Edmonton's LRT
Setting the Stage for Heading Further South

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ABOUT EDMONTON

The City of Edmonton is one of Canada's fastest growing cities. The capital of Alberta, Edmonton currently houses over 750,000 people and has a metropolitan population of over 1.1 million people. By 2040, Edmonton is expected to grow by 400,000 people – an increase of over 50%. To accommodate the ever-growing population, Edmonton not only has to develop new infrastructure, but also a transportation network capable of supporting the growth.

Within the city, Edmonton has one of the highest car dependency rates in Canada. A 2005 Household Travel survey indicated that public transportation accounts for only 9% of the 2.5 million trips made each day, while vehicular travel accounts for approximately 77%. Further, between 1994 and 2005, the total amount of kilometers traveled by automobile in the city increased by 32%, despite a population growth of only 13% over the same period. The development and expansion of the existing public transportation system is thus fundamental to the City's Transportation Master Plan.

Figure 1. Location of Edmonton

LRT IN EDMONTON

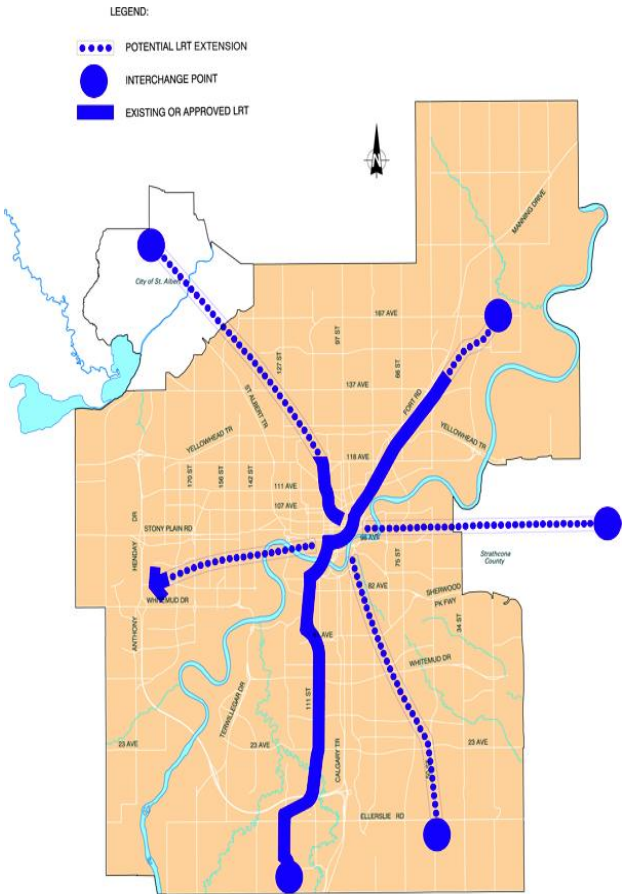
In 1978, the City of Edmonton opened its first LRT line, becoming the first city in North America with a population under one million to build a Light Rail Transit

System. Since that time, the system has expanded north-south to include approximately twenty kilometres of track and fifteen stations, six of which are underground. The most recent eight kilometre extension was completed in April 2010, bringing the route into Edmonton's highly populated south side and terminating at Century Park.

Figure 2. Existing LRT Alignment to Century Park

Expanding the LRT network has been identified as one of the ways to meet the objectives of the City's strategic vision of providing a more compact, livable and sustainable community. The City has recently developed an overall LRT network that will include six ultimate lines extending to the Northwest, Northeast, East, Southeast, South, and the West.

Planning and engineering for each of these lines is in varying stages. Concept planning is underway for the West and Southeast LRT. Preliminary engineering of the South LRT extension - the subject of this paper - has recently been completed, alongside preliminary design of the Northeast extension. Detailed engineering for the Northwest LRT extension to NAIT is scheduled for completion at the end of 2010, while strategic planning for the continuation of the Northwest extension to the City limit is ongoing. Strategic planning for long-term circulation in the Edmonton's downtown is also ongoing, as the existing downtown tunnel cannot accommodate the ultimate LRT network. While the tunnel can adequately accommodate the existing system and its extensions –the Northeast, South and Northwest lines – the West and Southeast LRT will be physically independent.



Separation of the West and Southeast LRT from the existing system is consistent with a technical review of LRT vehicle types, which was undertaken in early 2009 to identify which vehicle style would be most appropriate to meet long-term transportation objectives. High-floor LRT technology will be maintained along the existing system and its extension, including the Northeast, Northwest and South extensions. However, the West and Southeast lines will be developed using low-floor technology, allowing for easier integration in those mature areas of the city.

