Critical Parameters Governing the Planning of Calgary's Airport Trail as an Effective East-West Connector

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Abstract

With Calgary Airport's (YYC) growing passenger base bringing expansion of the passenger terminal and a fourth runway, the City of Calgary (City) had to decide whether to have the crossing through road, Airport Trail, to run as a continuous uninterrupted roadway; as the newly constructed runway will break Airport Trail into a discontinuous corridor. In February 2011, the decision was made by City Council to make Airport Trail continuous with a sub-lease agreement negotiated with YYC initiating the design and construction of the tunnel, along with a functional planning study of Airport Trail which this paper discusses.

The planning of the corridor was atypical of standard freeway facilities. A major design challenge encountered in the study was a change in Airport Trail's roadway classification from an arterial, which has more relaxed access and movement provisions, to the reclassified skeletal standard, which emphasizes on free-flow movement and on enhanced access management. Additional modelling effort was required at the onset of the study in order to allow Airport Trail to be designed to applicable volumes. Additionally, specific attention was required at constrained locations which involved geometric design decisions to provide safer and more efficient operations. Constraints include tunnel proximity, integrating high vehicle volumes and balancing the right-of-way requirements for vehicle and LRT inside the tunnel. As well, the design of Airport Trail was to be integrated with existing infrastructure including the construction of airport infrastructure. Challenges encountered during the study are outlined and their solutions described including lessons learnt from the project.

1.0 Project Background

With a population of just over one million, Calgary has experienced unprecedented population growth with plans carrying forward for an additional half-million residents. In conjunction with the population growth is the continual expansion of YYC which currently serves over 12 million passengers annually and is among the four busiest airports in Canada. YYC's current expansion plans include a new international terminal and a new parallel runway with additional plans in the future to meet growth in demand.

The construction of the fourth runway at YYC will essentially bisect Airport Trail (96 Avenue), an east-west skeletal roadway in northeast Calgary, into two sections, as shown in Figure 1 [1]. As a result of the new runway construction on YYC lands, City Council had to decide whether or not to have Airport Trail continuous. In February 2011, City Council approved the construction of the tunnel which will provide a continuous link between two major provincial roadways in Calgary: Deerfoot Trail, a major north-south freeway in Calgary at the west end; and Stoney Trail, a part of the City's east leg of the ring road at the east end. In addition to maintaining a continuous connection between the two major freeways, the newly planned Airport Trail will also provide access to adjacent commercial, industrial and residential development, and serve the airport as a major employment centre, passenger and cargo hub. Ultimately, with all adjacent development considered, Airport Trail will need to be designed to accommodate an AADT of up to 75,000 vehicles.

As depicted in the study area Figure 2 [2], the current four lane Airport Trail starts at Deerfoot Trail in the west and continues for approximately 2.4km east to Barlow Trail where it terminates and provides access to YYC, park and fly facilities, industrial development and connection to other significant roadways in the City's roadway network. There are currently at-grade intersections at 19 Street and Barlow Trail which are 800m apart. 19 Street currently serves for access to YYC lands to the south and other developments to the north and will continue to serve more developments in the future. The interim and ultimate plan is to have interchanges developed in stages at 19 Street and Barlow Trail. The close interchange spacing combined with dedicated ramps to YYC required an integrated interchange concept that is atypical of conventional interchange and corridor designs. With the construction of the new tunnel, Airport Trail will punch through towards the east and have interchanges at 36 Street, Metis Trail and 60 Street until meeting with Stoney Trail. With 36 Street in close proximity to Metis Trail and the tunnel, another integrated interchange will be required in the ultimate plan which also considers adjacent development. A standard interchange is only possible at 60 Street between Metis Trail and Stoney Trail.

Both the City and YYC jointly financed and were involved in the development of the functional plans on the west portion of the study from Deerfoot Trail to 36 Street (just over 3.5km) whereas the City was the primary client on the remaining eastern portion of the study from 36 Street to Stoney Trail (approximately 4km). Overall, the future Airport Trail shall be designed to provide free-flow movement between Deerfoot Trail and Stoney Trail and provide access to YYC and the adjacent lands through interchanges at select locations.

2.0 Project Genesis

The previous city transportation plan identified Airport Trail corridor as a continuous stretch of expressway (skeletal) from Deerfoot Trail to Stoney Trail: This implies a high-speed high-volume corridor that will not be bisected. Since that time, numerous other studies were undertaken including the 2005 *Functional Planning Study* [3] and the 2008 *96 Avenue N/Runway Crossing – Planning Summary* [4] which confirmed the cross-section, profile and structural requirements for Airport Trail. The current 2009 *Calgary Transportation Plan* [1] reclassified Airport Trail from Deerfoot Trail to 36 Street as an arterial street. The reclassification of Airport Trail included reduction of the tunnel width from ten (10) lanes to six (6) lanes and an expected change in the posted speed limit. This decision in turn impacted the design and configuration of various geometric elements of Airport Trail in the preliminary design of the tunnel which is now under construction.

As YYC prepared for the expansion of their terminal building and construction of a fourth runway, which falls in the alignment of Airport Trail between Barlow Trail and 36 Street, the City had to decide whether or not to have Airport Trail continuous with a tunnel under the fourth runway. The construction of the tunnel was a major 2010 civic election topic which was heavily discussed with proponents in support of and in opposition to constructing the tunnel. Arguments supporting construction of the tunnel included the cost savings of building prior to runway construction with a cut-and-cover method and the addition of a more direct link to the growing northeast quadrant of the city. As such, a decision by council was critical to coordinate the construction of the tunnel with the new runway. On November 8, 2010, a notice of motion was put forward to study the feasibility of the tunnel and to carry out a functional design of the tunnel. The City advanced an accelerated study, *Airport Trail Underpass Functional Planning Study* [5], January 2011, between Barlow Trail and 36 Street to identify the design parameters of the tunnel. Following the January 2011 functional report, the construction of the tunnel was approved by City Council on February 7, 2011. This was followed by a sublease agreement being signed with YYC on June 16, 2011. This paper discusses the functional planning study efforts involved for Airport Trail inclusive of the newly constructed tunnel and the parameters which governed numerous design elements along the corridor.

