North Central LRT Corridor Study

December 1, 2014
Final Draft

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Sign-off Sheet

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Abbreviations

BAU	Business As Usual
BRT	Bus Rapid Transit
Context	Context Research Ltd.
CPR	Canadian Pacific Rail
LRT	Light Rail Transit
LRV	Light Rail Vehicle
LUN	Land-Use and Network
MAE	Multiple Account Evaluation
NCLRT	North Central LRT
NE	Northeast
NW	Northwest
OCS	Overhead Catenary Systems
OMSF	Operations, Maintenance, and Storage Facility
OPC	Opinion of Probable Cost
RC BRT	Rail Convertible BRT
ROW	Right of Way
RTM	Regional Transportation Model
SE	Southeast
SELRT	Southeast LRT
SETWAY	Southeast Transitway
Stantec	Stantec Consulting Ltd.
SW	Southwest
The City	The City of Calgary
TIA	Transportation Impact Assessment
TOD	Transit Oriented Development
TPSS	Traction Power Substation

1.0 INTRODUCTION

The North Central LRT Concept Study represents a departure from the previously approved plan to build one of the two final branches of Calgary's six-branch LRT network parallel to Nose Creek. The previously approved alignment had the advantage of minimizing community impact and achieving low travel times between the City Centre and the communities north of Beddington Trail. However, many stakeholders viewed the previously approved alignment as a lost opportunity for creating a positive impact in communities north of the Bow River, such as Crescent Heights, Tuxedo Park, Mount Pleasant, and Highland Park.

Moving the North Central LRT line away from the Nose Creek alignment has had several implications:

- The North Central line no longer has to join the Northeast LRT line. Instead, The City has stated that the North Central LRT will be connected to the Southeast LRT line to form what is being referred to as the Green Line.
- The Green Line will operate independently of the existing LRT system which allows for a change in vehicle technology from high floor to low floor. The City's selection of low-floor LRT as the preferred technology for the Green Line will provide an opportunity to integrate rail based transit with land use in a manner that has difficult to accomplish in the City of Calgary with the current high floor LRT.

For the time being, planning and design for the Green Line – North Central (NCLRT) and Green Line – Southeast (SETWAY) are proceeding on different schedules, although coordination is occurring at The City and consultant levels. It is expected that the results of this study will be able to serve as the basis for preliminary design efforts.

The balance of this report summarizes the approach to and findings of this study. In some cases the information contained in this document is a brief summary of the more detailed memorandums or reports that have been prepared and are appended to this study.

1.1 VISION & OBJECTIVES

The City of Calgary has a number of existing documents and policies that set out the philosophical priorities for The City. The objective of this study has been to align the recommendations for the NCLRT with these guiding policy documents. Policy documents that were reviewed during the development of the project objectives include the 2020 Sustainability Direction, Calgary 'Triple Bottom Line,' the Transportation Infrastructure Investment Plan and subsequently Investing in Mobility, imagineCalgary, the Municipal Development Plan (MDP), Calgary Transportation Plan (CTP), and RouteAhead.

A draft project vision was developed through a review of the City policies, consultation with City Administration and a several series of public workshops. Following the input received throughout the consultation process, the vision was refined based on input from the Project Steering Committee which includes representation various City departments including Calgary Transit, Transportation Planning, Transportation Infrastructure, Roads, and Land Use Policy & Planning. The final vision statement developed based on input from all of the above parties was to provide "*A transit service that improves mobility in existing and new communities in North Central Calgary, connecting people and places, and enhancing the quality of life in the City.*" To be successful, the study must identify a transit service for existing and new communities in North Central Calgary that will achieve these outcomes.

Vision

A transit service that improves mobility in existing and new communities in North Central Calgary, connecting people and places, and enhancing the quality of life in the City.

Overall Project Objective

The objective of this study is to identify a preferred corridor and alignment and supporting conceptual details such as station locations, roadway geometry, opinions of probable cost (OPC), land use development prospects, and place-making opportunities for the NCLRT.

The project objectives are intended to be the manner in which the vision is brought to life as a series of **value based statements**. The policy document review and assimilation of feedback generated by stakeholders and the public culminated in the following project objectives.

Detailed Project Objectives for the GL-NC:

- An affordable and cost-effective service; A service with manageable costs, that is sustainable in the longer term and provides value for money
- A safe, secure and socially inclusive service that improves access to key community destinations and encourages walking and cycling
- A service that promotes economic development by improving access to employment, without adversely impacting goods movement
- A high priority transit service that promotes transit use, walking and cycling as preferred mobility choices for Calgarians, improves the customer experience and integrates with, meets the future demands of, and strengthens the regional and frequent transit networks
- A service that supports current and future land use and intensification of development along the corridor, integrating with the character of the communities it passes through
- A service that facilitates a reduction in GHG emissions while not impacting The City's current natural environment
- A service that can be constructed and operated without significant technical issues or constraints

Through the stakeholder consultation process, a number of community members requested that the vision be expanded to be more specific about certain issues. Although the sense was that these issues had been covered adequately in the vision and the project objectives, an additional set of 'community principles' for the project and the consultation process were formed. The community principles laid out below, sit between the vision and objectives and aim to expand on some of the points in the vision without having to create a very detailed and complex vision statement.

Community Principles for the NCLRT:

- Enhance connectivity between people and places, connecting to all modes of transportation in the community
- Contribute positively to community development and revitalization
- Be the affordable transportation mode
- Be accessible for people to get to, board and use
- Contribute to the character and cohesion of the community through integrated design with no barriers to accessibility
- Contribute to an efficient traffic management system that promotes the right transportation choice, and reduces congestion and travel times
- Contribute to the vitality of businesses in the community by promoting business development and access
- Enhance the environment by contributing to reducing GHGs, protecting natural areas and urban beautification
- Create a positive transportation experience; one which is safe, accessible, and efficient
- Contribute to complete streets principles including landscaping and urban form, and pedestrian and cycling systems.

Figure 1.1 shows a summary of community input that was received throughout the first round of public consultation that helped form the community principles listed above. Further information on the complete public consultation process can be found in **Appendix A**.

Figure 1.1 Summary of Community Principles

1.2 BACKGROUND

This section provides additional information about the plans and policy documents that were used as a basis for the Vision & Objectives and how they specifically relate to the North Central LRT Concept Study. In many respects, each of the plans / policy documents utilized in this study builds on the previous document referenced. **Figure 1.2** shows how the plans and policy documents related to each other and to the NCLRT.

1.2.1 Existing Plans/Policy Documents

City of Calgary Triple Bottom Line Policy

The City of Calgary's Triple Bottom Line policy was adopted in September 2005 and is currently being updated. The policy states that The City must consider and address the social, economic, environmental and smart growth impacts of all of its decisions in order to ensure a high quality of life for future generations. The objectives of the North Central LRT Concept Study are consistent with the Triple Bottom Line Policy Framework in their attention to community impacts, cost, safety, economic development, land use intensification, and air quality.

ImagineCalgary (Calgary's Plan for Long Range Urban Sustainability)

This plan was the result of a comprehensive consultation process called imagineCalgary that gathered input from some 18,000 Calgarians over the course of 18 months and was completed in 2006. The plan was developed to capture the long-term, 100-year aspirations residents had for The City. The input was summarized into goals and targets in the following categories:

- Built environment and infrastructure system
- Economic system
- Governance system
- Natural environment
- Social

In total, 114 targets were developed, and the intention is for organizations and governments to reflect and report on their progress towards achieving these targets every year.

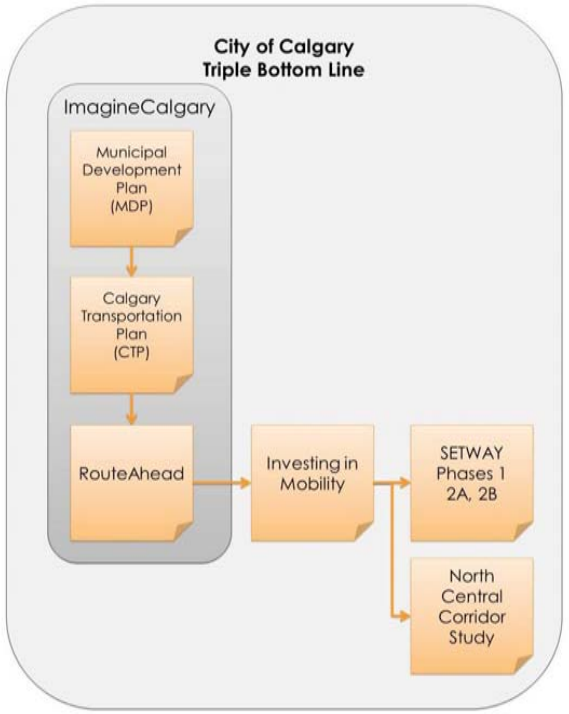


Figure 1.2 Relevant Plans and Policy Documents

The imagineCalgary targets most applicable to the North Central LRT Concept Study are listed in **Table 1.1.1**Error! Reference source not found. The 2020 Sustainability Direction is the short-term plan for moving Calgary towards the goals established in imagineCalgary. In addition, the work completed as part of ImagineCalgary informed the development of the Municipal Development Plan (MDP) and the Calgary Transportation Plan (CTP).

Table 1.1.1: Applicable imagineCalgary Targets

Target Number	Target Description
T14	By 2036, we are developing "complete communities" that, among other aspects, allow people to obtain daily goods and services within a reasonable walking distance from home.
T15	By 2036, all new commercial buildings are designed to encourage the use of alternative forms of transportation (e.g. walking, cycling and transit).
T22	By 2036, we reduce the annual private vehicle kilometres travelled per capita by 20 per cent.
T23	By 2016, we increase the residential population within walking distance (600 metres) of LRT stations and major transit nodes by 100 per cent.
T24	By 2016, we increase the number of jobs within walking distance (600 metres) of LRT stations and major transit nodes by 35 per cent.
T26	By 2036, we increase peak period transit, walking and cycling and carpool travel to downtown by 50 per cent, 40 per cent and 20 per cent, respectively.
T28	By 2036, transit trips per capita increase 40 per cent over 2006 levels.
T29	By 2036, the number of on-street bikeways increases by 200 per cent, and the number of pathways by 100 per cent.
T30	By 2036, fatal collisions per 100,000 people and injury collisions per 1,000 people decrease by 50 per cent.
T62	By 2036, all publicly provided goods and services are affordable, accessible and priced in accordance with their public benefits.
T103	By 2016, 95 per cent of Calgarians report that they feel safe walking alone in their neighbourhoods and walking alone downtown after dark.

Municipal Development Plan (MDP) and Calgary Transportation Plan (CTP)

Great effort was put into developing the MDP and CTP to be complementary documents that provide a framework for the implementation of the visions outlined in Imagine Calgary. Preparation of these documents began in 2007 when City Council approved the Terms of Reference for an Integrated Land Use and Mobility Plan that built on the previous transportation plan (*The Go Plan* (1995)) and the previous development plan (*The Calgary Plan (1998)).* Collectively, the MDP and CTP set a long-term 60-year strategy of a more sustainable city form for Calgary and the transportation networks needed to serve it.

Municipal Development Plan (MDP)

The MDP for Calgary was finalized in September 2009 and provides high level goals and policies for land use in The City. The goals and policies are broken down into six categories, as follows:

- Prosperous economy
- Shaping a more compact urban form
- Creating great communities
- Urban design
- Connecting the City
- Greening the City

These policies and goals are discussed in the context of six key land use typologies: Centre City, Activity Centres, Corridors, Developed Residential Areas, Developing Residential Areas, and Industrial Areas. The plan recognizes that a transportation network will contain both roads and streets, where roads serve the movement of vehicles, and streets serve all modes and encourage an interaction between land use and the people traveling through the corridor. The plan also encourages the diversification of housing choice in communities such as those in the North Central corridor through the construction of more townhouses, cottage houses, and accessory suites.

The MDP supports the concept that the GL-NC project is as much about land use as it is about transportation. The MDP expects that transit stops be surrounded by vibrant, mixed-use areas incorporating public gathering areas and public art. It is expected that the GL-NC should contribute to the goals and strategies listed above in a cost-effective manner.

Calgary Transportation Plan (CTP)

This document, adopted by Council in September 2009, lays out the long-term transportation goals and policies for The City of Calgary. The document recognizes that the design of the City's "transportation system has a **significant impact on the urban form of the city**. It contributes to the **shape of our communities** and employment centres, and it determines **how we move** within and among these places. It supports the economy by facilitating the timely movement of goods, services and **people** within the City. It **can either enhance or degrade the environment** depending on how well it is **integrated** with its surroundings and the degree to which we depend on fossil fuels to reach our destinations." The plan lays out seven key goals:

- Align transportation Planning and infrastructure investment with City and regional land use directions and implementation strategies.
- Promote safety for all transportation system users.
- Provide affordable mobility and universal access for all.
- Enable public transit, walking and cycling as the preferred mobility choices for more people.
- Promote economic development by ensuring the efficient movement of workers and goods.
- Advance environmental sustainability.
- Ensure transportation infrastructure is well managed.

The plan focuses on a significant shift in how people move throughout the City. Unlike how much of the planning in the City had historically taken place, the CTP places a high priority on moving people rather than on moving vehicles. As **Table 1.1.2** indicates, one of the goals outlined in the CTP is an increase in the share of trips made by walking, cycling, and transit. This shows a significant shift in the transportation priorities for the City from Single Occupancy Vehicles (SOVs) and even High Occupancy Vehicles (HOVs) towards walking, cycling and transit.

The NCLRT, along with other City investments and policies are focused on increasing the transit mode share, and to some extent, increase walking and cycling mode share to support The City goals of shifting how people move.

Table 1.1.2: Mode Share: Current and Recommended Direction

Mode of Transportation	Percent of all daily trips	
	Current	Recommended Direction
Walk / Cycle	14%	20% - 25%
Transit	9%	15% - 20%
Vehicles (SOV & HOV)	77%	65% - 55%

Source: Calgary Transportation Plan

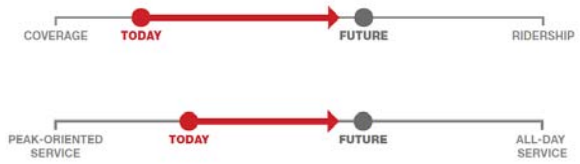
Map 2 in the CTP identifies the Primary Transit Network for the City. That map indicates that the full length of Centre Street and Edmonton Trail from the downtown to 32 Avenue form part of the Primary Transit Network (PTN) which provides frequent, fast, reliable and connected transit service on less than 10 minute frequency at least 15 hours a day 7 day/week. These north-south connections will be supported by a series of east-west cross town primary transit connections. These east-west routes are planned to be located along 16 Avenue, 32 Avenue, 96 Avenue (Airport Trail), and Country Hills Boulevard. At the time the CTP was prepared, the North Central LRT was approved to be located within the Nose Creek Corridor. Pending Council's approval of this concept study, an amendment to Map 2 will required to show the new proposed alignment of the Skeletal Light Rail Transit (LRT) Network.

RouteAhead

RouteAhead was developed to provide a comprehensive strategy for transit in Calgary over the next 30 years. It aims to address issues beyond the basic structure of the transit network (i.e., the bus routes and LRT lines) and crystalizes a vision for the key elements that support transit, such as the organization that provides transit services, the financing of transit, and transit infrastructure.

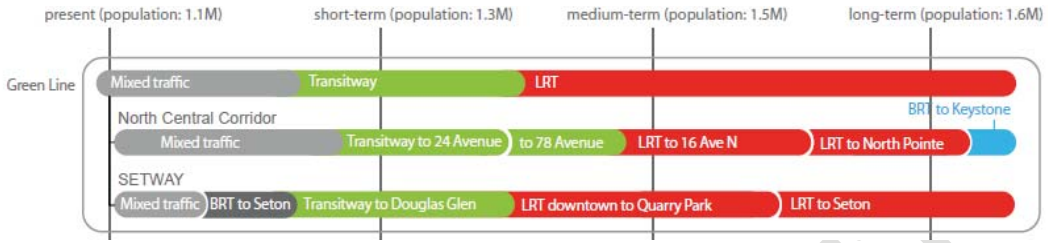
To create RouteAhead, intensive efforts were dedicated to public engagement. Engagement efforts included outreach with current transit riders and the use of creative outreach mechanisms such as the RouteAhead Engagement Bus and an on-line budget allocation tool. Multiple stakeholder groups were engaged, such as City employees and students. Over the course of the project, the project team met with 4,000 people and received thousands of comments. The public engagement activities associated with this project collected more comments about customer service than any other topic. The top five concerns were related to **frequency**, **network design**, **fares, vehicles**, and **reliability**.

Figure 1.3 A Policy Shift Example: Coverage to Ridership



Source: Route Ahead

Figure 1.4 Green Line Implementation



Source: RouteAhead

RouteAhead resulted in the development of many core principles that have been applied to the planning of the NCLRT in the development of the Multiple Account Evaluation (MAE) framework that was used to inform decisions made throughout the project. The core RouteAhead principles include:

- Easy connections
- Safe waiting environments
- Reliable services
- Stations that are easy to access
- The development of a grid network
- Attracting current non-users to transit
- Focusing investments on features that will attract passengers
- Achieve 50/50 or 55/45 revenue/cost targets
- Make transit the preferred transportation option
- Pursue investments that fit within the funding allocation for transit projects
- Use high-capacity vehicles when necessary to reduce crowding
- Use energy-efficient vehicles
- Allow for spontaneous trip-making
- Project evaluation criteria based on land use, customer experience, and project characteristics
- Mode progression in key corridors from existing BRT to upgraded BRT to LRT, with upgrades tied to demand driven by the development and population growth in respective corridors

RouteAhead directly identifies (see **Figure 1.4**) the NCLRT project as part of the overall phasing of the Green Line project changing area and technology as ridership dictates. It refers to a future line along Centre Street as the Green Line, starting as a transitway segment connecting downtown to 24 Avenue N, extending to 78 Avenue N in the future. In future years, this transitway could be converted to LRT along its entire length, likely in stages.

Investing in Mobility: 2015-2024 Transportation Infrastructure Investment Plan

Approved on May 26, 2014, this plan summarizes the major transportation infrastructure projects anticipated between 2015 and 2024 and organizes them into the following six categories:

- Mobility Hubs and Transit Corridors
- Goods Movements and Traffic Growth
- Transportation Network Optimization
- Lifecycle and Asset Management
- Support Functions
- Flood-related Projects

These projects are identified as aligning as much as possible with City directives such as the CT, Corporate Growth Management and Route Ahead with specific focus on the Green Line Program. The plan budgets approximately $674 million for the Green Line Program ($524 million funded and $150 million unfunded).

The Green Line Program includes segments of dedicated bus-only lanes and transit priority measures that will improve travel time reliability along the entire length of the Green Line. The plan notes that "this is particularly important for the Centre Street Transitway, which has the highest ridership and most frequent service of all non-LRT corridors in Calgary." These improvements will improve customer experience within the corridor and include the provision of streetscape and pedestrian improvements at key locations along the corridor which will support land use intensification at strategic locations.

Based on the findings from the NCLRT concept study, the Centre Street Transitway is expected to be key part of phasing the LRT on Centre Street. The plan notes that even "if Centre Street is not selected as the alignment for the north –central portion of the Green-Line LRT, it will continue to operate as a bus-based transitway." The provision of a transitway on Centre Street will form the base scenario for comparison of the LRT later described in **Section 6.4**.

1.2.2 Study Process

This study was launched in May 2013 to evaluate the potential to change the previously approved corridor alignment that placed the NCLRT on the Nose Creek alignment. The potential to change the alignment opened up the opportunity for a review of alternative alignments that would better serve existing neighbourhoods – particularly those south of Beddington Trail. This potential change in alignment would also allow the project team to explore the opportunity to link the NCLRT line to the Southeast LRT line and to use a more adaptable and more accessible vehicle technology than the one currently used within the existing CTrain system.

The study was organized into the following four stages shown in **Figure 1.5**; Defining Stage, Developing Stage, Deciding Stage, and Delivering Stage.

Defining Stage

In the Defining Stage of the project the vision, objectives and the study boundaries were defined. The development of the multiple account evaluation frameworks was also undertaken during this stage as it is tied to the project vision and objectives. This stage included extensive public consultation to ensure that the project met the needs of the communities in the study area.

Developing Stage

In the Developing Stage, the project team carried out various forms of analysis to inform the decisions that would need to be made later on in the Deciding Stage. These analyses included the development and evaluation of options for the downtown alignment and the alignment north of 16 Avenue N, traffic simulation, market potential analysis, and a comparison of the analyzed corridors. In addition, modelling and tunneling evaluations are some of the key elements that supported the development of different options throughout the project.

Modelling

In order to inform development of the alignment for the North Central LRT project, the City of Calgary Regional Transportation Model (RTM) was used. The RTM uses the latest City forecasts for land-use and population, in conjunction with the existing and planned transportation infrastructure to help provide insight into the likely ridership that the new line in North Central Calgary might be expected to generate. For the purposes of our study, a forecast year of 2076 was used along with the Land-Use and Network (LUN) version of the existing model. While the outputs from models should not be assumed to be an exact representation of what will occur in the future, they can provide information to help inform decisions that are based on the City's best forecasts for how the City may grow and develop in the future.