Figure 3. LRT Network Plan

With respect to construction priorities, a detailed business case of the LRT network is to be completed. This will include an assessment of the network for projected ridership, and include factors such as cost, redevelopment potential and funding availability.

THE SOUTH LRT EXTENSION: CENTURY PARK TO ELLERSLIE ROAD

In July 2008, Edmonton City Council approved the concept plan for the South LRT extension from Century Park to the south City Limit. The concept plan established the alignment, right of way, station locations and land uses along the South LRT. Four route alignments were identified and evaluated during concept planning, all of which provided the potential to attract ridership and to respond to future growth and land use plans in southwest Edmonton. Among several other factors, the finalized route maximized the use of available public right-of-way for the LRT infrastructure, minimizing utility impacts and the effects on natural and social environmental features.

In April 2009, Edmonton City Council approved funding for preliminary engineering of the South LRT extension from Century Park to Ellerslie Road. In the absence of funding and a defined construction schedule, the primary purpose of the preliminary engineering assignment was to further define the LRT right-of-way; optimize the concept design, identify major risk activities and develop mitigation strategies to reduce the construction schedule and overall project costs; and integrate LRT into the existing landscape, adjacent communities, and transportation system. Preliminary engineering for this 4.5 km extension was recently completed through a partnership of Prime Consultant AECOM Canada Ltd., and Associate Consultants, Stantec

Consulting Ltd. and ISL Engineering and Land Services Ltd., with assistance from numerous specialists and sub-consultants.

The proposed extension will head south from the newly opened Century Park station, located within the median of 111 Street north of 23 Avenue, to a station and fully integrated Transit Centre at Ellerslie Road. The LRT will travel through an underpass at 23 Avenue and 111 Street, and return to grade south of 23 Avenue along the west side of 111 Street. The LRT will operate along the west side of 111 Street up to the Transportation and Utility Corridor (TUC), with surface crossings at Saddleback Road (19 Avenue), 12 Avenue and 9 Avenue, all collector roads servicing residential areas along the 111 Street corridor.

South of 9th Avenue, the route will diverge from the 111th Street right of way. Once within the TUC, the LRT will curve west and over Anthony Henday Drive, a major goods and services movement corridor and part of Edmonton's outer ring road. South of Anthony Henday Drive, the LRT alignment will head westward, then veer south and continue within provincially-owned lands, approximately 300m west of 127 Street to terminate (for the purpose of the preliminary engineering assignment) at Ellerslie Road. This is the location of the proposed Ellerslie Station and Transit Centre, as well as a proposed Park and Ride Facility and a potential Operations and Maintenance (O&M) Facility.

Figure 4. Route Alignment

PROJECT ISSUES AND CHALLENGES

Numerous project issues and challenges were identified during the preliminary design phase of the South LRT extension, through value engineering of various components of the extension. Formal risk analysis and constructability reviews were fundamental components of the preliminary engineering assignment. Public involvement was also an important factor throughout the project, influencing integration of the design into neighbouring communities.

Project highlights discussed in this paper include:

- Stakeholder and Public Involvement;
- Design of the underpass at 23rd Avenue and 111th Street;
- Design of the combined pedestrian and LRT bridge across Blackmud Creek;
- Protection for future integration of a community station at Twin Brooks;
- Design of the major grade separation at Anthony Henday Drive;
- Integration of the LRT Station with the Park and Ride Facility and Transit Centre;
- Provisions for future Operations, Maintenance and Storage Facility.

Stakeholder and Public Involvement

In accordance with the City of Edmonton's Public Involvement Framework, a public involvement plan was developed for the South LRT Extension preliminary design project. The objective of the public involvement plan was to inform stakeholders such as adjacent landowners, businesses, residents and interested members of the public about the project and provide opportunities for input in a straightforward, timely manner. Public input was specifically sought for aspects such as architectural features, landscaping, noise attenuation and visual screening, with the objective of determining the "best fit" for LRT with neighbouring communities.

A number of strategies were used for the public involvement component of the project, including: one-on-one meetings with key stakeholders; meetings with landowners and businesses immediately adjacent to the LRT corridor; two public open houses; and a Stakeholder Involvement Panel (SIP). The SIP was set up with volunteer members from adjacent communities and representatives from the community leagues likely to experience the most direct impact of the LRT extension. Two SIP meetings were held during the preliminary design phase to allow SIP members a direct opportunity

to discuss landscaping, aesthetics, noise mitigation and traffic impacts with the project team.

Of particular interest to many stakeholders were noise attenuation and visual screening; property values; construction staging; traffic impacts and neighbourhood access; and station design and aesthetics. Many expressed a desire for a nature-related, suburban design theme. This became the basis of the decision to incorporate natural and suburban landscaping and aesthetic features into the final preliminary design.