3.0 Study Approach

The functional plan developed for Airport Trail was to accommodate various issues including:

- *institutional* in meeting the goals and objectives of the City, YYC and stakeholders;
- *technical* in meeting the design parameters and constraints along the corridor; and,
- *financial* in minimizing impacts to adjacent developable land and ensuring that the future construction costs are allocated between the City and YYC as per their sublease agreement.

From the above issues, there were constraining parameters which were to be incorporated into the design. It is recognized that the constraining parameters from the above institutional, technical and financial issues are not mutually exclusive and may considered as part of one, two or all three of the issues. Some of the constraining parameters in the study included:

- Grades on interchange bridges to be longitudinal and grades at tunnel portals to match tunnel profile
- Number of travel lanes in tunnel, reduced from previous plans, and core lanes on Airport Trail
- Desired design speed of 90 km/h on Airport Trail
- Classification of Airport Trail and cross-streets were undetermined or previously planned as a lower classification
- Design horizons of 2029 and 2039 and the related traffic projections and land constraints
- Projected high annual average daily traffic and hourly volumes
- Access and egress provision along short and constrained corridor segments
- Access (recirculation) and movement (free-flow) provision at the constrained segment at YYC
- Location of interchanges and land constraints from adjacent development plans
- Cost-sharing of specific infrastructure elements between the City and YYC
- Provision of light rail transit along the corridor and in the reduced tunnel cross-section

The integration of the issues and the parameters are discussed further in terms of the resulting challenges and the solution approach.

4.0 Challenges of Constraining Parameters

The planning process for Airport Trail was atypical from other planning studies with various parameters resulting in design challenges and limiting the flexibility in design. Some of the unconventional features in the project include having both the City and the airport authority, YYC, as joint clients; having reclassification of the roadway part way through the project from earlier plans; and incorporating into the study the tunnel and various other infrastructure and land development projects. This planning study of Airport Trail required the development of an interim (year 2029) and ultimate (year 2039) plan in coordination with other ongoing projects including the Northeast Light Rail Transit Extension to Stoney Trail North (NE LRT) Study, Northeast Roadway Network (NE Network) Study and the Airport Trail Tunnel (ATT) construction project. Coordination with these paralleling projects during the study was critical in the sharing of knowledge and information as they became available.

This study was unique in that it involved the City and YYC as joint clients in the study with each having their goals, which were at times conflicting. The City's goal was to determine a future roadway plan that is consistent with its transportation plan: YYC's goal was to ensure efficient and free-flow movement of people and goods within and into-and-out-of the airport lands. Most of the conflicting goals were addressed technically in the project which involved close liaison with both the City and YYC. The study was further complicated given the project was initiated prior to signing a sublease agreement for the tunnel between the City and YYC. For instance, the sublease agreement concluded a cost sharing agreement for the future infrastructure which required a higher level of attention in the development of cost estimates. As a result, the methodology of the study had to be modified continuously as parameters were confirmed with various parties. Close liaison was required with YYC in order to confirm the numerous planned developments on its lands and to ensure that the proposed roadway plans complimented future development within YYC lands including future terminal and parking garage expansions.

Technical parameters coming from the sublease agreement, which propagated issues, include the reduction in the number of lanes in the tunnel from ten (10) lanes to six (6) lanes per the January 2011 study which assumed an arterial Airport Trail between 36 Street and Deerfoot Trail. Complicating the issue above was the requirement to accommodate a LRT line both along the corridor and through the constrained tunnel cross-section. The forecasted high traffic volume at sections along the corridor required specific attention to a variety of design elements and was more involved compared to typical freeway designs. In addition to providing access to adjacent development and the airport, the access constraint was superimposed with and complicated in two locations where adjacent interchanges were 800m apart: 19 Street to Barlow Trail and 36 Street to Metis Trail. These two locations required specific attention to traffic movement and geometric design.

Although much of the land along the corridor is currently greenfield, many of those properties are currently being developed or have plans for development. As a result, liaison with adjacent property owners was crucial in this study. An important issue with the developers was to ensure that the future access points and interchange layouts would have minimal impact on their developments.

The Calgary Regional Transportation Model (RTM) is the source of future traffic forecasts in the City of Calgary where forecast intersection turning movement data from the EMME-based model is calibrated against current turning movement counts, and corrections made to the intersections, as well as nearby new intersections. In general, this approach produces strong forecasts, however one limitation to the modelling process is that traffic from special generators is generally not as accurate as traffic in other areas. Traffic from special generators like YYC are harder to model in a four-stage model because airport trip generation is not strictly linked to the number of employees at the airport, as is generally the case in other employment categories. Airline passengers using the airport arrive and depart throughout the day with their peak periods not necessarily coinciding with the adjacent street traffic and its peak traffic not a mirror image of one another as for typical employment centres. Additionally, it was determined that several large mixed-use employment centres to the west, north, and east of the airport were also under-represented in terms of development in the RTM and needed to be adjusted for in the model.

5.0 Study Approach: Accommodating Constrained Design Parameters

This project required significant involvement with stakeholders, owners, developers, and consultants who were performing work or studies in the area. The various technical challenges required a unique balance which weighs the advantages and disadvantages of the design approaches to provide an optimal solution which addresses the design parameters and issues.

5.1 Liaison with Various Parties

Given the numerous constraints and technical challenges along the corridor, the design process was not a traditional option development and evaluation for a preferred option; rather, the project involved an ongoing design process requiring liaison with the City, YYC and their consultants as the design evolved. To expedite the study, the design process involved weekly meetings as a platform to exchange ideas and to incorporate the goals of the owners while also addressing the numerous technical constraints along the corridor. The interactive collaboration with the owners in the design process allowed for a unique balance between ensuring a safe and efficient transportation system with one that meets both the technical requirements and agency goals.