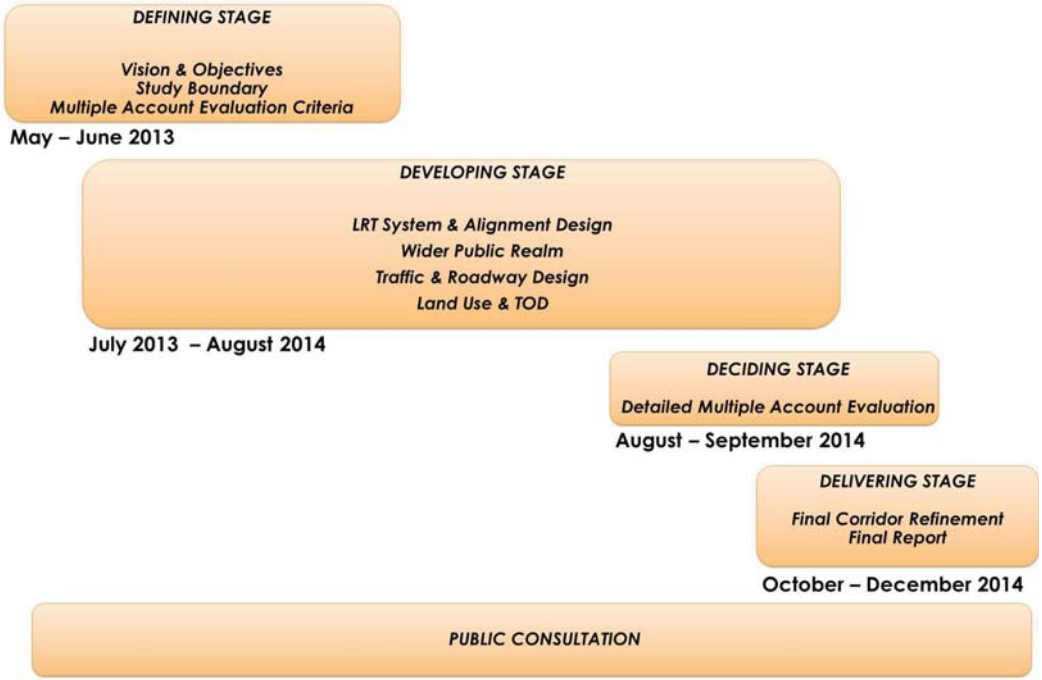


Figure 1.5: Project Timeline

A number of different scenarios were specified by the consultant team and then coded and run by City staff. The aim was to make best use of the existing models and undertake a limited number of scenarios that could best inform the option evaluation. Initial work focused on generating a comparison between the potential Centre Street, Edmonton Trail and Nose Creek alignments which helped inform the decision to remove Nose Creek from further consideration. Later work ran more refined scenarios for the Edmonton Trail and Centre Street options to allow a decision to be

made on the emerging preferred alignment. The final scenarios refined the Centre Street alignment option to better reflect the emerging route detail. Standard outputs produced included ridership on the proposed NCLRT line as well as wider transit ridership, traffic flows and impacts across the City. Further information about the modelling work undertaken is provided in **Appendix B**.

Street Classification

The development of a Complete Streets Guide was directed by the Plan It Calgary Implementation Committee that was formed at the direction of Council in 2009. The guide builds on the 22 complete streets principles that are included within the CTP. The classification of the corridors was an important consideration in the evaluation process as the classification provides guidance on the level of mode accommodation anticipated within each of the corridors. **Figure 1.6** shows the road and street Palette contained in the City's Complete Streets Guide. The 2014 Complete Streets Guide was approved by Council on November 3, 2014.

Figure 1.6: Road and Street Palette

Source: 2014 Complete Streets Guide

The 2014 Complete Streets Guide provides definition of the characteristics of the Liveable Streets "family" introduced in the CTP. It notes that these streets "serve to provide higher-capacity streets within communities and development areas where **active modes and local commercial activity will take precedence over private vehicle and goods movement activity**." It also states that a "liveable street is a street with **emphasis on modes of travel that enable social interaction (e.g. walking, cycling, transit)**. It is a destination as well as a route for travel."

Within the liveable streets family, the Urban Boulevard is identified as the "backbone of higher density corridors and activity centres" where "high volumes of vehicular traffic are still expected", but "walking, cycling and and transit are given higher priority." It also notes that "a level of congestion appropriate for a dense urban area is acceptable for this street type." Centre Street is classified as an Urban Boulevard between the Bow River and McKnight Boulevard and Edmonton Trail is classified as an Urban Boulevard between 1 Avenue NE and 32 Avenue NE.

Also within the liveable streets family, the Neighbourhood Boulevard is noted as being "similar to an Urban Boulevard, but on a smaller scale, with walking and cycling given higher priority. These streets are destinations for the local communities surrounding them, and provide the highest level of connectivity within this family of streets. Though not a requirement, these streets support mixed-use retail and medium-density residential uses."

These street classifications were an important consideration when evaluating the corridors, since as noted in Figure 6 they speak to a different emphasis for the accommodation of automobile traffic within the subject corridors than currently exists. Urban Boulevards accommodate autos with variable standards and Neighbourhood Boulevards accommodation of autos is noted as not required or poor performance acceptable.

Using the traffic data outputs from the model runs described previously, analysis of the anticipated traffic operations was performed . on the Centre Street and Edmonton Trail corridors. The analysis focused on evaluating traffic conditions at 2076 levels of demand with LRT in operation. The 2076 scenario assumed one lane of general traffic in each direction on both Edmonton Trail and Centre Street, a corridor-wide ban on U-turns, left turns restricted to a set number of signalized intersections, and optimized traffic signal operation with the assumption that full priority would be given to LRT movements.

The analysis was carried out using existing and forecasted AM and PM peak volumes to capture the full effect of the traffic demand. VISSIM version 5.4 was used for the analysis. A baseline model was first created using existing signal timing plans, existing lane geometry, and existing travel volumes. The model was set up such that all signalized intersections were represented and intermediate intersections were created to balance the flows.

The 2076 simulation reduced the available left turns, redirecting traffic to the signalized intersections. The 2076 simulations included LRT stations, five-minute headways, 37 second dwell times, and 3-car vehicles. A 2076 version without LRT was also developed to assess the impact of the LRT. For Centre Street, the 2076 no build scenario was similar to the LRT scenario because it included only one lane of traffic in each direction, due to the assumed existence of an exclusive bus lane. As anticipated, this analysis showed significant impacts to vehicular traffic in comparison to existing conditions, but in comparison to the scenarios where the number of travel lanes were already reduced there was a relatively limited impact. These operations are in line with those anticipated based on the street classifications. Additional analysis will be required in future studies to look at impacts to the selected corridor in more detail as well as considering improvements to adjacent routes.

TOD

With the new low-floor technology of the proposed Green Line, the NCLRT is bringing the LRT closer to the existing communities through alignments along Centre Street, Edmonton Trail and 4 Street NW. Due to the importance of regeneration of the North Central communities and the potential for economic development, an economic evaluation of the alternative alignments was done based two main criteria:

- Ability to catalyze TOD – the selected alternative should enhance the feasibility of mixed-se, mid- or high-rise development. This was assessed base on availability of vacant and publicly owned lots, as well as short and long term TOD potential.
- Impact on existing and future businesses – the selected alternative should minimize disruption to existing businesses during construction and create a favorable environment for existing, returning, and new businesses after construction is

complete. This was assessed based on existing retail and mixed-use parcel sizes.

Reports on the TOD evaluation can be found in **Appendix C**.

Road Geometrics

For each of the alignments, road geometrics were assessed to determine the feasibility of at-grade LRT. With the LRT able to achieve a 6% vertical grade all of the alternatives were deemed feasible. The ROW widths were also assessed to ensure that at minimum one vehicle lane of traffic in each direction, sidewalks on both sides, and two LRT tracks could fit into the existing ROW. The ROW geometrics are further explained in section **Error! Reference source not found.** and **Error! Reference source not found.**.

Tunneling

In order to develop different options to cross the Bow River and other constraints in the downtown, two tunneling methods were studied for the North Central LRT project. The two methods include; Tunnel Boring Machine (TBM) Excavation, and Sequential Excavation Method (SEM).

The TBM excavation is a mechanical excavation method which uses a rotating cutter head. There are different shield types for this machine that may be selected depending on the ground conditions, surface conditions, dimensions of the tunnel section, boring distance, tunnel alignment, and construction schedule. Replacement of the cutter head based on different geology can be extremely costly and result in schedule delays and higher risk in cost fluctuations. For the purposes of this study it was assumed that tunneling would be deep enough to be in consistent geological material. Based on the assumptions made and the length of tunneling TBM would be anticipated to be approximately 3.5 years of 24 hour 7 days construction operations.

SEM excavation is a method where the surrounding rock or soil formations of a tunnel are integrated into an overall ring-like support structure. Due to higher costs this method is typically used for shorter tunnels and is more versatile to deal with complex and varying geological conditions and different cross-section geometry.

In ordered to develop options for the LRT alignment the various assumptions needed to be made given the lack of detailed information available at this stage of the study.

- Construction crews would maintain round the clock work as the ground has time dependent behavior (i.e. ground settlement)
- Two twin tunnels running parallel at the same elevation with an assumed tunnel separation of approximately 1.5 tunnel diameters
- Tunnel inverts depth below the river bed at 19m (approximately 3 tunnel diameters)
- TBM (type to be determined) for the longer tunnel option below the Bow River
- SEM is more economical for shorter tunnel lengths ie. downtown tunnel options
- Minimum overburden at the tunnel portals would be 5m to the ground surface
- Impacts due to groundwater would be assessed in later studies
- The approach structures (110m long) and the cut and cover portion (85m long) will be located at each end of the mined tunnels
- The width of the excavation pit based on the twin tunnel concept is in order of 25m
- Twin-tube and single-tube tunnel systems can be designed in different geometric conditions and arrangements – these can be refined in further studies
    - Single-tube tunnel systems are typically favored from a civil engineering point of view
    - Twin-tube tunnel systems are favored from an aerodynamic, ventilation, or safety point of view – this was used for all assumed tunnel options for the NC LRT study
- Designing shallow tunnels will require foundation analysis to be taken into consideration which has not been completed in this study
- Near surface soils are expected to have more movements than soils in confined conditions at greater depth – as a result SEM excavation is assumed for these tunnels due to its ability to deal with variable geology
- Tunnel cross sections may need to be locally enlarged to accommodate for the ventilation system (fans)
- The tunnel lining will be designed to accommodate ground and hydrostatic loads which can change the tunnel diameter

Deciding

The Deciding Stage involved the development of a final set of distinct options and a comprehensive analysis of how they compared in relation to a set of uniquely tailored evaluation criteria. The high level MAE criteria were revisited to develop a set of detailed MAE criteria that would support in distinguishing between the options.

Delivering

The Delivering Stage involved finalizing the corridor choice and alignment recommendations for the final report and engagement to bring forward a project recommendation at the end of 2014.

Public Consultation

To complement and support the technical stages of the study, public consultation was carried out throughout the duration of the project. A communication and engagement plan was developed in collaboration with the project team and the City of Calgary. The goals of this plan were to:

1. Build public and stakeholder awareness and understanding about the value of, and need for the NC LRT
2. Inform the public and stakeholders about the alignment options, including the challenges and opportunities posed by different alignments
3. Engage the public and stakeholders so they can provide informed input to the design of the engagement program, and the analysis and selection of a preferred route option.

4. Foster community support for LRT and public transit as a means to improve the livability of communities within the City

A series of open houses, public workshops, and ongoing online engagement was held throughout the year to provide different methods for people to be engaged and provide their input. In addition, a Community Advisory Group (CAG) was also developed as a focus group of community members that received information and provided advice during the concept planning phase including input on the public consultation process and the potential effects of the NC LRT route options on North Central communities. The CAG was engaged throughout the consultation process in order to get ongoing feedback on the alignment, design concepts, and the public engagement strategy.

As previously noted, further information about the public consultation process and the feedback generated by participants is provided in Appendix A.

1.2.3 Evaluation Steps

The evaluation process for the NCLRT concept study was a 5 step process shown in **Figure 1.7** that included:

1. ***Boundary Definition*** – definition of the scope area in order to determine all potential corridors.

2. ***Identify all possible corridors***

3. ***Refine possible corridors to 2 preferred corridors*** – this included a high level MAE of the identified corridors and a secondary step to determine the possible connections into downtown as well as potential routing within the downtown. This secondary step was critical in determining the challenges of the downtown area as well as the options for the connection to the southeast portion of the Green Line.

4. ***Selection of one preferred corridor*** – additional evaluation done on the top two preferred corridors to determine which meets more of the project objectives and community principles.

5. ***Determine the alignment within the corridor*** – based on the selection of one preferred corridor additional details were assessed on the mechanics of the corridor including impacts on traffic lanes, pedestrian movements, station locations, grade separation with tunneling or bridge structures, etc…

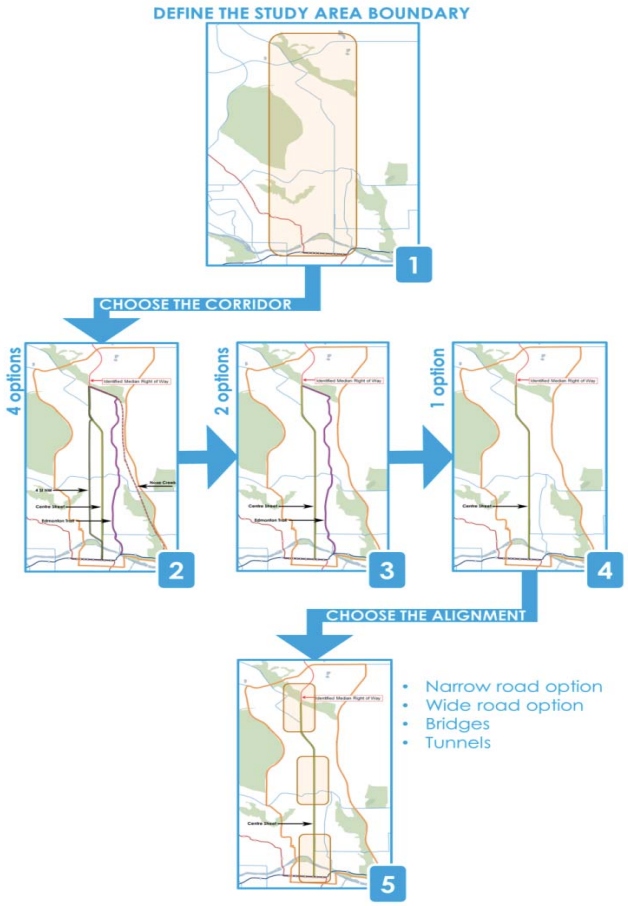


Figure 1.7: Decision Process Chart

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2.0 STUDY AREA BOUNDARY

The study area was initially presumed to be all areas between Nose Hill and Nose Creek and between Downtown and Stoney Trail. As the process of understanding available statistics, influence of the existing LRT lines on neighborhoods, and avoiding unnecessary review of areas where a decision on the corridor has already been finalized (north of Beddington Trail in the median), the study area boundary was redefined using Transportation Zones (TZ). The area north of Beddington Trail was retained but only to ensure that the connectivity between the neighborhoods remained a critical consideration at the north end of the study area. The final study area is shown in **Figure 2.1.1**.

2.1 STUDY PARAMETERS

Through the development of options additional considerations for fully elevated and fully tunneled options from the downtown to McKnight Boulevard (or further north to North Pointe station) were not considered in detail. Due to the city's mobility priorities, emphasizing active modes and transit before private vehicles was a key factor as part of the City's Triple Bottom Line approach to the project. Fully tunneling or fully elevating the alignment was seen as an emphasis to maintain road capacity for motorists incurring higher capital costs, rather than more economical options that would still meet the needs of active modes and transit service.

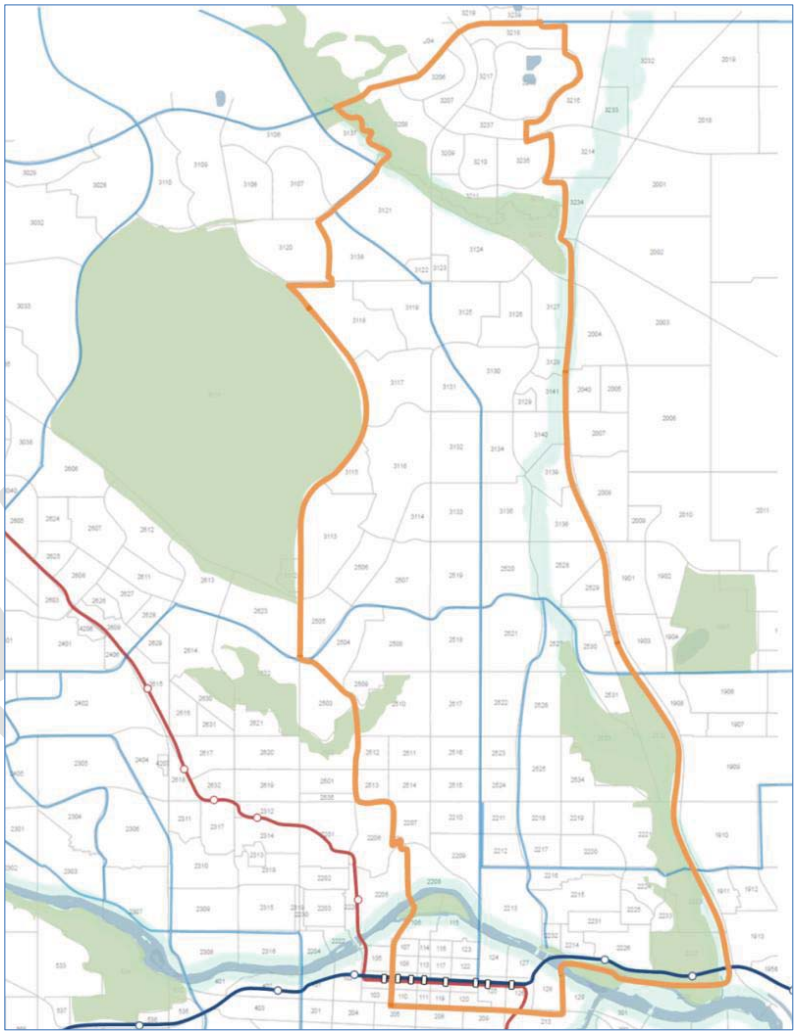

Figure 2.1.1 Study Area Boundary

NORTH CENTRAL LRT CORRIDOR STUDY

/Study Area Boundary
December 1, 2014

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3.0 HIGH LEVEL MAE: 16 AVENUE N TO BEDDINGTON TRAIL

3.1 OVERVIEW

The high level MAE involved the identification and high level evaluation of the potential corridors within the study area. In addition to the then council approved Nose Creek corridor, there were initially only two additional corridors selected for evaluation: Centre Street and Edmonton Trail. However, after the initial public consultation and engagement, a fourth corridor was added to the evaluation: 4 St NW. The candidate corridors are shown in **Figure 3.1.**

The purpose of the high level MAE was to evaluate the alternative locations and configurations for the NCLRT and identify two alignment options that would best meet the objectives for the project. Four corridors were evaluate during the high level MAE: Centre Street, 4 Street NW, Edmonton Trail, and Nose Creek. Elevated, at-grade, and tunnel alternatives were considered for Centre Street, 4 Street NW, and Edmonton Trail, and an at-grade alternative was considered for the Nose Creek alignment. This resulted in a total of ten alternatives considered during the MAE process. Since the alignments were assumed to be the same north of Beddington Trail and due to a mandate to consider the downtown options through a separate process, the evaluation of alternatives was confined to the area between the 16 Avenue N and Beddington Trail in the north.

10 options were evaluated for the high level MAE review

The 4 Street NW corridor was added based on public input

The evaluation of the ten alternatives considered seven accounts, each one aligned with the project's vision and objectives.

- **Financial Capacity/Sustainable Corporation** - primarily financial impact of the option
- **Community Well-Being** – how well the option allows for connectivity to key community destinations
- **Prosperous Economy** – evaluation of the future population and employment along the corridor and the access to Calgary Airport
- **Transportation** – A review of potential ridership, transit efficiency and compatibility with the future network of routes and the journey time
- **Urban Development / Urban Realm** – A review of the development opportunity around stations and the impact on the urban realm both positive and negative
- **Sustainable Environment** – this refers to the impact on the natural environment
- **Deliverability** – what are the technical constraints on the corridor

Each area is evaluated on a scale from 1 (greatest impact or least positive) to 5 (best or most positive impact).

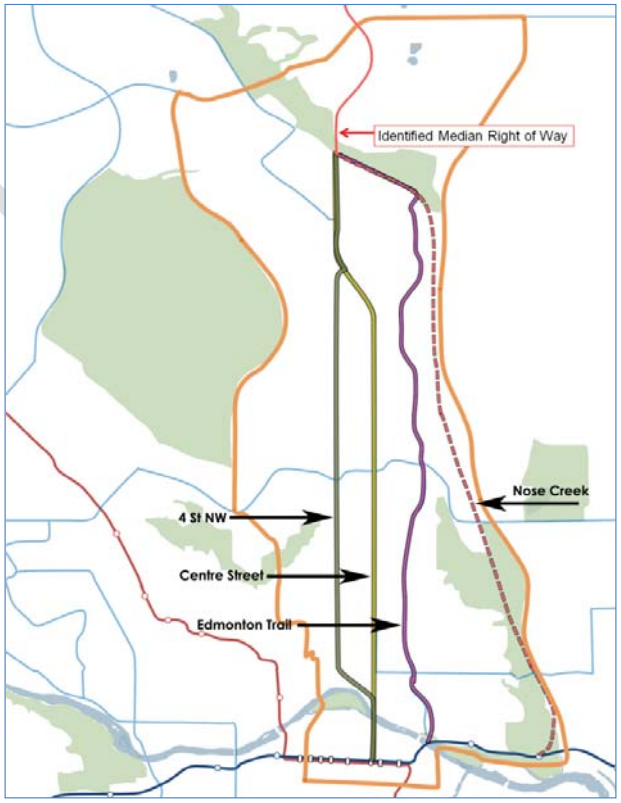


Figure 3.1: Candidate Corridors

3.2 SUMMARY OF RESULTS

As shown in **Table 3.1**, the at-grade options along Centre Street and Edmonton Trail received the highest scores from the evaluation process. Based on this evaluation, both 4 Street NW and Nose Creek corridors were determined to be less able to meet the stated objectives of the LRT than either Edmonton Trail or Centre Street. Fully tunneled and fully elevated alignments were considered at this stage of the project as a due diligence in the comparison of the alignments. The fully tunneled options on any of the corridors typically ranked lower due to higher capital cost. Fully elevated options on any of the corridors also ranked lower due the negative impact on directly adjacent communities. As a result of this evaluation, the number of corridors was reduced to two to be brought forward for further analysis: Centre Street and Edmonton Trail. Further details about the high level MAE are provided in **Appendix D**.

