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EXECUTIVE SUMMARY

PSL Group Inc. (PSL) has prepared the final deliverable submission as part of the Allen Road Revitalization project package. Currently, Allen Road has a variety of problems not limited to extreme congestion. Transportation and land use goals were considered to improve the entire corridor and to develop various alternatives. In order to do so, four transportation manuals, most importantly the Geometric Design Standards, and two land use guidelines were thoroughly studied. After a comprehensive qualitative analysis, Alternative 2 was selected for the corridor alignment. This alternative implements a do nothing in the Northern Section, and decking the existing road into a tunnel in the Southern Section. Evaluation methods also determined the revamping of the Allen-Lawrence interchange into a Parclo B4, and utilizing the land above the proposed tunnel for recreational use in accordance to the City of Toronto Official Plan.

For the detailed design of the corridor alignment, the Northern Section will only require maintenance and aesthetic upgrades. The Southern Section will require a structural design for the decking system by a third-party firm. The Parclo B4 detailed design includes alignments, profiles, and cross sectional assemblies of the six new on-and-off ramps – which are all drawn in accordance to the Geometric Design Manual. Recreational land use recommendations propose a series of eight linear urban parks between Lawrence Ave to Eglinton Ave. The land use design will focus on at-grade amenities, walkways and trails, improved landscaping and public art.

The constructability of the project is discussed and is deemed constructible. It is determined that for decking, precast reinforced concrete material will be made off-site and simply installed on-site during off-peak hours. Additionally, for the interchange to be constructed, land acquisitions of over a dozen homes is necessary and full reimbursement to the land owners will be carried out. A comprehensive cost analysis puts the total project costs at approximately $210,000,000 – with the majority of the costs going towards the structural elements required for decking.

With the current preliminary design complete, the implementation plan will continue with an individual EA process where public consultation will play a significant role. Afterwards, the design will be finalized in a way that satisfies all major stakeholders. Finally, the project will go forward to the procurement stage where a Public-Private-Partnership strategy is recommended.
1.0. INTRODUCTION

PSL Group Inc. ("PSL") has prepared the following document for the final submission as part of the Allen Road Revitalization project package. This document will provide a detailed analysis of the Allen Road study area. In specific, the Allen Road study established in this report discusses the issues imposed by Allen Road, the municipal plans for the study area, alternatives in addressing issues of Allen Road, and a preliminary design of the recommended alternative.

2.0. PROJECT RATIONALE

2.1. History & Background

The existing Allen Road corridor is a short freeway in the Greater Toronto Area (GTA) which runs from Kennard Avenue down to Eglinton Avenue West. Named after Metro Toronto’s Chairman William R. Allen, the 7.3 km corridor serves up to 9,000 users of vehicular traffic in morning peak hours, as well as numerous Toronto landmarks along the road including Downsview Park, Yorkdale Shopping Centre, and Lawrence Square Shopping Centre [1]. In the early 1960’s, the Spadina Expressway was proposed and approved for construction, which was intended to extend from Highway 401 to Spadina Road [2]. At the time, the public was very instrumental in stopping the Spadina Expressway construction after issues were brought up by Jane Jacobs [3]. Jacobs had believed that the construction of an expressway through a major city would drive out the middle class of the neighbourhoods, and would lead to the demise of the downtown core. The Spadina Expressway design would have crossed the Forest Hill, The Annex, Harbord Village, Kensington Market, and Chinatown neighbourhoods, which was highly opposed by the public. The project was cancelled in 1971, and the completed sections were remained up to Eglinton Avenue West and is now known today as Allen Road [2]. As a result of the project cancellation and sudden termination at Eglinton Ave, Allen Road now experiences a high volume of traffic and congestion, hence the critical need for infrastructure improvements.

2.2. Project Area Features & Characteristics

The Project study area undertaken by PSL is separated to two sections shown in Figure 1. Much of the overall study area is comprised of low-rise residential development; however, retail commercial and institutional developments such as shopping complexes and schools are also within the area. The northern section is bounded by major arterials: Dufferin Street to the west,
Bathurst Street to the east, Lawrence Avenue West to the south, and Highway 401 to the north. The southern section is bounded by Dufferin Street to the west, Bathurst Street to the east, Lawrence Avenue West to the north, and Eglinton Avenue West to the south. Much of the street network in the study area is comprised of several low-density residential streets that connect to a system of collector roads, which then feed to major and minor arterial roads. The fact that the Allen Road is located below ground level at the center of the study area suggests that there is a limited number of road connectivity within the network. In the northern section, there are only three continuous east-west crossings of Allen Road, that being Flemington Road, Ranee Avenue, and Yorkdale Road. Similarly, in the southern section, Elm Ridge Drive/Roselawn Avenue, Ridelle Avenue, and Glencairn Drive are the only roads that pass over the Allen Road [1]. This lack of transportation connectivity greatly prompts the need for further infrastructure development. Additionally, PSL conducted a site visit of study area on January 29, 2016 as shown in appendices.
2.3. Traffic Dilemma

Currently, Allen Road functions as a primary freeway link for automobiles and freight services to enter the southern portion of Toronto from the north. Despite the parallel TTC Yonge-University Subway line along the alignment of Allen Road, high volumes of automobiles continue to utilize the road. Between Highway 401 and Lawrence Avenue West, the morning peak hour traffic volumes are averaged between 7,000 and 9,000 [1]. Similarly, the Lawrence Avenue West to Eglinton Avenue West portion accommodates 5,000 to 7,000 morning peak hour vehicles [1]. The particular areas of interest along the corridor are 2 interchanges: Lawrence Avenue West and Eglinton Avenue West. Since these two are the only interchanges south of Highway 401, all of the peak hour traffic is expected to exit at these interchanges, which causes major congestion. Currently, both Lawrence Avenue West and Eglinton Avenue West interchanges function at Level of Service F during the peak hours, averaging approximately 90 seconds of delay per vehicle [1]. Although officially called an expressway, the traffic caused at these interchanges turns the Allen Road into a congested arterial road from Lawrence Avenue West to Eglinton Avenue West as shown in Figure 2. The demand at both interchanges (particularly the exit ramps and intersections) is severely greater than capacity, which, as shown in Figure 3, results in long queue lengths that extend into the expressway, adversely impacting the performance of the system.

![Figure 2. Allen Road Traffic (Google Maps)](image1)

![Figure 3. Long Queues at Lawrence Avenue Exit Ramp](image2)
Pedestrian traffic is another key issue that contributes to the congestion in the corridor. Every day, approximately 11,200 and 12,600 pedestrian crossings occur at Lawrence Avenue West and Eglinton Avenue West interchanges respectively [1]. The large number of crossings is primarily due to the location of the TTC Yonge-University line stations. The stations at these two interchanges are located at the middle of the interchange, which causes pedestrians to cross the corridor’s entrance and exit ramps as shown in Figure 1. As a result, not only do pedestrian movement at these interchanges hinder automobile movement, but the current crossing infrastructure poses a major safety threat to the pedestrians. Figure 4 shows the use of channelized turns, small refuge islands, damaged sidewalks, and high automobile traffic, which together create a challenging environment for pedestrians to cross these intersections.

![Eglinton Avenue Crosswalk to Eglinton West Station](image)

*Figure 4. Eglinton Avenue Crosswalk to Eglinton West Station*
2.4. Environmental Issues

The two primary environmental issues of concern to various stakeholders in the corridor area are noise and air pollution [1].

The primary sources of noise in the corridor are the automobile traffic on the expressway, as well as the TTC Subway trains. The corridor can be classified as Class 1 under Ministry of Environment Noise Guideline which places a restriction on noise to not exceed 50 dBA [4]. There are various noise sensitive areas in the corridor such as schools and residential houses. As a result, the corridor has placed several noise attenuation systems such as the expressways below grade separation, berms, and noise walls as shown in Figure 5. Despite these measures, the City of Toronto receives several noise complaints generating from the corridor; making it a priority issue in the Allen Road Environmental Assessment Public Consultation [5]. The EA ToR report assumes the sound levels from the corridor are 55 dBA or greater, exceeding the MOE’s guidelines [1] [4].

Figure 5. Noise Barrier Separating Allen Road and Residential Neighbourhood
Furthermore, the large number of vehicles and congestion in the corridor impact the air quality in the surrounding land. For example, the residential houses are within 50 meters of the expressway [1]. The main source of air pollution in the corridor is the fuel combustion emissions generated from the automobile traffic on the expressway. This is of particular concern especially because of the prolonged idle times at the intersections due to the congestion. As a result, the contribution towards air pollution per vehicle during the rush hour is expected to be significantly higher. This poses a serious issue to several air quality sensitive areas such as health care and child care centres, situated within 500 m of the corridor [1].

3.0. PROJECT VISION

3.1. Project Purpose, Goals, and Objectives

The purpose of the Project is to revitalize the current Allen Road and surrounding area. To clarify this purpose, multiple goals have been determined by PSL. Each goal will correspond to objectives, which are more specific statements related to the attainment of goals. Finally, each objective will correspond to a measure of effectiveness (MOE), which will be represent a clear and quantitative way to measure the attainment of each objective. Figure 6 summarizes all of the Goals, Objectives, and Measures of Effectiveness in a flowchart.
Allen Road Corridor Revitalization – Goals and Objectives

Purpose: Improve the current traffic and amenities at and around Allen Road south of Highway 401

**OBJECTIVES**

**GOALS**

**MEASURES OF EFFECTIVENESS**

**TRANSPORTATION**

- Improve design and efficiency of road network
- Improve safety of travel
- Reduce vehicle congestion in and around Allen Road
- Vehicle flow per hour
- Level of emissions due to vehicle idling
- Time spent solely due to congestion
- Number of collisions per 1000 veh-km within corridor
- Length of shockwaves (queues)
- Number of cyclists and pedestrians crossing the corridor

**LAND USE**

- Improve quality of life in study area
- Promote sustainability and urban design
- Average noise level (dBA) induced on study area
- Income level and employment of study area
- Number of cyclists and pedestrians crossing the corridor
- Total trip travel times for cyclists and pedestrians to cross the corridor

Figure 6. Project Goals & Objectives
As shown in Figure 6, PSL has come up with two major goals for the project:

**Goal #1:** Improve the design and efficiency of the road network. This is a direct transportation related goal which is concerned with improving mobility within and beyond the study area.

The main objective under this goal is improving travel times by reducing congestion on the Allen Road and Lawrence Ave. This can be measured in various way such as trying to reduce shockwaves (length of queues) during peak hours, and trying to improve the vehicle-flows per hour through the corridor.

The second objective is to improve safety of travel. This is not necessarily just for motorists, but is also valid for pedestrians and cyclists as well. For example, pedestrians crossing the on ramps on Lawrence Avenue are always at risk of being hit by vehicles rushing into the Allen. Reducing vehicle-vehicle and vehicle-pedestrian/cyclist collisions must be addressed.

**Goal #2:** The second goal is primarily concerned with land use rather than transportation, and it intends to improve the quality of life within the study area.

The first objective under this goal is to improve the accessibility for pedestrians, cyclists, and transit users. Currently, Allen Road is a huge disturbance for pedestrians and cyclists who want to travel East/West. Pedestrians who want to cross the Allen must do so at predetermined overpasses, which again become cumbersome. As previously discussed, the same problem exists for cyclists and transit users as well. Thus, improving accessibility for non-motorists is a huge objective that must be addressed.

The other objective is to promote urban design and sustainability which will lead to better quality of life. This can be done by implementing strategies to improve the household income level and employment within the study area. Additionally, reducing the noise and pollution levels caused by the traffic on the Allen can also increase the sustainability in the area.
3.2. Review of Existing Regional and Municipal Plans

PSL’s primary intent when constructing the Project goals and objectives was to stay in line with the planning visions of various provincial and regional entities. PSL considers it crucial to review the policies from all levels of governments (provincial, regional, and municipal) to ensure uniformity in relationship with the Project's vision. As such, existing reports from the Province of Ontario and City of Toronto were reviewed to form the core principles in devising our vision for the Project. Given the nature of the Project, particular attention was placed on the plans and policies that are focused towards land-use and transportation integration. Although the plans do not have an explicit future project in development for the Allen Road, PSL believes that the Project is still a necessity. Table 1 shows the plans reviewed by PSL and their corresponding goals that relate to the Project.
<table>
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<th>Goals/Visions Shared With Project</th>
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| City of Toronto: Lawrence-Allen Revitalization Plan (LARP) [6] | LARP is a 20 year undertaking by the City as a framework towards growth and change in the Lawrence-Allen Area. The plan is a combination of Transportation Master Plan and Infrastructure Plan that focuses on a mixed-income, park centred mixed-use neighbourhood, transit supported corridor that is integrated with surrounding areas of the City. | • Provide direct and continuous pedestrian and cycling routes along the Allen Road corridor between the subway stations that are safe, convenient and interconnected with the surrounding pedestrian and cycling network  
• Improve the Allen Road & Lawrence Avenue West interchange and the area around the Lawrence West subway station to prioritize pedestrians, cyclists and transit and to improve potential development opportunities  
• Create a positive physical and social relationship between the Allen Road and its adjacent neighbourhoods to create an improved sense of place.  
• Provide opportunities for auto traffic in the study area to better access and use the auto capacity of the Allen Road.  
• Minimize the financial cost of any proposed changes to the Allen Road. |
| Ministry of Infrastructure: Growth Plan for the Greater Golden Horseshoe (GGH), 2006 [7] | GGH Growth Plan is a framework to the Places to Grow Act legislation that gives the provincial government the authority to conduct planning for growth in a coordinated and strategic manner. It ensures that the plans meet the needs of communities while balancing the economic and environmental obligations | • Accommodate intensification areas with mixed land uses including residential and employment uses to create a vibrant neighbourhood.  
• Provide balance in transportation modes by reducing dependence on one mode (primarily automobile) through developments that promote transit, pedestrians safety, and mixed-use infrastructure  
• Promote convenience towards access to intra- and inter-city transit systems  
• Conserve cultural heritage during intensification of built-up areas. |
| Ministry of Municipal Affairs and Housing: Provincial Policy Statement, 2014 [8] | The Provincial Policy Statement sets out policies that are coherent to government’s vision of land use. The policies are set to achieve livable and resilient communities through long term management of land and resources | • Promote healthy and active communities by planning public streets, spaces and facilities that meet the needs of pedestrians and cyclists to foster social interaction, active transportation, and community connectivity.  
• New developments adjacent to existing built-up areas should allow for efficient use of land, infrastructure, and public service facilities |
| Metrolinx: Regional Transportation Plan (RTP) [9] | RTP establishes visions, goals and objectives for GTHA transportation system to achieve coordination, efficiency, equitability, and user-centricty | • Provide a wide range of transportation choices to people of all demographics by increasing accessibility and convenience  
• Implement integration of multi-modal transportation system that makes user’s decision on getting from Point A to Point B easier by having access to accurate and timely information in a transparent manner |
| City of Toronto: Official Plan [10] | Toronto’s Official Plan is a response to the Ontario’s Planning Act. It states the policies and future plans to direct growth to existing urban areas by establishing guidelines for intensification. Ultimately, it helps realize the City’s potential in land use development, transit, and environment | • Establish high quality public realm of streets, parks and building defined open spaces that create an environment for community life, economic health, and social equity  
• Achieve sustainability by balancing the needs of existing and future users within the right-of-way while accommodating various modes and features  
• Make better use of existing urban infrastructure and services  
• Ensuring health and safety of the public by maintaining infrastructure and assets in a state of good repair |
3.3. Stakeholders

Stakeholders are those individuals who may impact or be impacted by the Project. They have been classified into the following major groups, with additional sub-classifications.

Local Community
- Residents within the study area and whose lives are directly affected by the existence or future construction of Allen Road
  - Includes local communities, schools, cyclists, pedestrians, etc.

Local Businesses and Institutions
- Large commercial retailers - ex: Yorkdale Shopping Centre
- Smaller businesses - ex: privately owned businesses in the study area
- Parks and other public institutions

City Wide & Miscellaneous groups
- Commuters - long distance commuters that will use the corridor by all modes of applicable transportation including transit, automobiles, cycling, etc.
- Residential and commercial developers who will want to be involved during the planning and construction of the Project
- Non-Governmental Organizations (NGO’s) - includes planning or advocacy groups (ex: Ontario Professional Planners Institute)

Transit Providers
- TTC - operates a segment of the University line parallel to Allen Road
- Metrolinx - the future Eglinton Crosstown LRT will intersect with Allen Road

Municipal & Provincial Agencies
- City of Toronto - owns and operates Allen Road and surrounding infrastructure (with the exception of Highway 401 which is a provincial highway)
  - City departments involved and interested in the development of the Project and EA process
- Province of Ontario - Ministry of Transportation (they operate the adjoining 401), Ministry of Environment

Aboriginal Communities
- During the EA process, Aboriginal communities should be contacted to see if they have an interest during the Environmental Assessment (EA) process
4.0. CORRIDOR ALIGNMENT ALTERNATIVES

The three design aspects that PSL will focus on the Allen Road layout will be on the general road infrastructure, the Lawrence Ave. interchange, and the integrated land-use. Figure 7 demonstrates sketches of the alternatives. The following section describes in detail, these alternatives that are to be considered in the evaluation and detailed design process.

Figure 7. Allen Road Corridor Revitalization Alternatives
4.1. Alternative 1: N – Arterial, S – Arterial

The motive for the first alternative is to completely redesign Allen Road south of the 401 and change its design from a freeway to an arterial road. This would require elevating the current Allen Road to make it on-grade with the surrounding land. As such, appropriate earth fill material will be required to grade the Allen Road to the existing neighboring streets. Moving the TTC University subway line is unfeasible and thus that must remain untouched, below grade.

Transforming the majority of the Allen Road into an arterial will require intelligent design. First, a “transition” corridor is required. It’ll be too costly and unnecessary to change the current 401-Allen Interchange design, and the portion of Allen Road above the 401 will remain a freeway. Thus, there will be an influx of vehicles coming into Allen Road both from the ‘freeway’ portion of the Allen Road above the 401, and from the 401 itself at rather fast speeds. As a result, a buffer area will be required for vehicles to slow down and transition into the arterial road. The best current example of this is the transition of the 400-series highway into Black Creek right after the 400 terminates (see Figure 9). The purpose of such a corridor is to reduce speeds and provide for a smooth transition between a freeway and an arterial. In the Allen Road, this transition corridor could be between Yorkdale Rd and Flemington Rd. Secondly, turning the Allen Road from a freeway into an arterial will reduce the vehicular capacity of the road. The Allen Road is already congested as a freeway, and turning it into an arterial may cause further delays. While this will be true in an ‘overnight’ scenario, a purpose of turning the Allen into an arterial is to redefine the Allen Road. As a result, some users will find other alternative routes for travel and vehicular demand in the long run will decrease. That being said, the overall capacity of an arterial can be enhanced by the use of coordinated traffic lights and Intelligent Transportation Systems (ITS). An ITS system can increase the capacity and reduce congestion by 40% [11]. It is important to note that portions of both Lawrence Ave. and Eglinton Ave. near Allen Road will also require
the implementation of ITS in order to coordinate signal timings that benefit the users within and around the corridor.

Turning the Allen Road into an on-grade arterial opens up significant opportunities for land-use integration. This would provide direct connectivity with surrounding arterial roads, which will increase accessibility for residents in the area. Pedestrians and cyclists would have an easier time crossing the Allen Road in a more efficient and safer manner. Local businesses can also utilize the land adjacent to the Allen Road, which is not currently feasible due to the Allen Road’s below grade location. Overall, this alternative will have three main design components: arterial road design, ITS signalized intersection designs, and arterial land use opportunities.

![Figure 9. Highway 400 Transition to Black Creek Dr Arterial (Google Maps)](image-url)
4.2. **Alternative 2: N - Do Nothing, S – Tunnel**

The motive for the second design alternative to be considered is to retain the current expressway infrastructure in the northern section, but to improve the system in the southern section by converting the Allen Road expressway to a tunnel. Leaving the expressway in the northern section as is will ensure less capital expenditures in infrastructure, as well as maintaining existing upstream traffic operations coming off of Highway 401. The conversion of Allen Road to a tunnel will retain the primary functions of the corridor as an expressway, but at the same time, will also relieve some of the environmental and social implications that the existing Allen Road currently has on its surrounding residential communities, such as poor accessibility, noise, and air pollution.