The overall result of the public involvement process was that those affected by the South LRT extension were provided with a number of formal and informal opportunities to obtain information and to provide comment throughout the project. Though stakeholder input had to be balanced with budgetary and technical considerations, public feedback was beneficial to the project team in finalizing preliminary engineering.

LRT Underpass at 23rd Avenue

The intersection of 23 Avenue and 111 Street, both major arterial roadways within the City of Edmonton, is closely bordered by commercial and residential developments. With current traffic volumes of up to 32,000 vehicles per day, projected to increase with further development in southwest Edmonton, a grade separation is required.

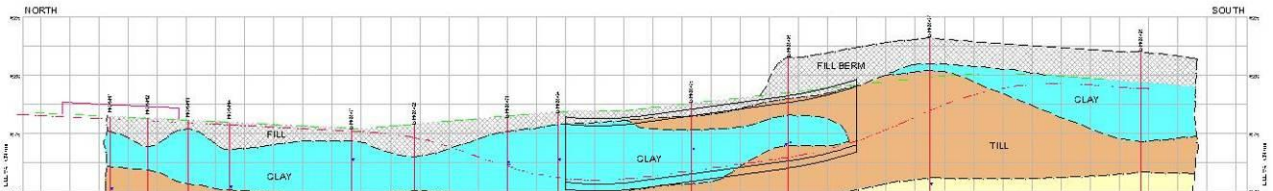
Conceptual planning for the 23 Avenue crossing identified a cut and cover section of approximately 350m in length, with 450m portals. In order to maintain operation of the intersection during construction with similar capacity to what exists today, it was recognized that a significant amount of temporary roadwork would be required for construction of the underpass. In addition, the duration of construction was estimated at approximately three years. The only underpass within this 4.5km LRT extension, this presented a key area for potential cost savings and optimization of the construction schedule.

Several options for this LRT crossing were thus reviewed upon initiation of preliminary engineering. The resulting plan included tightening of the horizontal and vertical geometry, and widening of the median along 111 Street. Widening of the median could be accomplished by realigning the existing southbound lanes of 111 Street toward the west limit of the road right-of-way, creating an opportunity for an open cut underpass and a reduction of the amount of structural work required. What followed was an iterative process and review of various structural alternatives, including a comparison of two structures separated by approximately 60m of open cut, and a single tunnel measuring approximately 230m from portal to portal – still a significant reduction from the original concept plan. Both options were comparable from a cost and constructability perspective, however the single tunnel option was preferred based on sight lines and operations and maintenance issues caused by the area of open cut.

Figure 5. 23 Avenue/111 Street Southbound Rendering

Geotechnical conditions were also a complicating factor in the design of the underpass. Preliminary geotechnical investigations identified the presence of an outwash sand layer. Although the proposed track elevation is above the outwash sand layer, groundwater levels were measured up to 2.5m above the LRT track over a distance of approximately 400m, posing significant implications with respect to the underpass.

Mitigation strategies were identified for both construction and long-term operation of the LRT, involving depressurization of the sand layer using vertical pressure-relief drains connected to a permanent granular drainage blanket. Similar sand layers within the City of Edmonton have been found to be discontinuous, with high permeability but low storage capacity. As such, the risk of long-term settlement was deemed to be low and within acceptable limits. With respect to construction, it has been recommended that piezometric levels in the outwash



sand be drawn down to a minimum of one meter below the proposed bottom of excavation, prior to construction. Based on preliminary investigations, these levels could potentially be maintained with a well-point system, vertical pumping wells, and/or passive relief wells. However, additional site investigations such as pump tests will be required to confirm the depressurization strategy for construction of the underpass, and to confirm the spacing and staging of the dewatering wells.

Constructability of the 23 Avenue underpass presents a significant challenge and construction of the underpass, estimated to take three years, will likely be the driving factor for the overall project schedule. Land around the existing intersection is fully developed, restricting potential laydown areas. A traffic accommodation strategy has been developed to maintain access throughout construction and create a laydown area. However, construction of the detour is fairly extensive and in itself will add several months to the project. In addition, multiple major utility relocates will be required, including relocation of a major water line, an existing high pressure gas line and tunneling of a new storm sewer. Utility relocates will require a substantial amount of lead time, and utility coordination will be critical to the construction schedule. To reduce the schedule, partial road closures will also be considered during Detailed Design.