5.1.1 Integration with Concurrent Studies and Projects

In addition to having the City and YYC as primary contributors to the project, the project also required the coordination with consultants from other projects running concurrently in the area. The functional planning study required continuous integration with the development in plans from other projects in the area including the incorporation of transit parameters from the NE LRT Study, integration with the findings from the overall NE Network Study, and the establishment of the ATT parameters as the tunnel is being constructed. The coordination with these paralleling projects often brought other design parameters which were to be addressed and incorporated into the functional plan.

5.1.1.1 Transit Integration

Integration of the LRT was crucial to this project. In addition to the NE LRT which parallels 60 Street and crosses over Airport Trail, the plans were to also accommodate a spur-LRT line from the NE LRT to YYC along Airport Trail. Given the various access and egress ramps along the corridor, the potential spur-line was located within the median of Airport Trail to minimize conflicts with vehicles and to improve safety. As the potential future LRT station locations were not determined, a constant median width had to be provided in certain sections of the corridor to accommodate both the LRT line and a potential station. The wider median is protected along longer sections of the corridor to provide flexibility of accommodating stations in the future. The intricate balance of the competing right-of-way requirements for the vehicular and transit realm in the tunnel is discussed further in a subsequent section of this paper.

5.1.1.2 Roadway Network Integration

The NE Network Study worked on confirming the classification of one of the major cross-streets on Airport Trail: Metis Trail. The NE Network Study was to confirm whether Metis Trail will be classified as either a skeletal, requiring a systems interchange at Airport Trail with free-flow ramps, or an arterial, allowing a service interchange with intersections. The classification of Metis Trail has a significant impact on the overall northeast network and locally at Airport Trail. With the classification of Metis Trail undetermined, the functional plans for Airport Trail required flexibility to be built-in to allow for either scenario regarding the classification of Metis Trail and the corresponding interchange layout.

The skeletal Metis Trail was designed with a cloverleaf interchange with collector distributor roads and loop ramps requiring significantly greater costs in roadway width, structure area and right-of-way acquisition costs in addition to having operational issues due to close proximity of the 36 Street interchange. The provision of a skeletal classification for Metis Trail would have allowed for free-flow movement along the Metis Trail, which also parallels the neighbouring freeways Deerfoot Trail, 4.5km to the west, and Stoney Trail, 3.5km to the east.

The arterial Metis Trail allows for a service, Parclo A, interchange, which allows for intersections on Metis Trail while also reducing right-of-way acquisition and various cost elements. The provision of an arterial would allow for additional access points along Metis Trail to adjacent lands and provide direct connection from communities to commercial and employment areas. Near the conclusion of the study, the classification of Metis Trail was approved by council as an arterial classification which was included in this study as the preferred option.

5.1.1.3 Airport Trail Tunnel Integration

A unique aspect of the study was that the transportation requirements from this study did not dictate tunnel parameters; rather, the tunnel parameters dictated the allowable transportation requirements for the functional plan. Since the tunnel was being designed and constructed as the functional plan for Airport Trail was developed, ongoing communication with the ATT construction team was vital for the functional plan development. It was to be ensured that the functional plan complement the constructed tunnel attributes as much as possible to minimize reconstruction during the implementation of future plans and maximize investment in infrastructure. Various design elements from the ATT project required integration into the design including the cross-section elements, horizontal/vertical geometry and structural requirements outside the tunnel.

The cross-section elements of the constructed tunnel would ultimately put a constraint on the number of vehicular and transit lanes that may be offered in the tunnel. The lane restrictions within the tunnel resultantly put severe constraints on the laning requirements outside the tunnel and particularly at adjacent interchange ramps and their geometry. The challenges with the lane balance and geometric features of the ramps are discussed in further detail in a subsequent section.

The straight horizontal geometry of the tunnel was simply matched with what was being constructed and was not a major design constraint; the vertical geometry of the tunnel, however, required greater attention when integrating the constructed tunnel portal grades with future functional plan implementation of the adjacent interchanges which are as close as 330m from the tunnel. Through the planning study, it was identified that the future grade of Airport Trail at Barlow Trail, immediately west of the tunnel, would need to be lowered from the current constructed grade in order to accommodate required ramp grades and structure elevations when the interchange is constructed in the future. When designing the interchanges adjacent to the tunnel and incorporating the constructed tunnel portal grades, instead of following what is typically done in design in setting the cross-street profile first then the ramp profiles, a reverse approach was required to accommodate the constraints from the tunnel and to minimize future reconstruction when the Barlow Trail interchange is constructed. The ramp profile adjacent to the tunnel portal was set first as the constraining factor to determine the minimum amount of reconstruction on Airport Trail required in light of the design parameters. The profile of the Barlow Trail cross-street was then set with respect to the ramp grade, the clearance requirements over Airport Trail and the impacts to YYC lands. This reverse approach to design was significant in ensuring that the minimal amount of reconstruction would be required while also meeting the technical standards for ramp geometry.

The initial plan for the tunnel portals was to construct the retaining walls which were nearly parallel to the through travel lanes. The provision of such walls would have had significant impacts on the adjacent interchanges' ramp designs since standard parallel lanes or tapers could not be properly developed to provide acceptable ramp designs. Through further liaison with the ATT construction team, it was determined that the retaining walls, which were previously planned to be constructed, would be replaced with cut-slopes; resultantly, more acceptable ramp designs with proper tapers may be implemented at the tunnel portals. The change in structural requirement at the tunnel portals provided greater flexibility in the development of future plans and exemplifies that less is more in some applications.

5.2 Technical Parameters

The primary parameters to be integrated in the study was the adjusted traffic volumes, reduction in the number of lanes through the tunnel from previous plans at ten (10) lanes to six (6) lanes and the reclassification of Airport Trail to skeletal standard. The approach for the solution to the traffic volumes and the other issues that resulted from changes in the key design parameters of the number of tunnel lanes and classification of Airport Trail are described subsequently.

5.2.1 Modelling

In order to approach the issue of accommodating traffic generated by the special trip generators into the EMME model, there were options to be considered to calibrate the model in order to properly accommodate the unique land use. One method used to resolve model-related problems stemming from a large RTM is to create a subarea model with smaller zones. That was not done in this case because the issue was not related to a lack of spatial or land use detail, but because of the trouble inherent in modelling a non-typical traffic generator like an airport. A manual methodology using basic traffic impact assessment (TIA) principles for estimating traffic was used instead.