Creating a tunnel in the southern section will also provide various land use opportunities such as the development of a pedestrian promenade, consisting of recreational and business facilities. Integrated land use can also be strategically implemented to facilitate different modes of transportation in and out of the downtown core, including walking and cycling. Figure 11 demonstrates an ideal application of integrated land use with the existing transportation network at Millennium Park in Chicago, Illinois. With a similar application in the Allen Road corridor, the combination of prominent land use techniques and transportation along the above-grade corridor will provide enhanced mobility and accessibility, producing an iconic landmark that aligns with future municipal plans of development in the area.

As an effort to address the issue of traffic congestion on the exit ramps to Lawrence Ave and Eglinton Ave, an interchange design will also be accommodated. The design exits will either allow for continuous or controlled traffic flow. Continuous traffic flow can be accommodated with the design of a ramp interchange, which allows exiting vehicles to merge into existing arterial traffic without having to come to a stop. In comparison, controlled traffic flow can be accommodated by integrating an Intelligent Transportation System (ITS) to the transportation network, which will make use of smart technologies to dynamically control traffic at various times of the day.
Overall, this alternative will have three main design components: tunnel design, interchange/intersection redesign, and land use opportunities.

4.3. **Alternative 3: N - Arterial, S – Tunnel**

This alternative consists of transforming the northern section to a major arterial road, and constructing a tunnel over the southern section. The rationale behind converting the northern section into an arterial road is due to the current land use and demographics of that section. The northern section acts as a commercial area with two shopping malls within the boundaries as well as social community centres. Hence, the arterial road will provide improved accessibility to these facilities by establishing an east-west link. As part of the arterial road, appropriate earth fill material or excavations will be required to grade the northern Allen Road to the existing neighboring streets, and a tunnel will be required for the TTC subway line. Through appropriate landscaping and infrastructure design, this section can encourage a social vibe for pedestrians as well as cyclists. Similar to Alternative 2, the southern portion of the Allen Road will be fully converted into a tunnel. The southern portion is a primarily residential area, and as a result, despite various measures, the City of Toronto is receiving numerous complaints emerging from noise and air pollution. The tunnel provides a great opportunity for the southern portion to function as an
expressway with much less social and environmental implications. Furthermore, a below-grade
tunnel will provide significant opportunities for integrated land use. To promote the livelihood of
the residents in the surrounding neighborhoods, various land-use opportunities can be discovered
such as over-deck parks, as well as a small car-free commercial corridor providing a multi-use
convenience shopping area. As such, the priority of the land use shifts away from automobiles
and focuses on encouraging more cyclists, pedestrians, and transit users as it falls right on TTC
University subway line. Figure 13 shows Third Street Promenade in Santa Monica, which is a car-
free commercial and entertainment street with excellent use of street design that encourages
and enhances the neighbourhood quality of life.

This alternative will also address the choke point intersections: Lawrence Avenue West and
Eglinton Avenue West. Various options will be evaluated for both interchanges to accommodate
the incoming vehicular flows while minimizing the existing congestion effects. The Lawrence
Avenue West interchange will be redesigned as arterial intersection while implementing the
optimum systems such as ITS smart traffic lights. Similar traffic lights options will also be explored
for Eglinton Avenue interchange in addition to a complete redesign of the interchange ramps.
Overall, this alternative will have three main design components: Arterial and Tunnel design,
Interchange/Intersection redesign, and Land-Use Opportunities.

Figure 13. Third Street Promenade, Santa Monica, CA [13]
5.0. PROJECT INSPIRATION

It is apparent that the intent of transportation infrastructure projects are no longer merely about enhancing mobility, but rather to improve accessibility by providing means to activity generation, economic productivity, and recreational opportunities. Doing so will enhance the transportation network both directly through infrastructure upgrades, and indirectly by alleviating some of the traffic demands implied by the supplementation of land developments. This section will describe the inspiration from other cities and countries with the same motive for development projects.

5.1. At-Grade Commercial Developments

This section will discuss some of the projects that transforms an ordinary street into a lively high retail shopping street in order to provide an abundance of economic opportunity. These projects will provide inspiration for the at-grade right-of-way corridor if PSL chooses to utilize it for commercial and economic development.

5.1.1. Third Street Promenade – Santa Monica, CA

Third Street Promenade (Figure 14) is an outdoor shopping, dining, and entertainment complex in California in which draws many tourists and California residents daily.

![Figure 14. Third Street Promenade](image)
5.1.2. Miami Worldcenter – Miami, FL

Miami Worldcenter (Figure 15) is a proposed project currently in its development and planning phase. Miami Worldcenter has recently announced their change in project scope from building a large shopping mall into a high retail shopping street.

![Miami Worldcenter](image)

5.2. Existing Decked Expressway Projects

With respect to Alternatives 2 and 3, the following section will demonstrate some of the existing projects that decks regional expressways in order to provide at-grade public spaces.

5.2.1. Klyde Warren Park – Dallas, TX

Klyde Warren Park (Figure 16) is an urban green space constructed in 2012 that sits above the Woodall Rodgers Freeway. The park provides numerous recreational activities to the public including hosting cultural events, as well as outdoor concerts and festivals.

5.2.2. Rose Fitzgerald Kennedy Greenway – Boston, MA

Completed in 2008, the Rose Fitzgerald Kennedy Greenway (Figure 17) is a 15-acre linear urban park that spans on top of an expressway. Also known as the “Big Dig”, this urban park brings richness to Boston’s urban landscape.
Figure 16. Klyde Warren Park – Dallas, TX

Figure 17. Rose Fitzgerald Kennedy Greenway – Boston, MA
5.3. Proposed Decked Expressway Projects

Similar to Section 6.2, this section will demonstrate similar projects that is currently under development or in its proposal phase.

5.3.1. Interstate 70 East – Denver, CO

The Interstate 70 East (Figure 18) project in Denver, Colorado is a development proposal to bring the I-70 expressway below-grade in order to accommodate an at-grade facility for recreational use.

![Before and After Images of Interstate 70 East](image)

Figure 18. Interstate 70 East – Denver, CO

5.3.2. Park 101 – Los Angeles, CA

Park 101 (Figure 19) is a project proposed to promote urban sustainability and economic prosperity for the city of Los Angeles above its 101 Freeway. The project is intended to separate traffic by the use of a deck to accommodate a green space and pedestrian trail.

![Before and After Images of Park 101](image)

Figure 19. Park 101 – Los Angeles, CA
5.3.3. **CityArchRiver – St Louis, MO**

The CityArchRiver (Figure 20) is a proposed project that will overtop a small portion of the Interstate 44 and will provide biking and running trails at grade-level.

![CityArchRiver before and after](image)

*Figure 20. CityArchRiver – St Louis, MO*

5.3.4. **Autobahn A7 – Hamburg, Germany**

The Autobahn A7 (Figure 21) is a project that was proposed to address the issue of increasing noise pollution by decking the existing A7 freeway and providing an at-grade public space.

![Autobahn A7](image)

*Figure 21. Autobahn A7 – Hamburg, Germany*
6.0. QUALITATIVE ANALYSIS OF ALTERNATIVES

6.1. Table of Alternative Features

Table 2 summarizes the features of each corridor realignment alternative.

6.2. Corridor Alignment Alternatives

6.2.1. Evaluation Criteria

The following section lists the criteria used to qualitatively evaluate the three alternatives as outlined in Section 4.0 in order to provide conclusions on the preferred alternative.

Minimize Cost

This criteria takes into account the economic considerations of each alternative. The governing alternative will be that which minimizes the capital expenditures and public funding of the City of Toronto. Minimizing costs and being cost efficient could also mean that the project could be done in a shorter duration of time. It is important to note that costs must include both construction and maintenance costs.

Alternative 1:

This would require raising the majority of the Allen road to the surrounding ground level. Thus, current land must be filled and the entire road be re-paved. Additionally, to convert the freeway into an arterial, coordinated intersections must be added, and they not only require capital costs, but also ongoing maintenance costs. As a result, this alternative is not preferred when it comes to minimizing cost.

Alternative 2:

This alternative requires doing nothing in the Northern section, and decking the existing infrastructure to establish a tunnel in the Southern section. As such, the only additional cost will be for the Southern section. The costs for decking is much less when compared to a boring, although structural columns and slabs will be required. As such, this alternative is preferred when it comes to minimizing costs.

Alternative 3:

This alternative includes the costs of the above two alternatives. The Northern section must be turned into an arterial, and as such would require filling, paving, and signalized intersections. The Southern section would require decking. Similar to alternative one, this alternative is also not preferred.
<table>
<thead>
<tr>
<th>Advantage</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
</tr>
</thead>
</table>
| **Advantages** | • Provides for better vehicular connectivity within the neighborhood  
• Accessibility of residents in the area will increase; pedestrians, transit users and cyclists will have an easier time traversing the area  
• Can allow for businesses to open up and utilize Allen Road  
• Revitalizes Allen Road as a residential and commercial street rather than a congested freeway  
• Makes use of smart technologies in controlling traffic flow | • Minimizes social and environmental impacts (ex. Air and noise pollution) to the residents in tunnel portion  
• Enhances neighbourhood livelihood through multi-land use opportunities  
• Interchange redesign at Lawrence Ave. W and Eglinton Ave. W will enhance pedestrian safety and reduce congestion queues  
• Encourages cycling, walking, and transit use through integrated land-use  
• Provides a green space that promotes sustainable design  
• Overall design requires a relatively smaller capital expenditure due to the do nothing alternative in the northern section  
• Retains the primary function of Allen Road as an expressway | • Northern portion provides for better vehicular connectivity within the neighborhood  
• Minimizes social and environmental impacts (ex. Air and noise pollution) to the residents in tunnel portion  
• Enhances neighbourhood livelihood through multi-land use opportunities  
• Interchange redesign at Lawrence Ave. W and Eglinton Ave. W will enhance pedestrian safety and reduce congestion queues  
• Encourages cycling, walking, and transit use through integrated land-use  
• Provides a green space that promotes sustainable design  
• Can increase the income level of the corridor area through the use of on-deck commercial area |
| **Disadvantages** | • Costly expenditure to reconfigure the road and TTC subway line  
• The overall vehicular capacity and free-flow speeds of the corridor will be reduced due to arterial function, (even with ITS implementation or demand management)  
• Although good for nearby residents, it does nothing to improve the transportation connectivity to the downtown core for out of town commuters | • May imply higher traffic volumes as a result since it will remain a freeway  
• Tunnel will require frequent maintenance including ventilation, lighting, and fire protection | • Removes the expressway function of Allen Road in Northern portion  
• Speed discontinuity in roadway function: Northern Arterial, and Southern Expressway  
• Costly expenditure to reconfigure the northern portion to on-grade arterial road, and tunnel in southern portion  
• Reduced capacity of the northern portion of Allen Road corridor due to arterial function, which will have lower speed limit as well as more signalized intersections  
• Tunnel will require frequent maintenance including ventilation, lighting, and fire protection |
Integration with Existing Transportation Network and Corridor Features

An important criteria to consider to ensure that the selected alternative integrates coherently with the existing features of the corridor and Toronto’s transportation network without major disruptions.

Alternative 1:
With a complete arterial system, there are several opportunities to establish connectivity with the surrounding street network of the corridor. As a result, the arterial system will be well integrated into the transportation network, making it the most preferred under this category amongst the others.

Alternative 2:
This alternative keeps Allen Road the way it exists right now: a grade separated expressway. As a result, there remains limited connectivity with the surrounding network with the exception of Highway 401, Lawrence Ave. W, and Eglinton Ave. W interchanges. Due to no improvement to the corridor street network integration, this alternative is least preferred.

Alternative 3:
As the northern section is converted to an arterial road system, there are some connections established to the street network in the corridor. This partial integration to the existing transportation system in the corridor makes this alternative the second most preferred under this criteria.

Provide Multiple Land Use Opportunities

This criteria is a qualitative measure of how much land in the corridor right-of-way is available for land use opportunities. Whether the land is being used for commercial or recreational developments is not considered in this criteria. The governing alternative shall be one that provides sufficient land for any potential future developments along the corridor.

Alternative 1:
As alternative 1 is comprised of a complete conversion of the Allen Road corridor to an arterial system, much of the corridor will contain adequate soil foundations to facilitate building developments along the corridor right-of-way.
Alternative 2:
With the decked expressway in the southern section of Allen Road, building developments are limited to the available depth of foundation. As such, developments for recreational use are intended for this alternative and will accommodate primarily at-grade facilities requiring minimal subgrade requirements.

Alternative 3:
As a hybrid of alternative 1 and 2, this alternative will comprise of a combination of both commercial and recreational land developments in the respective locations.

**Improve East-West Connectivity and Accessibility for Pedestrians & Cyclists**

With the lack of pedestrian and cycling east-west connectivity currently in the corridor, this criteria will be taken into great consideration for the alternative selection in order to encourage multi-modal transportation behaviour.

**Alternative 1:**
The arterial road system will produce numerous east-west connections for automobiles. However, there will be limited opportunities that promote a multi-modal behavior from pedestrians and cyclists as the interaction with automobiles will still exist. As a result, this partial improvement in connectivity and accessibility makes this alternative least preferred under this criteria.

**Alternative 2:**
The numerous land-use opportunities introduced by the decking the southern section establishes east-west connectivity for pedestrians and cyclists while isolating them from automobiles. This promotes an overall multi-modal transportation behaviour. However, as this connectivity is only in the southern section, this alternative is also least preferred under pedestrian connectivity criteria.

**Alternative 3:**
With multiple land-use opportunities over the deck in southern section and partial connectivity established by arterial system in the northern, this alternative is the most preferred under this criteria. Overall, there is significant improvement in the connectivity and accessibilities for pedestrians and cyclists that will help promote a multi-modal behavior.
Reduce Congestion and Delay Times In and Around the Corridor

Congestion is a major issue on the Allen Road. Currently, demand greatly exceeds the capacity which leads to consistent queues. Queues are not only present on the Allen, but also on feeder roads such as Lawrence Ave. The chosen alternative must not increase delay and must try to improve the current capacity of the surrounding network.

Alternative 1:
This alternative would replace the freeway structure of the Allen Road with an arterial system. Arterial roads have much reduced capacity compared to a freeway, and as such, this alternative could actually make congestion worse. Although there is an argument that demand itself will decrease, it is unlikely to decrease enough to provide a smooth functioning arterial. Additionally, the use of ITS technologies as being developed by Dr. Abdulhai of UofT can only increase the capacity of the network by up to 30%. As such, this alternative is not preferred.

Alternative 2:
A do-nothing action in the Northern section, and decking the Southern section will not change the transportation aspects of the freeway. Allen Road's capacity will remain as is, and will not be reduced. However, several improvement opportunities in the southern intersections are present that can efficiently manage the demand within the existing capacity that will alleviate congestion. As such, this is the preferred alternative.

Alternative 3:
Turning the Allen into an arterial in the Northern section will greatly reduce its capacity. The flow of vehicles coming from the 401 into the Allen will also be hindered, and will require additional design. The decking of the Southern section will keep the current road capacity, but considering the greatly reduced capacity of the Northern section, overall capacity will be reduced and vehicles will be heavily congestion between the 401 and Lawrence. Similar to alternative one, this is not preferred.

Increase Safety of Travel
Due to the frequency of pedestrian, transit, and automobile interactions at the Lawrence Ave W. intersection, the governing alternative shall minimize or eliminate, where necessary, all multi-modal interactions that are deemed a safety hazard.
**Alternative 1:**
As a complete conversion to an arterial, there will be increased vehicle and pedestrian interaction due to the shared roads for multi-modal use. As such, travel safety is greatly dependent on the safety measures established in the detailed design of the arterial to mitigate safety hazards.

**Alternative 2:**
Currently, the northern section of Allen Road contains no interaction with other modes of transportation until traffic reaches the first intersection of Lawrence Avenue. As a do-nothing alternative in the northern section, this will remain the same. In the southern section, decking the expressway will completely separate vehicle operations from pedestrians and cyclists which will surely increase the safety of travel.

**Alternative 3:**
The arterial in the northern section will imply a shared use of transportation modes, hence the limitations in safety. However, the decked portion in the southern section will act as a measure of vehicle operation separation from pedestrians which will provide the best of both alternatives.

**Reduce Noise and Air Pollution**
This criteria is important as noise and air pollution are one of the major problems currently faced by the residents of City of Toronto within the corridor. The city receives numerous complaints regarding these issues imposed by TTC subway line and expressway automobile traffic, producing a public health hazard. Hence, promoting a healthy lifestyle by isolating the public from air and noise issues is an important consideration in alternative evaluation.

**Alternative 1:**
As the arterial road will be on-grade with the surrounding features of the neighbourhood, it will eliminate the pre-existing noise mitigation features. Additionally, as the arterial road is more susceptible to congestion due to high automobile demand in the corridor, worse air quality conditions will be experienced. As a result, this alternative is least considered under this criteria.

**Alternative 2:**
The decking in the southern section will help mitigate the noise issues to the residences in that area. Additionally, some technological measures such as carbon capture and storage can be used to isolate the air emissions away from the residential areas. However, due to no changes in northern section (keeping noise mitigation measures still there), some extent of noise and air
pollution still persist in that area. Overall, this alternative is most preferred under this criteria than complete arterial option.

**Alternative 3:**
The arterial alignment in the northern section will eliminate the noise mitigation measures and bring the traffic on-grade with the surrounding neighbourhoods. This, accompanied by numerous intersections that can potentially congest the road, will show no improvement to noise and air pollution. Additionally, with the decked section in the south, the automobile and TTC line isolate the noise while producing several opportunities to mitigate air pollution. Hence, with potentially deteriorating conditions in northern section and partial improvements in southern section, this alternative is second most preferred under this criteria.

### 6.3. Interchange Design Alternatives

**6.3.1. Simple Diamond Revamp**
The simple diamond interchange layout, as shown in Figure 22, is similar to the existing configuration at Lawrence Ave. W interchange. The primary change under consideration is to increase the capacity (i.e. widening) of the expressway off-ramps and overpass such that the ramp queues do not interfere with the expressway. This alternative is proposed to integrate it well within the existing conditions without any major conflicting disruptions.

![Figure 22. Simple Diamond Interchange Layout](image)

**6.3.2. Parclo B4**
This alternative will be a complete redesign of the current interchange layout. The current simple diamond layout will be replaced by a Parclo B4 (Figure 23). Parclo B4 will provide smooth and natural movements as the traffic exiting the freeway goes in either direction of Lawrence Ave. without having to stop at an intersection to make turns. The layout will comprise of dedicated
ramps that will merge into Lawrence Avenue. Northbound traffic entering the Allen will still require making a left-turn at an intersection; however, the volume of traffic entering the Allen is much less than exiting and this is why Parclo B4 was chosen over Parclo A4. One major consideration for this alternative is that adjacent land must be acquired to build the necessary ramps.

![Figure 23. Parclo B4 Interchange Layout](image)

6.3.3. Evaluation Criteria

**Minimize Cost**

Similar to the corridor alignment, economic consideration is established as a criteria to ensure the optimum use of public infrastructure expenditures. The cost associated within this criteria accounts the construction, maintenance, and any other external costs associated with land acquisitions and reimbursements to stakeholders.

**Simple Diamond Revamp:** This option would widen the current off-ramps such that ramp queues not to interfere with the traffic on Allen Road. The widening costs will be minimal compared to replacing the current interchange layout with another one. As such, this option is preferred when it comes to minimizing the costs.

**Parclo B4:** This option would require a complete transformation of the current simple diamond interchange layout to a Parclo B4 interchange layout. This process would require large capital costs as multiple ramps (including looped ramps) must be constructed. This option does not minimize costs and such fails in this criteria.
**Promote Pedestrian Safety**

Defined in the problem definition, it was established that Lawrence Ave. W interchange is subject to high number of pedestrian crossings due to the current interchange configuration and placement of the TTC subway station entrance. Due to high interaction of pedestrians with automobiles during crossings accompanied by poorly maintained infrastructure, a significant safety hazard is present. Hence, maximizing safety, as a paramount criteria is established for interchange evaluation.