Following the high level MAE review the top two options were:

CENTRE STREET AT-GRADE &

EDMONTON TRAIL AT-GRADE

With further considerations for grade separation of portions of the alignment to be considered as a tool to overcome technical constraints.

Table 3.1 High Level MAE Summary

	4 Street NW			Centre Street			Edmonton Trail			Nose Creek
	AT- Grade	Elevated	Underground	AT- Grade	Elevated	Underground	AT- Grade	Elevated	Underground	At-Grade
Financial Capacity	5	2	1	5	2	1	5	4	2	5
Community Well being	5	4.5	4	5	4.5	4	4	3.5	3	1
Prosperous Economy	2.3	2.5	2.5	2.8	3	3	3.8	4	4	2.1
Transportation	3.5	3.2	3.2	4	3.7	4	4	4	4	2
Urban Development	2	1.5	3	4	2.5	4.5	4	2.5	4.5	3
Environment	4	4	4	5	5	5	3	3	3	1
Deliverability	1	1	1	3	3	3	2	2	2	4
OVERALL	22.8	18.7	18.7	**28.8**	23.7	24.5	**25.8**	23	22.5	18.7

4.0 DOWNTOWN REVIEW

The downtown component of this review was undertaken in order to develop an understanding of the relationship between the two LRT projects – the North Central LRT and the Southeast Transitway. These two lines, though now termed the Green Line, have not undergone significant evaluation of the downtown routing as a united line. Therefore, a higher level review was developed to provide direction to this review as well as future preliminary engineering of the SELRT.

The downtown review consisted of a workshop with City staff, a multiple account evaluation, a review of corridors and alignments, a high level review of geology and traffic, as well as potential growth opportunities. This review was intended to fix a connecting point to the SELRT alignment as well as understand the general location of a north-south corridor. Further refinement is required in subsequent stages of the project in order to fully understand the below grade risks and challenges in the downtown area. **Figure 4.3.1** shows a summary of the key considerations in the downtown.

Due to challenges in the downtown and current data, 1 STREET SW was the highest ranked corridor in the MAE for the southeast to north central connection. Without further detailed analysis, the alignment in the downtown could shift east or west. To remain consistent with the approved SELRT alignment, and with input from City administration the recommended corridor in the downtown is between 3 STREET SW to 1 STREET SW.

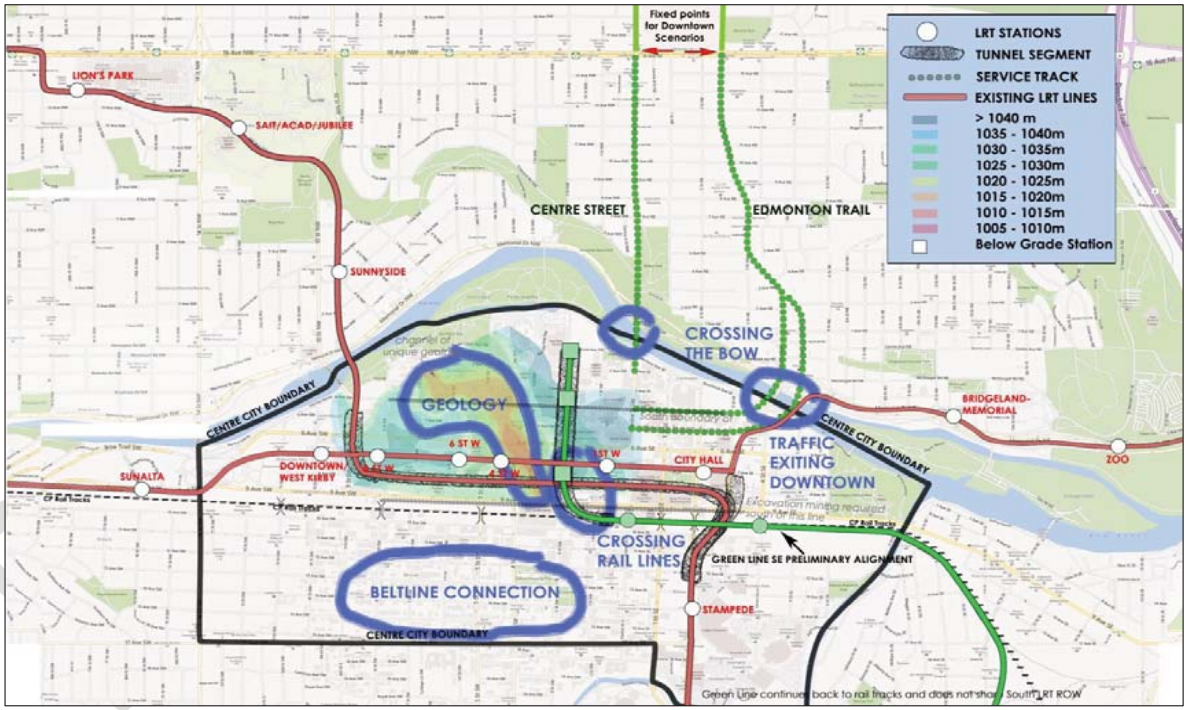


Figure 4.3.1 Key Downtown Considerations

4.1 HIGH LEVEL REVIEW OF ALIGNMENTS

The City and the project team collaborated on the process to identify a preferred alignment in the downtown area. The results reflect careful consideration of the vision for the Centre City, the goals for transportation and the tecltnical analysis conducted by the NCLRT project team. The workshop showed a clear preference for a corridor further west on 4 Street SW than from the MAE, however, the degree of questions regarding the environment, geology, and existing infrastructure and below grade building structures mean that the variablity from the preferred corridors may be several blocks. There were a number of options reviewed (5 from the workshop and 18 for the MAE) representing the full cross section of options through the downtown area. The top two options from this analysis included a fully tunneled option along 1 Street SW (option1 in the report "Centre City connection between the North Central and Southeast Lines" in **Appendix E**) and a partially at-grade option along 1 Street SW with a shorter tunnel below the 7 Avenue and CPR tracks (option 3A in the report "Centre City connection between the North Central and Southeast Lines" in **Appendix E**). The detailed downtown MAE was presented to the Standing Policy Committee on Transportation and Transit on March 12 ,2014. A full version is available online at: http://agendaminutes.calgary.ca/sirepub/mtgviewer.aspx?meetid=1310&doctype=AGENDA

4.2 ELEVATED OPTIONS IN DOWNTOWN

The downtown analysis assumed that the downtown alignment of the Green Line would be at-grade or tunneled or a combination of two. The approved alignment for the SELRT includes a tunnel in the Centre City, and the high level MAE had resulted in a recommendation to pursue the analysis of at-grade options, so at-grade and tunnel were assumed to be the preferred alignment types in the Centre City. In response to a request to consider elevated LRT in the downtown in the interest of saving construction costs compared to tunneling, a study of the feasibility was carried out. This feasibility study considered existing infrastructure, roadway geometry, shadows, noise/vibration, stations, safety/security, maintenance, Green Line continuity, transfers, costs, and public acceptance. The analysis indicated that presence of the +15 and +30 networks would likely require very high structures to facilitate elevated LRT, and that this would create additional costs and noise/vibration issues. Some mitigating strategies were

Figure 4.2: Calgary West LRT Sunalta Station

recommended from other cities with elevated rail lines in their downtowns in the event elevated LRT becomes a feature of the Green Line.

Existing Infrastructure

The existing infrastructure in Downtown provides some constraints on a future aerial structure. For one, the aerial structure would have to pass over the 7 Avenue LRT catenary wires and also have to avoid interfering with the existing overhead walkway network (the "+15" Network). This network is continually being expanded and improved and will require an aerial LRT structure to rise at least three stories (or twelve metres) above street level or higher where the +15 network is at the +30 height. For reasons of cost, passenger comfort, and noise abatement, it is likely preferable for an aerial alignment to maintain a constant elevation throughout the Downtown; operating above most of the "+15" Network.

Roadway Geometry

The question of geometry pertains to the question of how an aerial structure would fit into the available space above roadways and intersections, and how the supporting piers would fit into the roadways at street level. For this discussion, it is assumed that the alignment would follow the street network and resemble the conceptual alignment of the approved SELRT alignment along 2 Street. A conceptual plan and profile is shown in **Figure 4.3.**

At street level, it is unlikely that sufficient space will be available in the downtown roadways for piers to be placed in sidewalks without severely impacting the pedestrian environment. Rather, the piers will probably be placed in the median of the streets. This will slightly reduce shadows and preserve pedestrian space, but will require considerable redesign of the streets, including the possible disruption to utilities and removal of a lane of traffic. With the height clearance requirements of the +15 network and CPR, the taller the elvated structure is, the wider the supporting piers must be, resulting in greater street level impacts.

Shadows

As a northern city, Calgary's streets will be impacted by an aerial structure that is more than two levels above the street with more shadows introduced along 2 Street SW. Mitigation may be possible through additional lighting, as well as heating and wind protection. The impacts may also be reduced if stations are integrated into buildings rather than built as stand-alone structures. This opportunity will only present itself for new construction or significant remodeling in a location a station.

Noise / Vibration

Elevated tracks will create a new noise source, separate from the general traffic noise coming from street level. Tenants in the third and fourth floors of buildings will be particularly impacted by noises associated with turns and announcements at stations. In addition there will likely need to be some special trackwork in the Downtown to accommodate alternative operations, such as short turns. Special trackwork tends to introduce additional noise as a result of the trains traveling over switches. Noise walls may be able to mitigate the impacts of noise to some extent, although they create additional visual impacts.

Stations

In aerial alignments, stations are typically large and visible, as the required platforms, elevators, escalators, and stairs are all within plain sight. However, there are possible opportunities for integrating aerial stations into new buildings and into the existing overhead

walkway network. Stations on aerial structures also have passenger comfort impacts; wind speeds tend to increase with elevation, so passengers waiting on an elevated platform tend to be colder than ones waiting on a street level platform.

Safety / Security

The safety offered by an aerial system in Downtown would be an improvement compared to that of an at-grade system due to the separation of rail operation from roadway traffic. However, there are additional safety concerns with the stations being located away from the street with less "eyes on the street" than in an at-grade option. Also, due to the need for a sufficiently wide and safe evacuation route, the cross section of an elevated alignment may have to be wider than the at-grade or underground alignment which will increase the impacts of shadows in the Downtown.

Maintenance

Aerial structures create various maintenance challenges that are different than at-grade or underground structures. Access for maintenance crews is more challenging and requires special equipment. In addition, for safety reasons, regular traffic may have to be stopped if overhead maintenance is taking place.

Green Line Continuity

Green Line continuity is a consideration for an aerial alignment in the Downtown. An aerial structure is likely compatible with at-grade operation across the Centre Street Bridge, but a connection to a tunnel under the Bow River is likely infeasible and uneconomical. While connecting an aerial LRT structure in Downtown to an at-grade structure that is currently planned for 10 Avenue SE in the Beltline area is feasible, it will require the "Second Street Station" of the approved SELRT to be elevated as well.

Transfers

An aerial structure will change the transfer experience as compared to a tunnel. With an aerial station, transfers between the 7 Avenue LRT and Green Line will take place largely outdoors. The transfers between the Green Line and a future 8 Avenue tunnel will require a significant elevation change that will likely not be comfortably completed by most people on foot. As a result, extensive escalators and elevators may be required, increasing the cost and footprint of the station.

Costs

An elevated structure will likely be less costly than a tunnel through Downtown. As indicated in the RouteAhead document, an above ground LRT would be expected to cost between $50 and $100 million per km, while an underground LRT would typically cost between $200 and $250 million per km. Pursuing a less expensive elevated structure in the Centre City would potentially allow for the earlier construction of a rail line.

There are various indications, however, than an aerial structure would more expensive than typical in the Centre City. It is expected that for every increase in five meters (the height of a building story), there would be a 25% increase in structure cost. Furthermore, the additional height of the stations would likely require more elevators and station-related costs than a typical station. The pier foundations are another cost driver that would need to be estimated with more detailed information on the foundations in the downtown and utility elevations.

Storm Resistance

The flooding that occurred in the City of Calgary in 2013 has made City staff and residents more aware of the risks that are inherent to The City's transportation systems. While an elevated LRT line might recover faster from flooding than a tunnel, it is still exposed to certain risks, such as damage to its structures from floating debris and to its elevators, escalators, and substations from street level water. There are means for mitigating the risks of tunnel flooding through the design of flood break vent shafts and the use of gates and pumps.

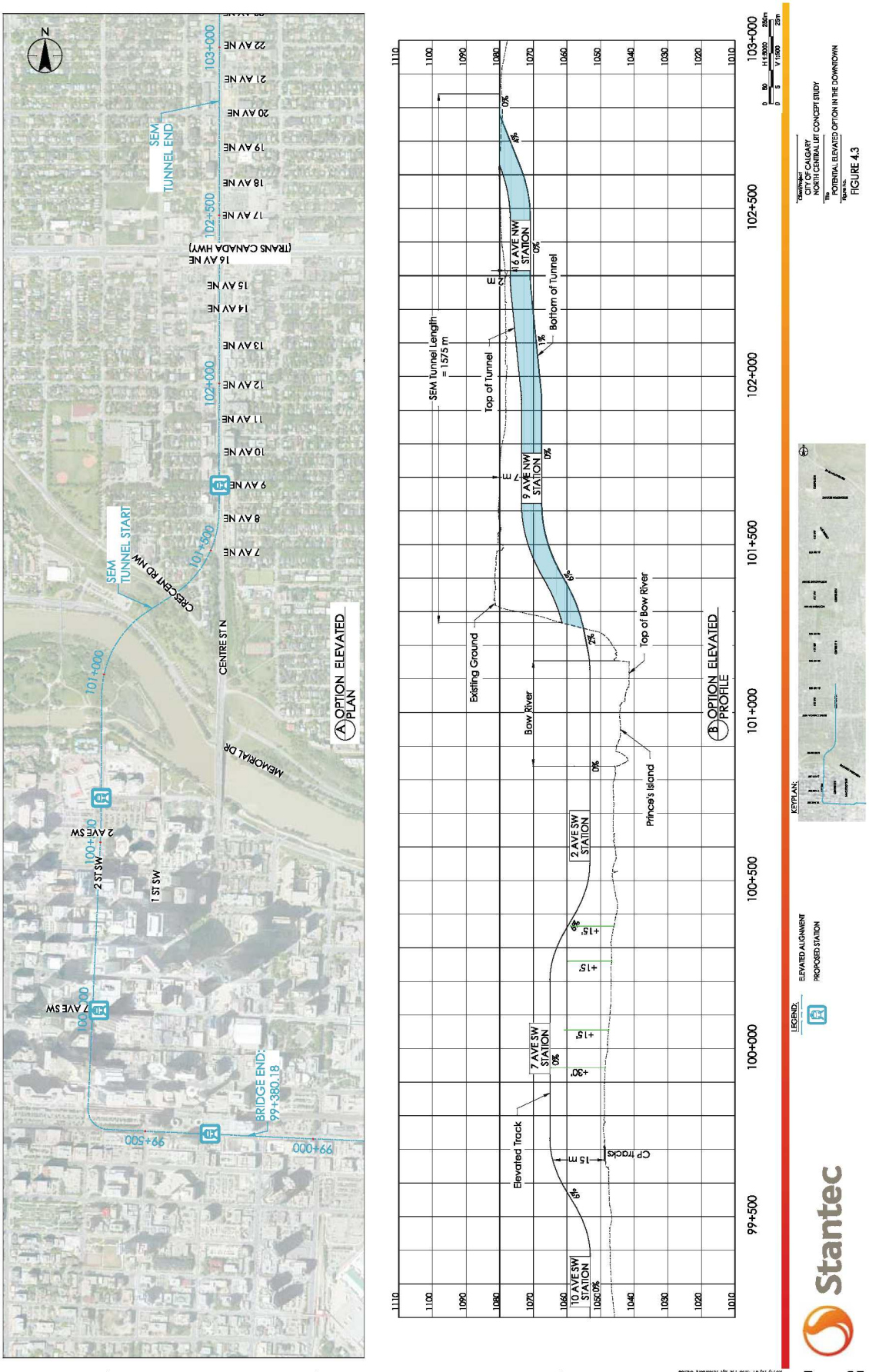
Public Acceptance

From the previous analysis and public engagement that was done throughout the project the community was not in support of elevated LRT options for the NCLRT. There is also evidence from past studies that the public has various concerns about elevated structures for rail transit, notably that they will decrease property values and negatively impact views.

Overall the analysis for the elevated LRT in the downtown indicated that presence of the +15 and +30 networks would likely require very high structures to facilitate elevated LRT, and that this would create additional costs and noise/vibration issues. The analysis also included a high level review of other existing elevated LRT systems including the Vancouver Canada Line, Chicago Loop, Seattle Monorail, Bangkok SkyTrain, and Calgary's West LRT at Sunalta. Some mitigating strategies were recommended from other cities with elevated rail lines in their downtowns in the event elevated LRT becomes a feature of the Green Line.

Refer to **Appendix E** for a summary of the analysis on elevated options in the downtown.

The +15 and +30 network, and clearance requirements over the CPR corridor create significant height restrictions on elevated options in the downtown. Dramatic changes in the character of the downtown and Prince's Island Park are key considerations for any elevated LRT line in the downtown.


A OPTION ELEVATED PLAN
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CRESCENT RD NW
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2 AVE SW
7 AVE SW
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7 AVE SW STATION
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9 AVE NW STATION
16 AVE NW STATION
Elevated Track
CP tracks
Existing Ground
Top of Tunnel
Bottom of Tunnel
SEM Tunnel Length = 1575 m
Bow River
Top of Bow River
Prince's Island
LEGEND:
ELEVATED ALIGNMENT
PROPOSED STATION
KEYPLAN:
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
POTENTIAL ELEVATED OPTION IN THE DOWNTOWN
FIGURE 4.3

5.0 EDMONTON TRAIL VS CENTRE STREET

The high level MAE resulted in the reduction of candidate corridors to only two as highlighted in **Table 5.1**.

Table 5.1: Summary of High Level MAE

Accounts	Centre Street	Edmonton Trail
FINANCIAL CAPACITY (capital cost)	5	5
COMMUNITY WELL BEING (linkage to destinations)	5	4
PROSPEROUS ECONOMY (population served, jobs served, access to YYC)	2.8	3.8
TRANSPORTATION (ridership, efficiency, journey time, compatibility)	4	4
URBAN DEVELOPMENT (TOD opportunity, development potential)	4	4
SUSTAINABLE ENVIRONMENT (Impact on the natural environment)	5	3
DELIVERABILITY (technical considerations)	3	2
TOTAL	**28.8**	**25.8**

Though the scoring was specifically for the at-grade options, these considerations were set aside once a corridor was chosen. This preliminary review showed that Centre Street had an overall advantage to the city over the Edmonton Trail option due to challenges of building in the Nose Creek corridor at the north end of Edmonton Trail.

CENTRE STREET was selected as the PREFERRED CORRIDOR based on performance on the high level MAE in additional to more detailed analysis done on ROW width, walk sheds, ridership, geometrics speed restrictions, access to downtown, TOD potential, environmental issues, and public preference.

A review was conducted of both corridors based on a number of key factors in LRT success including the impact of the high level MAE. The other factors included:

- Public preference
- Width of the right-of-way (ROW) and the constraints that exist in different sections of each corridor.
- Potential walksheds for each corridor which helps define potential ridership
- Estimated ridership
- Ability to access downtown easily
- Potential for development opportunities
- Impact on the natural environment

Details on each of the factors are provided below.

Public Preference

The public engagement for the NCLRT was ongoing since the summer of 2013 with a detailed set of workshops and open houses in April 2014 aimed at seeking public input on the two alignments. Attendees to the open houses were shown the alignment at a scale of 1:700 so that individual houses were identifiable. The alignments were placed on the floor in order to allow attendees to 'walk' the alignment with stations shown. Information boards along the alignment showed the available right of way and a number of optional designs with different width requirements. The intent was to solicit feedback on a preference for corridors along with the character of the corridor (i.e. LRT with one travel lane, two travel lanes, parking etc).

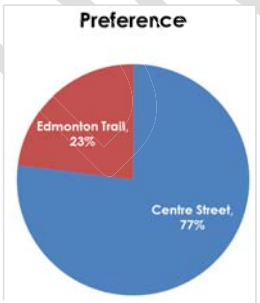

Figure 5.1 Public Preference (Open House and Online Respondents)

Several hundred residents attended the two open houses and provided significant verbal and written feedback. A preferential survey conducted for the entire corridors (as opposed to the previous review from 16 Avenue NE northwards) showed overwhelming support of those who responded at the open house and online for the use of Centre Street for an LRT line as shown in **Figure 5.1**. There were a number of residents of Edmonton Trail that commented verbally to staff that they understood that traffic would likely divert to their area if Centre Street was used but still maintained a preference for Centre Street.