To resolve the issues related to the traffic modelling at the airport, the following process was followed:

1. Obtain traffic forecasts from City's Forecasting Division.
2. Isolate the traffic flowing into and out of the airport in the forecast data based on "select zone" and "select link" data.
3. Remove these traffic volumes from the forecast volumes – The remaining traffic is "background traffic" not related to the airport.
4. Determine new volumes of traffic to and from the airport.
5. Use routing of the traffic volumes from the zones that were in the RTM as a basis for determining routing and turning movements of newly-calculated airport traffic volumes.
6. Combine the derived turning movements with the background traffic.
7. Use these figures for analysis/design of network.

First, the forecast turning-movement data was obtained from the City's Forecasting Division including "select link" and "select zone" volumes from EMME for traffic into and out of the zones representing the Airport in the model. The traffic representing the Airport and the various nearby large mixed-use employment centres was subtracted, or "zeroed out", from turning movements in the City's volumes, leaving "background" turning movement data. Next it was necessary to create estimated volumes for traffic entering and leaving the various components of the under-represented areas and incorporate these into the modelled turning movement volumes.

With respect to the airport, there were two methodologies which were used to estimate airport traffic volumes. One method used data from Institute of Transportation Engineers (ITE) Trip Generation Manual to estimate the number of trips based on the number of flights on a daily basis at the airport. Future estimates on the number of flights at YYC were available from planning documents from the airport, and were used to estimate total trips in and out of the airport. The second method used rates from a joint YYC and City study, 2003 *Northeast Network Study* [6], where counts had been made at various locations on the road network serving the airport. This data was synthesized, along with other sources of data such as annual origin-destination passenger totals and figures related to the number of travellers leaving and not leaving the airport (passing through en route) to generate three classes: travellers, airport staff or employees, and airport services such as deliveries and security.

After generating estimates of 2029 and 2039 trip totals, the data was discussed with the City with a decision made to use the City-based data rates, the second method, rather than ITE rates. Although the number of trips generated was relatively close in terms of total traffic generated, the second method generated fewer trips, and it was assumed that the second method was more representative as it was based on local data rather than a set of data from various airports from other cities. Separate volumes were estimated for the three classes for the A.M. and P.M. periods. Additional data from a separate functional planning study completed for the 2005 *Airport Trail Functional Planning Study* [3] was used to estimate the number of recirculating trips (trips that circulated on the site but did not leave the airport site) for each class – such as security patrols and shuttles servicing different areas of the airport.

The routing of traffic within the airport was classified into three distinct areas using the 2005 study:

1. Terminal (a major location for passengers being dropped off or picked up)
2. Airport Services (a cluster of multiple parking lots for employees and airport services)
3. Parking (a major parking structure on site for airport passengers)

For the large developments near the airport, the following process was followed to incorporate their traffic volumes onto the network. After zeroing out the existing trip generation in the RTM, trip generation for the proposed developments, which were based on the private developer's TIAs, was tallied. The majority of these volumes had been estimated using the ITE Trip Generation Manual. Trips were distributed using the distribution patterns from the RTM for the zones. Traffic was then manually assigned using a diagram of the future road network for the Airport Trail corridor and the on-site intersections composing the 2029 and 2039 stages of build-out of the transportation network in a spreadsheet model.

The recalibration of the model was a multi-stage process where the different classifications of traffic, as well as background traffic, were added using a spreadsheet with multiple worksheets. These were then summed to estimate the traffic at each intersection making up the network with the turning movement figures reviewed for inaccuracies such as over-assignment on one route where an alternative existed. Turning movement figures were then incorporated into Synchro/SimTraffic modeling as well for use by the designers in sizing ramps, adding or removing turn bays and auxiliary lanes. The 24 hour volumes for the 2029 and 2039 horizons are shown in Figure 3 [2]; the 2039 peak hour volumes are shown in Figure 4 [2].

5.2.2 Design Speed to Maintain Access and Interchange Spacing

The initial design speed for the skeletal Airport Trail was considered to be 90km/h along the entire corridor. As the project developed, it was realized that a reduction in the design speed to 80km/h was required from Deerfoot Trail to Metis Trail for several reasons: to provide the desired access and egress at specified locations at the airport, to maintain interchange locations, and to improve weaving lengths.

With the design speed reduction, previously planned interchange locations may be maintained which subsequently minimizes the impact to developer plans on adjacent properties. If the design speed was to be maintained, there would be additional sight distance constraints to the ramp exits as traffic exited the tunnel and travelled towards the 36 Street and Metis Trail exits. Given that adjacent developers have produced plans for their properties with the previously assumed interchange location, the realignment of Metis Trail towards the east is notably undesirable as not only will land need to be acquired but also developer plans would need to be amended.

The lower design speed on Airport Trail allows for shorter ramp length requirements based on design standards. Considering the significant weave segment between Deerfoot Trail and 19 Street, the shorter ramp lengths, resulting from a lower design speed, would entail greater weaving lengths between entrance and exit ramps – effectively helping to improve operational and safety issues along Airport Trail. With a higher design speed, additional operational and safety issues would evolve where there are sequential entrance ramps. Having sequential entrance ramps, in a higher speed design, would require longer ramp lengths and would increasingly saturate the lanes in which the downstream ramps are merging with.

5.2.2.1 Airport Access

The configuration of the access to the Airport was complicated by the close proximity (600m) of the terminal to Airport Trail. With future airport expansion, this distance will be further reduced to just over 100 m (See Figure 5 [2]). This short distance combined with YYC’s objective to provide free-flow access to and from the terminal was especially unique with grade-separation required at Airport Service Road which is half way between Airport Trail and the current terminal. As with other ramps, careful attention was required in identifying how ramps would be merging and diverging from one another with specific consideration to intersections, weaving segments, horizontal and vertical geometry. The functional design developed for the roadway system on YYC lands was a unique system that incorporated grade separations, intersections and recirculation movements all within a constrained parcel of land.

