

Relative Risks for the Green Line Centre City Options

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UNRESTRICTED
TT2016-0483
ATTACHMENT 2

Risk Category	Issue	Mitigation	Option A Existing Bridge	Option B New Bridge & Shallow Tunnel	Option C Shallow Tunnel & Elevated	Option D Fully Tunnel	Option E Hybrid
Utilities	- Unidentified or mislocated utilities - Long duration for utility relocations, lack of utility company resources to carry out utility relocations - Insufficient electrical energy requirements to power the system - All options require utility relocation	- Utility conflicts have been identified as part of the functional design to inform cost and risk valuation for the 5 Options - Further investigation, advance planning for relocations and early works strategy, and engagement with franchise utilities will be carried out for the Recommended Option during next design phase	Length: Surface = 1.9km Tunnel = 1.6km Existing Bridge = 0.3km Total = 3.8km Stations: Surface = 1 Underground = 2	Length: Surface = 0.7km Tunnel = 2.3km New Bridge = 0.5km Total = 3.5km Stations: Surface = 1 Underground = 3	Length: Surface = 0.3km Tunnel = 1.6km New Bridge & Elevated = 1.6km Total = 3.5km Stations: Elevated = 2 Underground = 2	Length: Surface = 0.2km Tunnel = 3.3km Total = 3.5km Stations: Underground = 4	Length: Surface = 1.6km Tunnel = 1.5km New Bridge = 0.5km Total = 3.6km Stations: Surface = 2 Underground = 2
			Highest Risk Surface LRT guideway requires that all utilities running parallel to the guideway be relocated including the existing Centre Street Bridge.	Lowest Risk A combination of tunnelled and surface LRT guideway requires that some utilities running parallel to the guideway be relocated.	Lowest Risk A combination of tunnelled and surface LRT guideway requires that some utilities running parallel to the guideway be relocated.	Lowest Risk Fully tunnelled LRT requires that some utilities running parallel to the guideway be relocated.	Medium Risk A combination of tunnelled and surface LRT guideway requires that some utilities running parallel to the guideway be relocated.

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Geotechnical and Hydrotechnical	- Uncertainly about ground conditions - Ground conditions different than assumed - Exposure of station and portals to flood conditions - Potential for river scour above tunnel during flood events	- Preliminary geotechnical investigations have been carried out as part of functional design to inform cost and risk valuation for the 5 Options - Additional investigations planned for Recommended Option during next design phase - Pressurized face TBM with segmental lining to mitigate influence of variable geotechnical conditions - Flood mitigation measures incorporated in design - Tunnel Scour mitigated by depth of burial below river channel.	 Lowest Risk <i>Partially tunnelled LRT provides medium exposure to geotechnical variations</i>	 Medium Risk <i>Partially tunnelled LRT provides medium exposure to geotechnical variations</i>	 Lowest Risk <i>Partially tunnelled LRT provides medium exposure to geotechnical variations</i>	 Highest Risk <i>Fully tunnelled LRT provides greater exposure to geotechnical variations</i>	 Medium Risk <i>Partially tunnelled LRT provides medium exposure to geotechnical variations</i>
Loss of Public and Political Support	Public or political support may not align with technically recommended option	- Extensive public engagement program throughout analysis - Public support is in favour of the underground option	 Highest Risk <i>Limited public support for option as it introduces community and business access impacts and constrains traffic circulation.</i>	 Highest Risk <i>Limited public support for option due to the new river crossing over Prince's Island Park and access and circulation restrictions in Eau Claire.</i>	 Highest Risk <i>Limited public support for option due to the new river crossing over Prince's Island Park and access and circulation restrictions in Eau Claire.</i>	 Lowest Risk <i>Significant public support as option avoids community impacts and leaves flexibility for urban realm and development.</i>	 Highest Risk <i>Limited public support for option due to the new river crossing over Prince's Island Park and access and circulation restrictions in Crescent Heights and Eau Claire.</i>