The directness of the Centre Street routing, the greater proxmity of residences near Centre Street (as opposed to the existing light industrial character of the northern half of Edmonton Trail) and the value placed on the Nose Creek green space were prime factors cited for the preference.

Right of Way Width

The review of the existing right of way (ROW) from the Bow River to Beddington Trail shows that both corridors vary considerably in width through the segments and intersections. Both have constricted areas; however Edmonton Trail has a greater percentage that is 20 metres wide that is primarily situated south of 16 Avenue NE where there are also several new developments adjacent to the ROW. Centre Streets has more than 70% of its length with ROW greater than 26m in width providing opportunity for left turn bays at key intersections north of 24 Avenue NE. Edmonton Trail has a more constrained ROW than Centre Street but does have more than 40% of its route in undeveloped greenfield areas.

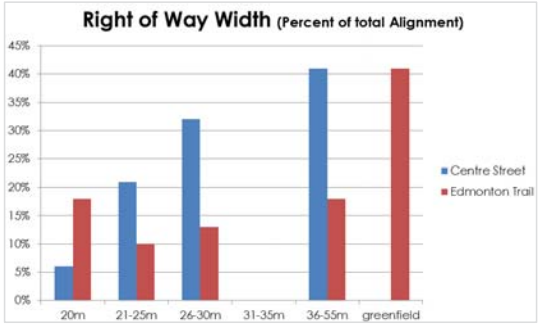

Figure 5.2 Right of Way Width Comparison

NORTH CENTRAL LRT CORRIDOR STUDY

Edmonton Trail vs Centre Street
December 1, 2014

The basic cross section for running an LRT in both directions is approximately 7 metres with an additional 3.5 meters for a side loading station adjacent to a sidewalk or up to 7+ metres for a centre loading station. The two options for the central portion of each alignment are a narrow option and a wide option as shown in **Figure 5.3 and Figure 5.4.**

Walksheds

Based on the City of Calgary's walkshed assessment for the North Central LRT Regional Context Study and HR&A's short term TOD assessment, Centre Street provides for a larger population (43,000 to 35,000) while Edmonton Trail effectively misses the residential area between Beddington Trail and 64 Avenue NW.

Boardings

An analysis of peak hour boardings on each alignment between 16 Avenue NE and Stoney Trail was based on the use of the 2076 LUN model travel demand forecast. This analysis estimates that the Centre Street alignment option would potentially generate 14-19% higher boardings per hour or per peak direction than the Edmonton Trail Option

Table 5.2 – Boardings Comparison North of 16th Avenue

	A Centre Street	B Edmonton Trail	C Difference (C=(A-B)/A)
AM Peak Hour	6,500	5,600	14%
PM Peak Hour	6,100	5,000	18%
AM Peak Hour Peak Direction	8,400	6,800	19%
PM Peak Hour Peak Direction	2,900	2,500	14%

North

Figure 5.3 Narrow Option (LRT plus one travel lane in each direction)

Figure 5.4: Wide Option (LRT plus two travel lanes in each direction)

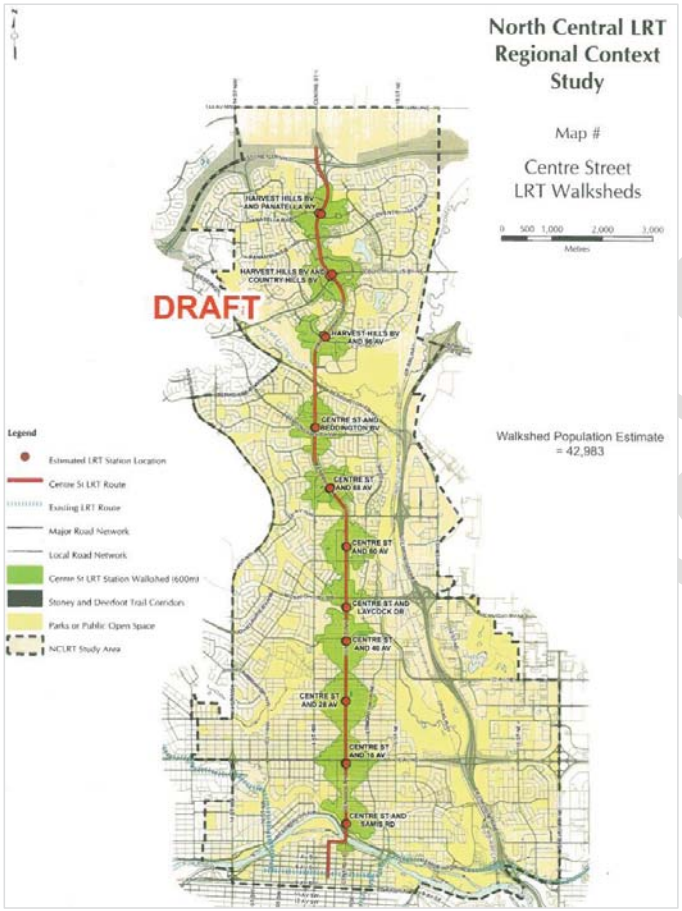

Figure 5.5 Centre Street LRT Walksheds

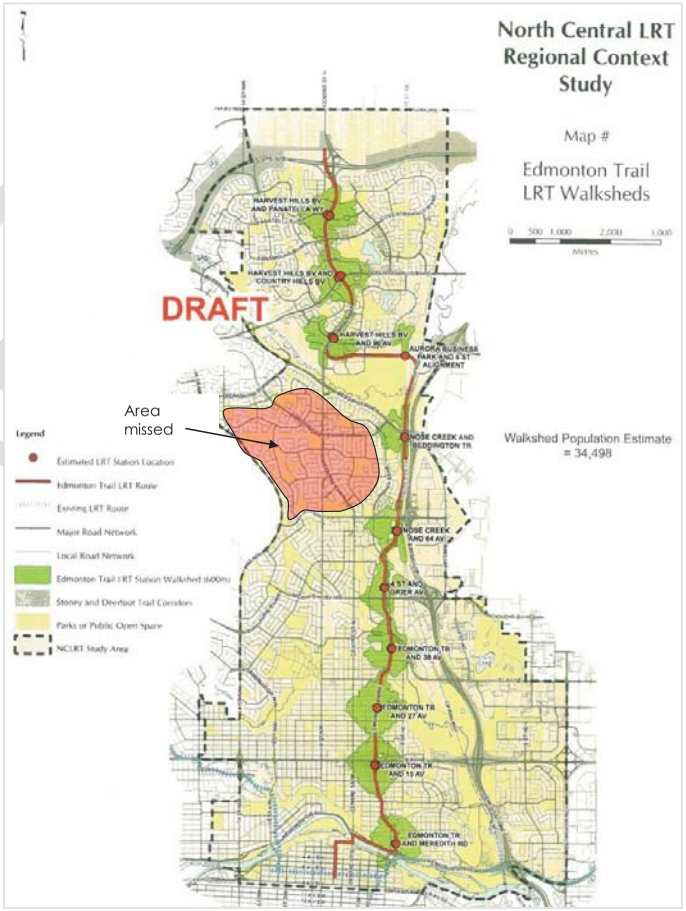

Figure 5.6 Edmonton Trail LRT Walksheds

Speed Restrictions

An initial review of the corridors for potential running speeds has indicated that the curvature of Edmonton Trail in two areas potentially create speed restrictions in order to maintain a minimal ROW width. These two areas are at 33 Avenue NE and 5 Avenue NE as shown in **Figure 5.9**. There are no similar restricted areas on the Centre Street corridor. Speed restrictions can correlate to reduced travel times and are in place to reduce the potential noise issues from wheels on an LRT.

Figure 5.9: Areas with potential speed restriction

Access to Downtown

The entry of an LRT into the downtown area at-grade presents some challenges with respect to impacts on existing traffic and transportation systems. The Centre Street alignment, if it uses Centre Street in the downtown would likely reduce traffic access into the downtown across the bridge and into the Chinatown area. Edmonton Trail has two potential options, both of which have an impact upon existing access into the downtown. Using Memorial Drive and onto Centre Street or the 5 Avenue SE option have similar ramifications to the Centre Street option. Bringing LRT through Edmonton Trail and onto 4 Avenue SE or 5 Avenue SE will exacerbate existing entry and exit congestion into the downtown.

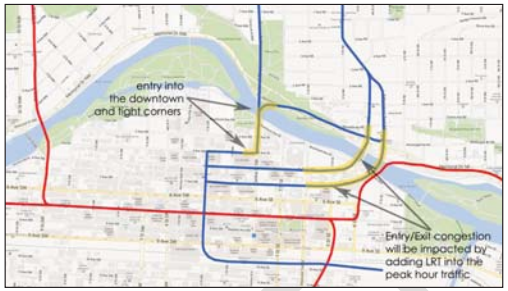

Figure 5.7: Access challenges into Downtown

TOD and Development Potential

A review by HR &A on the relative development potential of each alignment determined that development potential could be categorized into a number of categories:

- Downtown and adjacent communities (eg. Beltline, Eau Claire, Stampede, Railtown)
- Business or Industrial Parks (Aurora and Greenview)Station Areas
- Vacant Sites
- Active but underutilized sites

The main challenge to creating TOD sites is the ability to agglomerate parcels into a usable bundle, the rezoning opportunities, and access to LRT. The review examined the potential of each corridor with respect to the TOD potential in the future (See **Figure 5.8**). These sites and neighbourhoods were reviewed as potential catalytic sites with concrete construction which was identified as a minimum in order to support the economics of redevelopment. Neighbourhoods closer to the downtown core fared better than isolated lots, and Centre Street had a larger proportion of publicly owned land in large lots than Edmonton Trail. Edmonton Trail has the Greenview Industrial Park nearby and both alignments are accessible to the Aurora Business Park. The Beddington Boulevard/Centre Street area has the largest pool of private and public land in large parcels that could facilitate TOD outside of the downtown.

Overall, the Centre Street corridor had a greater potential for TOD style development in the near term, particularly from 24th Avenue North south while Edmonton Trail had longer term advantages due to the potential to redevelop light industrial land. Edmonton Trail has shown development potential between approximately 6 Avenue NE south to Memorial Drive but was not perceived to have the same overall potential north of 56 Street NE as did Centre Street.

Environment Issues

More than 40% of the total Edmonton Trail alignment runs through 'greenfield' areas where there is no existing development. A portion of this includes the development of the Aurora Business Park north of Beddington Trail while a large segment is within the Nose Creek Corridor adjacent to the creek bed. This has not been examined in detailed, but a cursory review shows that there are pockets of environmentally challenged areas along Centre Street from old businesses but a greater concern on Edmonton Trail through Nose Creek.

Figure 5.8: Sites with TOD Potential

Summary of Corridor Comparison

The technical analysis considered the ROW widths available versus the needs for a number of segments along each line as well as potential property requirements, station locations and ability to access downtown as part of a preliminary design discovery phase of the project. The intent was to provide sufficient detail in order to allow a comparison of the corridors and ultimately begin the process of selecting a final corridor to bring forward to the public and council in the fall of 2014.

From a development perspective, the Centre Street corridor appears to have a greater potential for short term TOD, particularly from 24 Avenue south while Edmonton Trail had long term TOD advantages due to the potential to redevelop light industrial land at Greenview Industrial Park and a more direct connection to the Aurora Business Park but also through the miscellaneous light industrial area between 32nd Ave and McKnight Boulevard.

Generally, Centre Street was found to better meet the assessment criteria in most categories of the high level MAE except for access into downtown and the development potential. Edmonton Trail offered some basic challenges in terms of speed reductions, access to downtown, and environmental impacts. Overall, Centre Street was demonstrated to be the preferred alignment based on all categories considered in the analysis. More information on how Centre Street was identified as the preferred alignment for the NCLRT Concept Study can be found in **Appendix F.**

Table 5.3: MAE summary

Assessment	Centre Street	Edmonton Trail
1 – 16 Avenue N High Level MAE	●	
2 – Public Preference	●	
3 – ROW Width	●	
4 – Walksheds	●	
5 – Boardings	●	
6 – Speed Restrictions	●	
7 – Access to Downtown	●	●
8 – TOD Potential	●	●
9 – Environment Issues	●	

● - Indicates a clear benefit over the other corridor

● - Indicates that the corridors are equal

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6.0 DEVELOPING CENTRE STREET OPTIONS

6.1 PRINCIPLES

With the selection of Centre Street as the preferred corridor, several options were developed for the proposed alignments based on principles that formed the basis of conceptual design assumptions that were made. The assumptions are listed below:

- Future LRVs were assumed to be low-floor technology and up to four-cars in length (approximately 100m in length for four cars)
- Station dimensions used were approximately 120m to 150m to account for 0% slopes along station lengths
- Due to headways, grade separation would be required between other rail lines including the existing 7 Avenue tracks, the future 8 Avenue tunnel, and freight lines of CPR
- Integrated in-street LRT would run with full signal preemption but would still encounter some delay at intersections for pedestrian crossings
- Special track work, OCS, and TPSS are included in the proposed LRT ROW width
- Strategic partial land acquisition will be required at the majority of station and left turn locations
- Provision of a maintenance facility will be on the GL-SE due to land availability
- Direct connection between the GL-SE and the GL-NC

6.2 CHARACTERISTICS OF CENTRE STREET

Centre Street does not have a homogenous character or ROW, but rather it has a mix of residential and commercial properties in addition to varying ROW widths. The land uses combined with ROW widths were used to determine the character areas in order to help identify the different constraints that are faced within each segment. This division helped to develop different context sensitive solutions for each segment. The characteristics of the different segments are summarized in **Table 6.1**.

In general several options existed within areas #1 - #4, and #7. These areas were focused on in order to develop options that were context sensitive to the surrounding environment. For the MAE character area #1 was focused on due to the Bow River crossing and the downtown connection for the corridor. For Segment #2 it was determined that the solution developed for Segment #1 would dictate the options for Segment #2. Segments #3 and #4 were combined for the MAE analysis as they both had similar characteristics. Segments #5 and #6 were not assessed as it was determined that the LRT could fit with minimal constraints. Segment #7 was assessed independently as it faced more unique challenges with parking for the adjacent residential properties. Lastly, Segment #8 was also not assessed as there were no anticipated challenges with dedicated space for the LRT.

Table 6.1: Characteristics of Centre Street

Area #1 Downtown to 9 Avenue N	**Land Use:** Typically higher density mixed uses of residential and commercial properties	**Area #3** 24 Avenue N to 40 Avenue N	**Land Use:** Mixed use with commercial, multi-family, and single-family residential properties fronting onto Centre Street	**Area #5** McKnight Blvd. to 64 Avenue N.	**Land Use:** Largely single-family residential properties with some mixed use parcels including Thorncliffe Community Centre	**Area #7** Beddington Blvd. to Beddington Tr.	**Land Use:** Typically single-family residential properties fronting onto Centre Street
	ROW Range: Average 20m to 24m available		**ROW Range:** Average 20m to 26m available		**ROW Range:** Average 30m available		**ROW Range:** Average 22m available
Challenges: Narrow ROW requires tight turns for the LRT at-grade in the downtown and may also have conflicts with below-grade structures. The Bow River crossing also presents challenges for the LRT to connect North Central communities to the downtown. Based on the CTP, any new river crossing for primary transit requires strong justification and optimization of other options before considering new river crossings.		**Challenges:** Narrow ROW will require some strategic land acquisition along this segment. Typically properties in this area have more setback distance to avoid conflicts with private buildings on the property.		**Challenges:** Wider ROW has few constraints and minimal impacts to adjacent properties.		**Challenges:** With the narrow ROW and the proximity of the residential properties strategic land acquisition would be a consideration in this segment. The crossing of Beddington Trail is also a challenge for this segment with redesign of the interchange likely required in order for the RLT to cross below Begginton Trail at-grade along Centre Street / Harvest Hills Boulevard.	
Area #2 9 Avenue N to 24 Avenue N	**Land Use:** Typically commercial properties front onto Centre Street on both sides	**Area #4** 40 Avenue N to McKnight Blvd.	**Land Use:** Largely single-family residential properties fronting onto Centre Street	**Area #6** 64 Avenue N to Beddington Blvd.	**Land Use:** Largely single-family residential with some multi-family residential and a large big box commercial property	**Area #8** Beddington Tr. to Country Hills Blvd.	**Land Use:** Typically single-family residential properties separated from Harvest Hills Boulevard, in addition to some isolated
	ROW Range: Average 22m available		**ROW Range:** Average 24m to 27m available		**Average 36m available**		**ROW Range:** Average 45m available
Challenges: Narrow ROW will require some strategic land acquisition along this segment for left turns and stations. Due to the age of the buildings some properties do not meet the required setback bylaws for Centre Street. These properties may be in conflict with partial land acquisitions and may require full parcel acquisition.		**Challenges:** With the slightly wider ROW there is more space with fewer constraints. The character of this area is largely uniform.		**Challenges:** The wide ROW has few constraints. The character of this area changes with the center island median dividing Centre Street into two seemingly separate areas.		**Challenges:** This area would have almost no challenges as the LRT was pre-determined to fit within the 1.5m dedicated center island.	

6.3 IDENTIFYING ALIGNMENT OPTIONS

Based on the character areas along Centre Street, a detailed review of the corridor was done in order to establish the type of alignments possible based on location specific issues that impact alignment choices on either side of the segment. Key segments that were focused on are shown in **Figure 6.1**.

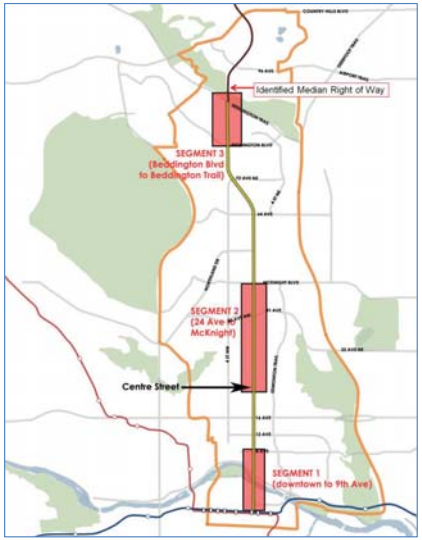


Figure 6.1: Centre Street Segments

6.4 BUSINESS AS USUAL (BAU)

One of the keys to conducting a MAE is to compare the alternatives to a Business As Usual (BAU) scenario. The BAU refers to the facilities and operating conditions that are expected to be in place right before any LRT project is implemented in the corridor. Typically the BAU is assumed to be similar to narrow cross section options with the proposed LRT in place. The purpose of developing this scenario is to provide a common point of reference for the options that are developed and compared through the multiple account evaluation process. The BAU scenario is different than existing conditions; it is based on an approved plan to introduce bus lanes for the benefit of transit customers in the near term through the Centre Street Transitway project.

The BAU scenario was defined as the designation of existing curb lanes between the Bow River and Beddington Trail as bus lanes. Buses would have access to the bus-only gate that connects Centre Street to Harvest Hills Boulevard in the area around Beddington Trail. It is possible that the bus lanes will be open to high-occupancy vehicles or to vehicles turning right. For the purpose of creating the BAU, it was assumed that station locations would coincide with current BRT stations located on Centre Street, which include facilities at 16 Avenue N, 40 Avenue N, 56 Avenue N, 64 Avenue N, 78 Avenue N, and north of Beddington Boulevard. There are also seven BRT stations located north of Beddington Trail in the Harvest Hills alignment. Given that buses would be operating in the curb lanes, it was assumed that bus stops would be integrated into the sidewalks.

The Business as Usual (BAU) scenario outlines the Base Point or the detailed MAE analysis that was done for the alignment options along Centre Street.

For the BAU it was assumed that there would be modifications to traffic signals to increase speeds of bus service and that additional restrictions on general traffic would be implemented in the form of left turn restrictions. The BAU is not assumed to have any right turn restrictions. However, when the LRT is in place it is expected that lane widths would be reduced and would result in private vehicles and trucks potentially encroaching on the LRT guideway for right turns from driveways and side streets. Some land acquisitions may also be needed to accommodate exclusive left turn lanes in the BAU but these have not been accounted for as the details for the Centre Street Transitway remain unknown. It is assumed that no structures would be built in this scenario to provide grade separation for the busways. As for the rest of the bus network, it is assumed that there would not be changes required as a result of the development of these bus lanes.

It is important to highlight that one of the major implications of the use of the BAU scenario described above is that when LRT is implemented in the corridor, it has been assumed that capacity for general traffic in the corridor will already have been reduced from two to one lane in each direction. Therefore, by the time the LRT is implemented, the general traffic will already have adjusted in response to the reduced capacity along Centre Street. It is expected that, to the degree possible, the bus lanes will remain in place for as long as possible during the construction of the LRT system.

6.5 MAE 1: DOWNTOWN TO 9 AVENUE N

As previously outlined in section 6.2, MAE 1 is focused on character Area #1 of the alignment. This first segment of the final MAE has various physical constraints including:

- Connecting the NCLRT to the SELRT
- Grade separating the existing 7 Avenue LRT service to optimize LRT operations
- Requirement to avoid the future 8 Avenue LRT subway
- Crossing the Bow River
- Traversing the escarpment north of the Bow River

The options were developed to meet these basic requirements and best meet the vision and goals for the NCLRT. It is assumed that the alignment selected for this segment will heavily influence the nature of the alignment between 9 Avenue N to 24 Avenue N, including the width of the ROW. In addition, although it is outside of the limits of the MAE 1 area, it has been assumed for costing purposes that the LRT will be grade separated at 16 Avenue for all alternatives.