The ingress ramps from the airport lands to Airport Trail required specific attention as a result of the reduction in the number of lanes in the tunnel. Previous plans with the ten (10) lane tunnel allowed for two lane additions, on top of the three core lanes, from the airport area entering into the tunnel. With the new six lane tunnel, the ingress ramps from the airport lands were severely constrained. An efficient combination of traffic movements was required which included consideration of structures, roadway costs, and traffic volumes coming from the various trip generators. The optimal solution was to merge parking with southbound Barlow Trail traffic through a loop ramp and merging Airport Service Road with terminal traffic (See Figure 5). This final configuration eliminated an intersection on Barlow Trail or the need to construct additional grade-separation bringing an operationally sound configuration with lower construction costs.

5.2.3 Tunnel Lane Reduction

Given the reduced tunnel cross section, the requirement for LRT in the tunnel and future development in the area and its associated traffic volumes, there was a challenge in accommodating lane balance and in dedicating vehicular and transit right-of-way along the corridor and in the tunnel. The above constraints combined with the previous technical challenges required a vigorous design process that would either meet or balance the requirements of the various constraints.

5.2.3.1 Lane Balance and Core Lanes

It was required to ensure that a lane balance scenario may be developed which will satisfy three primary parameters for the ramps: accommodate projected volumes, be feasible geometrically at their identified and desired location, and have the appropriate spacing to other ramps or the tunnel. When considering the traffic volumes along the corridor, it was acknowledged that two-lane exit ramps were required at various locations. As a principle of lane balance at exits, the sum of the downstream lanes (number of core lanes plus number of ramp lanes) shall be one more than the number of upstream lanes. As two lane exits were required sequentially at various locations along the corridor, one lane was lost on Airport Trail at each of the two-lane exits, as standard two-lane exits involve one must-exit lane and one diverge lane. Where two-lane exits were numerous, there was the consequence of requiring the reduction of core lanes on Airport Trail from the desired three (3) lanes to two (2) lanes per direction at several locations. The sequential lane drops which reduced Airport Trail to two (2) core lanes required a mutual agreement between the City and YYC.

5.2.3.2 Balancing Transit and Vehicular Demands

Another unique approach in this study was in how lane balance was worked backwards to determine that four (4) lanes would be required on Airport Trail in the westbound direction of the tunnel, which is one additional lane than what was previously planned for in the preliminary design. With an absolute minimum of two (2) core lanes to be provided on Airport Trail and two sequential two-lane exits to YYC and Barlow Trail, four (4) lanes were required westbound through the tunnel to accommodate future volumes and provide lane balance.

With the requirement for a four lane tunnel determined, there was the issue that the tunnel is currently being constructed to accommodate three travel lanes with an LRT line in each direction. The NE LRT Study consultants confirmed that there would not be sufficient demand to warrant a LRT line from the Northeast line to the airport. However, the City desired to provide a LRT line through the tunnel. Similarly, as with other aspects in this project, a balance between vehicular and transit demands was achieved by providing a single two-way track LRT on the eastbound cell of the tunnel which would allow for the required four vehicular lanes through the tunnel on the westbound carriageway.

6.0 Conclusions and Lessons Learnt

The Airport Trail functional planning study is a unique planning experience with a high level of constraint in several areas including institutional, technical and socio-economic, requiring close attention to details and the monitoring of a continuous and ever evolving change in design parameters. With funding of the project coming from both the City and YYC, the design of the final skeletal roadway configuration is a result of a collaborative effort between the two jurisdictions. Close liaison and frequent meetings was the key to the project’s ultimate success. Changes in design parameters have resulted in profound changes to the roadway geometry, and in the layout of adjacent interchanges. The provision for a future LRT within the corridor introduces a risk that needs to be addressed by the City with a very high price tag for implementation in consideration of forecasted demand. Compared to these institutional and financial considerations, technical issues such as interchange spacing, access points and ingress and egress, lane balancing, and heavy projected traffic volumes seem to be less onerous with adequate design skills and some ingenuity.

References

1. City of Calgary, “Calgary Transportation Plan”, September 2009
2. City of Calgary, “Airport Trail NE Functional Planning Study: Deerfoot Trail NE to East of 36 Street NE” and “Airport Trail NE Functional Planning Study: 36 Street NE to Stoney Trail NE”, June 2012.
3. City of Calgary and Calgary Airport Authority, “Airport Trail Functional Planning Study”, April 2005
4. City of Calgary, “96 Avenue N/Runway Crossing – Planning Summary”, December, 2008
5. City of Calgary, “Airport Trail Underpass Functional Planning Study”, January 2011
6. City of Calgary and Calgary Airport, “Northeast Network Study”, 2003