**Simple Diamond Revamp:** As this interchange is very similar to existing one with the exception of increased automobile capacity, there are still many crossing areas within the interchange that pose safety issues for pedestrians. Hence, this interchange is least preferred under pedestrian safety category as there are no improvements towards it.

**Parclo B4:** The continuous flow structure of this interchange eliminates need of signalized intersections within the area. As a result, the number of north-south crossings are significantly reduced while still ensuring the east-west crossings are still there. This interchange also introduces new opportunities to create bridges to accommodate the pedestrian flow in and out of the Lawrence Ave. W. station.

**Minimize Backup Queues**

Due to demand significantly exceeding the capacity at the southbound off-ramps at Lawrence Ave. W, the congested queues build onto the expressway lanes. This decreases the overall performance of Allen Road Expressway. Hence, reducing the length of these queues is established as a criteria to address the congestion problem in the corridor.

**Simple Diamond Revamp:** The widening of the off-ramps will slightly increase the capacity of the off-ramps and thus marginally reduce backup queues on the Allen. However, compared to the Parclo B-4 option, this option pales in comparison when it comes to providing a smooth off-ramp flow and increase capacity. As such, this option is not preferred.

**Parclo B-4:** This option will include off-ramps that more naturally and smoothly merge traffic into Lawrence Ave W. There will be no left-turns needed at off-ramps and thus no traffic lights as all movement will pass through channelized-right turns. This would greatly increase the capacity of the off-ramps and reduce backup queues on the Allen, and as such is the preferred option.
Minimize Land Requirements

The Allen-Lawrence interchange is surrounded by varying lands. This includes residential housing on the south-east, south-west, and north-east corners of the interchange. The north-west corner has a commercial space and includes a large plaza. Expanding and reconfiguring the current interchange might be a good idea in terms of improving capacity and safety, but it must keep lands necessary to be acquired to a minimum. Homeowners and businesses can complain a great deal if their land has to be acquired.

Simple Diamond Revamp: The widening will likely not intrude into any surrounding lands as it is based off the existing interchange configuration. Thus, this option would require no acquirement of any additional land and is the preferred option.

Parclo B-4: This option would include building new ramps on the south-west and north-east portions of the interchange. These looped ramps would require significant additional space. The space that has to be acquired is residential land including houses and apartments and may cause significant backlash from the local residents. As such this option is not preferred under land requirement criteria.

6.4. Land Use Alternatives

6.4.1. Land for Commercial Use

Using the available land along the corridor right-of-way for commercial use will comprise of developments that contribute to economic growth, such as a shopping district, entertainment district, or a plaza of numerous small businesses. As such, this alternative will transform the area into a district consisting of buildings, public walkways, theatres, and promenades as shown in Figure 24.

Figure 24. Third Street Promenade Shopping District
6.4.2. Land for Recreational Use

This alternative entails utilizing the land along the corridor right-of-way for recreational use in order to bring vibrancy to the Allen Road communities. This can be achieved by transforming the area into a linear urban park that may consist of pedestrian/cycling trails, landscaped gardens, public art, sports fields, and concert stages as shown in Figure 25.

![Figure 25. Klyde Warren Park Conceptual Art](image)

6.4.3. Evaluation Criteria

**Maximize Economic Productivity**

This criteria will be used to evaluate the potential for developments on the designated land along the decked portion of the Allen Road expressway to generate revenues and contribute to the City economy.

**Land for Commercial Use:** This alternative will provide relatively more opportunities for economic productivity by creating a corridor that will emphasize on local businesses, shops, and entertainment facilities that can contribute to Toronto’s economic output.

**Land for Recreational Use:** The intent of this alternative is not to provide economic opportunities, however, facilities can be used to host private and public events that can generate minimal revenues.
Maximize Recreational Opportunities

This criteria will be used to evaluate the potential for developments on the designated land along the Allen Road expressway deck to generate activities for social and cultural use, as well as contribution to the City’s urban green space to enhance the quality of life for communities.

Land for Commercial Use: The intent of this alternative is not to provide recreational opportunities, however, the corridor may contain components that will encourage some recreational use such as public art or adequate landscaping for community leisure.

Land for Recreational Use: This alternative will provide an abundance of land developments for recreational purposes such as concert venues, sports fields, and public art that will be intended for public use.

Promote Growth and Sustainability

As part of the City of Toronto’s Official Plan, the City aims to achieve a growing and sustainable city by developing purposeful projects throughout Toronto. The governing alternative for land use must adhere to these plans by promoting growth and sustainability through its intended use.

Land for Commercial Use: While commercial developments along the Allen Road corridor will contribute to economic growth, it will not contribute significantly to the environmental growth and sustainability plans that the City has for future developments.

Land for Recreational Use: Transforming the southern section of Allen Road to a decked expressway will provide for an urban park that enhances the vibrancy and richness of the City’s public realm, hence contributing significantly to promote the growth and sustainability of the City.
7.0. ALTERNATIVE SELECTION

The criterion established within this section provides an evaluation framework that is used to generate the evaluation matrices labelled Table 3, 4 and 5. As such, the preferred alternative to be selected is Alternative 2 (Section 4.2) and further detailed design will be comprised of an interchange design as well as land development for recreational purposes.

7.1. Corridor Alignment

Alternative 2 (N: Do Nothing, S: Tunnel/Deck) is the preferred corridor alignment as shown in Table 3. While it provides limited opportunities for integration, land-use, and connectivity in the northern section, the decking in the southern section opens up these opportunities which is the most significant part of the corridor as it is bounded by residential areas. Similarly, congestion will be addressed at the 2 interchanges of the southern portion while addressing the key issues of east-west connectivity, safety, noise, and air pollution. Additionally, this alternative retains Allen Road’s function as an expressway. This, combined with minimal cost, makes Alternative 2 the preferred option for the design phase.

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<thead>
<tr>
<th></th>
<th>Alternative #1</th>
<th>Alternative #2</th>
<th>Alternative #3</th>
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<tbody>
<tr>
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<td>Integration with Transportation Network</td>
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7.2. Interchange Design

The qualitative evaluation results shown in Table 4 demonstrates a tie between the two interchange layouts. Upon judgement call, PSL has decided to go for complete modification and choose Parclo B4 as the preferred interchange. Although this modification will cost more and encroach into lands shown in Figure 26 that need to be acquired, the interchange will help address the root issues that Allen Road is known for: congestion and pedestrian safety. With minimized congestion, positive impacts will be generated towards economy and public health within the corridor. As well, the interchange will produce opportunities to create isolated crossings in and out of Lawrence Ave. W. TTC Station to promote safety and maximize traffic operations. Hence, Parclo B4 interchange will be designed as the benefits outperform the costs associated with construction and land acquisition.

Table 4. Interchange Alternatives Evaluation Matrix

<table>
<thead>
<tr>
<th>Simple Diamond</th>
<th>Parclo B4</th>
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<tbody>
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<td>Minimize Land Requirement</td>
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<tr>
<td>Promote Pedestrian Safety</td>
<td></td>
</tr>
<tr>
<td>Minimize Backup Queues</td>
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</tbody>
</table>

PREFERRED ALTERNATIVE
7.3. Land Use Design

The results of the evaluation for the integration of land use shown in Table 5 has granted the selection of using the dedicated land for recreational purposes. The two alternatives serve vastly different functionalities, however the selection of the recreational land use alternative can be justified by the correspondence of the design intent with the City of Toronto's growth plans for future development. As described in the Official Plan, future developments must be able to contribute to the public realm of the City in order to sustain our communities, and thus become the forefront of city sustainability. This alternative also provides for numerous recreational opportunities that can be thoroughly enjoyed by Toronto communities and tourists as shown in Figure 27 and 28.

<table>
<thead>
<tr>
<th></th>
<th>Commercial Use</th>
<th>Recreational Use</th>
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<tr>
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Table 5. Land Use Alternatives Evaluation Matrix
Figure 27. 3D Conceptual Model of Recreational Land Use

Figure 28. 3D Conceptual Model of Allen Road Tunnel Cross Section
8.0. DETAILED DESIGN

This section follows from Alternative Selection where the preferred alternatives in regards to corridor alignment, interchange, and land use were chosen. Here, important information regarding the detailed design including procedures, summaries, and impacts of design will be discussed. The design drawings set are provided in the attached drawing set.

8.1. Corridor Alignment Design

The corridor alignment chosen was Alternative #2. This alternative was composed of do nothing for the Northern Section, and conversion into tunnel via decking in the Southern Section.

8.1.1. Northern Section

As the strategy suggests, a do nothing option will keep intact the existing road infrastructure for the Allen Road. Thus, there is no detailed design required for this section. However, minor maintenance and aesthetic changes can still be implemented. Current road cracks and spalls are not acceptable, and as the project name suggests, revitalization is required in the form of road maintenance. This would include repaving of cracked surfaces throughout the Allen Road. Additionally, since noise is a major concern for residents, improved noise barrier options should be considered. New noise abatement walls, such as the LSE Barrier System can bring improved noise reduction since these systems use newer material that absorbs noise rather than current systems that deflect it in various directions [14]. Due to the sparse grade separated residential areas within the Northern Sections, the public will be consulted and the need for new noise abatement solutions in the area will be determined. Finally, aesthetics of the road will be improved through increased landscaping, and implementation of artistic designs on existing or newly installed noise barrier systems – which can revitalize the Northern Section into a form of public art as shown in Figure 29.

Figure 29. Noise abatement walls as public art in Scottsdale, AZ
8.1.2. Southern Section

The alternative chosen calls for the transformation of the Southern Section into a tunnel by overtopping Allen Road with a decking system, with no changes in the expressway components within the right-of-way (i.e. lanes and shoulders). This is to provide for the benefits discussed in Section 6.0 and 7.0. Furthermore, this will address the potential issue of induced demand, where expanding the transportation network horizontally may imply an increased auto mode share as a result of improved capacity. As such, the deck will simply serve as a means to separate vehicular traffic and transit operations from the pedestrian public realm. It is important to note that there will be no boring involved in order to transform the current road into a tunnel. Rather, structural components such as reinforced concrete columns, beams, and two-way slabs will be designed and implemented in order to support the proposed deck structure. Drawing 27 shows the general profile of the decking project, which contains structural components that are then overtopped with a layer of engineered soil to provide for amenities placed on the deck. Precast materials are most preferred in order to efficiently erect the structure without significant compromise in vehicle operations. Structural details are subject to change with correspondence to further consulting with a third party entity. For the details of the land use design above the proposed tunnel, see Section 8.3.

8.2. Interchange Design

The Parclo B4 interchange, such as the one shown in Figure 30, was chosen to be implemented at Allen-Lawrence. The existing simple diamond interchange will need to be completely transformed to accommodate such a change. This section will briefly discuss the general design process that was implemented, and give an overview of the detailed design guidelines used.
8.2.1. Design Process

The design process relied on two primary resources: Geometric Design Standards for Ontario Highways, and Autodesk’s Civil 3D software. Chapters from the Geometric Design Standards relevant to the detailed design include Chapter C – Alignment, Chapter D – Cross Section Elements, and Chapter F – Interchanges. All necessary guidelines were checked before drawing the detailed design to ensure full compliance with the manual. Concurrently, for the production of detailed road design drawings, Civil 3D was utilized. Existing road data for the Allen Road and Lawrence Avenue, including current elevations, were used to produce a base map as shown in Figure 31. Then, the modifications for the Parclo B4 on and off ramps were drawn through various steps to produce a detailed design – all while simultaneously meeting the Geometric Design Standards.
The design in Civil 3D required the detailing of the following drawings – most of which will be presented in the attached drawing set.

- **Alignments** – also known as horizontal alignments. They include a plan view of the horizontal positions and locations of the to-be-built on and off ramps. An alignment is required for each ramp.

- **Profile** – also known as vertical alignments. They are the vertical profile of the roads (alignments). Lawrence Avenue is situated well above Allen Road and the profile drawings are of vital importance to understand how the elevations of the road will change throughout each alignment.

- **Assembly** – these include the details of the cross-sectional elements of the ramps, including ramp width, curb, and gutter dimensions.

From the above drawings and details, the corridor was produced that compiled of all the above three drawings and details into a singular file.
8.2.2. Detailed Design

Some of the guidelines used to construct the detailed designs and their outcomes will be presented here. As discussed in the previous section, this section will focus on the three design elements: alignments, profile, and assembly.

**Alignments**

- Since there will be nothing built adjacent to the on or off ramps, sight distance values were not considered, and thus full attention was paid to the geometric design.
- Parclo B minimum values for highway design speed of 100 km/hr and ramp design speed of 50 km/hr are [15]:
  - Superelevation $e_{\text{max}}$ of 0.08 m/m
  - Minimum radius of 80m
- Spiral curves used instead of circular curves due to the high speed nature of freeway interchanges. Spiral are based on comfort, superelevation, and aesthetics:
  - Table C3-5 used for determination of spiral curve parameters for maximum superelevation of 0.08, speeds of 50 km/hr, and $A = 90$ (a spiral parameter)
  - Note: To minimize the land requirement for cloverleaf ramps, the minimum radii were chosen for the spiral curves. This limited the ramp speeds for comfort and safety reasons due to the required sharp spiral curves.
- Length of taper for off-ramps entering Lawrence is designed at 80m, taper for on ramps on Allen will remain as is [15]
Figure 32. Detailed design location shown on existing infrastructure
Profile

- Maximum grade of 12% and minimum grade of 0.1% met throughout all ramp profiles [15]
- At VPI’s (vertical points of inflection), parabolic curves used to provide for a smooth transition
- Minimum K values met at all points to optimize for vertical sight distance and driver comfort
  - For a ramp with design speed of 50 km/hr, these are K = 8 for crests, and K = 12 for sags which were met throughout the design [15]

Assembly

All assemblies were produced based on the assumption that 150 mm Granular A base and 300 mm Granular B sub-base will be used for roadway pavement design, except where otherwise noted.

Expressway:

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 3.75 m
- Shoulder widths: 1.0m on left side, 3.0 m on right size
- Drainage slope: 3:1 daylight grading for non-decked portions

Figure 33. Northbound and Southbound Expressway Typical Section
Lawrence Avenue W:

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 3.60 m
- Shoulder widths: No shoulders. Curb and gutter on the edge of each travelled way
- Safety median is placed to isolate the bi-directional flows

![Figure 34. Lawrence Avenue West Typical Cross Section](image)

Cloverleaf Ramps:

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 4.75 m
- Shoulder widths: 1.0 m on left side, 2.50 m on right side.
- Drainage slopes: 3:1 daylight grading with additional 6:1 grading towards the center of ramp radius.
- Extra features: Conditional cut or fill grading on either side to optimize earthworks.

![Figure 35. Cloverleaf Ramp Cross Section](image)
Non-cloverleaf Ramps

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 4.50 m
- Shoulder widths: 1.0 m on left side, 1.0 m on right side.
- Drainage slopes: 2:1 daylight grading on each side
- Extra features: Conditional cut or fill grading on either side to optimize earthworks.

Ramp Connectors

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 4.50 m
- Shoulder widths: No shoulders as they are relatively short in length
8.3. Land Use Design

The implications of a deck in the Southern Section suggest numerous opportunities for recreational developments. It was established that a deck for commercial development will result in the need for a durable geotechnical foundation, as well as a robust structural design in order to support structures above the deck. Doing so may result in the compromise of cost, maintenance, and vehicle operations below-grade. As such, the expressway deck will be used to facilitate components that are devoted to revitalizing the public realm. It is important to note that the east-west arterials (Dell Park Ave, Glengrove Ave, Glencairn Ave, Viewmount Ave, Ridelle Ave, Elm Ridge Dr, and Aldburn Rd) overpassing the existing below-grade Allen Road will still remain in order to serve the same east-west connectivity. As a result, any land use implementation along the decked corridor will be disconnected and will provide for a series of eight linear urban landscapes rather than a single continuous urban park, similar to that of the Boston Rose Fitzgerald Kennedy Greenway.

It is important to note that, while manuals and guidelines were reviewed for acknowledging the necessary land use design components, no elaborate detailed land use design was established due to the vast 30-acre right-of-way that would have been designed. Rather, specific design recommendations are provided in order to guide the public with the selection of a sophisticated design. Recommendations are provided in the following section in categories of at-grade amenities, walkways and trails, landscaping, and public art. For graphical samples of land use applications for the Project, see Drawing 25 and 26.
### 8.3.1. At-Grade Amenities

The functionality of an at-grade amenity is to attract and assemble communities in order to generate recreational activities. The options for such amenities are boundless, and will be in the form of parks, playgrounds, concert stages, fountains, outdoor athletic courts, markets, and dining. Drawings 25 and 26 demonstrate an example of a park segment in which contains a fountain, basketball courts, and playgrounds. With 30 acres of available land along the decked portion, quantity and orientation of such amenities are very flexible, and can be placed in strategic locations to draw out the appropriate demographic. With the disconnection of land due to the east-west arterials, the functionality of each park segment may differ. For example, between Lawrence Avenue and Dell Park Avenue may contain some public art or attraction such as a fountain as it is located beside neighbourhoods and shopping malls which may draw out people from these activities. Similar strategies can be implemented near the center of the corridor can accommodate outdoor athletic facilities, to serve the abundance of residents in the adjacent area. An elaborate landscape design for each park segment will be finalized with approval and correspondence with the public.

*Figure 39. Concert stage attracting people at one of the Rose Fitzgerald Kennedy Greenway Parks*
8.3.2. Walkways and Trails

One of the primary intents of the Project is to create a multi-modal corridor with a distributed mode share for pedestrian and cycling traffic. The deck will provide for a linear walkway for pedestrians and recreational trail for cyclists with applicable paving techniques and materials, as shown in Figure 40. A wide boardwalk will span throughout the corridor, with safe crossings where applicable in order to facilitate safe pedestrian movement on the deck. As mentioned, the continuity of the urban park will be fragmented due to the east-west arterials along the corridor. Hence, appropriate crossings will be designed as well with the use of pavement materials and road surface markings to accentuate the crossing for safer movement, similar to that shown in Figure 41. In addressing the discontinuity issue of the York and Kay Gardner Beltline east-west trails (see Figure 42) between Elm Ridge Dr and Aldburn Rd, the deck will allow connection of these trails, granting it as a reliable trail for cyclists to reach the downtown core from the west side of Allen Road.

Figure 40. Pedestrian walkway at Klyde Warren Park
Figure 41. Clearly marked pedestrian/cycling crossing through arterial road

Figure 42. The Allen Deck will connect the east Kay Gardner Beltline trail with the west York Beltline trail
8.3.3. Landscaping

According to the City of Toronto Official Plan, it is vital to provide an abundance of green spaces through a diversity of landscaping techniques in order to promote the sustainability motive of Toronto. Landscaping is a major component to add vibrancy to the urban park, and will be achieved with a diversity of flora and tree species, paving, and lighting. Paving materials used for pedestrian walkways and other landscaping purposes will be designed to accentuate the urban landscape, similar to the techniques applied at Perk Park of Cleveland, Ohio (Figure 43). Trees to be planted shall be native and include species such as oak, maple, pines, and ashes to provide richness in species, as well as a traditional green landscape. Lighting will be placed in locations required to illuminate pathways for evening and night time leisure, and parks will accommodate for seasonal lighting such as Christmas lighting as well (Figure 44).
8.3.4. Public Art

With the City’s plans for the revitalization of the Lawrence-Allen neighbourhood, public art will be essential for adding elegance to the area. Public art has proved its value in numerous applications across the world and has provided a means for social gathering and activity generation. Public art is to be selected in favour by the City, and shall be coherent with the culture of adjacent neighbourhoods. While much public art can be in the form of contemporary art as shown in Figure 45, public art incorporated with landscaping techniques can be implemented as well in order to attract tourists and a larger demographic in different times of the year, such as the Dodge Memorial Fountain in Detroit (Figure 46).
9.0. **CONSTRUCTABILITY**

The constructability of the preliminary design must be evaluated to see how feasible the proposed design really is. Feasibility measures the degree that the design can conveniently be implemented by considering all the possible obstacles that the project may face.