LRT and Pedestrian Bridge over Blackmud Creek

There are currently two parallel bridge structures across Blackmud Creek on 111 Street, to accommodate northbound and southbound traffic. Pedestrians and cyclists are accommodated on a multi-use trail along the west side of the southbound bridge. Concept planning for the LRT extension included a separate LRT bridge, west of the southbound structure. To maintain multi-use trail connectivity north and south of the creek, a higher bridge structure was proposed for the LRT, with the multi-use trail passing below the LRT structure to tie into the existing southbound bridge. This resulted in an unnecessarily long bridge with an odd aesthetic, elevated above the roadway.

Several options were thus evaluated to reduce the length and height of the new bridge, and to accommodate both the LRT crossing and multi-use trail. Based on preliminary engineering, the recommended LRT crossing consists of a joint use girder bridge, matching the elevation of the existing structures.

A separate, fourth structure was considered to accommodate multi-use trail users; however, public consultation and communications with the City of Edmonton Parks Branch indicated a preference to reduce the total number of crossings, and to minimize the environmental and visual impact of the project within Blackmud Creek. Including the multi-use trail along the LRT bridge was also preferable from the perspective of minimizing vertical grades along the trail. Finally, inclusion of the multi-use trail on the new structure would effectively result in the abandonment of the existing multi-use trail on the southbound bridge. A conceptual review of the bridge indicated that, should it be warranted by future traffic volumes, the multi-use trail can be converted to a third southbound lane.

An environmental overview was completed for the Blackmud Creek crossing to define the existing environmental conditions within the footprint of the project. Potential impacts to terrain, topography and soils, vegetation, wildlife and wildlife habitat were identified alongside potential mitigation strategies.

Details and timing for an Environmental Impact Assessment will be considered prior to Detailed Design.

Figure 7. Blackmud Creek Bridge Rendering

Protection for Future Integration of a Community Station at Twin Brooks

The Twin Brooks community is located between Blackmud Creek and Anthony Henday Drive. It is a relatively new community and consists primarily of single family residential housing. Based on the relatively low population density and low potential for ridership, Twin Brooks was identified as a low priority location for an LRT station during concept planning. However, part of the preliminary engineering assignment included the development of a staging plan for a possible future community station between 9th and 12th Avenue. An evaluation was undertaken of the costs and operational

impacts of constructing a station sometime later than construction of the main line.

Three options were identified to protect for a 6.0m center-loading station within the existing road right-of-way. These options were evaluated, primarily based on constructability and operational impacts during retrofit of the LRT line to include a new station. Advantages and disadvantages of each alternative were identified along with any variances required to current design guidelines.

For preliminary design purposes, the design team was instructed to proceed with a design protecting for the station by road modification only, with a provision for future track modifications to accommodate the station. The northbound track was thus fixed along an alignment that would accommodate a future station. By fixing the northbound track, traffic disruption along 111 Street would be minimized during retrofit of the LRT and construction of the station. Preliminary design also included two single cross-overs with the initial extension to Heritage Valley. The cross-overs were designed in their ultimate location, so that no special track work would be required at a later date and only the southbound track between the cross-overs would need re-aligning.

Grade Separation Over Anthony Henday Drive

South of 9th Avenue, the proposed south LRT extension will intersect a portion of Anthony Henday Drive, the City's Outer Ring Road, and a key corridor for the movement of goods and services located within the Transportation and Utility Corridor (TUC). In carrying forward the decision to use an overpass from the concept design phase, extensive analysis was required at this crossing. The horizontal and vertical alignment, including the span length, height, skew and exact bridge location, were constrained by a number of factors. Constraints included provisions for future roadway expansion and major utility crossings – chief among which were two high voltage power lines located parallel and north of Anthony Henday Drive. The challenge was in designing the bridge to mitigate these issues, while maintaining desirable track geometry for LRT operation.

Anthony Henday Drive currently consists of a four lane cross-section with a 34.9 m median separation. Design of the LRT overpass must accommodate any future expansion plans of Anthony Henday Drive, and provisions for widening of the highway have included an increase in the length of spans to meet clear zone requirements for the piers. Clear zone and vertical clearance requirements over Anthony Henday Drive were dictated to be equal to or exceeding those of the 111th Street interchange, located approximately 400m east of the proposed LRT crossing.

The most significant challenge for the design of the overpass was the presence of two high voltage transmission lines immediately north of Anthony Henday Drive, roughly parallel to the roadway between 111th Street and 127th Street. Two alignment options for the crossing were evaluated, including the original concept plan, to assess the potential electromagnetic interference on the LRT.