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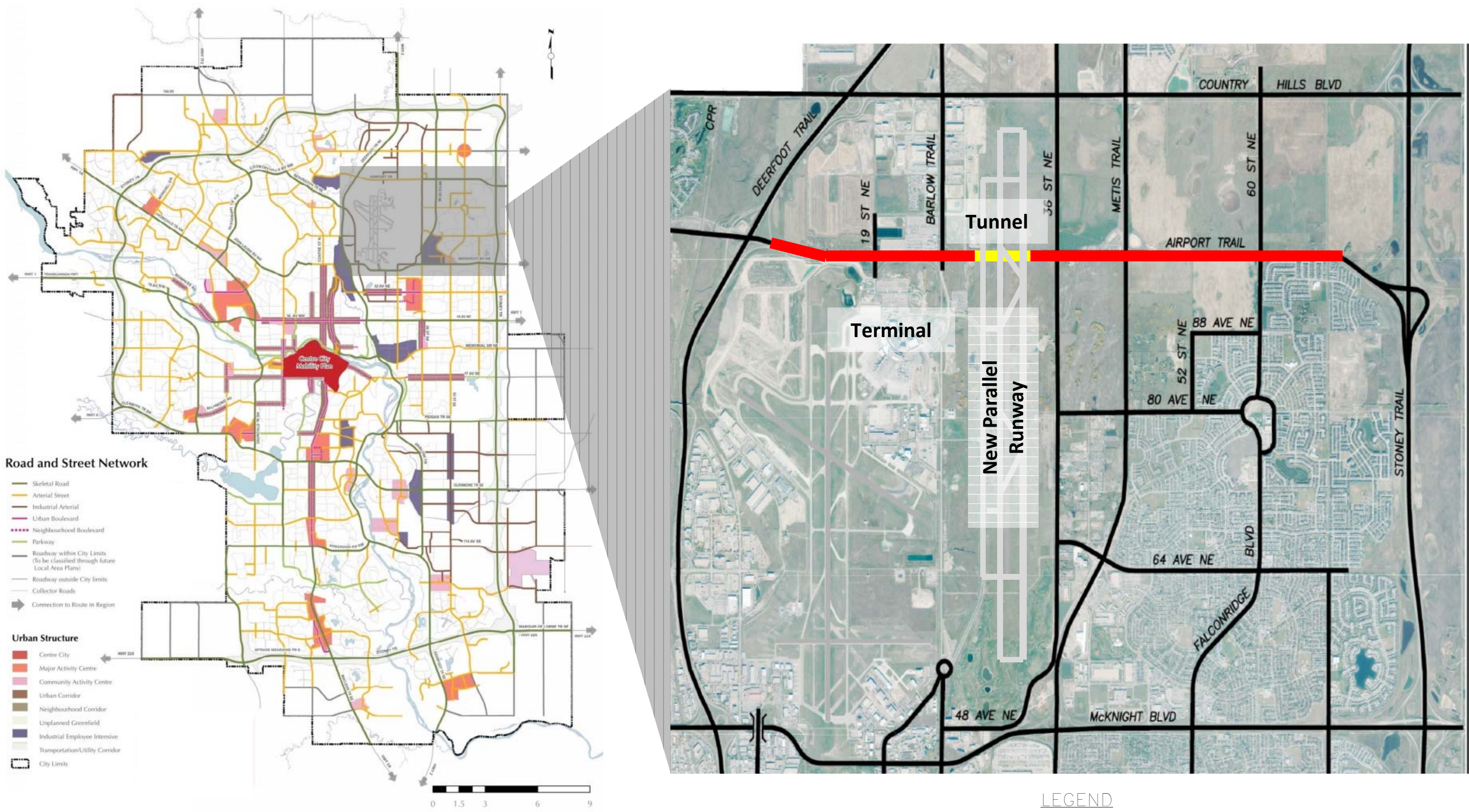


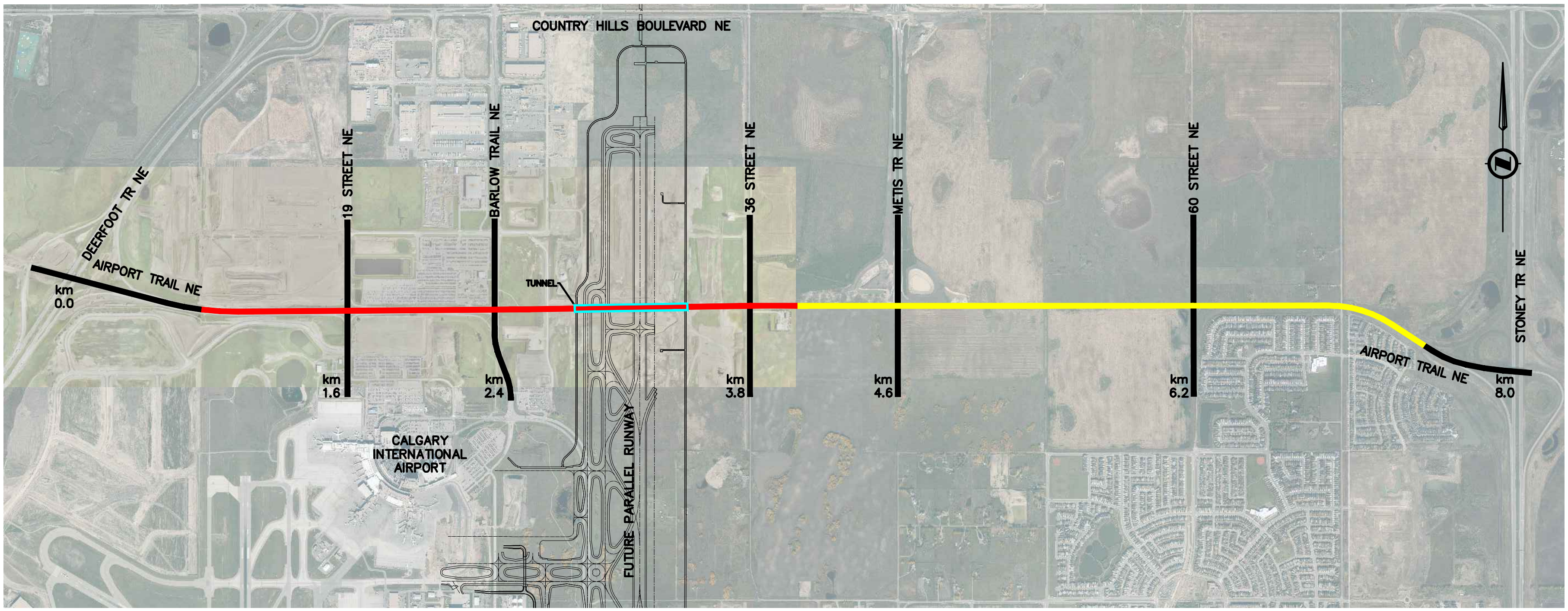
Note:
–Road and street network map obtained from City of Calgary, *Calgary Transportation Plan*, 2009 [1]