9.1. **Corridor Alignment**

The *Northern Section* does not face any major challenges. Re-pavement of certain cracked or spalled areas is a common freeway maintenance work. The installation of improved noise barrier systems will be done from the lands adjacent to the freeway, thus not impacting the vehicles on the Allen. Finally, aesthetic improvements such as improved green space and addition of artistic design to noise barrier systems can be done during off-peak hours to avoid major interruption to vehicular traffic.

The *Southern Section* requires deckign the existing road to create a tunnel. As the creation of the tunnel does not require boring, but rather decking, the construction process may be much simpler. To minimize disruptions to vehicle operation, as well as construction schedules, precast concrete materials will be utilized. This can be in the form of regular reinforced concrete or prestressed concrete which are to be cast off site. The latter is more costly, but has a much stronger capacity to resist loads which could result in columns and slabs with a slimmer profile. During the installation of structural elements, certain portions (or the entire road) should be closed off due to safety reasons. With that being said, the transformation process can be divided into stages and be continuously done during late-night and off-peak hours to minimize impacts to vehicular traffic. For example, a precast reinforced concrete column can be installed during an off-peak period with the required portion of the road being closed off, and during the succeeding peak period the road can be fully re-opened. Such a technique is possible since there will be no changes or disruptions to the current lanes or shoulder, all structural elements will be around or on-top of vehicular traffic.
9.1.1. Decking Challenges & Best Practices

Decking projects similar to the Allen Road Revitalization decking project are not uncommon, and have proven their constructability through numerous applications around the world. Most prominent is Klyde Warren Park of Dallas, Texas, which involved overtopping the Woodall Rodgers Freeway with a deck, providing the necessary space for an urban park.

As the Klyde Warren Park project was an all-in-one bridge, park, and tunnel project, many challenges were brought up in the design and construction [16]. One major concern was how to design a slim structure with minimal foundation to support numerous heavy-loaded amenities, such as performance stages, water features, and other live loads. Drainage, sufficient soil for tree growth, and ensuring deck elevations were matched with existing roads were other issues as well. Today, these engineering challenges has resulted in a vibrant urban park that has dynamically enhanced the Dallas landscape.

The schematic shown in Figure 48 demonstrates the construction process of erecting the Klyde Warren deck. The project begins with the construction of support bearing walls which are designed to support the anticipated heavy loads above the deck. These walls are then spanned with a girder system that provides further support to the deck. Overtopping the girders is the decking system, with a similar profile to that shown in Figure 47, containing the foundation for above-grade amenities.

It is apparent in applications similar to Klyde Warren Park, that the Allen Road Revitalization will experience the same challenges, concerns, and construction processes. As such, utilizing similar design and construction techniques from best practices applications will ensure a project that contributes significantly to the City of Toronto.
Figure 48. Klyde Warren Park Construction Process
9.2. Parclo B4 Interchange

The constructability of the proposed interchange has two primary challenges: land acquisitions, and ramp constructions. For each of these two categories, the impacts and mitigations are discussed.

9.2.1. Land Acquisitions – Impacts & Mitigation

The implementation of the Parclo B4 interchange at Allen-Lawrence is not possible with the current spatial boundaries of the interchange. Adjacent lands must be acquired to incorporate the two loop ramps on the north east and south west portions of the interchange. Please see Figure 49 for a visual representation.

**South-West Portion**

The on and off ramps in the south-western portion of the interchange will require additional land acquisition. The lands in that portion are all residential; they are all detached houses located on Fairholm Avenue. While it's possible to install the ramps with the acquirement of only a few houses, due to safety and noise reasons it is suggested that all the houses on Fairholme Ave. (including all houses within the Marlee Ave. and Dell Park Ave. block) be acquired. The homeowners will have to be evicted, but will have to be compensated fairly by the City of Toronto which should consider the real estate property, relocation fees, and perhaps an extra compensation.

Since southbound traffic off the Allen onto Lawrence is one of the current major causes of congestion, the development of this loop ramp and acquisition of property is deemed as necessary.
North-East Portion

Similar to the south-west portion, lands on north-western region must be acquired to implement on and off ramps. However, unlike the type of land in the south-west section, the land in the north-east portion is currently the Lawrence Heights Community Centre. Acquiring such lands causes a great challenge since they are public institutions serving the neighbourhood. Under City of Toronto’s Lawrence-Alen Revitalization project, there are several community centers that are to be located within the Lawrence-Alen area. It is possible that proposed community centers can serve as an alternative to the existing Lawrence Heights Community Centre. If such seems feasible to the community and the City, detailed scheduling will be required to align the timelines for commissioning of new centers and decommissioning of the existing one to ensure minimal impact to the community. Upon successful decommissioning, the construction of the ramps in north-eastern portion will be commenced.

With that being said, the northbound traffic exiting and entering Allen Road at Lawrence is not a major cause for congestion in the corridor as mentioned previously in the report. As such, the proposed ramps in the north-eastern portion do not hold a strong importance towards solution of congestion as compared to the south-western ramps. Thus, if acquisition of the public institutions in the area are either too costly, or considered unacceptable by the local community, leaving the existing on and off ramps on the north-eastern portion of the Allen Road is a viable option.

9.2.2. Ramp Construction – Impacts & Mitigation

Once the required lands are acquired, the succeeding step is to construct the proposed ramps. Typical ramp maintenance or overhauls will require the closing of existing ramps before any work is done, which would cause major traffic disruptions for the people that want to exit or enter the Allen at Lawrence. However, due to the nature of the design, 4 of the 6 proposed ramps will be completely new ramps – they include the Allen North-to-Lawrence West off ramp, the Allen South-to-Lawrence East off ramp, the Lawrence-to-Allen North on ramp, and the Lawrence-to-Allen South on ramp. As a result, these new ramps can be fully constructed without the closure of the existing ramps serving the same purpose. Once the new ramps are constructed and ready for use, the former ramps will be decommissioned appropriately. The other two ramps: the Allen North-to-Lawrence East and Allen South-to-Lawrence West off ramps will make use to modify the existing off ramps and
incorporate the new spiral curves – thus for these two ramps, partial closures (i.e. overnight closures) of the existing ramps will be necessary, which will cause temporary traffic disruptions to some commuters.

During all construction processes, traffic control staging plans will be implemented along with variable messaging signage to notify the drivers of upcoming and current traffic disruptions such that they can plan their commute accordingly.

10.0. COSTS

The project is expected to cost approximately $210,000,000. The details of cost estimate are shown in Table 6. The construction cost is comprised of $1.95 million for interchange, $137.6 million for the structural deck, $500,000 for decommissioning of existing ramps and making modifications on Lawrence Ave. W., and $42 million for Engineering, Design, and Management. Additionally, a mark-up of $28 million was added for land acquisition and reimbursement for the residents in south-west of the interchange.
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<th>Quantity</th>
<th>Unit of Measure</th>
<th>Rate</th>
<th>Total</th>
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**Notes:**
* Rates obtained from previous experience in heavy civil projects
** Plug number as a placeholder for maximum expected cost for the item
### 11.0. IMPLEMENTATION

#### Allen Road Corridor Revitalization – Project Work Plan

<table>
<thead>
<tr>
<th>PRELIMINARY DESIGN</th>
<th>EA REVIEW</th>
<th>DESIGN FINALIZATION</th>
<th>PROCUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define project rationale of Allen Road revitalization project</td>
<td>Await approval of Terms of Reference sent to the Ministry of Environment and Climate Change (MOECC)</td>
<td>Amend preliminary design from things learned during EA Process</td>
<td>Issue Request For Qualification (RFQ)</td>
</tr>
<tr>
<td>Establish suitable alternatives</td>
<td>Conduct detailed applicable surveys and baseline studies including traffic, geotechnical, topography required for EA</td>
<td>Review design with the City and major stakeholders</td>
<td>Issue Request For Proposal (RFP) to shortlist proponents</td>
</tr>
<tr>
<td>Develop Preliminary Detailed Design</td>
<td>Fully analyze potential impacts and mitigations</td>
<td>Amend design</td>
<td>Reward contract to preferred proponent</td>
</tr>
</tbody>
</table>

- MOECC review of EA
- MOECC decision on EA approval
- Public Consultation
- MOECC decision on EA approval
- Approval from the City and major stakeholders, handover Project
- Commence construction of project
- Make design changes due to on-site challenges, if required
With the Preliminary Design section of the project work plan being completed with this report, the three major proceeding steps are the Environmental Assessment (EA) Review, Public Consultation, Design Finalization, and Construction.

11.1. EA Review

The Allen Road is a public road owned by the City of Toronto. Although small scale road projects can be done through a very brief Class EA which can be done completely by the proponent, since the proposed changes to Allen Road are somewhat significant, a full individual EA will be carried out.

The first step – which gives an overview of the project entitled the Terms of References has already been completed by the City of Toronto and sent to the Ministry of Environment and Climate Change (MOECC). Upon its approval, applicable surveys and baseline studies will be conducted to better understand the physical and socio-economic environment. These studies must cover a wide range of time and go further into the past in order to correctly identify patterns. Subsequently, impacts of significance must be determined and evaluated through studies and consultation with experts. Afterwards, mitigations measures that address the identified impacts must be determined. It is recommended to avoid, and if unavoidable, minimize the impacts. The necessary documents will then be submitted to the MOECC for approval. During the entire EA Process, and especially during the impacts and mitigation determination, public consultation will play an integral part.

11.1.1.1. Public Consultation

PSL envisions a strong public interest in this project, specifically due to the direct impacts posed by the interchange land requirements as discussed in Section 9.2.1. It will be crucial to hold several public consultation meetings to educate the public of the ultimate goals of the project and how it will improve the quality of life within the neighbourhood. It might be beneficial to hold Lawrence-Allen Revitalization and the Project consultations coherently as the Lawrence-Allen Revitalization produces numerous residential and commercial opportunities that will serve as potential alternatives for displaced residences and community center. This joint consultation meeting will also help show the final vision that the corridor area holds. Additionally, the public will also have opportunities to voice their concerns that can be addressed in the detailed design to address their needs. Ultimately, the public consultation will be a vital process to successfully
achieve the goals and objectives that are envisioned by the project during the EA process and beyond.

Figure 51. Port Lands public consultation session organized by Waterfront Toronto

11.2. Design Finalization

Once the MOECC approves the project and the public is satisfied with the project, the design finalization phase can begin. The preliminary design developed within this report will be amended to take into account the EA process. Afterwards, the design will be reviewed with the City and major stakeholders and amended accordingly – this will be an iterative process until a design that the PSL Group, the City, and major stakeholders are happy with is reached. Subsequently, the final design will be produced and submitted to the City for approval.

11.3. Funding and Procurement

Certain measures will be required to obtain the required funding for the project. The currently elected federal Liberal government has voiced its strong interest towards social infrastructure by setting aside $20 billion dollars towards it over the next 10 years [17].

In terms of procurement, PSL recommends the City to establish a Public-Private-Partnership (P3). It is expected that the project will serve as a long-term contract as it will require maintenance
for the roadway portion under the deck as well as the landscaped section above the deck. As such, establishing a Design-Build-Finance-Operate-Maintain contract will help the City share the liability of the project with a private concessionaire in terms of financing and construction to ensure effective performance is delivered by the project from the start over to the long-term. Additionally, the government will have control over the cost overruns and payments as it will only be able to pay the private concessionaire upon successful delivery and maintenance as per the specifications. Ultimately, P3 serves as an excellent procurement method for the Project to maximize the overall performance and hold financial securities over the taxpayers’ money in cases of delays and cost overruns.
12.0. PROJECT METHODOLOGY

PSL has determined three primary phases that encompass the scope of the Project: Pre-Design, Design, and Review and Consultation. These phases chronologically help organize the future expectations to ultimately produce the detailed design. See Figure 29 for a diagram of the methodology.

12.1. Pre-Design Phase

Task 1 - Full review of design manuals
As part of this report, the design manuals listed in the Proposal are critically reviewed in Section 3.0. Under this section, the chapters and sections relevant to the scope of the alternatives are reviewed to get a design criteria as well as to obtain the in-depth knowledge. This task allows for envisioning the feasibility and as-constructed perspective of the alternatives which will not only assist in Design phase, but also in the evaluation of the alternatives in the forthcoming tasks.

Task 2 - Establish the software required for design and analysis
As a preparation for future steps, with an overview of the design criteria and components in the Task 1, the required software to perform the detailed design and analysis of the Project will be acquired and set-up. The following software packages are anticipated to be used:

**AutoCAD Civil 3D/InRoads**
Autodesk’s AutoCAD Civil 3D and Bentley’s InRoads are both drafting softwares that provide a means of design, analysis, survey, and mapping. Depending upon the availability, one of the aforementioned softwares will be used. These softwares will assist in providing integrated visual means of the detailed design, including cross sections as well as horizontal and vertical alignments. Additionally, they will provide quantity take-offs which can be used for cost estimates.
### Allen Road Corridor Revitalization – Project Methodology

#### Pre-Design
- **Full review of design manuals**
- **Establish the software required for design and analysis**
- **Obtain geographic, geotechnical and traffic analysis data**
- **Select One of the Three Corridor Design Alternatives**
- **Select the Interchange/Intersection for Lawrence Ave. W.**
- **Select the Integrated Land-Use Layout**

#### Design
- **Tunnel Intersection/Interchange @ Lawrence Ave. W**
  - Produce detailed cross-section of the Tunnel/Roadway
  - Produce Horizontal Alignment of the Tunnel/Roadway
  - Produce Vertical Alignment of the Tunnel/Roadway
  - Integrate safety features
  - Produce detailed cross-sections of the intersection/Interchange
  - Produce Horizontal Alignment of the Intersection/Interchange
  - Produce Vertical Alignment or Signal Design
  - Integrate safety features

- **Integrated Land-Use**
  - Produce detailed design of integrated land use
  - Produce a 3D visual representation of integrated land use

#### Review and Consultation
- **Review design with the City of Toronto**
- **Approval from the City**
- **Commence full Environmental Assessment and Public Consultation**

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Figure 52. Allen Road Project Methodology
ArcGIS

Esri’s ArcGIS is a geographic information system (GIS) platform that creates maps, compiles geographic data, and analyzes mapping information. ArcGIS will assist in the next task (Task 3) in providing geographic data such as elevations of the corridor study area which will be imported into the drafting software for detailed design.
Excel

Excel is a spreadsheet tool by Microsoft that allows for performing extensive calculations, producing graphs and charts as well as tables. This software will be utilized in performing calculations that involve the use of extensive data in order to accomplish tasks in an organized and efficient manner.

![Figure 55. Microsoft Excel software interface](image)

**Task 3 - Obtain geographic, geotechnical and traffic analysis data**

To start the design on the required software, data will be obtained and imported such as the geographic data for horizontal and vertical alignment of the corridor. This geographic data will primarily come from the base maps in ArcGIS which will be exported into drafting software compatible data. Moreover, to produce a feasible vertical alignment as per the standards, geotechnical data will be required to get information of the study area such as geology and soil characteristics. Additionally, to perform traffic analysis within the corridor for each of the alternatives, traffic data will be obtained. At this stage, the primary source of data is anticipated to be Cordon Count, which provides a variety of data at major intersections and access points such as total number of vehicles as various times, modal splits, and transit users. This data will be utilized in next step (Task 4) to perform EMME analysis of alternatives. Should any data deems incapable of obtaining from external sources, a site visit will be conducted to obtain the required information.
Task 4 - EMME analysis of alternatives → Cancelled
Due to time constrains and lack of software availability, EMME analysis cannot be performed. Instead, qualitative evaluation criteria was established to assist with the evaluation in Task 5.

Task 5 - Select One of the Three Corridor Design Alternatives
Using the traffic analysis data and the goals and objectives of the project defined in the proposal, detailed qualitative evaluation of alternatives (as seen in Figure 7) will be performed. Upon the review of each alternative, one specific alternative will be chosen to move on with the design phase of the Project.

Task 6 - Select the Interchange/Intersection for Lawrence Ave. W
The review of manuals in Task 1 and the context of the report will provide information for possible options of geometric layout of the interchange/intersection at Lawrence Ave. W., depending on the corridor alignment chosen in Task 5. Primary source of information for this task will be the Ontario Geometric Design Standards Manual. A detailed evaluation of the options will be performed to select the optimum layout that satisfies the project goals and objectives while integrating with the current characteristics of the study area.

Task 7 - Select the Integrated Land-Use Layout
As a follow-up to Task 1, the review of plans and policy documents from the City of Toronto will help envision the integrated land-use layout. Different layouts of land-use will be generated and evaluated to select the optimum layout that is in line with Project goals and objectives.

12.2. Design Phase

12.2.1. Tunnel/Roadway

Task 1 - Produce detailed cross-section of the Tunnel/Roadway
Using the preferred alternative chosen in Pre-Design phase Task 5, a detailed cross section design will be produced on drafting softwares as per applicable design standards as well as R.O.W. and other constraints within the study area.
Task 2 - Produce Horizontal Alignment of the Tunnel/Roadway
The cross-section produced in Task 1 will be prorated into the length of the study area to produce a horizontal alignment. Adjustments to the cross-section will be made for cases where the horizontal alignment produces several constraints such as utilities.

Task 3 - Produce Vertical Alignment of the Tunnel/Roadway
Utilizing the cross-section, horizontal alignment, and geographic data from the preceding tasks to produce a vertical alignment of the R.O.W segment. Optimum alignment will be chosen which will account for any geotechnical or utility constraints as well as minimizing earthwork cost.

Task 4 - Integrate safety features
Applicable safety features as per the design manuals will be integrated into the R.O.W. segment.

12.2.2. Intersection/Interchange at Lawrence Ave. W
Task 5 - Produce detailed cross-sections of the Intersection/Interchange
The detailed cross-sectional design will be produced for the selected Lawrence Ave. W. intersection/interchange in Task 6 of Pre-Design phase. It is understood that cross-section varies significantly at various parts of the intersections and interchanges. As a result, cross-sections will be produced for different important parts of the interchange.

Task 6 - Produce Horizontal Alignment of the Intersection/Interchange
The cross-sections produced in Task 5 will be integrated into the available area in existing the Lawrence Ave. W. interchange to produce the horizontal alignment. Details of this alignment include curb lengths and radii at different parts of the interchange and intersections.

Task 7 - Produce Vertical Alignment or Signal Design at Lawrence Ave. W.
Depending on the option selected in Task 6 of Pre-Design phase, the applicability of this task will be determined. Based on the existing layout, there will be no grade changes at the intersection which eliminates the need for vertical alignment. However, if an interchange is chosen as preferred option, vertical alignment will be produced as there will be various grade changes such
as the on and off ramps. Whereas, if an intersection is selected, detailed design of the signals will be produced which includes cycle lengths and timings of different signal phases.

**Task 8 - Integrate safety features**

Applicable safety features as per the design manuals will be integrated into the intersection/interchange.

**12.2.3. Land Use**

**Task 9 - Produce detailed design of integrated land use**

The preceding tasks will provide a clear visual idea of the land that is available to be utilized to maximize the livelihood and produce positive social impacts. The policies and plans from City of Toronto discussed in Section 9.0 will be used to produce a detailed design of the multi-use land layout chosen in Task 7 of Pre-Design phase. This detailed design includes detailed characterization of various parts of the available land such as commercial and recreational areas.

**Task 10 - Produce a 3D visual representation of integrated land use**

The detail design in Task 8 will be used to produce a realistic representation of the land-use area. This will be a key in public consultation process to help the public envision the ultimate goal of the Project.

**12.2.4. Amalgamation**

**Task 11 - Amalgamate design components into one**

The detailed design components of the R.O.W., Lawrence Ave. W intersection/interchange, and the integrated land-use will be amalgamated into a singular format that produces a uniform representation of these design components. 3D visual representations of this final integrated design will also be produced to show the overall scope of the Project.

**12.3. Review and Consultation**

**Task 1 - Review the design with the City of Toronto**

PSL will present the design to the City of Toronto and review with them to ensure that their political interests, end goals, and the intent of the Project are in-line with the design produced.
Modifications to the designs will be made as per the request of the City to ensure that the Project satisfies their needs.