6.5.1 Option 1: New Bridge River Crossing

Option 1 was developed to avoid modifications to the Centre Street Bridge and to provide more accessible stations that connect directly to the SELRT and to the community of Crescent Heights, as shown in **Figure 6.2**. This option ties the north central and southeast portions of the Green Line in a tunnel at 10 Avenue S and Centre Street. The profile goes below the potential future 8 Avenue LRT tunnel to avoid future construction conflicts. In this tunnel segment an underground station at 7 Avenue S is proposed at 15 metres deep. This station will serve as a main transfer point from the Green Line to the existing red and blue LRT lines. The tunnel would daylight at 2 Avenue S to minimize vehicular impacts on 4, 5, and 6 Avenues in the downtown. The expected length of this tunnel would be 1.2 kilometres. North of the northern tunnel portal, an at-grade station is proposed at Eau Claire in order to tie into future redevelopment of the area. North of Eau Claire station the LRT will transition into a bridge for 470 metres over Prince's Island Park. The bridge would tie into the McHugh Bluffs on the north side of the Bow River into a tunnel below the community of Crescent Heights. The second tunnel segment north of the Bow River would begin turning towards the station at 10 Avenue and Centre Street. The depth of this station in Crescent Height is expected to be 18 metres. The tunnel will extend north and daylight at 18 Avenue N in order to avoid an at-grade crossing of 16 Avenue N. A third underground station would be proposed at 16 Avenue N. The anticipated length of the tunnel north of the Bow River would be 0.9 kilometres.

6.5.2 Option 2: Existing Centre Street Bridge River Crossing

This option was developed to minimize construction costs. The LRT would still require a tunnel in the downtown from 10 Avenue S and Centre Street to travel below the CPR tracks, the future 8 Avenue LRT tunnel, and the existing 7 Avenue tracks. Similar to option 1, a 15 metre deep underground station at 7 Avenue would be provided. The LRT would daylight at 2 Avenue SW and 1 Street SW. The expected tunnel length for this option would be 1.2 kilometres. East of the tunnel portal, a station would be provided between the Eau Claire area and Chinatown at 2 Avenue SW and 1 Street SW. The LRT would travel along 2 Avenue SW and turn on Centre Street to continue at-grade along the existing Centre Street Bridge to 9 Avenue N. An at-grade station would be provided at 9 Avenue N at the community of Crescent Heights. At 16 Avenue the LRT will likely grade separate below the intersection and provide a grade separated station. This option is shown in **Figure 6.3**.

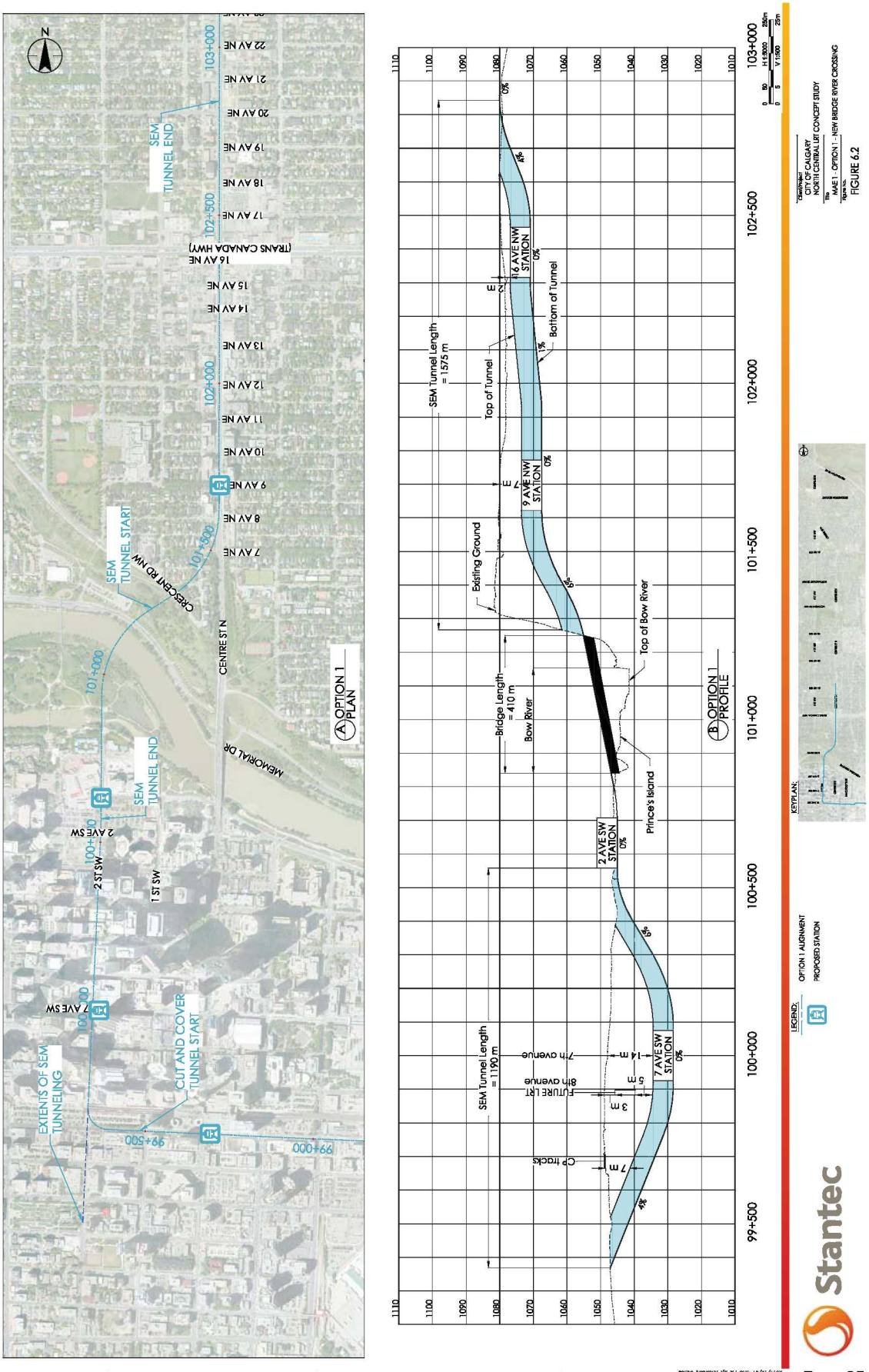
6.5.3 Option 3: Tunnel River Crossing

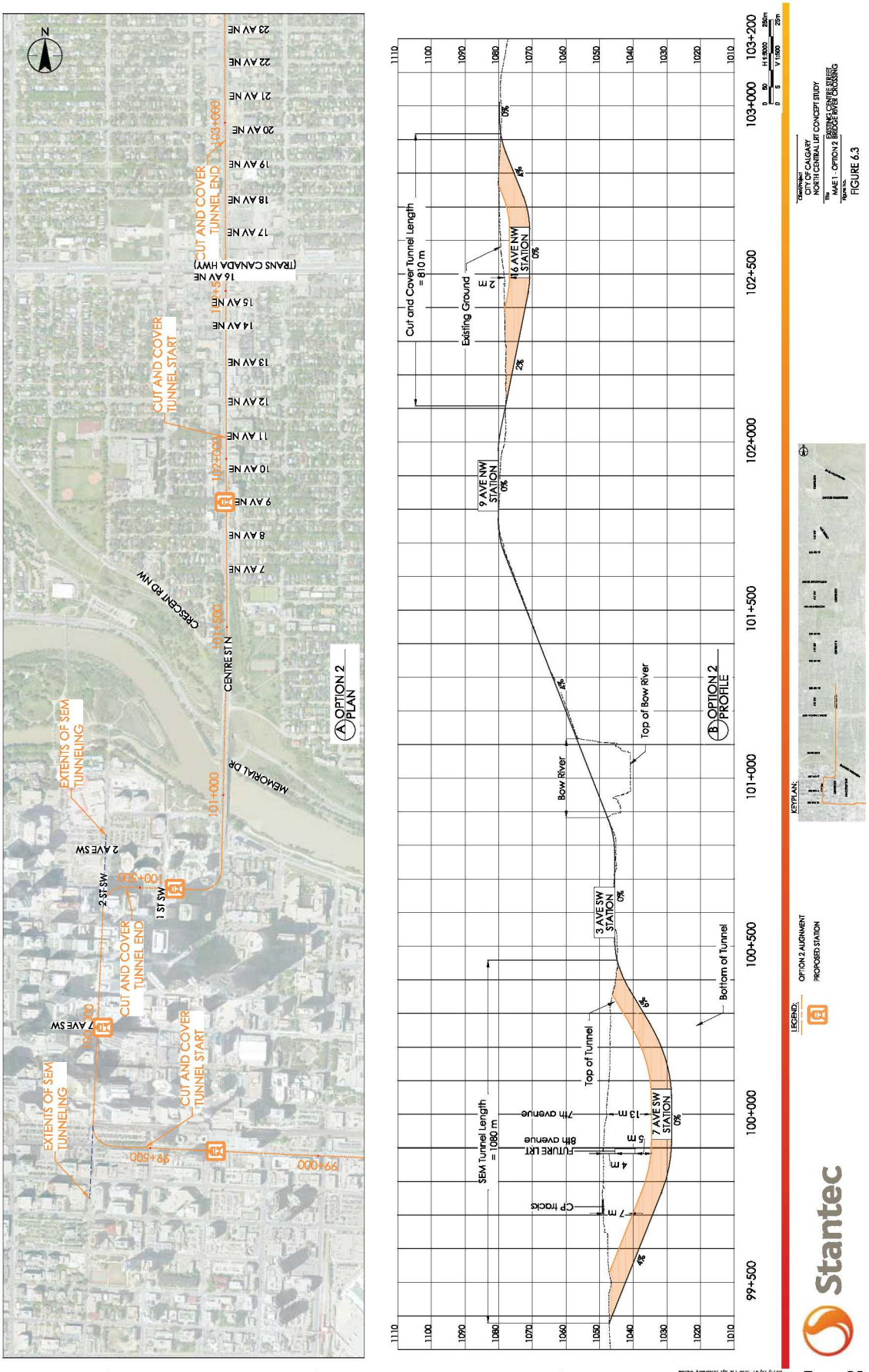
Another option for crossing the Bow River was to use a Tunnel Boring Machine (TBM) to tunnel below the river and connect the LRT from the downtown to Crescent Heights in one tunnel. This option would require a depth of 21 metres below the bottom of the river.[1] For this option the top of the tunnel would be 7 metres below the CPR tracks at 10 Avenue and 1 Street SW. The tunnel would follow the approved SELRT alignment along 2 Street SW with an underground station at 7 Avenue S at a depth of 15 metres. A station would also be provided at Eau Claire at a depth of 22 metres. Due to the grade of the hill along Centre Street and the required 150-metre tangent length required for each station, the LRT would daylight at approximately 24 Avenue N. This was determined using a more conservative vertical grade of 4% rather than the maximum 6% grade. Due to the height of the escarpment and the grade used, the station at 9 Avenue N would be approximately 45 metres deep. This depth may pose cost and design challenges which will require further study and assessment compared to the anticipated ridership at this station. A station at 16 Avenue N would also be provided at approximately 29 metres deep. The total tunnel length of this option is expected to be 3.9 kilometres. This option is shown in **Figure 6.4.**

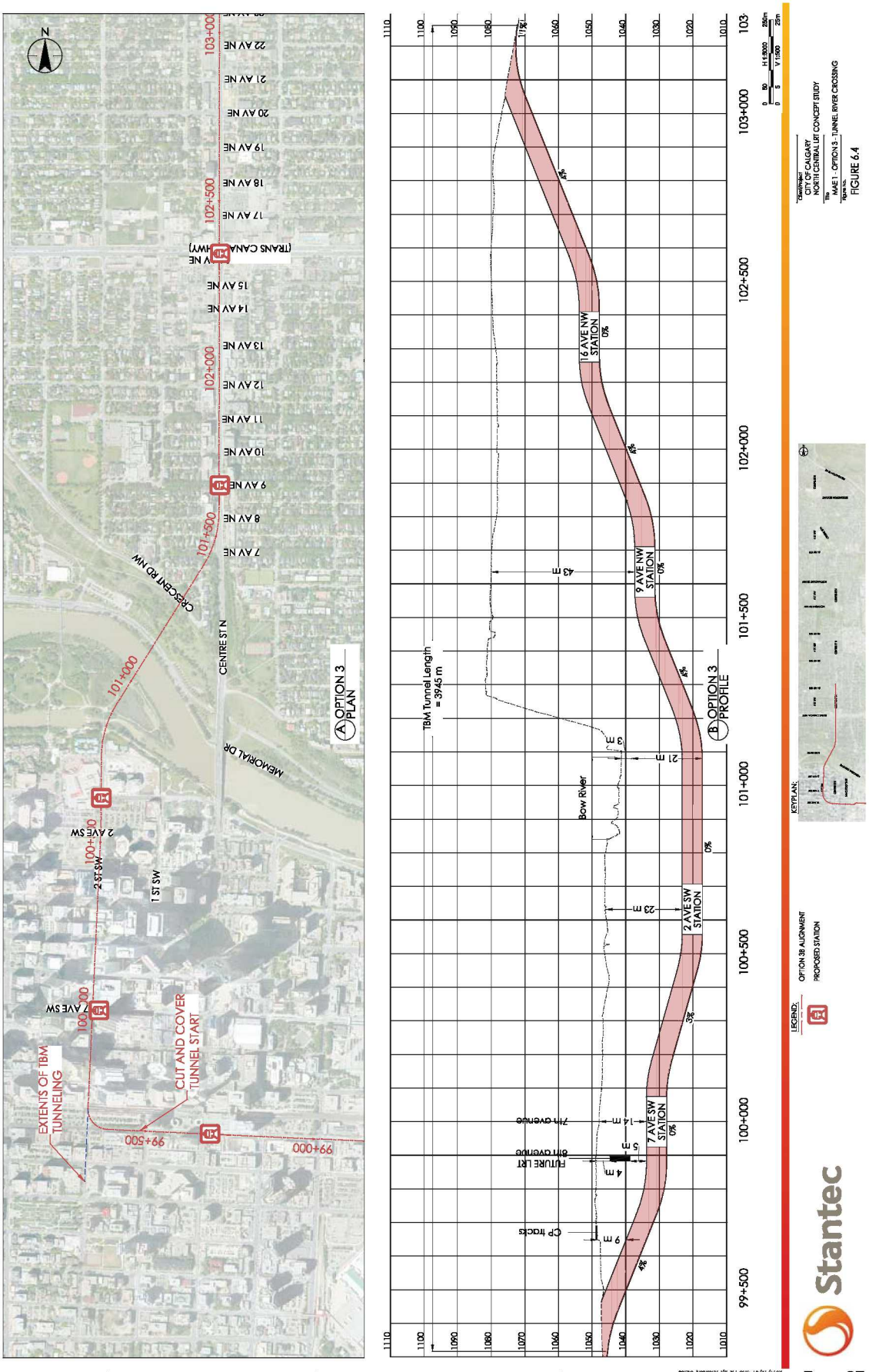
MAE 1: 3 OPTIONS that all include some level of TUNNELING. These options were developed based on different methods of CROSSING THE BOW RIVER and providing LRT service to CRESCENT HEIGHTS.

ALL of the options would be BELOW-GRADE at 16 AVENUE N.

[1] It is assumed that the depth of river would be 3 metres based on data received following the June floods. (http://www.theglobeandmail.com/news/national/interactive-water-level-in-calgary-river-more-than-doubled-in-24-hours/article12749501/) The tunnel would be a total of 24 metres from the top of the river to the bottom of the tunnel.


A OPTION 1 PLAN
B OPTION 1 PROFILE
SEM TUNNEL START
SEM TUNNEL END
CUT AND COVER TUNNEL START
EXTENTS OF SEM TUNNELING
CENTRE ST N
MEMORIAL DR
CRESCENT RD NW
1 ST SW
2 ST SW
2 AVE SW
7 AVE SW
9 AV NE
16 AV NE (TRANS CANADA HWY)
SEM Tunnel Length = 1575 m
SEM Tunnel Length = 1190 m
Top of Tunnel
Bottom of Tunnel
Existing Ground
Top of Bow River
Bridge Length = 410 m
Bow River
Prince's Island
9 AVE NW STATION
2 AVE SW STATION
7 AVE SW STATION
FUTURE LRT
8th avenue
7th avenue
C-P tracks
LEGEND:
OPTION 1 ALIGNMENT
PROPOSED STATION
KEYPLAN:
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
MAE 1 - OPTION 1 - NEW BRIDGE RIVER CROSSING
FIGURE 6.2
Stantec


A OPTION 2 PLAN
B OPTION 2 PROFILE
EXTENTS OF SEM TUNNELING
CUT AND COVER TUNNEL START
CUT AND COVER TUNNEL END
CRESCENT RD NW
CENTRE ST N
MEMORIAL DR
2 AVE SW
1 ST SW
2 ST SW
7 AVE SW
16 AV NE (TRANS CANADA HWY)
9 AV NE
16 AVE NW STATION
9 AVE NW STATION
3 AVE SW STATION
7 AVE SW STATION
Cut and Cover Tunnel Length = 810 m
Existing Ground
Top of Bow River
Bow River
Top of Tunnel
Bottom of Tunnel
SEM Tunnel Length = 1080 m
FUTURE LRT
8th avenue
7th avenue
CP tracks
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
KEYPLAN:
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
MAE 1 - OPTION 2
EXISTING CENTRE STREET BRIDGE RIVER CROSSING
FIGURE 6.3


A OPTION 3 PLAN
B OPTION 3 PROFILE
CRESCENT RD NW
CENTRE ST N
MEMORIAL DR
1 ST SW
2 AVE SW
7 AVE SW
EXTENTS OF TBM TUNNELING
CUT AND COVER TUNNEL START
TBM Tunnel Length = 3945 m
Bow River
16 AVE NW STATION
9 AVE NW STATION
2 AVE SW STATION
7 AVE SW STATION
FUTURE LRT
CP tracks
LEGEND:
OPTION 3B ALIGNMENT
PROPOSED STATION
KEYPLAN:
FIGURE 6.4

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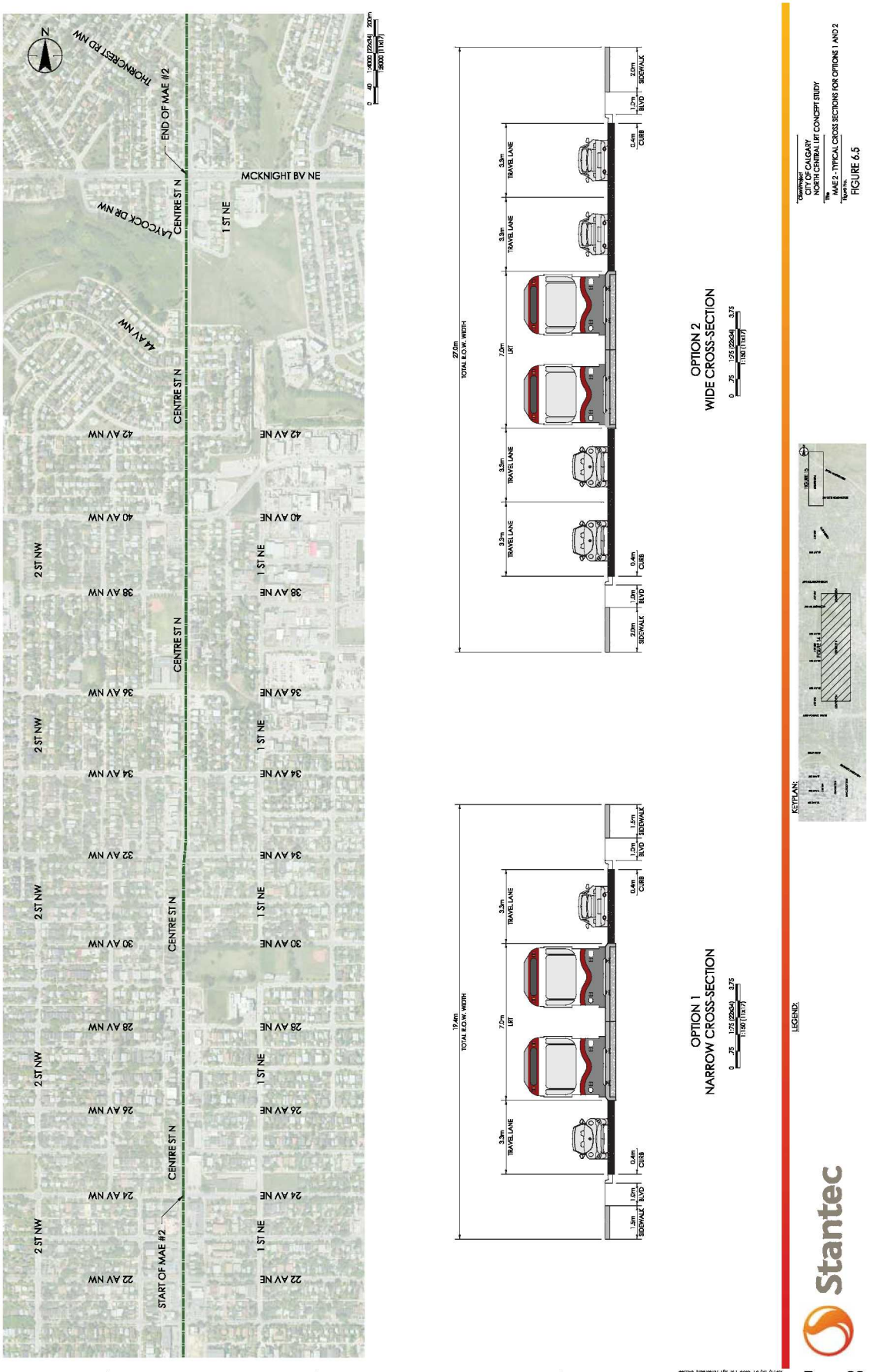

N
THORNCREST FD NW
END OF MAE #2
MCKNIGHT BV NE
LAYCOCK DR NW
CENTRE ST N
1 ST NE
44 AV NW
42 AV NW
42 AV NE
40 AV NW
40 AV NE
38 AV NW
38 AV NE
36 AV NW
36 AV NE
34 AV NW
34 AV NE
32 AV NW
30 AV NW
30 AV NE
28 AV NW
28 AV NE
26 AV NW
26 AV NE
24 AV NW
24 AV NE
22 AV NW
22 AV NE
2 ST NW
START OF MAE #2
OPTION 2
WIDE CROSS-SECTION
27.0m
TOTAL R.O.W. WIDTH
3.3m
TRAVEL LANE
7.0m
LRT
0.4m
CURB
1.0m
BLVD
2.0m
SIDEWALK
OPTION 1
NARROW CROSS-SECTION
19.4m
TOTAL R.O.W. WIDTH
1.5m
KEYPLAN:
LEGEND:
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
MAE 2 - TYPICAL CROSS SECTIONS FOR OPTIONS 1 AND 2
FIGURE 6.5

6.6 MAE 2: 24 AVENUE N TO MCKNIGHT BOULEVARD

As previously outlined in section 6.2, MAE 2 has combined character Areas #3 and #4 for the analysis as the options developed for these segments are fairly similar. The main physical constraints of these segments are the narrow ROW width available and the crossing of the intersection at McKnight Boulevard.