LEGEND

STUDY CORRIDOR

TUNNEL

Figure 1: Overview Map



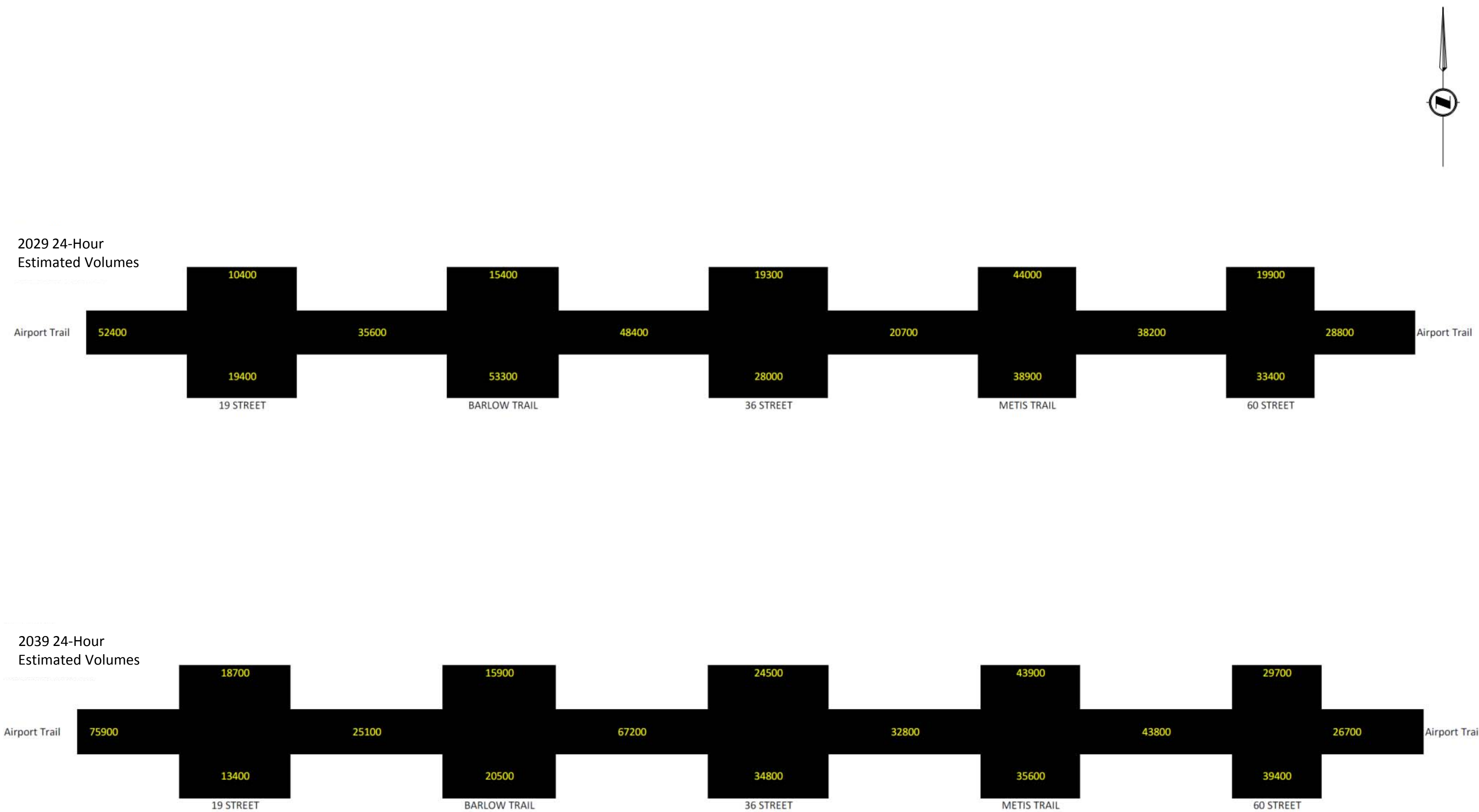
LEGEND:

- STUDY AREA – WEST
- STUDY AREA – EAST
- CROSS STREET – ROADWAY
- TUNNEL

100m 0 200m
HORIZONTAL

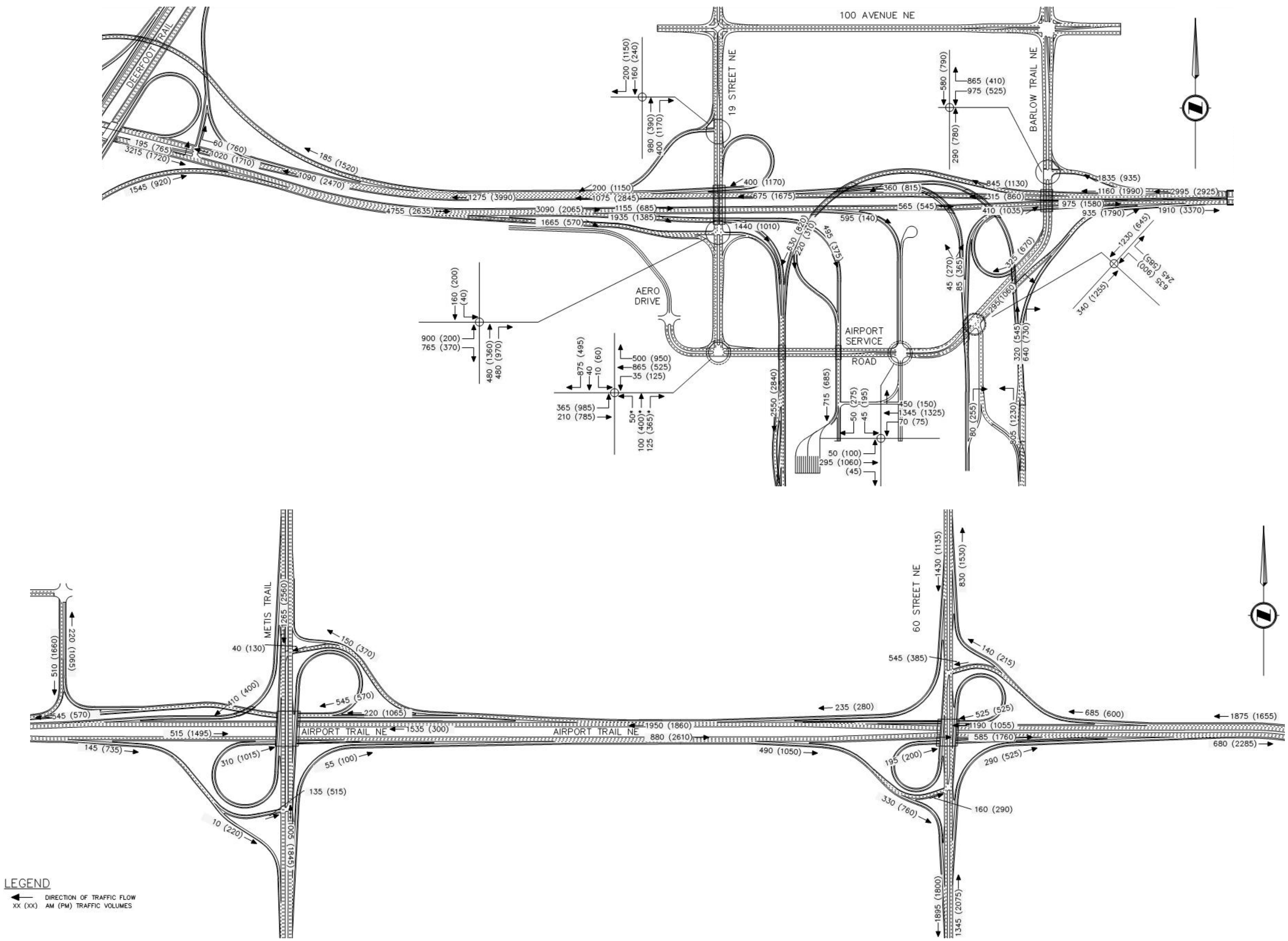
NOTES:
–FIGURE MODIFIED FROM THE 2012 AIRPORT TRAIL NE FUNCTIONAL PLANNING STUDY: DEERFOOT TRAIL NE TO EAST OF 36 STREET NE AND 36 STREET NE TO STONEY TRAIL NE [2]