**Task 2 - Commence full Environmental Assessment and Public Consultation**

Once the approval from the City is received, the detailed Environmental Assessment (EA) will be performed to evaluate the impacts of the detailed design on the biophysical, socio-economic, and human environment. PSL respects the public’s view on the Project as they are the ultimate end users. Hence, various public consultation meetings will be held during the EA process to inform the public about the project and any mitigation efforts that are to be incorporated. These consultation meetings will also provide public an opportunity to provide input and address their concerns on the design. As a result, the design will possibly go through various changes that accounts for the public's concerns and integrates mitigation efforts in it.

### 13.0. REVIEW OF DESIGN MANUALS & GUIDELINES

**13.1. City of Toronto Official Plan [10]**

#### 13.1.1. Manual Description

The City of Toronto Official Plan ("the Plan") is a consolidation of policies that ensures the growth of Toronto in the transportation, land use, and environment sectors. The Official Plan is made up of seven chapters that focuses on topics pertaining to the aforementioned sectors.

#### 13.1.2. Design Criteria

##### 13.1.2.1. Chapter Two: Shaping the City

Chapter Two of the City of Toronto official Plan describes the principles and strategies that stimulates growth and shapes the future of the City of Toronto. The chapter outlines several municipal policies that are to be adhered to in any future decision-making for any project.

**Applicable Criteria**

*Building a More Liveable Urban Region (§ 2.1) [10]*

In order to develop a framework for stimulating growth across the GTA, Toronto intends to work with neighbouring municipalities, the Province of Ontario, and Metrolinx. This is to ensure
proper coordination of inter-regional services including transportation. As Allen Road is directly connected to the 401 Provincial Highway, it is likely that much of the traffic and transit volumes induced on Allen Road are from residents of outer regions. As a result, decision-making related to the Project must be consulted with adjacent municipalities to develop mutual interest.

**Structuring Growth in the City: Integrating Land Use and Transportation (§ 2.2) [10]**

The integration of transportation and land use is of key importance to achieving the desired accessibility throughout the City. As described in the Official Plan, accessibility has two components: mobility (transportation), and proximity (land use). Increasing mobility can be achieved by accommodating infrastructure that promotes various modal choices, or enhancing travel times. Increasing proximity can be achieved by proper land use techniques to provide convenient employment and social opportunities, as well as high density development to facilitate a greater community. Further, the transportation and land use policies in this section states that the transportation network is to be maintained and developed such that it promotes the growth management objectives of the Plan. This includes the following, but are not limited to:

- Ensuring that new streets will provide public open spaces that are accessible by vehicles, pedestrians, and cyclists
- Maintaining and enhancing inter-regional transportation connections to other municipalities
- Increasing or maintaining transit priority throughout the City

As such, the Project corridor design must comply with the Plan in order to protect the integrity of the City’s transportation system, and can be used as qualitative measures to determine the success of the Project.

This section also contains policies pertaining to the use of Centres, Avenues, and Employment Districts as land use elements to promote the Plan’s growth management strategy. A Centre is defined as a place with excellent accessibility and is central to where jobs and housing are concentrated. These Centres illuminate the area and draws people from across the City to these hubs for numerous activities. An Avenue is defined as a corridor along major streets at which reurbanization is anticipated to provide new housing and job opportunities. Lastly, Employment Districts are areas where employment opportunities are heavily concentrated in order to promote
With the numerous land use opportunities that the Project implies along the on-grade corridor, Centres, Avenues, and Employment Districts will be strategically implemented throughout the corridor to ensure compliance with the Plan policies.

*Bringing the City Together: A Progressive Agenda of Transportation Change (§ 2.4) [10]*

This section describes the policies related to the development of transportation infrastructure, which is of particular interest given the Project intent for the Allen Road expressway. The policies which are to be complied include the following:

- Integrating pedestrian and cycling infrastructure in the design of all streets, transit facilities, and mobility hubs throughout the City
- Implement measures to reduce automobile use and traffic congestion, specifically in areas of anticipated population growth
- Policies, programs and infrastructure will be used to create a safe environment for pedestrians and cyclists of all demographics
- An urban environment and infrastructure will be developed to encourage safe mobility throughout the City

### 13.1.2.2. Chapter Four: Land Use Designations

This chapter describes the types of land use applications that support the City of Toronto’s growth management strategies. As the Project will greatly use land use techniques in providing prominent parks and open space areas along the Allen Road corridor at grade-level, the policies of this chapter will be considered in order to integrate Allen Road to the general public realm.

**Applicable Criteria**

*Parks and Open Space Areas (§ 4.3) [10]*

As shown on *Map 17 Land Use Plan* in Appendix A, the entire Allen Road expressway is listed as a “Park and Open Space Area”. As such, the criteria listed in this chapter is taken into great consideration in any development in this area. Design of the Project will be assured for proper coherence to the following policies to respect the nature and intent of the Plan.

- Any development provided in this area will:
  - Protect, enhance, or restore trees, vegetation and other natural heritage features
○ Preserve or improve public visibility and access
○ Maintain and create linkages between parks and open spaces
○ Maintain or expand the size and usability of publicly owned parks
○ Provide comfortable and safe pedestrian conditions

13.2. Lawrence-Allen Urban Design Guidelines [18]

13.2.1. Manual Description
The City of Toronto’s Lawrence-Allen Urban Design Guidelines are tools which establishes a framework at which the City’s Lawrence-Allen Revitalization plan in the focus area must comply with to ensure consistency with the City of Toronto’s Official Plan. These guidelines are within the Secondary Plan areas that are listed in Chapter 6 of the City of Toronto Official Plan. Specifically, the guidelines outlines the city’s vision for the focus area in terms of parks, built forms, as well as residential and commercial developments. These guidelines will be used to coordinate the project alternatives with the planning vision that the City has as part of the City’s Lawrence-Allen Revitalization Plan. Although the guideline focuses only on the revitalization of a specific study area within the northern section of Allen Road (Highway 401 to Lawrence Ave), PSL will utilize these guidelines for further implementation in PSL’s study area in both the northern and southern sections to coordinate with the City’s general plan for the area.

13.2.2. Design Criteria
13.2.2.1. Chapter Two: Built Form – General
Chapter Two discusses the applicable criterion with regards to the consideration of built forms in the Lawrence-Allen area to coordinate with the City of Toronto’s Official Plan. All elements of built form are considered from this chapter, except for those that involve vehicle accessibility, including roads and parking which are not to be considered in any design alternative.

Applicable Criteria

Relationship of Buildings to Streets, Parks and Open Space (§ 2.1) [18]
- Blank walls, loading doors, and other servicing areas along street frontages, parks, and public realms are to be restricted to promote a safe and attractive interface
- Buildings that generate public activities are to be located such that windows are visible to
streets, parks and other public spaces

- Accommodate high quality landscaping along development blocks
- Separate residential yards with low fences and landscaped edges to balance privacy and aesthetic appeal

Transition (§ 2.2) [18]

- New building developments on the boundaries of the focus area is limited to 11 metres to ensure appropriate transition between new developments and surrounding residential areas
- Mid-rise blocks are to be located with frontage on primary streets or Allen Road. On Allen Road, buildings are to be taller than buildings on primary streets
- Tall buildings are to be located south of Flemington Road, and east of Allen Road
- Tall buildings surround the Lawrence West subway station
- Highest development densities are to be located closest to the Lawrence West subway station
- All building types will be restricted to heights that may affect the airport flight paths from the Downsview Airport runway
- Building blocks with a frontage in excess of 60 metres along any public street needs to be designed to reduce the visual length of a continuous wall
- Figure 33 is a figure extracted from the Lawrence-Allen Urban Design Guidelines showing the height limitations within the area to eliminate flight path obstructions
Landscaped Setbacks (§ 2.3 [18])
At least 60% of any building’s facade will be built to the following landscaped setbacks:
- At least 2 to 3 metres from streets, parks and pedestrian connections
- At least 3 metres from the Greenway park block located on the east side of Allen Road
- At least 9 metres from the west side of Allen Road

Pedestrian and Bicycle Circulation: Walkways and Trails (§ 2.5) [18]
Pedestrian walkways and cycling trails will be implemented along the corridor to:
- Create routes to enhance pedestrian and cycling connectivity and safety
- Combine paths with different functions to increase modal utilization
- Provide adequate lighting for use at night
- Limit planting along trail edges to low vegetation to promote visibility and safety
- Walkways and trails are to be at least 6 metres wide
- Walkways and trails are to provide connection to fronting building facades
**Building Entrances (§ 2.6) [18]**

- Main building entrances are to be located and visually connected to the public street
- All buildings are to be oriented to have direct access from the street and provide opportunities for overlook and social interaction to the public street
- Figure 34 shows a concept of the Queens Quay Revitalization project in Toronto, Ontario, which facilitates a multi-modal corridor with efficient access to buildings

![Figure 34. Concept of the Queens Quay Revitalization project in Toronto, Ontario.](image)

**General Landscaping and Lighting (§ 2.9) [18]**

- All planting areas located “on-slab” are to provide a minimum depth of 1.2 metres of topsoil to support vigorous plant growth
- Planted landscape areas are to be irrigated. Alternatively, water services need to be identified on landscaping plans for manual watering programs
- Lighting fixtures are to consistently illuminate all pedestrian routes and spaces. Fixtures with minimal vandalism potential and maintenance are to be used
- Figure 35 portrays the infamous Literary Walk in New York’s Central Park, which contains stunning landscaping and lighting in its open space to provide numerous social opportunities including leisure walks and street performances

![Figure 57. Concept of Queens Quay Revitalization project.](image)
Public Art (§ 2.10) [18]

- Public art is to be strategically implemented throughout the corridor and is to be complied with the City of Toronto Percent for Public Art Program Guidelines
- Public art is to be implemented to enhance character and reflect diversity of the study area, while avoiding obstruction of important views
- Figure 36 portrays the brilliant use of public art (Cloud Gate) to attract people to Millenium Park in Chicago, Illinois

Environment and Sustainability (§ 2.11) [18]

- All noise attenuation measures, including walls and berms, must complement the Allen Road streetscape, otherwise prohibited
Chapter Three: Building Location, Organization and Massing

Chapter Three discusses the applicable criterion with regards to the development of buildings on and around Allen Road. Consideration is only given to mid-rise developments, as larger developments are beyond the scope of the Project.

**Mid-Rise Building Blocks: Primary Streets (§ 3.2) [18]**
- The height of mid-rise developments may not exceed the width of the fronting street
- Distances between buildings within the same block will be a minimum of 11 metres
- A minimum of 5.5 metres is to be setback between buildings

**Mid-Rise Building Blocks: Allen Road (§ 3.3) [18]**
- Developments must provide a building envelope that allows for a minimum of 5 hours of sunlight onto the local, primary, and major street sidewalks from March 21 to September 21 (see Appendix L2 for a schematic on how to apply the guidelines)
- Developments must provide noise attenuation through buildings and landscaping where necessary
- Developments must provide a publicly accessible multi-use trail coordinated with the existing outdoor open spaces
13.3. MTO Highway Drainage Design Standards [22]

13.3.1. Manual Description
The Ministry of Transportation’s Drainage Design Standards provide hydrologic and hydraulic standards that are to be used in the design of highway drainage infrastructure such as highway surface drainage and stormwater management. This manual will not be used standalone, rather it will be used in conjunction with the Ontario Geometric Design Manual.

13.3.2. Design Criteria

SD-1 Design Flows for Surface Drainable Systems [22]
This substandard provides hydrologic bases of minimum design flows that the major and minor drainage system for the roadway should be sized for. Minor drainage system is considered for Project as the primary intent is to carry runoff generated from frequent storms from the roadway into the existing storm sewer utilities.

Applicable Standards
- § 1.1. Design Flows: the design flow of the freeway minor drainage system and should be 10-year as shown in Appendix B – design flow of minor & major systems.
- § 1.2.3. The drainage capacity of existing highway subject to modification shall not increase risk of flood to adjacent entities. Additionally, the overland flow route design shall comply with Roadside Ditches (Standard SD-9).

SD-2 Longitudinal Grade and Cross-fall [22]
This standard provides details on the elevation and cross-section of the roadway by providing minimum longitudinal grade and cross-fall. It considers various types of cross sections, pavement types, and number of lanes to provide with option that is most applicable to the Project.

Applicable Standards
- § 3.1. Drainage Standards for Longitudinal Grade (please see Appendix C – Minimum Standards for Sustainable Longitudinal Grade): the desirable standard for longitudinal grade of roadway is >=0.5%. Whereas, the minimum standard is 0.3% for Curbed roads and 0.0% for Uncurbed Roads.
§ 3.2. Drainage Standards for Pavement Cross-fall: As shown in Appendix D – Minimum Design Cross-fall, the minimum cross-fall (m/m) for three lanes of less roadway draining in one direction shall be 0.02 for Bituminous traffic lanes and 0.04 for paved shoulders.

**SD-3 Flow Spread on to Travel Lines** [22]
This standard provides the maximum allowable spread distance onto the travel lanes of arterial roads and highways. This distance is the spread distance of the ponded water at the shoulders of the roadway.

Applicable Standards
- § 3.1. Allowable Spread for Minor System Design Flow (from Curbs and Barriers) for Freeways, Arterials and Collections: the desirable maximum lateral spread distance shall be zero to keep the roadway clear of flooding. The maximum spread distance however shall be 2.5 meters of the lane width adjacent to a concrete barrier or curb, with maximum depth of flooding not exceeding 25mm as shown in Figure 37.

![Spread at Medians and Curbs](image)

**Figure 60. Spreads at Medians and Curbs** [22]

**SD-5 Storm Sewer Inlets on a Continuous Grade** [22]
This standard provides the maximum spacing between the adjacent storm sewer inlets along a curb or median of a roadway with continuous
Applicable Standards

- § 3.1. Maximum Inlet Spacing: The maximum spacing between the inlets shall be 150 meters, while ensuring that satisfied the flow spread criteria in SD-3.

**SD-6 Storm Sewer Inlets at Highway Sags [22]**
This standard provides the placement guidelines for storm sewer inlets at highway sags.

Applicable Standards

- § 3.1.2. At minimum, twin inlets shall be placed at the bottom of the sag.
- § 3.1.3. At locations where twin inlets are not sufficient to prevent flooding, additional inlets shall be provided at the points that are 0.06m higher than the bottom of the sag.

**SD-9 Roadside Ditches (Conveyance Only) [22]**
This standard provides the design requirements of the roadside ditches such that they convey the flow only. The water quality improvement within the roadside ditch is not a part of this standard.

Applicable Standards

- § 3.2. Physical Parameters: Appendix E – Roadside Ditch Design Parameters shows the physical parameters of the roadside ditch as per the standard.

**SD-10 Roadside Ditch Inlets [22]**
This standard provides design requirements for the spacing and positioning of the inlets at the roadside ditches

Applicable Standards

- § 3.1. Roadside Ditch Inlet Placement Across a Roadside Ditch: In cases of roadside ditch inlet placed across a roadside ditch which may be in contact with vehicles that have left the roadway, the grating slope shall be 6H:1V or flatter.
- § 3.2. Roadside Ditch Inlet Placement on a Slope: The grating slope must match the graded slope where the roadside ditch inlets are placed on the front or back slope of roadside ditch.
- § 3.3. Spacing of Ditch Inlets: The maximum spacing between roadside ditch inlets shall be same as the maintenance hole spacing for a stormwater sewer design.

13.4.1. Manual Description
The TMDCRT is published by the U.S. Department of Transportation - Federal Highway Administration. The manual's intent is to provide guidelines for planning, design and construction of roadway tunnels. The scope of the manual is primarily focused of the civil elements of design of various types of tunnels, which is PSL’s focus of area at this stage of the Project.

13.4.2. Design Criteria

Chapter 1 – Planning [23]
This chapter provides guidelines and suggestions that are involved in the planning stages of a tunnel project. These guidelines include geometric design, alternative analysis such as considerations of financial studies, geotechnical conditions, and sustainability.

Applicable Standards
- § 1.1.1. Tunnel Shape and Internal Elements: There are three main shapes of highway tunnels: circular (Figure 38), rectangular (Figure 39), and horseshoe or curvilinear (see Figure 40). Circular tunnel is constructed using tunnel boring machine or drill and blast rock; rectangular tunnel is constructed using cut and cover method, immersed method, or jacked box method; horseshoe tunnel is constructed using sequential excavation method or drill and blast rock. The applicability of these excavation methods is shown in Figure 41.
Figure 61. Circular Tunnel design type [23]

Figure 62. Rectangular Tunnel design type [23]
§ 1.1.2. Classes of Roads and Vehicle Sizes: The geometric configuration should accommodate all types of vehicles. However, the height of the tunnel should not exceed the height under bridges and overpasses of the road that leads to the tunnel.

§ 1.1.3. Traffic Capacity: The road tunnels should have at least the same traffic capacity as that of the surface roads

§ 1.3.6.1. Emergency Egress: The spacing of emergency egress to provide refuge to the users of the tunnels should not exceed 300 meters.

Chapter 2 - Geometric Configurations [23]

This guideline provides requirements for general geometric configuration of road tunnels. These configurations include vertical and horizontal alignments, and cross-section elements.
Applicable Standards

- § 2.2.1. Maximum Grades: The maximum effective grades in main roadway tunnels should not exceed 4%; though up to 6% is acceptable given that it provides climbing lanes for heavy vehicles.

- § 2.2.2. Horizontal and Vertical Curves: The horizontal and vertical curves should abide to local standards. However, the horizontal curve radii should be as large as possible and no less than 850-1000 ft. The superelevation should lie between 1%-6%.

- § 2.3. Travel Clearance: The minimum and desirable vertical and horizontal clearances are shown in Figure 42 and Figure 43, respectively.

![Figure 65. Minimum clearances [23]](image1)

![Figure 66. Desirable clearances [23]](image2)

- § 2.4.1. Typical Cross Section Elements: The typical cross section elements in a roadway tunnel are shown in Figure 44.
• § 2.4.2. **Travel Lane and Shoulder:** Each lane width within a tunnel should be no less than 3.6 m. It is suggested for unidirectional road tunnels that the right shoulder be at 1-2m and left shoulder at least 0.6m. A 1 m tall barrier should be provided to prevent vehicles from hitting the tunnel walls (the shoulder can be reduced between 0.6-1.2m to accommodate the barrier). See Figure 45 for typical tunnel roadway with reduced shoulder widths.

![Figure 45](image)

• § 2.4.3. **Sidewalks/Emergency Egress Walkway:** Raised sidewalks with 0.7 m width or wider should be provided for access to emergency egress.

![Figure 46](image)
• § 2.4.4. **Tunnel Drainage Requirements:** The road tunnel drainage should be designed as per local standards with capacity of surface water and water leakage. Additionally, due to fire safety, PVC, fiberglass pipe, or other combustible materials should not be used.

• § 2.4.5. **Ventilation Requirements:** A ventilation system for air quality and safety reasons must be selected from two types: longitudinal or transverse ventilation. Longitudinal system introduces air into and removes it from the tunnel with the longitudinal flow of traffic as shown in Figure 46. Whereas, transverse system supplies air from ducts located above, below or to the side of the tunnel. Also, exhaust ducts located above or to the side of the tunnel to remove air and contaminants.

![Example of longitudinal ventilation in roadway tunnel](image1)

• § 2.4.6. **Lighting Requirements:** The lighting fixtures are located in the ceiling or mounted on the walls near the ceiling. The lighting should be sufficient to provide maximum visibility during night time as well as day time.
Chapter 5 - Cut and Cover Tunnels [23]

This chapter provides guidelines for construction methodology and support systems for tunnels constructed using cut-and-cover technique. Detailed guidelines include structural considerations, maintenance of traffic, utilities and control of groundwater system. Cut-and-cover tunnel involves construction of structure inside an excavation and covered with backfill material. The Project is considered to be a hybrid of the cut-and-cover technique as the Allen Road is already grade separated and the tunnel structure will occupy the space to match the grade of the surrounding neighbourhoods through tunnel deck and earth fill on the edges.