6.6.1 Option 1: Narrow Cross-Section

Due to the constraints along this segment a narrow cross-section was developed that included compromises for all road users to the minimum widths possible including replacing one travel lane for motor vehicles with the LRT. It was developed based on fitting the LRT into the narrowest segment of the corridor at 20.12 metres to avoid land acquisition impacts. The proposed narrow cross-section included the following:

- Minimum 1.3 metre clearance between LRVs (minimum distance to include a pole or delineation to prevent pedestrians from standing between two LRVs)
- Minimum 0.15 metre clearance from the edge of the LRV to the end of the rolled curb
- Total space for the LRT at 7.0 metres minimum
- Minimum travel lanes at 3.3 metres to provide some flexibility if transit will operate buses to access portions of the corridor
- Minimum 1.0m clearance from the back of curb to the center of the OCS pole in the boulevard space on each side
- Minimum 0.6 metre space for the base of the OCS poles
- Minimum sidewalk space of 1.56 metres on each side to provide similar sidewalk space as the existing

Although this section is narrow, at station locations and left turn locations the cross-section would widen by an additional 3.5 metres on each side. This would provide space for split center loading stations offset from dedicated left turn lanes.

6.6.2 Option 2: Wide Cross-Section

Since the minimum spaces proposed above were considered as compromises for all road users, a wider cross section was developed if it was warranted to maintain two travel lanes for motor vehicles in addition to the space required for the LRT. Although wider, this option still maintained minimum widths where possible in order to mitigate the amount of anticipated land acquisition. The proposed wide cross-section included the following:

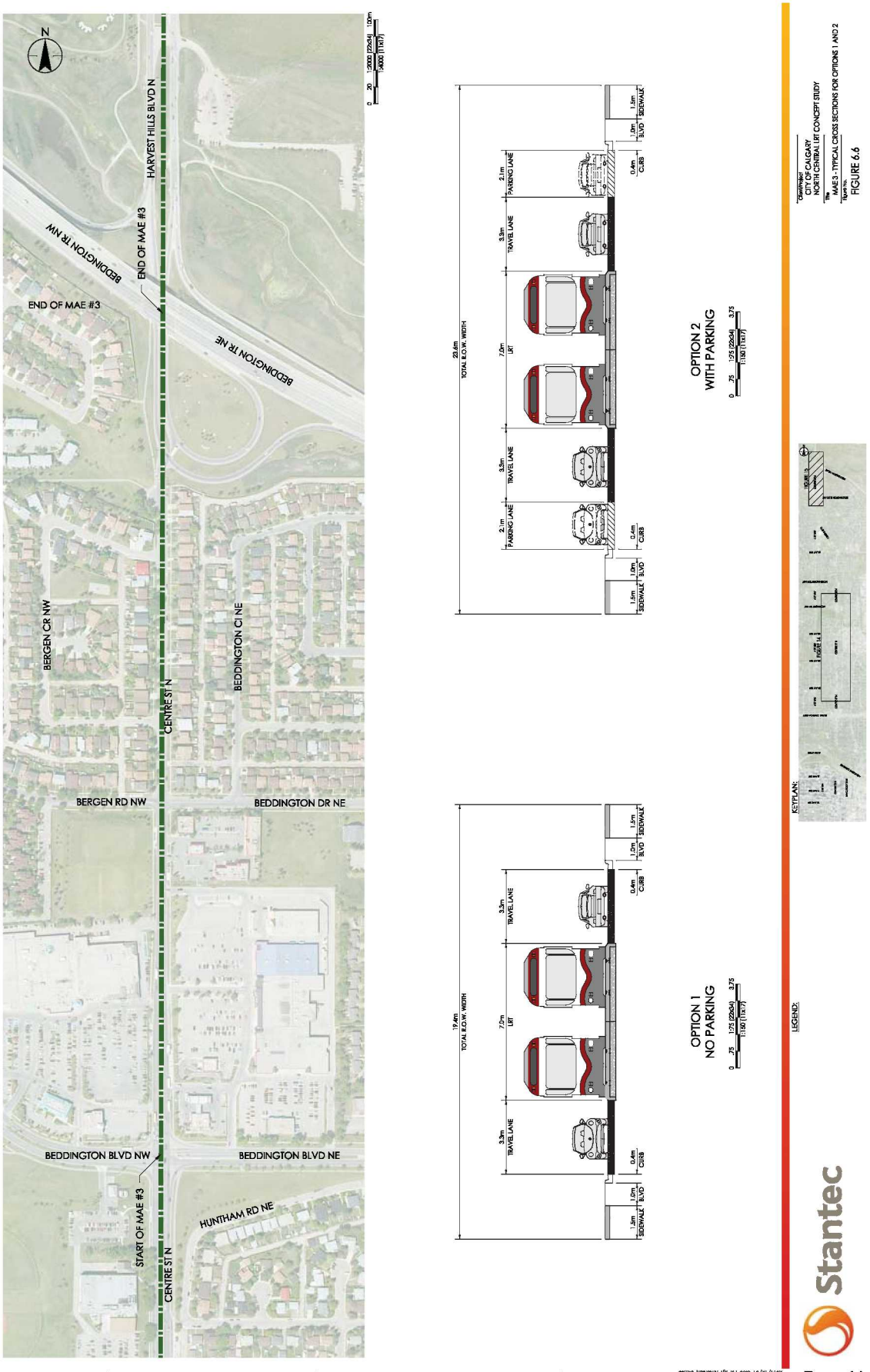
- Minimum 1.3 metre clearance between LRVs (minimum distance to include a pole or delineation to prevent pedestrians from standing between two LRVs)
- Minimum 0.15 metre clearance from the edge of the LRV to the end of the rolled curb
- Total space for the LRT at 7.0 metres minimum
- Two travel lanes with minimum widths at 3.3 metres to enhance right turn movements onto Centre Street
- Minimum 1.0m clearance from the back of curb to the center of the OCS pole in the boulevard space on each side
- Minimum 0.6 metre space for the base of the OCS poles
- Minimum sidewalk space of 2.0 metres on each side to provide some enhanced sidewalk space compared to the existing

At station locations and left turn locations the cross-section would widen by an additional 3.5 metres on each side. This would provide space for split center loading stations offset from dedicated left turn lanes.

Figure 6.5 shows the typical cross sections for both options 1 and 2 as they apply to this segment of Centre Street.

MAE 2 includes TWO OPTIONS that are both of AT-GRADE. These options were developed based on the impact to traffic and the narrow ROW. Both of these options include some level of LAND ACQUISITION.

ALL of the options would be BELOW-GRADE at MCKNIGHT BOULEVARD.


N
HARVEST HILLS BLVD N
END OF MAE #3
BEDDINGTON TR NW
END OF MAE #3
BEDDINGTON TR NE
BERGEN CR NW
CENTRE ST N
BEDDINGTON CI NE
BERGEN RD NW
BEDDINGTON DR NE
BEDDINGTON BLVD NW
BEDDINGTON BLVD NE
START OF MAE #3
CENTRE ST N
HUNTHAM RD NE
OPTION 2
WITH PARKING
OPTION 1
NO PARKING
KEYPLAN:
LEGEND:
Stantec

6.7 MAE 3: BEDDINGTON BOULEVARD TO BEDDINGTON TRAIL

As previously outlined in section 6.2, MAE 3 focuses solely on character area #7. The main physical constraint of this segment is the narrow ROW width available in addition to the on-street residential parking on both sides of Centre Street.

MAE 3 includes TWO OPTIONS that are both of AT-GRADE. These options were developed based on the impact to traffic and the narrow ROW. Both of these options include some level of LAND ACQUISITION.

For ALL of the options the LRT would travel BELOW BEDDINGTON TRAIL.

6.7.1 Option 1: No Parking in Right of Way

Similar to MAE 2 Option 1, due to the constraint in this segment a narrow cross-section was developed that included compromises for all road users to the minimum widths possible including replacing one travel lane for motor vehicles with the LRT. This would result in the center running LRT taking the space of the existing travel lanes, and the travel lanes being pushing to the curb lane where the existing parking is currently located. Although this segment is 21.95 metres (slightly wider than 20.12 metres), the cross-section developed was based on the same concepts to maintain consistency in the assumptions used throughout the corridor.

A station would be provided at Beddington Boulevard, however no stations and no left turn lanes would be provided between Beddington Boulevard to Beddington Trail.

6.7.2 Option 2: Parking in Right of Way

Since the main tradeoff for this segment is the residential on-street parking in front of the adjacent properties, a second option was created to restore the on-street parking. Since the existing road has one travel lane for motor vehicles, and since there will be no access to or from the north via Beddington Trail for private vehicles (location of the existing bus trap) the number of travel lanes will remain as one travel lane in each direction. The proposed wide cross-section included the following:

- Minimum 1.3 metre clearance between LRVs (minimum distance to include a pole or delineation to prevent pedestrians from standing between two LRVs)
- Minimum 0.15 metre clearance from the edge of the LRV to the end of the rolled curb
- Total space for the LRT at 7.0 metres minimum
- One parking lane at 2.1 metres wide and one travel lane at 3.3 metres wide
- Minimum 1.0m clearance from the back of curb to the center of the OCS pole in the boulevard space on each side
- Minimum 0.6 metre space for the base of the OCS poles
- Minimum sidewalk space of 1.5 metres on each side since the potential pedestrian demand in this segment is lower than segments south of McKnight Boulevard

A station would be provided at Beddington Boulevard, however no stations and no left turn lanes would be provided between Beddington Boulevard to Beddington Trail.

Figure 6.6 shows the typical cross sections for both options 1 and 2 as they apply to this segment of Centre Street.

6.7.3 General Consideration: Crossing Beddington Trail

North of the bus trap, the LRT is expected to remain at-grade below Bedlington Trail. This would require some reconstruction of the abutments for the Beddington Trail bridge in order to create more room for the LRT. The LRT could have various configurations with the north bound and southbound split or to have both tracks on one side below the bridge. North of this the LRT would require a bridge over the creek and would then have to transition back to center running to travel in the median along Harvest Hills Boulevard.

If tunneling were explored in this segment the tunnel extents would extend from Bergen Drive to 100 metres north of Beddington Trail. The total length of a tunnel below Beddington Trail would be approximately 900 metres based on the LRT clearance requirements and the steep grade south of Beddington Trail. It is recommended that tunneling below Beddington Trail be a last resort option if the interchange at Beddington Trail cannot be modified.

7.0 EVALUATION FRAMEWORK

The detailed MAE criteria were revised to develop a set of criteria that would help DISTINGUISH BETWEEN OPTIONS along Centre Street rather than different corridors.

In the early stages of the development of the evaluation process there were a number of criteria proposed for the detailed stage of the evaluation, but it was recognised that as the project progressed it was possible these criteria would be revised. The full lists of these criteria are shown in the High Level MAE Report in **Appendix D**.

It is key that the criteria selected are used to assess and compare options against each other to support a decision on a preferred package of measures to address the identified problem. The focus of the assessment is on those criteria that will highlight the key differences between options to support decision making. The MAE framework developed, was used to:

- Consider the broader impacts of projects beyond financial/cost to include qualitative impacts/benefits;
- Show the trade-off among often conflicting objectives; and
- Assess the alternatives against the project objectives examining the direct and broader public policy impacts.

In the early phases of the work it was considered that the criteria would need to differentiate between a number of route alternatives e.g. Centre Street or Edmonton Trail. It was also considered that there may be multiple different stop locations between the options even if they were on a single alignment.

Based on these assumptions, the preliminary proposals for the criteria for the detailed MAE included a number of geographic based criteria, which would distinguish between the options had they each been on different alignments or with different station locations or spacing. As the detailed evaluation Centre Street alignment has fixed station locations across the options, a number of the criteria became non-differentiating and were therefore dropped following a review of the criteria. This change in focus from evaluating a number of different alignments to instead evaluating options along a single alignment also led to the potential for duplication of some criteria, so again the criteria originally proposed were reviewed and any criteria that may be considered to 'double-count' were removed.

It was also important to ensure that across the multiple accounts that the overall number of criteria remained fairly consistent so that no single account had an undue influence on the outcome of the evaluation. To ensure this would remain the case, an average was calculated for each of the accounts. Finally, in order to demonstrate the impact that the Opinion of Probable Capital Cost (OPCCs) has on the evaluation, the summary of the evaluation of each of the alternatives is presented both with and without capital costs scoring.

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8.0 EVALUATION RESULTS FOR MAE 1: DOWNTOWN TO 9 AVENUE

8.1 OPINION OF PROBABLE CAPITAL COST

The OPCCs for each segment include requirements for construction and potential land acquisitions. The construction costs were calculated based on representative per kilometre costs for LRT construction and included the following elements:

- Roadworks
- LRT track and civil work
- LRT systems including power, OCS, signals, communications
- Structures including tunnels and bridge work (both for the existing Centre Street bridge and a new bridge crossing over the Bow River)
- Deep and shallow utility relocation
- Stations and facilities including TPSS

For the purpose of this study only, land acquisition impacts were estimated assuming a centre-running LRT configuration, where partial acquisition of adjacent land parcels on both the east side and west side of Centre Street may be required. Due to a high level of uncertainty surrounding the timing of land acquisitions, it was recommended that a factor of four to eight times the assessed market values be used. To be conservative, a factor of eight was applied to costs associated with all potential land purchases along the corridor.

For **OPTION 1**, the costs include two 'relatively' short tunnels and a new bridge crossing over the Bow River over Prince's Island Park. Due to the length of the tunnels it was assumed that a Sequential Excavation Method (SEM) would be used as it provides more flexibility to deal with locally unexpected ground conditions. However, a tunnel boring machine (TBM) could be used if available as some cost savings may be present depending on the geological conditions found. To be conservative, SEM tunneling was assumed for the downtown tunnel and for the tunnel north of the river to 18 Avenue N. The tunnel in the downtown assumes one underground station at 7 Avenue SW at $30 million. The tunnel would daylight at 2 Avenue SW to an at-grade station at Eau Claire. The bridge over the Prince's Island is assumed to be 10 meters wide and approximately 410 meters in length. The transition from a bridge to a tunnel into the McHugh Bluffs would need to be assessed further to determine additional costs that may result from this transition. As noted, the tunnel north of the river may continue with the SEM tunnel (shield tunneling may also be investigated for further study if geological conditions are unfavorable). For this segment the assumed costs for the 9 Avenue and 16 Avenue station have been assumed at $10 million due to the shallower depth of the station. Although the northern tunnel can be shorter, it has been extended in order to provide grade separation of the LRT to enhance LRT operations and mitigate traffic impacts. The overall OPCC for this option from downtown to 24 Avenue is estimated at $700 million.

For **OPTION 2**, the costs have assumed an SEM tunnel in the downtown with a similar station cost for 7 Avenue station at $30 million. Due to the tunneling geometry a cut and cover tunnel would be required to tie the SEM tunnel to 3 Avenue SW in order to achieve tighter turning radii to avoid conflicts between buildings in the downtown. Additional cut and cover costs have been included to account for tunneling tie ins. Additional costs have also been provided for potential upgrades of the Centre Street Bridge as there is some uncertainty on the southern span's capacity to carry additional LRT loads. Further north along this alignment some additional cut and cover tunneling has been included to grade separate 16 Avenue N station. This station may be constructed using a bridge for 16 Avenue and an underpass with retaining walls for the LRT. However, to be conservative the costs have assumed that cut and cover may be a requirement to grade separate 16 Avenue N. The overall OPCC for this option from downtown to 24 Avenue is estimated at $600 million.

For **OPTION 3**, the full costs have assumed TBM technology in 'good' geological conditions. TBM tunneling presents the most cost savings in tunneling technology when the length of the tunnel is greater than one mile (1.6 kilometers). For this segment increased station depths result from the required clearance below the river at 21 meters below the river bottom. This depth results in the deepest station at 45 meters at 9 Avenue N. The assumed cost for a deep TBM stations was $140 million. Station costs for this option varied based on depth with a cost of $100 million assumed for stations between 30 to 40 metres deep. The overall OPCC for this option from downtown to 24 Avenue is estimated at $1,300 million.

Table 8.1: MAE 1 – Opinions of Probable Capital Cost to 24 AVE

Option	Opinion of Probable Construction & Land Acquisition Costs	Assessment Score
1 – New Bridge Crossing of Bow River	$760 million	3
2 – Existing Centre Street Bridge Crossing of Bow River	$660 million	4
3 – Tunneled Crossing of Bow River	$1,300 million	1

A detailed breakdown of the OPCC for each option is provided in **Appendix G**.

8.2 FINANCIAL CAPACITY

NC LRT Project Objective: "An affordable and cost-effective service"

Phasing Possibilities

Phasing possibilities refer to the potential opportunities an option presents to be constructed in a phased approach. This is an important attribute because it represents a flexibility to deliver the GL-NC in a progressive way that is responsive to the available funding. All of the options presented for Segment 1 include a tunnel section traversing the existing 7 Avenue S LRT tracks, the future 8 Avenue S tunnel, and the CPR tracks. The opportunities to stage the construction of this tunnel are limited due to the high costs associated with tunnel construction. Conversely, the portions of at-grade profile featured in options 1 and 2 are more conducive to being delivered in a staged approach because construction costs are relatively smaller and more amenable to incremental funding access.

Table 8.2: MAE 1 – Financial Capacity: Phasing Possibilities

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	The downtown portion of the Green Line could be built independently of the bridge over the Bow River and the shallow tunnel north of the bridge.	3
2 – Existing Centre Street Bridge Crossing of Bow River	The downtown portion of the Green Line could be built independently of the alignment north of the Bow River.	3
3 – Tunneled Crossing of Bow River	The entire tunnel from south of the Bow River to the daylight at 24 Avenue N would have to be built in a single phase.	1

Impacts on Existing City Assets (e.g. Land)

Within Segment 1, there were multiple alignment opportunities identified for the downtown approach and entry, with each one presenting different impacts on existing City assets or facilities. Alignments which demonstrated a reliance on existing city assets were assigned a positive score. However, since the availability of publicly owned land along Centre Street south of 9 Avenue is minimal, the scoring for this criterion was focused on impacts to areas of historic importance. Heritage sites located within the bounds of Segment 1 include:

- McHugh Bluffs
- Sunnyside Bank
- Crescent Heights Park
- Crescent Heights High School
- Tigerstedt Block
- The Alberta Wheat Pool Building
- 7 Avenue and 8 Avenue boulevards

These sites are identified in **Figure 8.1.**

Table 8.3: MAE 1 – Financial Capacity: Impact on Existing City Assets (e.g. Land)

Option	Assessment Score
1 – New Bridge Crossing of Bow River	1
2 – Existing Centre Street Bridge Crossing of Bow River	1
3 – Tunneled Crossing of Bow River	4

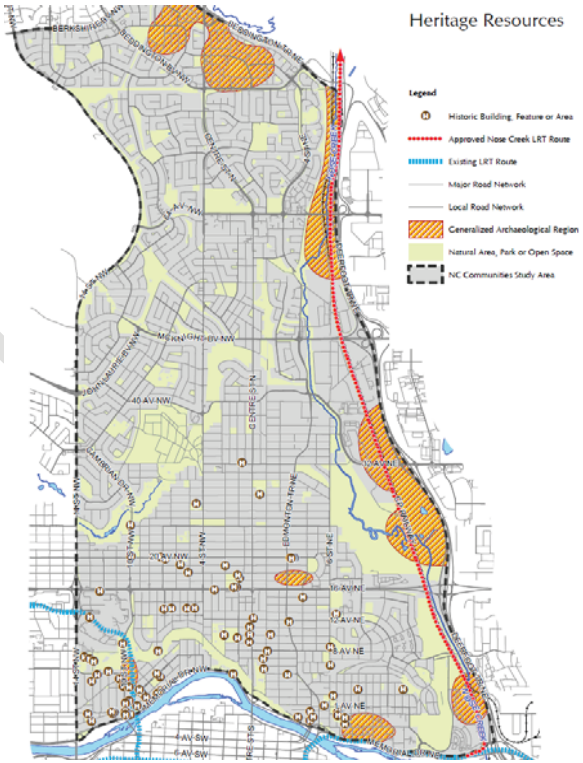

Figure 8.1: Heritage Resources

8.3 COMMUNITY WELL-BEING

NC LRT Project Objective: "A safe, secure and socially inclusive service that improves access to key community destinations and encourages active travel"

The "community cohesion" criterion was divided into two categories covering different aspects of community well-being: visual intrusion and severance.