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Property Impacts & Assembly	- High cost and long timelines to acquire property - Integration of station entrances to existing buildings - Identification of underground easements - Number of individual property owners that may be impacted	- Investigating scope and vision for downtown stations to determine opportunity to integrate stations into developments - Meeting with developers and impacted property owners to define impacts and opportunities - Development and costing of staged property acquisition strategy	 Medium Risk Because of the constrained right-of-way and the longest extent of surface LRT in this Option and tight geometry in Chinatown, there will be property impacts in order to incorporate LRT and stations and maintain a variation of access and road circulation.	 High Risk Tunnelled portions of this Option can maintain road and pedestrian circulation with localized property impacts for underground stations. Surface segment increases property impacts due to constrained right-of-way and surface impacts in the Eau Claire area. Properties required for underground station entrances have potential to be incorporated into future redevelopments.	 Low Risk Elevated and tunnelled LRT can maintain road and pedestrian circulation with localized property impacts for underground stations. Properties required for underground station entrances have potential to be incorporated into future redevelopments.	 Medium Risk Fully tunnelled LRT can maintain road and pedestrian circulation with localized property impacts for underground stations. Properties required for underground station entrances have potential to be incorporated into future redevelopments.	 High Risk Because of the constrained right-of-way and surface impacts in the Eau Claire area, the surface segment of Option will have property impacts in order to incorporate LRT and stations and maintain a variation of access and road circulation.

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Construction	• Disruption to private property and access during construction • Disruption to business operations and access during construction • Structural damage to adjacent property due to construction activities • Cost and schedule overruns • Litigation • TBM breakdown	• "Taking Care of Business" notice of motion to produce strategy to work with businesses during construction period • Pre- and post-construction surveys of adjacent structures • Identifying and mitigating risks through additional design phases • Utilization of a risk management process to identifying risks and price them into construction estimates • Experienced tunnel contractor utilizing purposed designed TBM and adhering to regular maintenance program	 Medium Risk Tunnelled portions may utilize open cut excavation at underground station and special track locations, while surface portions will require utility relocation and construction on the road.	 Medium Risk Tunnelled portions may utilize open cut excavation at underground station and special track locations, while surface portions will require utility relocation and construction on the road.	 Medium Risk Tunnelled portions may utilize open cut excavation at underground station and special track locations, while elevated segment will require utility relocations under the guideway.	 Medium Risk Fully tunnelled LRT may utilize open cut excavation at underground station and special track locations.	 Medium Risk Tunnelled portions may utilize open cut excavation at underground station and special track locations, while surface portions will require utility relocation and construction on the road.	
	Environmental	• Impacts to Bow River, wetlands and Prince's Island Park • Adaptability of the system to extreme weather conditions • Potential to encounter contaminated soils	• Tunnelling under Bow River has limited impact on the river valley • Further biophysical investigations and environmental site assessments will be carried out for the Recommended Option during next design phase	 Lowest Risk Using the existing Centre Street Bridge will have the least of impact on the environment.	 Highest Risk A new bridge over Prince's Island Park will disturb the environmental habitat.	 Highest Risk A new bridge over Prince's Island Park will disturb the environmental habitat.	 Medium Risk Tunnel under Prince's Island Park may provide some environmental exposure.	 Highest Risk A new bridge over Prince's Island Park will disturb the environmental habitat.

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Social Impact to Surrounding Communities	- Permanent disruption to communities of Crescent Heights, Chinatown, Eau Claire - Traffic and community access impacts - Visual impacts to river valley and privacy intrusion - Safety and Security	Tunnelling underground responds to community concerns and negates disruption, access and privacy and intrusion issues	Highest Risk Surface segments of the Option create traffic disruption along Centre Street N, restricted access in Chinatown.	Highest Risk Surface segments of the Option restrict access to the Eau Claire area.	Highest Risk Elevated segments of the Option create access impacts in Eau Claire and Downtown core.	Lowest Risk Fully tunnelled LRT provides least permanent changes to communities for access and circulation, visual intrusion and impacts to views.	Highest Risk Surface segments of the Option create traffic disruption along Centre Street N, restricted access in the Eau Claire area.
Reduced Operational Reliability	Maximizing reliability, LRT run time and ridership	Grade separated guideways (tunnel or elevated) optimize transportation network reliability, transit run times, and transit ridership	Highest Risk Longest portion of surface LRT creates most interaction with other modes, impeding reliability and runtimes. Ridership may be impacted because alignment cannot accommodate Chinatown station.	Medium Risk The surface portion of this Option provides some delay to run times and reliability.	Lowest Risk Elevated and tunnelled LRT provides greatest opportunity to manage run times and reliability.	Lowest Risk Fully tunnelled LRT provides greatest opportunity to manage run times and reliability.	Medium Risk The surface portion of this Option provides some delay to run times and reliability.