing 150mm watermain on Bond Street South was done because only last portion of it (from Main St W to Arkell S less than 100 m) is 150mm the rest is 300mm.**
- **The proposed upsize to 400mm of existing 150mm on Locke Street (pg.6, station 3+060) take in consideration the Water and Wastewater Master Plan, Project No.W-19.**
- **The proposed downsize to 400mm (pg.6, station 2+930) of proposed 450mm watermain, which intend the replacement of two existing 150mm and 300mm watermains, take in consideration the sum of section areas of pipes instead of sum of diameters of pipes (150+300mm) because the flow depends by section area. In same way was recommended downsize of proposed watermains in other sections (pg.6, 7, and 8, from station 2+930 to 4+235).**
- **The upsize to 150mm of existing 100mm watermain (pg.9, station 5+095) was base on MOE Water System Design Guideline where 100mm watermain was considered substandard.**
- **The proposal to upsize to 300mm the existing 150mm watermain (pg. 10- 15, from station 5+225 to 8+570) on King Street East from Wellington Street to Main Street E intend to improve fire flow capacity, hydraulic performance and to accommodate future intensification around b-line. In same way was recommended upsize to 300mm of existing 150mm watermains on Main Street E from King Street E to Wexford Av S (pg.16 and 17, from section 8+730 to 9+325).**
- **hydraulic modeling is required for pressure districts 1 and 2 for horizon year 2031 shall be carried out to identify required network improvements.**