Applicable Standards

- § 5.2.2. Conventional Bottom-Up Construction: In the bottom-up construction, a trench is excavated from the surface within which the tunnel is constructed and backfilled back up to the surface. The trench can be formed using side slopes or vertical faces. The steps involved in this method are (refer to Figure 47):

  - Step 1a: Installation of temporary excavation support walls, such as soldier pile and lagging, sheet piling, slurry walls, tangent or secant pile walls
  - Step 1b: Dewatering within the trench if required
  - Step 1c: Excavation and installation of temporary wall support elements such as struts or tie backs
  - Step 2: Construction of the tunnel structure by constructing the floor; Step 3: Complete construction of the walls and then the roof, apply waterproofing as required;
  - Step 4: Backfilling to final grade and restoring the ground surface.

![Figure 70](image-url)
§ 5.3. **Support of Excavation System**: Consideration must be given to the three different types of excavation support systems: Open cut slope, Temporary, and Permanent

- Open Cut Slope: Used in areas where sufficient room is available to open cut the tunnel excavation area by sloping down from existing ground
- Temporary: Designed to support vertical faces of excavation where open cut slope is not applicable. Examples include soldier piles, sheet piles.
- Permanent: Designed to support vertical faces of excavation where open cut slope is not applicable, which also become part of permanent tunnel structure. Example includes slurry walls, secant pile walls.

§ 5.3.4. **Ground Movement and Impact on Adjoining Structures**: Cut-and-cover tunnels are more disruptive and prone to ground movement than other tunnelling methods. Special consideration must be given to deflection of support of excavation walls and consolidation due to dewatering.

§ 5.4.3.1. **Cast-in-Place Concrete**: Commonly used due to ease with construction of large members in restricted work spaces. This also allows for complex geometry by assembling formwork corresponding to shapes.

§ 5.4.3.3. **Prestressed Concrete**: Generally used for large roof spans when clearances are tight and overall depth of section must be limited. The segments must be delivered in a single piece and be erected within the space available inside the excavation.

§ 5.5. **Loads**: The load combination shown in Appendix F – *cut and cover tunnel loading diagram*, must be considered in the structural design of the cut-and-cover tunnel constructed using the bottom up technique.

§ 5.7.1. **Construction Dewatering**: In areas of high groundwater table, especial consideration must be given to design of dewatering system. Precautions must be taken on lowering the water table outside excavation as it can cause settlement of adjacent structures, impact on vegetation, and drying of existing wells.
Despite being underground, tunnels are also impacted by earthquakes as they are surrounded by ground which can amplify the vibratory effects. Even though tunnels perform better than above ground structures during earthquakes, special consideration must still be given to mitigate the damage. Hence, this chapter provides guidelines and considerations that must be followed for seismic design of the tunnel.

**Applicable Standards**

- **§ 13.3. Factors that influence tunnel seismic performance:** The main consideration factors that impact the seismic performance of a tunnel are: seismic hazard, geologic conditions, and tunnel design, construction and condition.
  - **§ 13.3.1. Seismic Hazard:** The seismic hazard for tunnels can be grouped into two categories: ground shaking and ground failure
    - Ground Shaking: Refers to the vibration of the ground produced by the seismic wave’s propagation through the earth’s crust. This can cause severe deformations in a tunnel structure
    - Ground Failure: Broad types of ground instabilities such as fault rupture, tectonic uplift and subsidence, landslides, and soil liquefaction. These failures are of concern as they can cause shear displacements of the tunnel structure.
  - **§ 13.3.2. Geologic Conditions:** The primary focus is on unfavorable geologic conditions that cause unsatisfactory seismic performance of the tunnel. Some of the important geologic considerations include soft soils, and rocks with weak planes.
  - **§ 13.3.3. Tunnel Design, Construction and Condition:** Consideration of seismic loads in tunnel design, nature of support systems, history and current performance of tunnel lining and support walls altogether influence the seismic behaviour of a tunnel.
13.5. Geometric Design Standards for Ontario Highways [15]

13.5.1. Manual Description

The Geometric Standards for Ontario Highways is published by the Ministry of Transportation. It sets the design standards that the roads in Ontario are to abide by to ensure coherence throughout the highway network system while maximizing the safety of the users.

13.5.2. Design Criteria

Chapter A – Highway Classification [15]

This chapter provides context in the classification of a highway, which will assist in determining some factors to support the design of the preferred alternative.

Applicable Standards

- § A.5.9.5. Urban Freeways: This standard is applicable for Alternatives 2 and 3, where the southern sections are to be designed as a tunnel. In specific, these include:
  - Service Function: no parking, unloading, or pedestrian traffic is permitted. Service to adjacent lands are completely eliminated.
  - Design Speed: ranges between 80-120 km/h.
  - Running Speed: ranges between 60-110 km/h.
  - Vehicle Types: all vehicle types are to be considered, including 20% of the total traffic volume allocated to transport trucks. Only express bus service with no stop is permitted.

- § A.5.9.6. Urban Arterials: This standard is applicable for Alternatives 1 and 3, in the respective sections where an arterial is proposed, as displayed in Figure 1.
  - Service Function: arterials should limit the amount of direct private access to adjacent development. This access should be confined to only local and collector road connections.
  - Design Speed: ranges between 80-110 km/h.
  - Running Speed: ranges between 50-90 km/h.
  - Vehicle Types: all vehicle types are to be considered, including 20% of the total traffic volume allocated to trucks of all sizes. Both express and local buses are permitted.
Chapter C – Alignment [15]

This chapter provides design parameters of the vertical alignment (configuration as seen in longitudinal section) and horizontal alignment (configuration as seen in plan view) of the roadway. Particularly, the design components for both alignments include tangents, grades, and curves that together define the orientation of the roadway.

Applicable Standards

- § C.2.1. Sight Distance Policy: Sufficient sight distance must be provided so that drivers can control the speed of their vehicles to avoid striking an unexpected obstacle in the travelled way
- § C.2.3.4. Stopping Sight Distance - Design Values: The minimum stopping sight distance parameters for wet conditions and dry conditions are provided in Appendix G.1 and Appendix G.2, respectively
- § C.3. Horizontal Alignment - Policy: The Maximum superelevation rate for urban freeway interchange ramps is 0.08m/m, where a high level of maintenance prevails, and little ice or snow accumulation is anticipated. Whereas, the maximum superelevation rate for all other roadways is 0.06m/m.
  - C.3.2.5. Minimum Radii: The minimum radius as per the design speed, superelevation, and coefficient of side friction are shown in Appendix G.3
  - C.3.3.3. Spiral Curve Designation: The spiral parameter should be selected from the standard spiral parameters for design shown in Appendix G.4
- § C.3.3.5. Design Values: Appendix G.5 and Appendix G.6 provide the design standards for spiral curves with various combinations of design speeds and curve radii for superelevation rates of 0.06m/m and 0.08m/m, respectively
- § C.3.4.2. Minimum Curve Length: For deflection angles up to 0°30' horizontal curves are not necessary. Curves having deflection angles between 0°30’ to 1° should be at least 350m long. For curves having deflection angles between 1° to 5° will have a minimum length based on the expression \( L=400-50\Delta \) where \( L \) is length in meters and \( \Delta \) is deflection angle in degrees. Curves having central angle above 5° should be no less than 150m long. For purpose of determining curve length, where spiral curves are applied, 50% of spiral is regarded as part of the curve.
§ C3.4.3. Intersections: Right angle crossings are desirable with some acceptance of deviations. However, angles less than 70˚ and greater than 110˚ are not recommended.

§ C.4. Vertical Alignment
  o C.4.2.1. Maximum Grades Policy: The standard maximum grades for urban roads and freeways are shown in Appendix G.7 and Appendix G.8, respectively.

§ C.4.2.2. Minimum Grades Policy: The standard minimum gradients for curbed roads and ditches are shown in Appendix G.9

§ C.4.3.3. Vertical Curves - Designation: K constant is the length of a section of curve measured horizontally with 1% gradient change. K is positive for sag curves and negative for crest curves. The general expression for this parameter is \( K = \frac{L}{\Delta G} \), where \( L \) is horizontal length and \( \Delta G \) is change in gradient. Appendix G.10 has standard K values.

§ C.4.3.4. & C.4.3.5. Measurement of Stopping Sight Distance: Special consideration must be given for K values shown in Appendix G.11 as they are optimized for driver comfort on sag curves.

§ C.4.4.5. Minimum Curve Length - Policy: The minimum length of a vertical curve in metres should not be less than the design speed in kilometers per hour.

Chapter D – Cross Section Elements [15]
This chapter deals with cross section elements of a road. The cross section of a road is the view of a vertical plane perpendicular to the horizontal alignment. Please note that this section only addresses the visible elements, non-visible elements such as depths of asphalt or its granular base must be determined by structural and/or geotechnical engineering.

Applicable Standards

§ D.2.2 Through Lanes: Standard ministry lane widths are to be in multiples of 0.25 m and generally range from 3.0 m to 3.75 m. Lane widths are to be designed with accordance to Appendix G.12.

§ D.2.3. Auxiliary Lanes: These are lanes in addition to regular lanes intended for through travel. Appendix G.13 lists the criterion to be considered in the design of auxiliary lanes.

§ D.2.4 Ramps and Transfer Lanes: Pavement width for single-lane ramps & transfer lanes should be 4.75m, while the width for two-or-more lanes should be 3.75m (per lane).
• § D.3 Pavement Widening on Curves: the basis for lane-widening for curves is provided in Appendix G.14. Additionally, § D.3.2 includes the design values in tabular format for single-unit, and semi-trailer combination trucks.

• § D.4 Pavement Cross-Fall and Superelevation
  - For cross-falls: on a 4-lane divided highway with a median, the crown is placed at the centre of each roadway with a cross-fall of 2% to each edge.
  - For superelevations: a maximum superelevation rate of 8% is set for urban freeway interchange ramps, and 6% for all other conditions.

• § D.5.3 Minimum Shoulders Widths: shoulders are areas adjacent to roads for emergency travel. The normal should is approximately 3.0m, but the absolute minimum shoulder width acceptable for paved surfaces is 0.5m, and for unpaved gravel surfaces is 1.0m.

Chapter E – At-Grade Intersections [15]
This chapter deals with the geometric design of at-grade intersections, which is defined as the area where two or more roadways join or cross. The focus of this chapter is the intersection of highways with side roads, but it still touches upon signalized intersections which will be highlighted in this section.

Applicable Standards
• § E.2.3 Basic Intersection Forms: these can be seen in Appendix G.16.
• § E.2.5 Angle of Intersection: intersection angles should be greater than 70°, while also less than 110° (this refers to the angle between two intersection roadways, which is 90° normally).
• § E.3.2.4 Signal Control Minimum Sight Distance: intersections must provide sufficient sight distances for drivers to perceive conflicts and carry out necessary actions. The sight distance is the distance between two vehicles, and it should be clear of obstructions. For signalized intersections, a time of 3 seconds is used to provide vehicles on both roads to adjust their speeds and avoid a collision in case one vehicle disobeys the traffic light. The minimum distance travelled in 3 seconds is shown in Appendix G.17.
• § E.3.4.2 Pavement Cross-Sections at Intersections: at signalized intersections, a mutual adjustment in road profiles and cross-sections may be required. A cross-fall of 0.5% is desirable for both roads at the intersections, please see Appendix G.18.
An interchange provides a connection for traffic between intersecting roadways. An interchange is highly recommended when a highway contains high volumes of traffic.

**Applicable Standards**

- § F.3.3 *Interchanges between Freeways and Other Roads*: there are various pre-designed interchange types. The basic-diamond design, which is one of the most used, will be ignored in this section since the current Allen-Lawrence interchange utilizes one, and it will be impractical for the Allen-Eglinton interchange. The three relevant interchanges are Parclo A-4 (Appendix G.19), Parclo B-4 (Appendix G.20), and Parclo A-B (Appendix G.21). Please note that Parclo A-B is highly relevant when one complete side of the arterial road has obstructions that cannot be removed. Other relevant interchanges are Parclo B-2 and Parclo A-2, which are further discussed in § F.3.3.

- § F.5.2.1 *Ramp Geometry*: Maximum rate of superelevation for interchange ramps on urban freeways is 0.08 M/M, while all on other roadways it is 0.06 M/M

- § F.5.2.2 *Design Speed*: the ramp design speed depends on the highway design speed, and the superelevation. Appendix G.22 is to be used in determining ramp design speeds.

- § F.5.3.6 *Sight Distance at Exit Terminals*: the bullnose is a curb or gutter that separates the highway from the exit terminal. The bullnose must be clearly seen in advance, such that the driver has sufficient time to make the necessary adjustments. The minimum sight distance to bullnose is based on design speeds and can be seen in Appendix G.23

- § F.5.3.7 *Design Lengths for Exit Terminal Speed Change Lanes*: these are the lanes that are necessary for a driver to reduce their speeds on a freeway in order to enter a ramp. The length of these for a single lane ramp can be seen in Appendix G.24

- § F.5.4.6 *Design Lengths for Entrance Terminal Speed Change Lanes*: this is similar to the last sections. Drivers need time to accelerate until desired speed is reached and thus the need of entrance terminal speed change lanes is required. The design of such lanes can be seen in Appendix G.25

13.6.1. Manual Description

The main purpose MTO’s Ontario Traffic Manual is to provide guidance for transportation engineers such that the design and application of traffic control systems is consistent and uniform throughout. Traffic control devices include traffic lights, pavement markings, and signs that are used to convey critical messages to the road user.

13.6.2. Design Criteria


This book focuses on regulatory signs. Regulatory signs are the signs that instruct the users on what they must or should/should not do.

Applicable Criteria

Chapter 1 – Introduction [24]

- Regulatory signs are classified into:
  - Sub-class Ra: Right of Way Control Signs
  - Sub-class Rb: Road Use Control Signs
  - Sub-class Rc: Miscellaneous control signs
- With exception STOP, YIELD, and ONE-WAY; regulatory signs are rectangular in shape with longer dimension in vertical direction. They generally contain black, red and/or green text on a white background.
- All regulatory signs are required to be reflectorized (as to show the same sign in night as in day)
- Red or amber flashing beacons can be used to draw the user’s attention to the necessary sign

Chapter 5 – Speed Control Signs [24]

- Part of sub-class Rb: Road Use Control signs, its purpose is to indicate the maximum legal speed
- The regular MAXIMUM SPEED sign (Rb-1) can be supplemented with BEGINS tab sign (Rb-84t) and KM/H tab sign (RB-7t). Please see Figure 48.
Guidelines:
- Must be in units of km/hr, and in multiples of 10 km/hr (ex: 55 km/hr is NOT applicable)
- KM/H tab is only required near border and airports
- A MAXIMUM SPEED AHEAD (Rb-5) sign must be used to warn motorists of a reduction of speed of 20km/h or greater, and must be placed 100-250m upstream of reduced speed zone

Location:
- Signs with the BEGINS tab must be posted only at beginning of a new speed zone
- MAXIMUM SPEED signs should be posted downstream of major intersections

Other maximum speed variations, such as ones for school, are also discussed in this section

Chapter 6 – Turn Control Signs

- To indicate the prohibition of specific turns (sometimes during specific times of the day)
- Types include:
  - NO STRAIGHT THROUGH, NO RIGHT TURNS, NO LEFT TURNS, NO-U TURNS. All these can come with an additional tab specifying specific times
- Location:
  - Must be mounted facing the approaching traffic and have a minimum clearance of 4.5m above the roadway
Chapter 7 – One Way Control Signs [24]

- Motorists are only permitted to travel one way. Applicable for a variety of situations including for tunnels separated by a barrier, and entrances and exits to ramps
- The standard ONE-WAY Sign (Rb-21) should be used when speed limit is 60km/h or less, and the oversized ONE WAY Sign (Rb-121) should be used when speed limit is 70km/h or greater
- Location:
  ○ Must be placed at the near right corner or far left corner of an intersection, facing the approaching traffic

Chapter 9 – Lane Designation [24]

- Indicates what may or may not be done in specific lanes. Two types:
  ○ Turn Lane Designation signs: indicate turning movements. A few include:
    ■ LEFT TURN ONLY sign (Rb-41)
    ■ RIGHT TURN ONLY sign (Rb-42)
    ■ ALL MOVEMENTS ALLOWED sign (Rb-46)
  ○ Reserved Lane: indicate which classes of vehicle are permitted
- Guidelines:
  ○ Can be installed overhead (directly above the respective lane) or ground-mounted.
  ○ Overhead signs must be mounted such that the bottom of the sign is a minimum of 4.5-5.3m above roadway
- For an example of ground mounted turn designation signs please see Figure 49.
13.6.2.2. Book Six – Warning Signs [25]

This book focuses on warning signs, which are signs intended to provide advanced notice to users regarding unexpected and/or potentially dangerous conditions.

Chapter 1 - Introduction [25]

- They are classified as:
  - Sub-class Wa: Physical Conditions Warning Signs
    - Contains signs that indicate physical roadway conditions such that users are alerted. Include:
      - Roadway alignment changes (curves)
      - Intersections
  - Sub-class Wb: Traffic Regulations Ahead signs
    - Contains signs that indicate a regulatory sign downstream. Includes:
      - Keep right ahead
○ Sub-class Wc: Pedestrian and Intermittent Hazard Signs
  ■ Contains signs which alert users to intermittent conditions

Chapter 2 - Roadway Alignment Signs [25]

- Roadway alignment signs are signs warning of changes in road direction
- An example is the CURVE sign (Wa-3) which indicates the least extreme changes in road alignment. It can be accompanied by an ADVISORY SPEED tab sign (Wa-7t) which indicates a safe speed to travel during the curve. Please see Figure 50.

![CURVE Sign and ADVISORY SPEED Tab Sign](image)

- The advised speed is a function of curve radius, super elevation, and friction factor of the road and can be determined by:

\[ V = \left[ 11.7(e + f) \right]^\frac{1}{2}, \]

Where \( v \) is the advised speed (km/h), \( R \) is curve radius (m), \( e \) is super elevation rate (m/m) and \( f \) is coefficient of side friction

13.6.2.3. Book Eleven – Pavement, Hazard, and Delineation Markings [26]

This book focuses on pavement and delineation markings. Pavement and delineation markings provide information about lane positions including which lanes are available for certain use

Chapter 2 – General Principles [26]

- Markings must have high contrast, good illumination and retro reflectivity. They must be in either white, yellow, or orange.
Chapter 3 – Pavement Markings [26]

- Pavement markings must provide for guidance without diverting the user’s attention from the road
- Lines:
  - Yellow lines indicate separation of traffic flows in opposing directions
  - Broken White lines delineate traffic in same direction (different lanes)
  - Solid yellow lines indicate that changing lanes is unsafe
- Urban road - lane guidelines:
  - Lane lines must be white retro reflective lines, 10cm wide, composed of 3m line segments followed by a 6m gap
- Example of a multi-lane high speed urban lane is as follows:

![Figure 74. Example of a high speed urban lane](image)

- Detailed specifications of the following are also included:
  - Edge lines
  - Interchange ramp and channelization lines
  - Barrier lines


13.7.1. Manual Description

The Signal Timing Manual by the U.S. Department of Transportation has a wide breadth of information in regards to signalized intersection design. The manual includes the basics including data collection, capacity calculations, and uncoordinated signalized intersection design procedures. These procedures are the basics required for any intersection design. Furthermore, City of Toronto’s Traffic Signal Policies & Strategies must also be looked at to ensure PSL’s design meets the necessary policy requirements set by the City.
13.7.2. Design Criteria

13.7.2.1. Signalized Intersection Design

Chapter 3 – Concepts [27]

- Skewness of the two roads (different angles than 90) will impact the intersection width and design. If a road is very skewed, intersection widths will differ greatly impacting design
- Various formulas can be found, including:
  - Volume-to-Capacity ratio (formula 3-3) - this measures the degree of saturation
- The goal is to provide a volume-to-capacity ratio of 0.85-0.95. Here, higher delays (stochastic) may be present, but increasing delays (overland/deterministic) should not occur
- To evaluate delays, two types of performance measures can be found:
  - Intersection Level of Service (LoS) - factors include lane group volume and capacity, cycle length, and effective green times
  - Queue Length (formula 3-4/3-5) - this is the physical space vehicles will occupy while waiting before an intersection

Chapter 4 – Required Hardware and Preliminary Design [27]

- Physical components of a traffic signal include:
  - Detection - gathers information regarding the conditions at intersection
  - Local Controller - controls and operates the traffic signal - either directly (preprogrammed) or from input from traffic control centre
  - Master Controller - facilitates communication between the local controllers and traffic control centre
  - Traffic Control Centre - can perform a variety of tasks including coordination and advanced concepts
  - Communication - the hardware used for the communication of all these devices
- See Figure 52 for a visual representation of the above.
• Process for determination of left-turn phase are provided in figure 4-11. Factors include: left turn and opposing through volumes, number of opposing through lanes, cycle length, sight distance, and speed of opposing traffic.