Figure 2: Study Area and Segments



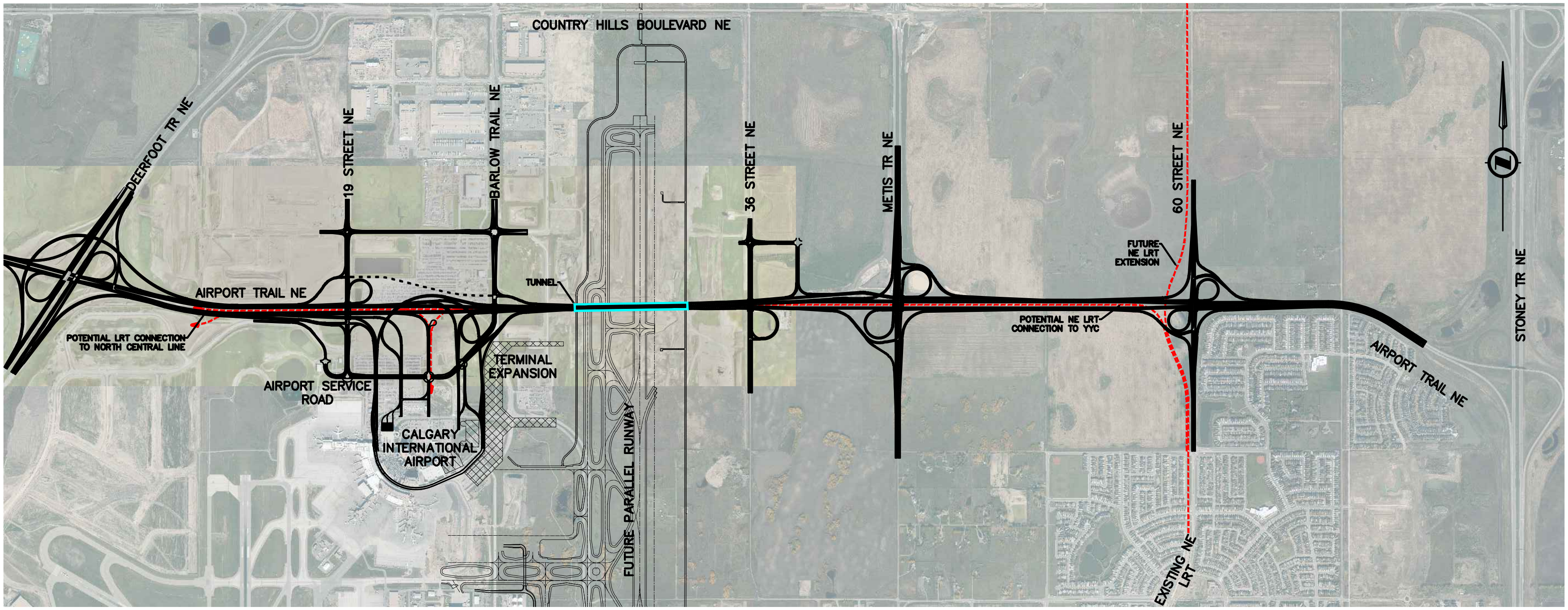
Note:
–Figure modified from the 2012 Airport Trail NE Functional Planning Study: Deerfoot Trail NE to East of 36 Street NE and 36 Street NE to Stoney Trail NE [2]

Figure 3: 24 Hour Volumes



Note:
–Figure modified from the 2012 Airport Trail NE Functional Planning Study: Deerfoot Trail NE to East of 36 Street NE and 36 Street NE to Stoney Trail NE [2]

Figure 4: 2039 Peak Hour Volumes



LEGEND:

- POTENTIAL AND FUTURE LRT
- TUNNEL

NOTES:
- NOT TO SCALE
- FIGURE MODIFIED FROM THE 2012 AIRPORT TRAIL NE FUNCTIONAL PLANNING STUDY: DEERFOOT TRAIL NE TO EAST OF 36 STREET NE AND 36 STREET NE TO STONEY TRAIL NE [2]

Figure 5: Functional Plan