Impact on Community Cohesion: Visual Intrusion

Visual intrusion refers to the aesthetic influence of the LRT on neighboring properties. For instance, in areas where partial land acquisitions may be required, there is a risk that the remaining land parcel may not be conducive to development due to size, resulting in potentially unsightly swaths of seemingly abandoned land. As another example, an at-grade LRT system would present different levels of visual intrusion than a tunneled system would. Each of the Segment 1 options has a tunneled portion, albeit featuring varying lengths. A tunnel running beneath the community would intrude minimally on neighboring properties as compared with an at-grade running LRT through the community. In consideration of new low floor LRVs, there is some subjectivity with respect to just how intrusive an at-grade system would be, with some stakeholders preferring the aesthetics of an at-grade system.

Table 8.4: MAE 1 – Community Well-Being: Impact on Community Cohesion – Visual Intrusion

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Bridge over the Bow River may be visually intrusive, as it may change or diminish heritage views of the Centre Street bridge. Will also result in changed views from Prince's Island Park.	2
2 – Existing Centre Street Bridge Crossing of Bow River	May be visually intrusive to some but highly subjective, as some people may prefer to see the LRT in operation while others may not.	3
3 – Tunneled Crossing of Bow River	Least intrusive, as the streetscape remains largely unchanged.	5

Impact on Community Cohesion: Severance

The second element of community cohesion is severance. Severance represents the separation of communities along the corridor resulting from barriers such as restricted pedestrian crossings and restrictions to east-west movement of pedestrians, cyclists, and vehicles. A tunneled system would result in minimal to no severance of neighboring communities, while an at-grade system with its multiple signalized pedestrian crossings could be seen as a negative compared to BAU, where east-west movements are unrestricted.

Table 8.5: MAE 1 - Community Well-Being: Impact on Community Cohesion - Severance

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Neither the new bridge over the Bow River nor the shallow tunnel at the north end of the bridge would sever the community.	4
2 – Existing Centre Street Bridge Crossing of Bow River	The LRT in this configuration would act as a barrier to crossing from one side of the street to the other, every five minutes, depending on LRT headways.	3
3 – Tunneled Crossing of Bow River	This LRT configuration would not divide the community and would actually present an improvement to the BAU	5

Safety

This criterion was used to assess the safety concerns associated with each LRT configuration, particularly in relation to LRT operation (i.e. collisions) and potential road user conflicts with the LRT including pedestrians, cyclists, and motorists.

In Segment 1, portions of the LRT system with a grade separated configuration were considered to have a minimal potential for conflicts to occur between the LRT and road users and for collisions.

Table 8.6: MAE 1 – Community Well-Being: Safety

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Minimal conflict points with the LRT in a tunnel below Crescent Heights. At-grade operation downtown would present safety issues at the crossings of 3 Avenue and 2 Avenue.	4
2 – Existing Centre Street Bridge Crossing of Bow River	Being a new 'barrier-free' system, at-grade LRT operation will have higher associated safety concerns at the outset, particularly with respect to the narrow width of the Centre Street Bridge.	2
3 – Tunneled Crossing of Bow River	Deemed the safest option since it minimizes any potential collisions or conflicts with road users.	5

Security

Personal security with regards to transit was highlighted as an important criterion for ensuring a strong sense of community well-being. Perceptions of personal security are highly subjective, but can be assessed using Crime Prevention Through Environmental Design (CPTED) principles as well as Gehl architect's measure of activity of 'people seen per minute'. The principle follows the rationale that with more activity on the street, more people would be seen per minute, resulting in an increase in one's sense of personal security.

In Segment 1, tunneled segments were considered to have the lowest offerings for personal security since there are likely to be fewer "eyes on the street" with the only activity being generated by transit customers. Generally, having more people and "eyes on the street", whether they are transit customers, pedestrians, motorists, etc., will tend to increase one's sense of personal security in a given area.

Table 8.7: MAE 1 – Community Well-Being: Security

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Perceived decrease in sense of personal security in tunneled sections, particularly during off peak periods, with fewer "eyes on the street".	2
2 – Existing Centre Street Bridge Crossing of Bow River	Perceptions of a higher level of personal security to more "eyes on the street" based on CPTED principles and greater street activity.	4
3 – Tunneled Crossing of Bow River	Perceived decrease in sense of personal security in tunnel due to high level of isolation from street level activity with few "eyes on the street".	2

Emergency Access

Emergency access was evaluated based on the number of barriers to emergency access and implemented mitigation. For Segment 1, emergency access to tunneled portions of the line will have to be made via stations, which would require the LRT operator to take the train to the nearest station. Maximum distances to stations were calculated in order to determine the maximum time that the LRT operator would need to travel to the nearest station. For the at-grade configured option, there will be no change to BAU, as emergency access vehicles will be able to drive on the LRT guideway.

Table 8.8: MAE 1 – Community Well-Being: Emergency Access

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Emergency services will access the LRT via stations. In the event that an immediate stop is warranted, the LRT operator will need to drive to the nearest station (farthest distance to the nearest station is 250m, which would take 15 seconds).	2
2 – Existing Centre Street Bridge Crossing of Bow River	Emergency vehicles will be able to drive along the LRT tracks as the rail will be embedded in-street and separated by a mountable-rolled curb. The tunnel will be accessible via the station (farthest distance to the nearest station is 250m, which would take 15 seconds).	3
3 – Tunneled Crossing of Bow River	Emergency services will access the LRT via stations. In the event that an immediate stop is warranted, the LRT operator will need to drive to the nearest station (farthest distance is 500m to the nearest station, which would take 30 seconds).	1

User Centered Design / Accessibility

User centered design and accessibility is a key factor to ensuring that the system is socially inclusive and promotes active travel. Grade separation of a station poses challenges for accessibility. Although all stations would be equipped with elevators and / or escalators, underground stations are inherently less accessible than at-grade stations.

In Segment 1, all three options have some degree of grade separation. Option 2 features the shortest distance of grade separated track, compared to Option 1 which features a shallow tunnel below Crescent Heights, and Option 3 which features a deep tunnel beneath the community of Crescent Heights.

Table 8.9: MAE 1 – Community Well-Being: User Centered Design / Accessibility

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	With two tunnels and a bridge segment this option presents some accessibility challenges although the grade separation is not as deep as Option 3.	2
2 – Existing Centre Street Bridge Crossing of Bow River	With a shorter tunnel section only in the downtown and the remainder at-grade there is less of an accessibility barrier.	3
3 – Tunneled Crossing of Bow River	Due to the required depth below the river, stations for this option introduce that most challenges for accessibility with the deepest station at 45 metres.	1

8.4 PROSPEROUS ECONOMY

NC LRT Project Objective: "A service that promotes economic development by improving access to employment, without adversely impacting goods movement"

Value Capture

The value capture criterion refers to the ability of an option to create a favourable financial situation for The City via land sales, higher tax revenues, or developer fees. Such revenues could be used to offset the costs of constructing, operating, and/or maintaining the Green Line, but benefits such as these cannot be realized unless there is a sufficient demand for land selling at relatively high residential and commercial prices with incentives in place for developers to carry out their projects at higher costs than are typical.

Even though TOD can be achieved with four or five story developments, high-rise concrete construction is the benchmark for making an impact on density around stations. For this purpose of assessing value capture, it is also assumed that high-rise construction is the scale of development needed to generate sufficient funding to make an impact on the net cost of construction, operation, and maintenance to The City. A market analysis carried out in January 2014 indicated that at current property prices, the high-rise concrete construction was only financially viable in the Centre City and adjacent communities (e.g. Bridgeland, Beltline). This means that even if there was a sufficiently sized, vacant parcel in a community such as Tuxedo Park or Highland Park for high-rise concrete construction, the financial incentives would not be in place except under special circumstances such as strong population growth combined with a lack of development elsewhere. Under typical conditions, it is actually likely that The City would have to subsidize developers to create high-density development around stations in outlying neighbourhoods.

For Segment 1, there is no difference in the assessment outcome for each of the options. This is because they all feature a station that could support development in Eau Claire where there are large parcels of land with market demand for high-rise concrete construction.

Table 8.10: MAE 1 – Prosperous Economy: Value Capture

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	New LRT station in Eau Claire community in Centre City has high likelihood of generating land-based value Negative association with the bridge over Prince's Island park due to economic impacts to the park use	4
2 – Existing Centre Street Bridge Crossing of Bow River	New LRT station in Eau Claire community in Centre City has high likelihood of generating land-based value	5
3 – Tunneled Crossing of Bow River	New LRT station in Eau Claire community in Centre City has high likelihood of generating land-based value	5

Impact on Goods Movement

The goods movement criterion refers to the ability of an option to create a favorable situation for the movement of goods via trucks along Centre Street and in the downtown. Centre Street is classified as an urban boulevard from the Bow River to McKnight Boulevard and as an Arterial between McKnight Boulevard and Beddington Drive. As such, it needs to provide truck access to the many businesses along Centre Street. Truck access is also required for certain types of businesses in the downtown.

Trucks require loading/unloading zones on the street or places where they can pull off of the street. Trucks can often be slower than regular traffic and generally do not mix well with bicyclists and pedestrians. Some cities restrict truck access to non-peak hours. As larger vehicles, they require more space for turning than regular vehicles, and this may pose a problem if the introduction of LRT into the roadway reduces the available space for turning.

Table 8.11: MAE 1 – Prosperous Economy: Impact on Goods Movement

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	A general travel lane in both directions will be restored to Centre Street Bridge once the LRT is introduced (bus-only lane restored to all traffic).	4
2 – Existing Centre Street Bridge Crossing of Bow River	Median running LRT will restrict the ability of trucks to turn in and out of business parking lots.	2
3 – Tunneled Crossing of Bow River	A general travel lane in both directions will be restored to Centre Street Bridge once the LRT is introduced (bus-only lane restored to all traffic).	4

8.5 TRANSPORTATION

NC LRT Project Objective: "A high priority transit service that attracts transit use, walking and cycling as preferred mobility choices for Calgarians and that integrates with, improves customer experience of, and strengthens the regional transit network"

Improvements for Walking and Cycling

In order to ensure the LRT is integrated with pedestrian and cyclist movements, each option was reviewed in conjunction with the cycling network to determine how connections could be made to the LRT.

Table 8.12: MAE 1 – Transportation: Improvements for Walking and Cycling

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Design considerations can be given to providing walking and cycling space along the new bridge over the Bow River, which would improve the pedestrian and cycling network. In areas of tunneled section, there would be no impacts to the existing road network, and therefore, the existing walking and cycling network would remain the same.	4
2 – Existing Centre Street Bridge Crossing of Bow River	This option would assume a narrow ROW with no room for enhanced sidewalks. Cyclists would be pushed to 2 Street or to Edmonton Trail as part of the primary cycling network.	3
3 – Tunneled Crossing of Bow River	Considering this fully tunneled option, there would be no impacts to the existing road network, and similarly, the walking and cycling network would remain the same at-grade.	3

The new bridge crossing in Option 1 offers pedestrians and cyclists an additional means by which to cross the Bow River over Prince's Island Park. Also, there is some potential to connect the river pathway to the 2 Avenue station on the south side of the Bow River. In the areas of the tunneled sections, there would be no change to the existing at-grade pedestrian and cyclist network.

In Option 2, with the alignment at-grade north of the river, there would be no room for added improvements for pedestrians or cyclists. The constrained ROW would result in a maximum boulevard width of 2.5 metres, which would result in a maximum sidewalk width of 1.5 metres which is no better than what is currently in place. On the existing Centre Street bridge, a narrow space will be provided for pedestrians, which would be similar to BAU when crossing over the river into the downtown.

In Option 3, the full tunnel would not impact the existing street network. With the LRT running underground, however, there may be some potential for the vehicle lanes to be narrowed in order to improve the pedestrian infrastructure or add room for cyclists along Centre Street.

Changes in Journey Time – LRT

For Option 1, the LRT transit travel time should be on par or less than the existing bus / BRT surface transit operating in a dedicated lane in the BAU scenario. The routing is direct, and signal pre-emption is assumed. In addition, faster boarding is expected through the provision of multiple doors and level boarding at the stations.

Table 8.13: MAE 1 – Transportation: Changes in Journey Time – LRT

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Anticipated improvements compared to BAU.	4
2 – Existing Centre Street Bridge Crossing of Bow River	Potential for delay.	2
3 – Tunneled Crossing of Bow River	Anticipated improvements compared to BAU.	4

For Option 2, the LRT transit travel time may not be less than existing bus / BRT surface transit travel time, although it is assumed that transit signal priority will be provided. Generally, due to the constrained nature of the existing Centre Street Bridge, there is a significant likelihood of regular delay for the LRT.

For Option 3, the LRT transit travel time should be less than that of the existing bus / BRT surface transit service, as the tunnel provides a completely segregated forum where trains can travel at a faster maximum travel speed.

Changes in Journey Time – Auto

In Option 1, provision of a new bridge and partially tunnelled section for the LRT for this section of the route would provide total segregation from the surface operating vehicles. Therefore, the impact on auto travel time will be negligible. There may even be very minor positive changes in auto travel time as compared to the BAU scenario, as it is assumed that some existing transit services (bus or BRT) may be replaced by the LRT service. This would potentially free up some road space and reduce congestion for auto vehicles and hence, improve journey time.

In Option 2, running the LRT at-grade across the existing Centre Street Bridge is likely to have significant impacts on auto vehicles and other surface transit routes. The impact on auto travel time will be moderate to severe and will be partially dependent on how many other existing surface transit routes (bus and BRT) in the BAU scenario are removed from service following the introduction of the LRT. Significant consideration will need to be given for determining how best to minimize the negative impacts to auto vehicle flow caused by the routing of LRT through the intersections from/to the bridge structure.

Table 8.14: MAE 1 – Transportation – Changes in Journey Time - Auto

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Negligible impacts to automobiles anticipated.	3
2 – Existing Centre Street Bridge Crossing of Bow River	Moderate to severe impacts to automobiles anticipated.	1
3 – Tunneled Crossing of Bow River	Negligible impacts to automobiles anticipated.	3

The fully tunneled section featured in Option 3 provides the LRT with a dedicated ROW that will have negligible impacts to surface running traffic. There may be the potential for enhancements to auto travel time as compared to the BAU scenario, since it is assumed that some surface running transit services (bus or BRT) may be replaced by the underground service, thereby potentially resulting in reduced congestion on the road network.

Reliability

Reliability is assumed as the interaction between the LRT & vehicles into the trackway. (Not about pedestrian delays – intended to highlight the challenges in the design itself)

In Option 1, the segregation from general traffic offered by the dedicated LRT bridge over the Bow River would likely increase the reliability of transit service, as the LRT would no longer be mixed with and delayed by general traffic on the existing Centre Street Bridge. Similarly, the short section of tunnel in this option would likely provide improvements to reliability because the LRT would again be separated from general traffic.

In Option 2, the lack of segregation from general traffic at intersections in downtown and along the southern end of Centre Street may lead to lower levels of reliability for LRT. Considering that the Centre Street Bridge is already a constraint on the road network, it is likely that cars would occasionally get stuck in the intersections and block an LRT vehicle. In addition, the narrow option would require a change in operating conditions due to the design constraint of right turn passenger & delivery vehicles overlapping over the LRT guideway. This is on par with the BAU.

The fully tunneled scenario of Option 3 would provide full segregation for LRT operations, where interactions with other vehicles can be avoided. This attribute should ensure the reliability of the system in terms of journey time certainty and would provide a good overall perception of the system's reliability.

Table 8.15: MAE 1 – Transportation: Reliability

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Minor impacts to automobiles anticipated; high LRT travel time reliability expected.	4
2 – Existing Centre Street Bridge Crossing of Bow River	Moderate to severe impacts to auto traffic anticipated; LRT travel time reliability expected to be similar to BAU.	3
3 – Tunneled Crossing of Bow River	No impacts to auto travel time reliability anticipated; high LRT travel time reliability expected.	4

Impact of Displaced Traffic and Demand on Parallel Routes

With Option 1, minimal traffic displacement would be expected. Depending on the access and priority required at signals to route the LRT to the new bridge, there may be some minor disruptions to traffic patterns, however, optimizing signal timings should minimize these issues.

In Option 2, with the Centre Street Bridge already established as a pinch point on the LRT route, there is a strong probability that traffic will be displaced, thereby significantly increasing demand on the limited available parallel route options. The use of this option may also lead to increased congestion in and out of the Downtown network.

In Option 3, there will be a reduced impact on traffic demand, as it is assumed that the dedicated BRT lane in the BAU scenario will be reverted to general traffic, thereby potentially reducing congestion on the alignment.

Table 8.16: MAE 1 – Transportation: Impact of Displaced Traffic and Demand on Parallel Routes

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Minimal traffic displacement expected.	4
2 – Existing Centre Street Bridge Crossing of Bow River	Additional traffic displacement expected as compared to the BAU scenario.	2
3 – Tunneled Crossing of Bow River	Minimal traffic displacement expected.	4

Impact on Parking

Parking impacts were quantified based on the potential loss of on-street parking along the corridor.

Along segment 1 there is minimal on-street parking between downtown and 9 Avenue N. In Option 1, parking in the downtown would remain unchanged as only a minor segment is at-grade at the Eau Claire station. In the tunneled section north of the river, there would be no change to existing on-street parking conditions. In Option 2, with the LRT running at –grade north of the river, the 2 hour on-street parking currently provided on the east side of Centre Street between 8 Avenue and 9 Avenue would be removed. Due to the existing lane reversal there is minimal parking on Centre Street N south of 9 Avenue. In the downtown portion of this option, on-street parking along 3 Avenue S between Centre Street and 2 Street W would be removed. Since these blocks are relatively small, these parking spaces would likely be removed for the BAU scenario. As a result, Option 2 would present no change to on-street parking as compared to BAU. In Option 3, there would be slight impacts to existing parking conditions near the intersection of Centre Street and 9 Avenue N as well as Centre Street and 8 Avenue N if a station is introduced at 9 Avenue, however, the remainder of on-street parking locations along Centre Street would remain unchanged compared to the BAU scenario.

Table 8.17: MAE 1 – Transportation: Impact on Parking

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	No impacts to parking on Centre Street south of 9 Avenue.	3
2 – Existing Centre Street Bridge Crossing of Bow River	Will result in loss of 2 hour street parking on the east side of Centre Street from 9 Ave to 8 Ave.	3
3 – Tunneled Crossing of Bow River	Will have some impact to parking at 9 Ave due to station location.	3

8.6 URBAN DEVELOPMENT

NC LRT Project Objective: "A service that support current and future land use and intensification of development along the corridor"

Land Acquisition Impacts

To simplify the land acquisition considerations, one might assume that land will only need to be acquired on a single side of Centre Street. However, with the LRT assumed to operate on a centre-running alignment, our study accounted for the acquisition of a strip of land on both sides of Centre Street, which means land would be impacted on both sides of the corridor. Due to the existing sizes of parcels along Centre Street, additional land acquistions may have negative impacts on the future development potential of certain lots. In general, buying more land from adjacent properties may result in lot sizes that may be too small to warrant future development.

In Option 1, the tunnel north of the river would require some land acquisition in the area of the north tunnel portal in order to accommodate construction activities. Land measuring approximately 150 metres in length and 2.5 metres in width on either side of the portal will likely be required. Surrounding the 9 Avenue N station, it is expected that given the ROW of 26.67 metres, only small areas of land acquisition would be required, if any.

In Option 2, with the LRT running at-grade between one vehicle lane on either side with travel running in each direction, it is anticipated that land acquisitions will be required in areas with left turns and at station locations. In the area surrounding the at-grade 9 Avenue N station, there are left turn lanes as well. Based on this, it is anticipated that less than 2 metres of land will be required, which will impact the commercial properties on both sides of Centre Street.

In Option 3, the full tunnel would require land acquisition in the areas of both tunnel portals. At the northern portal, the LRT would daylight at approximately 24 Avenue N where the ROW is 22.86 metres. Pending confirmation of further detailed analysis for the TBM, it is expected that the minimum space required would be 22 metres. However, it is anticipated that additional space will likely be required for construction staging. Also, given the depth of the 9 Avenue N station, it is expected that land acquisitions will also be required to construct the station access points.

Table 8.18: MAE 1 – Urban Development: Land Acquisition Impacts

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Will require some land acquisition at the tunnel portals for the tunnel north of the Bow River. It is assumed that no land acquisition will be required in the downtown core.	3
2 – Existing Centre Street Bridge Crossing of Bow River	Will require on average, approximately less than 2 metres of land acquisition from commercial properties on both sides of Centre Street, south of 9 Avenue N.	4
3 – Tunneled Crossing of Bow River	Will require full parcel acquisition at the 9 Avenue N station are and at the tunnel portals. Downtown stations will require further investigation, but have been assumed to fit within the existing ROW.	2

Contribution to Improved Streetscape and Public Realm

Several elements that contribute to the improved streetscape have been included under other accounts. This particular account was gauged in terms of an increased degree of activity at the street level, which could be perceived as the number of people observed per min at street level based on Gehl architect's measure for activity.

In Option 1, the bridge over the Bow River and the partial tunnel to 16 Avenue N provide the LRT with grade separation for the length of Segment 1. This means that while the LRT will generate and promote activity at the station locations themselves, there will be a perception of decreased quality of streetscape with respect to the BAU scenario, because there will be fewer people seen at street level along the corridor as a whole.

In Option 2, the at-grade running LRT would likely contribute the most to an improved streetscape. Although the majority of the activity will remain focused at stations, having an LRT visibly run along the street will create the perception of more activity and people seen per minute at the street level. This option would also be considered to offer an improvement to the BAU scenario, because the LRT is anticipated to generate more ridership than the BRT is likely to see.