• Detection systems are discussed. They are triggered into a ‘call’ when they activate
  ○ Pedestrian push buttons
  ○ Vehicular detection systems
    ■ Pulse detectors - measures passage of vehicles, located upstream of intersection, can give flow
    ■ Presence detectors - measures vehicles and time they’re within a zone, eg: loop detectors for left turning vehicles

Chapter 5 – Basic Timing [27]

• Relationship between intersection operation and control type is shown in Figure 53.
There are pre-timed and actuated intersections, with isolated, fully/semi actuated, or coordinated operations.

- For an urban setting, a pre-timed and coordinate setting is preferred. Pre-timed is preferred because of the high and known traffic volumes, and use of coordination will increase capacity

- A phase interval is period of time in which signals do not change. Three types of phase intervals are determined. Formula 5-2 is used for the following.

  - Vehicular Green Interval, a combination of:
    - Minimum green (formula 5-1) - based on:
      - Driver expectancy
      - Passenger walk/clearance times
      - Queue clearance
    - Extension times - based on detector information
    - Maximum green - guards against long green times due to continuous demand or broken detectors

- Vehicle Change Intervals
  - To provide safe transition between conflicting phases. Formula 5-2 is used
and applies to:

- Yellow Change - typically based on driver-perception time
- Red Clearance ("All-Red" interval) - to allow vehicles still within intersection to clear before the proceeding green interval starts
  - Pedestrian Intervals - they are timed concurrently with vehicular green intervals. Three phases include:
    - Walk - usually based on policies and the length of the vehicular green
    - Flashing Don't Walk - based on pedestrian clearance times. It is based on the time it takes an average passenger to fully clear the intersection. Formula 5-4 is used.
    - Solid Don't Walk
  - Actuated timing parameters are also discussed. They are mainly efficient when there's large fluctuations in demand including low demand

**Chapter 6 – Coordination [27]**

- Coordination is justified when there's closely spaced intersections with high thorough traffic.
- Coordination mechanics - the following are important and specific to coordination:
  - Cycle Length - this is the time required to complete sequence of signals. For a coordinated system, cycle length of different intersections must be the same, OR multiples of each other
  - Yield Point - it is the point where the controller decides to end the coordinated phase due to varying traffic conditions
  - Splits - the portion of time allocated to each phase, including green, yellow, and all-red (does NOT include typical red). Vehicles travelling through each 'split' within a cycle length are what must be coordinated
  - Offset - the time between the coordinated phases at subsequent traffic signals. This is what allows for smooth flow of traffic
- Coordination is heavily based on time-distance diagrams as can be seen in Figure 54.
The following guidelines can be followed for selecting the required coordination settings:

- Coordination phase assignment - all phases cannot be coordinated, it is common practice to assign the main-street thorough phase as the coordinated phase.
- Cycle length selection - various methods can be used, including “Critical Intersection Methods” (formulas 6-1 and 6-2).
- Split Distributions - once cycle length is determined, the duration of different phases must be set. The coordinated phase split includes the sum of green, yellow, and all-red times.
- Offset Optimization - must consider distance and speed between intersections, and traffic volumes. Ideally, platoons of cars leaving an upstream intersection at the start of the green should reach the downstream intersection at its start of green (please refer to fig 6-10 again). Time distance diagrams of the specific area must be analyzed to optimize offset values.

Coordination complexities include oversaturated conditions. This occurs when high overland queues form, and thus different set of strategies and timings are required during these periods.
14.0. CLOSING REMARKS

With the current growing problems around the existing Allen Road corridor, PSL strongly believes its corridor design, the Allen-Lawrence interchange detailed design, and above-deck recreational land use recommendations address the goals and objectives set out by the firm. Considering the constructability and costs; the project has been determined as feasible by PSL.

PSL is committed to stay in touch with the client during his review of the final report– and upon approval, negotiate on a new contract to continue advancing the project based on the implementation plan.
15.0. PSL TEAM

Parshan Bahrami—Chief Engineer
Parshan is the Chief Engineer at PSL Group Inc. under the Transportation Planning team. He is finishing his civil engineering undergraduate degree at the University of Toronto. He has worked in the transportation field as a summer research student at the University of Toronto where he worked on developing an integrated evacuation scheduling model. He also has consulting experience at PICCO Engineering where he worked as a structural engineering intern on residential housing. He’s very motivated in the field of transportation, more specifically airport planning, freight operations, and traffic optimization.

Shahzeb Bhutto—Senior Project Manager
Shahzeb is the Senior Project Manager at PSL Group Inc. under the Transportation Planning team. He recently completed his undergraduate civil engineering education at University of Toronto, obtaining a Bachelors of Applied Science degree. His most recent experience in the industry is an internship at a multi-national general contractor, Ferrovial Agroman Canada. He worked as a Project Estimator where he gained extensive experience in construction and bidding of heavy civil projects such as successful $1.2B Highway 407 East Phase 2 bid. Shahzeb also has summer internship experience at City of Toronto and Hydro One, where he gained valuable experience in civil engineering industry. His interests in the field are very broad, though he is keener towards transportation and construction engineering. Together, these experiences and interests make Shahzeb an invaluable part of PSL. Group Inc.’s team.

Luan Phan—Principal Designer
Luan is the Principal Designer at PSL Group Inc. under the Transportation Planning team. He is a civil engineering graduate at the University of Toronto with a minor in environmental engineering, and primary interests in transportation, water resources, and heavy civil construction. Luan has had work experience in the field operations of water and wastewater utilities at Veritec Consulting, as well as in the consulting of wastewater projects at AECOM. Although Luan’s experience primarily focuses in the water and wastewater sectors, his prolonged desire to contribute in the growth of cities and in building sustainable communities brings forth his passion to work on municipal infrastructure projects, including transportation. His expertise, passion, and attitude make Luan a great asset in PSL’s project team.
16.0. APPENDICES

Site Visit Photos

The following are photographs taken during a site visit conducted by PSL on January 29, 2016.

Figure 78. Lawrence Ave Pedestrian Crossing and Allen Road North Ramp

Figure 79. Busses Exiting Lawrence West Station
Figure 80. TTC Posters on Arterial Overpasses

Figure 81. Long Queue Backup from Eglinton Avenue
Figure 82. Approaching Eglinton Avenue on Allen Road

Figure 83. Congestion on Eglinton Avenue and Unsafe Pedestrian Crossing
Appendix A – Map 17 Land Use Plan
### Appendix B – Design Flow for Minor & Major Systems

<table>
<thead>
<tr>
<th>Functional Road Classifications</th>
<th>Drainage System Type</th>
<th>Design Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway</td>
<td>Minor System</td>
<td>10-Year</td>
</tr>
<tr>
<td>Arterial (Urban)</td>
<td>Major System</td>
<td>100-Year</td>
</tr>
<tr>
<td>Arterial (Rural)</td>
<td>Minor System</td>
<td>10-Year</td>
</tr>
<tr>
<td>Collector (Urban and Rural)</td>
<td>Major System</td>
<td>100-Year</td>
</tr>
<tr>
<td>Local Road (Urban and Rural)</td>
<td>Minor System</td>
<td>5-Year</td>
</tr>
<tr>
<td>Local Road (Rural)</td>
<td>Major System</td>
<td>-</td>
</tr>
<tr>
<td>Depressed Roadways (see SD-7)</td>
<td>Minor System</td>
<td>25-Year</td>
</tr>
<tr>
<td></td>
<td>Major System</td>
<td>100-Year</td>
</tr>
</tbody>
</table>

*Appendix B Design Flow for Minor & Major Systems [22]*

### Appendix C – Minimum Standards for Sustainable Longitudinal Grade

<table>
<thead>
<tr>
<th>Design Elements</th>
<th>Longitudinal Grade</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Desirable Standard</td>
<td>Minimum Standard</td>
</tr>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Curbed roads (gutter grade)</td>
<td>≥ 0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Road With Impermeable Barrier</td>
<td>≥ 0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Uncurbed roads</td>
<td>≥ 0.5</td>
<td>0.0</td>
</tr>
</tbody>
</table>

(1) Source: Table C4-4 of the Geometric Design Standards for Ontario Highways.
(2) In cases with a grade less than the Minimum Standard, with a curb or impermeable barrier, False Grading of the gutter or shoulder may have to be provided to produce a minimum slope of 0.3% to the inlet.
(3) On uncurbed roads where the lateral surface drainage is not obstructed, level grades are permissible provided that the minimum slope for the roadside ditch can achieve the requirements of Standard SD-9.

*Appendix C Minimum Standards for Sustainable Longitudinal Grade [22]*
### Appendix D – Minimum Design Cross-fall

<table>
<thead>
<tr>
<th>Traffic Lanes</th>
<th>Minimum Design Cross-fall (m/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete or Bituminous pavement</td>
<td>0.02</td>
</tr>
<tr>
<td>Gravel or crushed stone</td>
<td>0.03 to 0.04</td>
</tr>
<tr>
<td><strong>Shoulders</strong></td>
<td></td>
</tr>
<tr>
<td>Paved or treated</td>
<td>0.04</td>
</tr>
<tr>
<td>Gravel or crushed stone</td>
<td>0.06</td>
</tr>
<tr>
<td>Earth or turf</td>
<td>0.08</td>
</tr>
<tr>
<td><strong>Grassed Areas</strong></td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Sidewalks</strong></td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Note:**
1: On the high side of a super-elevated section, the minimum cross-fall shall be 0.02 m/m

### Appendix E – Roadside Ditch Design Parameters

<table>
<thead>
<tr>
<th>Roadside Ditch Design Parameters</th>
<th>2H:1V</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum Side Slope</strong></td>
<td></td>
</tr>
<tr>
<td>Minimum Longitudinal Slope</td>
<td>0.3 percent</td>
</tr>
<tr>
<td><strong>Base Width</strong></td>
<td></td>
</tr>
<tr>
<td>- Desirable Standard</td>
<td>1.0 metre</td>
</tr>
<tr>
<td>- Minimum Standard</td>
<td>Zero (V-ditch)</td>
</tr>
<tr>
<td><strong>Minimum Ditch Depth for Minor System</strong></td>
<td></td>
</tr>
<tr>
<td>Design Flow</td>
<td></td>
</tr>
<tr>
<td>- Normal Ditch (road at grade or in cut)</td>
<td>0.50 metres</td>
</tr>
<tr>
<td>- Ditch at toe of Fill Slope</td>
<td>0.25 metres</td>
</tr>
<tr>
<td><strong>Distance that roadside ditch invert shall be below the road subgrade elevation</strong></td>
<td></td>
</tr>
<tr>
<td>- Desirable Standard</td>
<td>0.5 metres</td>
</tr>
<tr>
<td>- Minimum Standard</td>
<td>0.3 metres</td>
</tr>
</tbody>
</table>

**Note (1):** Flatter side slopes may be incorporated into the design in accordance with the Roadside Design Manual (formerly the Roadside Safety Manual) and geotechnical characteristics.
Appendix F – Cut and Cover Tunnel Loading Diagram

FIGURE 5-12
CUT AND COVER TUNNEL LOADING DIAGRAM - BOTTOM UP CONSTRUCTION IN SOIL.

1. Live load - determined as per site conditions & AASHTO LRFD specifications
2. Vertical Earth Load = \( \gamma_s (H_1 - H_0) + \gamma_s (H_0) \)
3. Vertical Earth Load = \( \gamma_s (H_1 - H_0) + \gamma_s (H_0) \)
4. Vertical Surcharge Load - determined as per site conditions \( (\gamma_s) \)
5. Horizontal Hydrostatic Load: \( a = \gamma_s H_w \quad b = \gamma_s (H_0 - H_1) \)
6. Horizontal Earth Load: \( a = \gamma_s R_0 (H_1 - H_0) + \gamma_s H_w \quad b = a + \gamma_s R_0 H_1 \)
7. Horizontal Surcharge Load = \( F_e \quad R_0 \)

Where:
- \( \gamma_s \) = dry unit weight of soil
- \( \gamma_w \) = buoyant unit weight of soil
- \( H_0 \) = height of backfill over the tunnel
- \( H_w \) = height of water table over the tunnel
- \( H_1 \) = height of the tunnel structure
- \( R_0 \) = at-rest lateral earth pressure coefficient
- \( F_e \) = magnitude of surcharge in units of Force/Area

Appendix F Cut and Cover Tunnel Loading Diagram [23]
### Minimum Stopping Sight Distance for Wet Conditions

<table>
<thead>
<tr>
<th>Speed $v$</th>
<th>Perception and Brake Reaction</th>
<th>Coefficient of Friction Wet pav'</th>
<th>Braking Distance on Level</th>
<th>S-Min. Stopping Sight Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Assumed Condition</td>
<td>Time</td>
<td>Distance</td>
<td>$f$</td>
</tr>
<tr>
<td>km/h</td>
<td>km/h</td>
<td>s</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>2.5</td>
<td>28</td>
<td>0.380</td>
</tr>
<tr>
<td>50</td>
<td>50</td>
<td>2.5</td>
<td>35</td>
<td>0.358</td>
</tr>
<tr>
<td>60</td>
<td>60</td>
<td>2.5</td>
<td>42</td>
<td>0.337</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
<td>2.5</td>
<td>49</td>
<td>0.323</td>
</tr>
<tr>
<td>80</td>
<td>79</td>
<td>2.5</td>
<td>55</td>
<td>0.312</td>
</tr>
<tr>
<td>90</td>
<td>87</td>
<td>2.5</td>
<td>60</td>
<td>0.304</td>
</tr>
<tr>
<td>100</td>
<td>95</td>
<td>2.5</td>
<td>66</td>
<td>0.296</td>
</tr>
<tr>
<td>110</td>
<td>102</td>
<td>2.5</td>
<td>71</td>
<td>0.289</td>
</tr>
<tr>
<td>120</td>
<td>109</td>
<td>2.5</td>
<td>76</td>
<td>0.283</td>
</tr>
<tr>
<td>130*</td>
<td>116</td>
<td>2.5</td>
<td>81</td>
<td>0.279</td>
</tr>
<tr>
<td>140*</td>
<td>122</td>
<td>2.5</td>
<td>85</td>
<td>0.277</td>
</tr>
<tr>
<td>150*</td>
<td>127</td>
<td>2.5</td>
<td>88</td>
<td>0.273</td>
</tr>
<tr>
<td>160*</td>
<td>131</td>
<td>2.5</td>
<td>91</td>
<td>0.269</td>
</tr>
</tbody>
</table>

*Appendix G. 1 Minimum stopping sight distance for wet conditions [15]*

### Minimum Stopping Sight Distance for Dry Conditions

<table>
<thead>
<tr>
<th>Speed $v$</th>
<th>Perception and Brake Reaction</th>
<th>Coefficient of Friction Dry pav'</th>
<th>Braking Distance on Level</th>
<th>Stopping Distance (calculated)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Assumed Condition</td>
<td>Time</td>
<td>Distance</td>
<td>$f$</td>
</tr>
<tr>
<td>km/h</td>
<td>km/h</td>
<td>s</td>
<td>m</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>2.5</td>
<td>28</td>
<td>0.625</td>
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<tr>
<td>50</td>
<td>50</td>
<td>2.5</td>
<td>35</td>
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<td>60</td>
<td>60</td>
<td>2.5</td>
<td>42</td>
<td>0.603</td>
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<td>2.5</td>
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<td>0.590</td>
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<tr>
<td>80</td>
<td>80</td>
<td>2.5</td>
<td>56</td>
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<tr>
<td>90</td>
<td>90</td>
<td>2.5</td>
<td>63</td>
<td>0.570</td>
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<tr>
<td>100</td>
<td>100</td>
<td>2.5</td>
<td>69</td>
<td>0.562</td>
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<td>110</td>
<td>2.5</td>
<td>76</td>
<td>0.553</td>
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<td>120</td>
<td>120</td>
<td>2.5</td>
<td>83</td>
<td>0.545</td>
</tr>
<tr>
<td>130</td>
<td>130</td>
<td>2.5</td>
<td>90</td>
<td>0.540</td>
</tr>
<tr>
<td>140</td>
<td>140</td>
<td>2.5</td>
<td>97</td>
<td>0.535</td>
</tr>
<tr>
<td>150</td>
<td>150</td>
<td>2.5</td>
<td>104</td>
<td>0.530</td>
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<tr>
<td>160</td>
<td>160</td>
<td>2.5</td>
<td>111</td>
<td>0.528</td>
</tr>
</tbody>
</table>

*Appendix G. 2 Minimum stopping sight distance for dry conditions [15]*
### Appendix G. 3 Minimum Radii selection [15]

<table>
<thead>
<tr>
<th>Design speed km/h</th>
<th>( \rho_{\text{max}} ) (m/m)</th>
<th>Max. ( f )</th>
<th>Total ( e + f )</th>
<th>Min. Radius (calculated) m</th>
<th>Min. Radius (rounded) m</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.06</td>
<td>0.165</td>
<td>0.225</td>
<td>55.99</td>
<td>55</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>0.159</td>
<td>0.219</td>
<td>89.89</td>
<td>90</td>
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<tr>
<td>60</td>
<td></td>
<td>0.153</td>
<td>0.213</td>
<td>133.08</td>
<td>130</td>
</tr>
<tr>
<td>70</td>
<td></td>
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<td>0.207</td>
<td>186.39</td>
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</tr>
<tr>
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<td>0.140</td>
<td>0.200</td>
<td>251.97</td>
<td>250</td>
</tr>
<tr>
<td>90</td>
<td></td>
<td>0.134</td>
<td>0.194</td>
<td>328.76</td>
<td>340</td>
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<td>0.128</td>
<td>0.188</td>
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<td>525</td>
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<td>1150</td>
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<td>0.151</td>
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<td>1350</td>
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<table>
<thead>
<tr>
<th>Design speed km/h</th>
<th>( \rho_{\text{max}} ) (m/m)</th>
<th>Max. ( f )</th>
<th>Total ( e + f )</th>
<th>Min. Radius (calculated) m</th>
<th>Min. Radius (rounded) m</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.08</td>
<td>0.165</td>
<td>0.245</td>
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<td>0.239</td>
<td>82.36</td>
<td>80</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>0.153</td>
<td>0.233</td>
<td>121.66</td>
<td>120</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>0.140</td>
<td>0.227</td>
<td>169.97</td>
<td>170</td>
</tr>
<tr>
<td>80</td>
<td></td>
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<td>0.220</td>
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<td>230</td>
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<td>0.208</td>
<td>378.56</td>
<td>380</td>
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<tr>
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<td>0.091</td>
<td>0.171</td>
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### Appendix G. 4 Spiral curve designation [15]

<table>
<thead>
<tr>
<th>Speed km/h</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
<th>55</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>110</td>
<td>120</td>
<td>125</td>
<td>130</td>
<td>140</td>
<td>150</td>
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<td>190</td>
<td>200</td>
<td>210</td>
<td>220</td>
<td>230</td>
<td>240</td>
</tr>
<tr>
<td>175</td>
<td>240</td>
<td>250</td>
<td>260</td>
<td>270</td>
<td>275</td>
<td>280</td>
<td>290</td>
<td>300</td>
</tr>
<tr>
<td>240</td>
<td>325</td>
<td>350</td>
<td>375</td>
<td>400</td>
<td>425</td>
<td>450</td>
<td>475</td>
<td>500</td>
</tr>
<tr>
<td>325</td>
<td>550</td>
<td>600</td>
<td>650</td>
<td>700</td>
<td>750</td>
<td>800</td>
<td>900</td>
<td>1000</td>
</tr>
<tr>
<td>550</td>
<td>1100</td>
<td>1200</td>
<td>1300</td>
<td>1400</td>
<td>1500</td>
<td>1600</td>
<td>1700</td>
<td>1800</td>
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</table>
Appendix G. 5 Spiral design standards for superelevation rate of 0.06 [15]