The original concept plan alignment extended diagonally past the power lines and across Anthony Henday Drive, resulting in a skewed bridge structure approximately 170m long. The second option, developed during preliminary engineering, had a near perpendicular crossing at Anthony Henday Drive and reduced span of approximately 110m, resulting in approximately 250m of track parallel to the AltaLink power lines. From a cost perspective, the shorter span bridge was preferable; however, the implications of running a portion of the LRT track parallel to the power lines had to be evaluated to confirm whether that option was technically feasible. A study of the EMI effects was undertaken by a specialist consultant, in consultation with AltaLink Management.

In general, the study identified that exposure of track circuits to induced rail current and voltage is less for an alignment that crosses the transmission nearly orthogonally than it would be for an alignment running parallel or nearly parallel to the transmission lines for any distance before crossing. Smaller parallel sections resulted in proportionally lower track circuit currents, catenary rail voltage, and catenary rail current. In short, it was recommended that the length of parallel section between the LRT and the power lines be minimized.

Figure 8. Aerial of Anthony Henday Drive LRT Bridge

Specific to the South LRT extension, the original concept plan alignment, running diagonally beneath the power lines, produced the least electromagnetic interference. However, the costs associated with the longer bridge span were significantly higher than with the alternate option. Given that the greater electromagnetic interference existed with the less costly option, risk became the deciding factor. It was estimated that the LRT line could reach a voltage of 720V at the peak of the crossing, with a maximum amount of allowable induced current of approximately 800V. This small margin meant that the potential risk of having an LRT that was susceptible to electromagnetic interference was too high. It was concluded that the EMI implications outweighed any potential cost savings, and that the original alignment be carried forward to preliminary and detailed design.

Figure 9. Anthony Henday Drive Bridge Rendering

LRT Station, Transit Centre and Park and Ride Facility

Preliminary engineering also included the design of Ellerslie Station, immediately north of Ellerslie Road, as well as an integrated Transit Centre to accommodate 20 buses and a 2,500 stall Park and Ride Facility. The station will be designed for 5-car LRT trains (overall length of 123 metres) and a semi-enclosed 9 metre wide platform. In response to stakeholder feedback, a "natural theme" was adopted for these facilities including a curved inverted "whale bone" roof. Materials will comprise a low maintenance steel roof with natural elements of wood and stone, and tempered glass shelter enclosures. Primary service rooms for mechanical, electrical and communication systems will be located below the station platform. The Transit Centre will be located adjacent to the station and will have similar architectural features and may include concession booths or kiosks and washrooms. Gabion walls and other features will provide architectural interest and barriers to direct pedestrian movements.

The 2,500 stall Park and Ride Facility will provide convenient access to both the Transit Centre as well as the LRT Station through centralized walkways. The natural theme will include vegetated bio-swales as well as high level and low level vegetation to soften the hard surfaces, providing seasonal interest, summer shading and a visual screen. Paving will include alternate patterns of texture to provide way-finding through the site. This will be the largest Park and Ride Facility in the City.

Figure 10. Ellerslie Park and Ride

Figure 11. LRT Station and Transit Centre Architectural Rendering

Provisions for Potential Operations, Maintenance and Storage Facility

The requirement for an operations and maintenance facility for the South LRT extension was identified during concept planning. At a minimum, it was anticipated that a light maintenance and storage facility for light rail vehicles would be required to extend the line beyond Century Park. However, requirements for the facility will ultimately depend on which LRT extension is the next to be constructed. Should the existing system be extended Northwest prior to being extended further South, for instance, a full O&M facility would likely be constructed as part of that extension, reducing the scope of the facility along the South extension. Furthermore, staging of the South LRT extension itself is uncertain; construction could extend to the south city limits, or construction may be staged, terminating at any of the stations south of Century Park.

To maintain flexibility in the staging of construction, a temporary facility was evaluated within lands adjacent to the station at Ellerslie Road. Layout options for the temporary facility were developed, ranging from a light maintenance facility with storage for up to forty vehicles, to a heavy maintenance facility with storage capacity of up to eighty vehicles. Given the uncertainty with respect to construction staging, it was difficult to confirm the scope of the facility requirements. As such, preliminary engineering was not completed for any of the options identified. However, it was confirmed that it will be feasible to locate the Facility for each of these options within these lands.

Conclusions

Although timing of construction remains uncertain, completion of the preliminary engineering will provide the City with greater flexibility and an opportunity to fast track construction when funding becomes available. Most of the project risks and constructability issues have been identified through the preliminary engineering assignment, and mitigation strategies have been identified wherever possible.

Based on the constructability reviews, delivery of the project may proceed under the traditional model of design-bid-build or perhaps using a construction management (at-risk) approach. Portions of the work may also proceed as design-build packages. Decisions will be finalized once the schedule is determined and construction funding and cash flow are confirmed.