<table>
<thead>
<tr>
<th>Table for superelevation rate e = 0.06</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (km/h)</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>R (m)</td>
</tr>
<tr>
<td>e (%)</td>
</tr>
</tbody>
</table>

Appendix G. 6 Spiral design standards for superelevation rate of 0.08 [15]

<table>
<thead>
<tr>
<th>Table for superelevation rate e = 0.08</th>
</tr>
</thead>
<tbody>
<tr>
<td>V (km/h)</td>
</tr>
<tr>
<td>-------------------------------</td>
</tr>
<tr>
<td>R (m)</td>
</tr>
<tr>
<td>e (%)</td>
</tr>
</tbody>
</table>
Appendix G. 7. Maximum grades for urban roads [15]

<table>
<thead>
<tr>
<th>Design Speed km/h</th>
<th>Traffic Volume</th>
<th>AADT</th>
<th>DHV</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;8000</td>
<td>3000 - 6000</td>
<td>2000 - 3000</td>
<td>1000 - 2000</td>
</tr>
<tr>
<td>&gt;600</td>
<td>6 - 8</td>
<td>6 - 8</td>
<td></td>
</tr>
<tr>
<td>60 - 70</td>
<td>6 - 12</td>
<td>6 - 12</td>
<td>6 - 12</td>
</tr>
<tr>
<td>50</td>
<td>-</td>
<td>8 - 12</td>
<td>8 - 12</td>
</tr>
<tr>
<td>40 - 50</td>
<td>-</td>
<td>-</td>
<td>8 - 12</td>
</tr>
</tbody>
</table>

Appendix G. 8 Maximum grades for freeways [15]

<table>
<thead>
<tr>
<th>Design Speed km/h</th>
<th>Maximum Grade %</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>3</td>
</tr>
<tr>
<td>110°</td>
<td>3 - 4</td>
</tr>
<tr>
<td>100°</td>
<td>3 - 4</td>
</tr>
<tr>
<td>90°</td>
<td>4 - 5</td>
</tr>
</tbody>
</table>

Appendix G. 9 Minimum grade policies for curbed roads and ditches [15]

<table>
<thead>
<tr>
<th>Design Element</th>
<th>Desirable Minimum</th>
<th>Absolute Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curbed Roads</td>
<td>0.5%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Uncurbed Roads with Adequate Cross-Fall</td>
<td>0.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Unlined Ditches</td>
<td>0.5%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

Appendix G. 10 Designation of 'K' constant for vertical curves [15]

<table>
<thead>
<tr>
<th>Minimum sag vertical curvature K, comfort criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed km/h</td>
</tr>
<tr>
<td>Minimum sag</td>
</tr>
</tbody>
</table>

Appendix G. 11 Designation of 'K' constant for vertical curves for optimized driver comfort [15]
### LANE WIDTHS FOR UNDIVIDED & DIVIDED HIGHWAYS

**4-LANE UNDIVIDED AND DIVIDED RURAL ROADS**

Lane widths for 4-lane rural roads depend primarily on design speed and to a small degree on traffic volume or truck percentages. Widths for 4-lane rural roads are:

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 100 km/h</td>
<td>3.75 m</td>
</tr>
<tr>
<td>&lt; 100 km/h</td>
<td>3.50 m</td>
</tr>
</tbody>
</table>

**MULTI-LANE DIVIDED RURAL AND URBAN ROADS**

For multi-lane divided roads the width of the median lane is 3.50 m and all other lanes 3.75 m, to minimize the overall pavement width. The pavement may be striped in equal lane widths.

**2-LANE AND 4-LANE UNDIVIDED URBAN ROADS**

Lane widths for 2-lane and 4-lane undivided urban roads are shown in Table D2-4 for a range of design speeds from 40 km/h to 60 km/h and for ranges of traffic volumes stated in terms of AADT and DHV. No adjustment for truck percentages is required for the use of this table.

<table>
<thead>
<tr>
<th>Design Speed</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 80 km/h</td>
<td>3.75 m</td>
</tr>
<tr>
<td>&lt; 80 km/h</td>
<td>3.50 m</td>
</tr>
</tbody>
</table>

### AUXILIARY LANE WIDTHS

<table>
<thead>
<tr>
<th>Auxiliary Lane</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right-turn lane</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
<tr>
<td>Left-turn lane not adjacent to a median</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
<tr>
<td>Left-turn lane adjacent to a median</td>
<td>- 3.0 m minimum</td>
</tr>
<tr>
<td>Continuous left-turn lane</td>
<td>- 4.0 m where design speed is greater than 60 km/h</td>
</tr>
<tr>
<td></td>
<td>- 3.0 m where design speed is equal to or less than 60 km/h</td>
</tr>
<tr>
<td>Acceleration and deceleration lanes</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
<tr>
<td>Weaving lane</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
<tr>
<td>Truck-climbing lane</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
<tr>
<td>Passing lane</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
<tr>
<td>Left-turn slip-around lane</td>
<td>- not less than 0.25 m less than adjacent lane</td>
</tr>
<tr>
<td></td>
<td>- not less than 3.25 m</td>
</tr>
</tbody>
</table>
Appendix G. 14 Basis for lane-widening on curves [15]

\[
W = W_0 - W_A
\]

where: 
\(W\) = amount of widening \\
\(W_0\) = pavement width on curve \\
\(W_A\) = pavement width on tangent \\
\(W_c = 2(U+C) + FA + Z\)

where: 
\(U\) = vehicle track width on curve in metres \\
\(C\) = nominal clearance between vehicles 
- 0.457m for 6.0m wide pavements 
- 0.630m for 6.5m wide pavements 
- 0.782m for 7.0m wide pavements 
- 0.914m for 7.5m wide pavements \\
\(F_A\) = front overhang in metres \\
\(Z\) = additional clearance in metres to compensate for difficulty of driving on curves where

\[
Z = \frac{0.10456 \times V}{\sqrt{R}}
\]

\(V\) = design speed of highway in kilometres per hour \\
\(R\) = curve radius in metres

Appendix G. 15 Example of a 4-lane highway with a median [15]

Appendix G. 16 Basic intersection forms [15]
Appendix G. 17 Minimum sight distance at signalized intersections [15]

Appendix G. 18 Cross-fall of both intersection roads at a signalized intersection [15]

Appendix G. 19 Parclo A-4 interchange [15]

advantages
* favours the fast freeway traffic by placing exit terminals in advance of structure.
* weaving is eliminated.
* single exit features simplifies signing of freeway.
* high capacity.
* all traffic movements are natural.
* stop for left turns confined to ramps only.

disadvantages
* higher construction and property costs than parclo 2 - quadrant or diamond.
* signals required on minor road when through and turning volume high.
Appendix G. 20 Parclo B-4 interchange [15]

Advantages
* weaving is eliminated.
* not conducive to wrong way movement.
* all traffic movements are natural.
* favours freeway traffic with advanced exit terminals.
* single exits on freeway simplifies signing.
* ramp traffic entering crossing road does not stop.
* only one movement stops for signal.

Disadvantages
* higher construction and property costs than parclo 2 - quadrant or diamond.
* in urban conditions when the minor road has high through and left turning volumes, signals are required.
* stop on minor road for left turn with storage on or under the bridge between ramps terminals.
* high speed traffic must exit from freeway on a small radius loop.

Appendix G. 21 Parclo A-B interchange [15]

Advantages
* similar to parclos A-2 & B-2

Disadvantages
* similar to parclos A-2 & B-2
* weaving section on crossing road.
Appendix G. 22 Determination of ramp design speed [15]

<table>
<thead>
<tr>
<th>Highway Design Speed km/h</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ramp Design Speed, km/h</td>
<td>40</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>70</td>
<td>70</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>minimum</td>
<td>30</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>50</td>
<td>50</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>$\theta_{MAX} = 0.08 \text{ m/m}$</td>
<td>50</td>
<td>80</td>
<td>80</td>
<td>120</td>
<td>170</td>
<td>170</td>
<td>230</td>
<td>230</td>
</tr>
<tr>
<td>minimum radius, m</td>
<td>standard</td>
<td>30</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>80</td>
<td>80</td>
<td>120</td>
</tr>
<tr>
<td>minimum</td>
<td>55</td>
<td>90</td>
<td>90</td>
<td>130</td>
<td>190</td>
<td>190</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>$\theta_{MAX} = 0.06 \text{ m/m}$</td>
<td>30</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>90</td>
<td>90</td>
<td>130</td>
<td>130</td>
</tr>
</tbody>
</table>

Appendix G. 23 Determination of sight distance to bullnose [15]
### Appendix G. 24 Length of speed-change lanes at exit terminals on freeways for a single lane ramp [15]

<table>
<thead>
<tr>
<th>Design Speed of Freeway, km/h</th>
<th>100</th>
<th>110</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed at bulworse, km/h</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Length of Speed-Change Lane including taper, m</td>
<td>290</td>
<td>315</td>
<td>345</td>
</tr>
<tr>
<td>Length of taper, m</td>
<td>80</td>
<td>85</td>
<td>90</td>
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</table>

(i) Single-lane parallel exit terminal

### Appendix G. 25 Length of speed-change lanes at entrance terminals on freeways for a single lane ramp [15]

<table>
<thead>
<tr>
<th>Design Speed of Through Roadway, km/h</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>110</th>
<th>120</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed at bulworse, km/h</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>40</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Length of Speed-Change Lane</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>including Taper, m</td>
<td>70</td>
<td>70</td>
<td>95</td>
<td>150</td>
<td>220</td>
<td>300</td>
<td>400</td>
<td>500</td>
</tr>
<tr>
<td>Length of Taper, m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>75</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80</td>
<td>85</td>
<td>90</td>
</tr>
</tbody>
</table>

(i) Direct taper on entrance terminal
17.0. BIBLIOGRAPHY


Meet the Team

PSL Group Inc.

Parsh Bahrami
Chief Engineer

Shahzob Bhutto
Senior Project Manager

Luan Phan
Principal Designer
The image contains a presentation agenda slide. The agenda includes the following sections:

1. Project Recap
2. Detailed Design
3. Alternative Selection Process
4. Constructability, Cost, Implementation
5. Closing Remarks

The slide also features a mention of "We do Our Best for Your Business." Additionally, there is a text block in Latin that reads: "Sed ut perspiciatis unde omnis iste natus error sit voluptatem accusantium doloremque laudantium, totam rem aperiam eaque ipsa quae ab illo inventore.

The slide is titled "Presentation Agenda."
Where is Allen Road?

Comprised of:
- Low-rise residential development
- Some existing high-rise residential, more being proposed
- Commercial (Yorkdale Mall, Downsview Park)
- Shopping plazas
- Institutional (Schools)

History

- Spadina Expressway project proposed in 1960's
- Intended to span from Highway 401 to Spadina Road
- Jane Jacobs brought great controversy
  - Believed an expressway through a city would drive out the middle class in adjacent neighbourhoods
- Project was cancelled in 1971
  - Completed section remained and is known today as Allen Road
Problem Definition
The Dilemma

- Major congestion along the corridor
- Long queues extend into the expressway
- Lack of east-west road connectivity due to Allen Road being below-grade
- Noise issues from automobile despite barriers
- Pedestrian safety at interchanges
- Air pollution from idling cars

Lawrence Avenue W. Interchange

1. Signalized off-ramps with one lane per direction
2. TTC buses exiting the station at the same time as off-ramp traffic
3. Short distance between traffic lights at on and off ramps - encouraging gridlocks during peak hours
Stakeholders

Relevant stakeholders who may impact or be impacted by the project

- **Local Community**
  Residents such as: cyclists, pedestrians, students

- **Local Businesses & Institutions**
  Large commercial retailers (Yorkdale)
  Smaller businesses
  Parks and other institutions

- **City Wide & Miscellaneous Groups**
  Long Distance Commuters
  Residential/Commercial Developers
  Non-Governmental Organizations (NGOs)

- **Transit Providers**
  TTC - University Line
  Metrolinx - Eglinton Crosstown

- **Municipal & Provincial Agencies**
  City of Toronto (owner of Allen)
  Province of Ontario/MTO (owner of nearby 401)

- **Aboriginal Communities**
  Requirement during the EA and design process

Goals

1. **Transportation**
   Improve design and efficiency of road network

Purpose
   Improve the Allen Road study area, address the defined problem, and consider stakeholders wants and needs

2. **Land Use**
   Improve the quality of life in study area
Alternative #1
Northern Section: Arterial
Southern Section: Arterial

Alternative #2
Northern Section: Do Nothing
Southern Section: Tunnel/Deck
Alternative #3

Northern Section: Arterial
Southern Section: Tunnel/Deck

ALTERNATIVE SELECTION PROCESS
Selection Process

Corridor Alignment

<table>
<thead>
<tr>
<th>Alternative #1</th>
<th>Alternative #2</th>
<th>Alternative #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize Cost</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Integration with Transportation Network</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Provide Multiple Land Use Opportunities</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Improve Connectivity and Accessibility</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Reduce Congestion and Delay Times</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Increase Safety of Travel</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Reduce Noise and Air Pollution</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

PREFERRED ALTERNATIVE

Interchange Alternatives

Simple Diamond Interchange (Existing)  Parclo B-4
Selection Process

Interchange Design

Land Use Alternatives

Commercial Use

Recreational Use
**Selection Process**

**Land Use Design**

<table>
<thead>
<tr>
<th></th>
<th>Commercial Use</th>
<th>Recreational Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximize Economic Productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximize Recreational Opportunities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promote Growth and Sustainability</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PREFERRED ALTERNATIVE</strong></td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

DeTAILED DESIGN
Lawrence Ave. W Interchange

Maximum superelevation of 0.08 m/m was not exceeded in any portion
Lane width: 3.75 m
Shoulder widths: 1.0m on left side, 3.0 m on right size
Drainage slope: 3:1 daylight grading for non-decked portions
Lawrence Ave. W Cross-Section

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 3.60 m
- Shoulder widths: No shoulders. Curb and gutter on the edge of each travelled way
- Safety median is placed to isolate the bi-directional flows

Cloverleaf Ramps Cross-Section

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 4.75 m
- Shoulder widths: 1.0 m on left side, 2.50 m on right side
- Drainage slopes: 3:1 daylight grading with additional 6:1 grading towards the center of ramp radius
Non-Cloverleaf Ramps Cross-Section

- Maximum superelevation of 0.08 m/m was not exceeded in any portion
- Lane width: 4.50 m
- Shoulder widths: 1.0 m on left side, 1.0 m on right side.
- Drainage slopes: 2:1 daylight grading on each side
Final Lawrence Ave. W Interchange

Corridor Design
Southern Section - Cross Section
Corridor Design
Tunnel Profile & Breakdown of Components

TUNNEL PROFILE (NTS)

PLANTS, TREES, AND OTHER AMENITIES
PEDESTRIAN PAVING SYSTEM
ENGINEERED SOIL
TOPOGRAPHIC SLAB WITH WATERPROOFING
GEOTECHNICAL SUPPORT SYSTEM
LOAD BEARING WALL
FOOTING

Corridor Design
Sample At-Grade Amenities

PLAN VIEW - SAMPLE AT-GRADE AMENITIES (NTS)
Land Use Design
At-Grade Amenities

Concert Stage
Fountain

Playgrounds
Sports Courts
Land Use Design
Walkways and Trails

Pedestrian Walkways

Connecting the Beltline Trail

Land Use Design
Landscaping

Native Trees

Landscaped Gardens
Land Use Design

Public Art

Sculptures

Interactive Public Art

CONSTRUCTABILITY
Decking Challenges

- Need to build a structurally safe deck with minimal traffic disturbance
- Structural material will be precast or prestressed reinforced concrete, made off-site, and simply installed on site in non-peak hrs
- Will be done in stages
- Third party firm will provide structural details
- **EXAMPLE:** Klyde Warren Park

Klyde Warren Park

**Construction**

Start With Your Existing Freeway
In comparison to Klyde Warren, Allen Road will require filling the existing berms with granular material.

Build Support Walls
Load bearing walls to be placed in locations as per detailed structural design.
Klyde Warren Park

**Construction**

**Span the Walls With Support Beams**
The load bearing walls will be spanned with a support girder system as per detailed structural design.

**Cap the Freeway With a Deck**
The deck will be comprised of a waterproofed slab overtopping the support beams, a deep layer of engineered soil, and necessary paving.

**Finally, Build Your Park!**
Plant trees, build at-grade amenities, provide landscaping, build public art, etc.

**Generate Recreational & Economic Opportunities**
Host public events, including concerts and other social gatherings.
Land Acquisitions

- North-east: Lawrence Heights Community Centre
  - Mitigation: $$$

- South-west: Residential housing
  - Mitigation: Relocation
    (based on future Lawrence-Allen Revitalization Plan)

Ramp Construction

- 4 of the ramps will be constructed without interference to existing ramps

- 2 of the ramps will require modifications of existing ramps
  - Will require:
    - Temporary closures of existing ramps
    - Traffic control measures
Expected Project Cost

Construction and Overheads

<table>
<thead>
<tr>
<th>Construction</th>
<th>Projected Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Lawrence Ave. W Interchange</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>2 Deck (including structural and public space infrastructure)</td>
<td>$137,500,000</td>
</tr>
<tr>
<td>3 Decommissioning and modifications to existing areas</td>
<td>$500,000</td>
</tr>
<tr>
<td>4 Engineering, Design, and Management</td>
<td>$42,000,000</td>
</tr>
<tr>
<td><strong>Land Acquisition and Reimbursement</strong></td>
<td></td>
</tr>
<tr>
<td>5 Acquisition and reimbursement to residential areas</td>
<td>$28,000,000</td>
</tr>
<tr>
<td><strong>Total Cost:</strong></td>
<td><strong>$210,000,000</strong></td>
</tr>
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</table>

Sub-total: $182,000,000
Implementation Plan

1. Preliminary Design
2. EA Process
3. Design Finalization
4. Funding & Procurement

We Are Here

Implementation
**EA Process**

1. **BASELINE**
   - Conduct full baseline studies and surveys to fully understand the environment

2. **IMPACTS**
   - Determine impacts significant to the public and stakeholders

3. **MITIGATION**
   - Provide for mitigation measures that either prevent the impact, or minimize it

4. **APPROVAL**
   - Send necessary documents and await approval from MOECC

---

**PUBLIC CONSULTATION**

---

**EA Process**

**Public Consultation**

- Extensive consultation meetings to communicate project vision with the public
  - Special consideration to stakeholders in land acquisition areas

- Joint consultation with City of Toronto’s Lawrence-Allen Revitalization Plan to show the final vision of corridor area

- Provide opportunities for the public to voice their concerns in the design process
Design Finalization
An iterative process

Consult with client and stakeholders
Take the considerations of the City, stakeholders, and public into account

Amend design
Amend design accordingly

Funding
Suggestions

Committed to Public Infrastructure
Liberal Infrastructure Plan invests $20 Billion for social infrastructure over the next 10 years

Application for funding
Present the project to the Federal government to help facilitate Municipal budget deficit towards the funding

Prime Minister - Justin Trudeau
Procurement

Recommendations

- Public-Private-Partnership
  - Taxpayer financial security against cost overruns and delays
  - Ensures effective delivery of performance from the start over to the long-term
- Design-Build-Finance-Operate-Maintain Contract
  - Private Concessionaire shares liability of the Project and maintains it over the life-cycle
  - Minimizes responsibilities for the City
Thank you Boss

Sabbir Saiyed / Boss
Manager, Transportation System Planning
Region of Peel

Sabbir has been an excellent client and mentor
THANKS FOR LISTENING.
QUESTIONS?

CONTACT US:

www.pslgroup.ca  info@pslgroup.ca  @PSLGroup  linkedin.ca/PSLGroup

THANKS FOR LISTENING.
QUESTIONS?
# Executive Summary

- Introduction

## Detailed Design Write-up

- Corridor Alignment Design
- Interchange Design
- Land Use Design

## Detailed Design Drawings

- Interchange
- Deck & Land Use
- 3D Model

## Constructability

- Corridor Alignment
- Interchange

## Implementation

- Costs
- Presentation Slides
- Editing
- Formatting
- Referencing