In Option 3, similar to Option 1, while a grade separated LRT will still promote activity at station locations, there will be fewer people observed at street level along the corridor, which will result in the perceptions of a decreased streetscape quality as compared to the BAU scenario.

Table 8.19: MAE 1 – Urban Development: Contribution to Improved Streetscape and Public Realm

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Would not encourage an enhancement of the street scape as compared to the BAU scenario.	2
2 – Existing Centre Street Bridge Crossing of Bow River	Likely to promote more activity at the street level compared to the BAU scenario.	4
3 – Tunneled Crossing of Bow River	Would not encourage an enhancement of the street scape as compared to the BAU scenario.	2

8.7 SUSTAINABLE ENVIRONMENT

NC LRT Project Objective: A service that facilitates a reduction in GHG emissions while not impacting the City's current biodiversity

Impact on Existing Natural Environment

The Bow River crossing in this segment presents some significant environmental concerns. In general, any crossing of the Bow River will require notification under the Code of Practice for Watercourse Crossings provided that the conditions of the code can all be met; otherwise approval under the Water Act will be required.

For Option 1, with or without piers the bridge would require reviews of the Code of Practice for Watercourse Crossings or approval under the Water Act as outline above. Since the alignment crosses over existing natural lands in Prince's Island Park a Biophysical Impact Assessment (BIA) and a Tree Protection Plan (TPP) would be required.

For Option 2, assuming that the construction could be confined to the existing alignment of the Centre Street Bridge, a TPP would not be required. Additional coordination would be required with the City of Calgary Parks department on the potential impacts to Rotary Park and the Sunnyside Bank Parks.

For Option 3, due to the depth of the tunnel there would be minimal environmental impacts to the Bow River since there would be no in-stream work. Also, no BIA or TPP would be required since the tunnel would not be in close to any parks.

Table 8.20: MAE 1 – Sustainable Environment: Impact on Existing Natural Environment

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Highest environmental impact due to new constitution of a bridge over the Bow River in addition to construction over natural lands in Prince's Island Park.	1
2 – Existing Centre Street Bridge Crossing of Bow River	Fewer environmental risks if the proposed alignment remains along the existing Centre Street Bridge alignment.	3
3 – Tunneled Crossing of Bow River	Fewer environmental risks due to the tunnel depth.	3

Noise Impacts

In Option 1, a noise and vibration impact assessment may be required to evaluate the potential effects on receptors with the construction of a new bridge. There may be some impacts but there will be partial improvements to the BAU scenario with part of the alignment tunneled north of the Bow River to 18 Avenue. The new bridge over Prince's Island park will have some impacts on the park setting.

In Option 2, a noise and vibration impact assessment may be required to evaluate the potential effects on receptors along the existing bridge. There may be some noise and vibration impacts as the majority of the alignment is at-grade north of 3 Avenue SW in the downtown.

In Option 3, a noise and vibration impact assessment would be required to evaluate the potential effects on receptors along the proposed alignment. This would likely have the least impact due to the tunnel depth.

Table 8.21: MAE 1 – Sustainable Environment: Noise Impacts

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	May have some impact but will have some improvement with part of the alignment tunneled north of the Bow River. New bridge will have added impacts on Prince's Island park setting	2
2 – Existing Centre Street Bridge Crossing of Bow River	May result in more noise and vibration impacts with more of the alignment at-grade	2
3 – Tunneled Crossing of Bow River	Minimal noise and vibration impacts expected due to the tunnel depth	5

8.8 DELIVERABILITY

NC LRT Project Objective: "A service that is constructible and operable"

Constructability – Technical Constraints

In this segment of the MAE there are some general construction constraints that existing for all these options in the downtown:

- Anticipated geotechnical constraints for tunneling in the downtown (deep bedrock expected)
- CPR construction protection requires 30m space from CPR ROW, which will not be feasible for the tunnel portal at 10 Avenue SW and Centre Street in the downtown. Additional protection measures may be required and would likely need to be coordinated with CPR.

Specifically for Option 1, there are some slope stability issues along the McHugh Bluffs. The construction of a bridge-to-tunnel transition into the escarpment is expected to require additional design and slope stabilization measures. Also, for this option to reach an at-grade station at 2 Avenue a 150 metre tangent would be required. In order to have enough space for the 2 Avenue station the LRT will cross the bow river pathway at-grade before transitioning to the bridge.

For Option 2, with the LRT at-grade and on the existing Centre Street bridge some rehabilitation may be required for the southern span of the Centre Street Bridge. This span was not part of the 2007 rehabilitation done on the Centre Street Bridge. Preliminary structural analysis of the remaining bridge spans suggests that they should be able to withstand the load of the LRT although additional review may be required.

For Option 3, access to adequate geotechnical information is the primary constraint. In addition, it is anticipated that some soil stability may be required when constructing the 9 Avenue station. Due to the proximity to the McHugh Bluffs and Sunnyside Banks, it is expected that unfavorable soils may be found in this area.

Table 8.22: MAE1 – Deliverability: Constructability (technical constraints)

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Slope stability of the Sunnyside Banks and geometry of the bridge are key constraints in this option which require further analysis.	1
2 – Existing Centre Street Bridge Crossing of Bow River	It is anticipated that the Centre Street bridge will likely be able to withstand the load of the LRT with some rehabilitation for the southernmost span.	3
3 – Tunneled Crossing of Bow River	Consistent geology is key for this option. It is anticipated that the potential 9 Avenue N station will have more technical constraints due to its depth of 45 metres.	1

Construction Impacts

In general lane closures will result in more challenging access in addition to restricted parking for businesses along Centre Street, road closures may be required at all station locations.

In Option 1, the construction of the bridge will require the temporary closure of the bow river pathway. This would be a major impact on the pathway users as this section of the pathway has a high number of pedestrian and cycling commuters. During construction it is anticipated that the pathway would need to be closed or diverted resulting in a lower score. For the tunnel segment in the downtown 10 Avenue may be closed to construct the tunnel as it is also proposed that material hauling be done from this point. Lower noise impacts would be anticipated during construction since the majority of the alignment is grade separated.

In Option 2, the at-grade construction of the LRT will need to be staged in blocks. During construction the road would need to be reduced to one lane in peak hour direction only. This will result in higher traffic impacts during construction than the BAU as it is assumed that the BAU would be able to maintain one lanes in each directionThis option would have more noise impacts during construction with the alignment at-grade.

In Option 3, there would be fewer construction impacts, except at tunnel portals and at station locations, compared to the other options since the LRT is fully grade-separated. Material hauling operations would be conducted via the portal at 10 Avenue in order to minimize impacts to residential communities along Centre Street. This would result in some traffic disruptions at 10 Avenue.

Table 8.23: MAE 1 – Deliverability: Construction Impacts

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Closure of the river pathway would be a significant impact during construction.	1
2 – Existing Centre Street Bridge Crossing of Bow River	At-grade construction will result in traffic disruptions along Centre Street.	2
3 – Tunneled Crossing of Bow River	Material hauling operations would impact traffic at 10 Avenue for an extended period of time during the construction of the tunnel.	2

Conformance to CTP & MDP

This criterion was added to review the options based on how they fit with existing public policies and how they may help in achieving the goals and targets set by the CTP and MDP outlined in section 0.

In general, options that reduce auto capacity and support an increased mode shift to transit, cycling, and walking would have higher conformance to the CTP and MDP. Additionally, avoiding land acquisition was also considered to conform to the CTP and MDP goals to promote "good urban design". Based on these concepts the options were assessed as shown in the below table.

Table 8.24: MAE 1 – Deliverability: Conformance to CTP & MDP

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	With a new river crossing and maintaining vehicle access to the downtown this option does not push for a mode split.	2
2 – Existing Centre Street Bridge Crossing of Bow River	This option would be in conformance with the CTP & MDP but would not be a change compared to the BAU scenario.	3
3 – Tunneled Crossing of Bow River	Similar to Option 1, this option does not force a mode split as it maintains capacity for vehicles into the downtown.	2

Acceptability

The acceptability of the different options was gauged based on the consultation process that was done throughout the project. See Appendix A.

For Option 1, since the bridge concept was not considered in the consultation process it is deemed to be less acceptable. However, using the information gathered throughout the consolation process the following options would be expected:

- Negative impact to park users at the east end of Princess Island
- Negative visual impact on the park
- Negative impact on water feature and existing pedestrian bridge/walkway
- Negative impact to Sunnyside Bank Park and curling club parking lot
- Likely strong opposition from condo development and sports bar on 2 Avenue due to elevated structure, noise etc…
- At grade in the downtown area would be acceptable
- At grade from 9 Avenue N to 24 Avenue N not acceptable
- Narrow ROW from 9 Avenue to 24 Avenue is less publicly acceptable, but not to the Community Advisory Group (CAG).

For Option 2, it is likely to be controversial to the public with the lane reduction and reduced capacity on Centre Street. However, if not underground in this area, the second preference was to have one driving lane and no parking (44%). Positive opinions for this option were:

- Safer pedestrian environment
- Nice landscaping and street design
- Less effects on businesses and residents
- No land acquisition required
- May result in less traffic

Negative opinions on this option were:

- Lack of parking options may have negative impact on businesses
- Possible congestion issues due to constrained capacity
- Perception that LRT at surface travels slower
- At grade impact through China Town
- May be mitigated by advanced education given longer term implementation
- Congestion planning will need to be addressed
- If a BRT dedicated lane is introduced, concern may be mitigated

For Option 3 there is a high level of public acceptability based on the various workshops and open houses held. 54% of the public feel the LRT is underground would allow the LRT to travel at higher speed and result in less impact at street level. The general public preference was in line with this as the LRT "out of sight" would be perceived to be less intrusive to the status quo. Oher reasons in support of this option included:

- Minimizes impact to communities in the 9 Avenue N to 24 Avenue N
- Allows BRT to operate simultaneously in this corridor
- No impact to properties as well as reduced disruption in the downtown

Table 8.25: MAE 1 – Deliverability: Acceptability

Option	Impact	Assessment Score
1 – New Bridge Crossing of Bow River	Lower acceptability since this option was not included in previous engagement and due to impacts to the park.	1
2 – Existing Centre Street Bridge Crossing of Bow River	This would have lower acceptability due to the compromises for vehicle capacity but it would be the same as the BAU scenario.	3
3 – Tunneled Crossing of Bow River	This would have the highest acceptability and would be an improvement to the BAU scenario as travel lanes on Centre Street would be restored.	5

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9.0 EVALUATION RESULTS FOR MAE 2

9.1 OPINION OF PROBABLE CAPITAL COST

OPCCs were calculated for the options of Segment 2 in a similar fashion to those of Segment 1, with grade separation included at McKnight Boulevard for the LRT only and a possible below grade station. The infrastructure at McKnight Boulevard is anticipated to be simpler than a cut and cover section as the LRT only needs to be separated from the intersection. The OPCCs for segment 2 includes grade separation at McKnight Boulevard via a bridge for the existing intersection and retaining walls along the sides of the LRT at the northern and southern approaches to McKnight Boulevard along Centre Street.

The costs for LRT track construction were assumed to be the same for the narrow and wide options. Both options include grade separation at McKnight Boulevard for the LRT and have assumed cut and cover tunneling to be conservative. The wide option includes additional roadworks costs as it was assumed to require full reconstruction of the road and construction of two to three new lanes of the road structure.

For both the narrow and wide options, the land acquisition calculations account for a factor of 8 times the 2013 assessed market value for a partial acquisition. Due to the additional width of two 3.3 metre lanes in the wide option, higher costs are expected for land acquisition within Option 2. Additional details for the OPC are provided in **Appendix G**.

Table 9.1: MAE 2 – Opinion of Probable Capital Costs

Option	Opinion of Probable Construction & Land Acquisition Costs	Assessment Score
1 – Narrow cross-section	$200 million	3
2 – Wide cross-section	$300 million	2

9.2 FINANCIAL CAPACITY

NC LRT Project Objective: "An affordable and cost-effective service"

Phasing Possibilities

It is assumed that Segment 2 would be built in a single construction phase, regardless of whether Option 1 or 2 is selected, because neither the 28 Street N station nor the 40 Street N station are considered to be natural temporary terminals for the line. This is based on the assumption that neither location has space for a bus exchange, as well as the belief that ridership and operational benefits will be able to justify costs when the line extends north to at least Beddington Boulevard.

Table 9.2: MAE 2 – Financial Capacity: Phasing Possibilities

Option	Impact	Assessment Score
1 – Narrow cross-section	Limited phasing opportunity based on the unlikely character of 28 Street N station or 40 Street N station to act as a temporary terminus for the line.	3
2 – Wide cross-section	Limited phasing opportunity based on the unlikely character of 28 Street N station or 40 Street N station to act as a temporary terminus for the line.	3

Impact to Existing City Assets

The same City assets are implicated in both options 1 and 2 of Segment 2 because the areas covered by each option are the same. The asses affected include:

- Tuxedo Park
- Green space south of Laycock Drive
- 36 Avenue Park and Ride
- Buchanan School

Since both options run along the same alignment, it is conceivable that they could receive a similar ranking. However, the appropriation of park space to accommodate the wider cross section of Option 2 could be seen as a potential negative impact unique to Option 2. Therefore, Option 2 was given a slightly lower score in the assessment.

Table 9.3: MAE 2 – Financial Capacity: Impacts to Existing City Assets

Option	Assessment Score
1 – Narrow cross-section	3
2 – Wide cross-section	2

9.3 COMMUNITY WELL BEING

NC LRT Project Objective: "A safe, secure and socially inclusive service that improves access to key community destinations and encourages active travel"

Impact on Community Cohesion: Visual Intrusion

In Segment 2, both options run at-grade which was seen to be similar to the BAU scenario in terms of visual intrusion.

Table 9.4: MAE 2 – Community Well-Being: Impact on Community Cohesion: Visual Intrusion

Option	Impact	Assessment Score
1 – Narrow cross-section	May be visually intrusive to some but highly subjective, as some people may prefer to see the LRT in operation while others may not.	3
2 – Wide cross-section	May be visually intrusive to some but highly subjective, as some people may prefer to see the LRT in operation while others may not.	3

Impact on Community Cohesion: Severance

In Segment 2, which features an at-grade running LRT, all pedestrian crossings would require signalization. This could be seen as a barrier to accessibility as compared to the BAU scenario where east-west movements would remain unrestricted. For Option 2, with the widened ROW to accommodate two driving lanes on each side plus the LRT, the additional distance required to cross the road as a pedestrian would likely give the impression of a less accessible/more divided community.

Table 9.5: MAE 2 – Community Well-Being: Impact on Community Cohesion - Severance

Option	Impact	Assessment Score
1 – Narrow cross-section	The LRT would act as a barrier to crossing from one side of the street to the other, every five minutes, depending on LRT headways.	3
2 – Wide cross-section	The LRT would act as a barrier to crossing from one side of the street to the other, every five minutes, depending on LRT headways. The wider ROW will extend the crossing distance, which will be perceived as a barrier.	2

Safety

Since both options in Segment 2 feature an at-grade running LRT in the same location, both options would result in similar conflicts between road users and the LRT. Where Option 1 is concerned, however, an additional conflict for motor vehicles would be presented for right turning movements where motor vehicles in the narrow 3.3 metre wide lanes would be required to encroach on the LRT guideway by 0.3 to 1.5 metres.

Table 9.6: MAE 2 – Community Well-Being: Safety

Option	Impact	Assessment Score
1 – Narrow cross-section	More safety concerns with the narrow ROW, as vehicles making right turns will need to encroach on the LRT guideway, thereby increasing the risk of collisions.	2
2 – Wide cross-section	Fewer operational safety concerns with the wider ROW, as vehicles making right turns do not need to encroach on LRT guideway.	3

Security

The presence of the at-grade running LRT featured in both options of Segment 2 is considered to contribute to an increased sense of personal security in the corridor, as a boost in street level activity is expected as compared to the BAU scenario.

Table 9.7: MAE 2 – Community Well-Being: Security

Option	Impact	Assessment Score
1 – Narrow cross-section	Perceived increase in sense of personal security due to highly visible stations and greater number of "eyes on the street".	4
2 – Wide cross-section	Perceived increase in sense of personal security due to highly visible stations and greater number of "eyes on the street".	4

Emergency Access

In Segment 2, both the narrow and wide options would allow unrestricted emergency access and relative to the BAU scenario, were considered to be similar.

Table 9.8: MAE 2 – Community Well-Being: Emergency Access

Option	Impact	Assessment Score
1 – Narrow cross-section	Emergency vehicles will be able to drive along the LRT tracks, as the rail will be embedded in-street and separated by a mountable-rolled curb.	3
2 – Wide cross-section	Emergency vehicles will be able to drive along the LRT tracks, as the rail will be embedded in-street and separated by a mountable-rolled curb.	3

User Centered Design / Accessibility

In Segment 2, both at-grade options would offer the same levels of accessibility to the BAU scenario.

Table 9.9: MAE 2 – Community Well-Being: User Centered Design / Accessibility

Option	Assessment Score
1 – Narrow cross-section	3
2 – Wide cross-section	3

9.4 PROSPEROUS ECONOMY

NC LRT Project Objective: "A service that promotes economic development by improving access to employment, without adversely impacting goods movement"

Value Capture

In the area of the 28 Street N Stations, demand for concrete construction is non-existent under typical market conditions, but the market analysis noted that there are two large vacant parcels (or contiguous groupings of parcels) and one large, actively used parcel within 200 metres of the station. One of the vacant parcels is adjacent to a park, an attribute which may enable a potential developer to achieve higher prices. It is assumed that the purchase of both large vacant parcels would be incorporated into the Green Line budget (2802-2808 Centre Street NE and 101 29 Avenue NE) and that The City would be able to yield modest benefits by selling the portions not needed for the ROW and stations to a developer.

At the 40 Street N Station site, there is a similar situation – there is a low demand for high-rise concrete construction under normal market conditions but a vacancy of large land parcels within 200 metres of the station. It is assumed that the purchase of two large vacant parcels will be incorporated into the Green Line budget (4204 Centre Street NE & 116-124 41 Avenue NE and 4055-4111 1 Street NE) and that The City would be able to yield modest benefits by selling the portions not needed for the ROW and stations to a developer.

At the McKnight Station site, there is a large, actively used parcel within 200 metres of the station that could possibly be converted to another use in the future under more favorable market conditions. However, given that it is in active use, unlike the parcels surrounding 28 Street N station and 40 Street N station, it is assumed that the acquisition of this land would not be included in the Green Line budget.

It is assumed that the value capture potential for both options in Segment 2 is identical.

Table 9.10: MAE 2 – Prosperous Economy: Value Capture

Option	Impact	Assessment Score
1 – Narrow cross-section	Some parcels are available for redevelopment, but market demand may limit density that can be achieved.	3
2 – Wide cross-section	Some parcels are available for redevelopment, but market demand may limit density that can be achieved.	3

Impact on Goods Movement

The movement of goods requires trucks to be able to travel freely through an area as well as well as either park along the street to load/unload or to pull in and out of business driveways. Goods movement potential for Segment 2 is assessed in Table 42.

Table 9.11: MAE 2 – Prosperous Economy: Impact on Goods Movement

Option	Impact	Assessment Score
1 – Narrow cross-section	There will be insufficient space for trucks to park along the street to load/unload. There will be insufficient space for trucks to safely turn in and out of business driveways.	2
2 – Wide cross-section	There will be insufficient space for trucks to park along the street to load/unload, however, there will likely be adequate space for trucks to safely turn in and out of business driveways.	4

9.5 TRANSPORTATION

NC LRT Project Objective: "A high priority transit service that attracts transit use, walking and cycling as preferred mobility choices for Calgarians and that integrates with, improves customer experience of, and strengthens the regional transit network"

Improvements for Walking and Cycling

In Option 1 which features a narrow ROW, minimal land acquisitions have been considered solely at left turn and station locations. The sidewalk space within the boulevard space would be limited to 1.5 metres in width, which yields no improvement to the existing pedestrian infrastructure. This option is too narrow to accommodate cyclists in the corridor, however, cyclists will have the option of using the existing shared bicycle lane on 2 Street NW or future cycling infrastructure planned for Edmonton Trail as outlined in the Calgary Transportation Plan.

Option 2, which features a wider ROW, has space to accommodate slightly wider sidewalks than exist at present. With more land acquisition being considered for this option, sidewalks could be widened to between 2.0 and 2.5 metres from the existing 1.5 metres, which would better align with The City's pedestrian policy for sidewalk space in transit zones which calls for a width of 3.0 metres.

Table 9.12: MAE 2 – Transportation: Improvements for Walking and Cycling

Option	Impact	Assessment Score
1 – Narrow cross-section	The narrow ROW results in a no improvement in the space for pedestrians. With the speed of Centre Street reduced the pedestrian space would not feel as constrained.	3
2 – Wide cross-section	Providing a wider ROW gives more space for wider sidewalks of 2 to 2.5 metres in width.	4

Changes in Journey Time – LRT

In Option 1, the LRT travel time is expected to be comparable to the bus/BRT travel time in the BAU scenario as it is running in a dedicated lane. Within the narrow right of way, however, motor vehicles may impede the LRT operation slightly by encroaching on the LRT running way, and this could negatively affect travel times.

In Option 2, the LRT travel time is expected to be comparable to the bus/BRT travel time in the BAU scenario, is it is running in a dedicated lane. The ROW in this scenario would be wide enough to accommodate traffic such that LRT should not be impacted by motor vehicles.

Table 9.13: MAE 2 – Transportation: Changes in Journey Time - LRT

Option	Impact	Assessment Score
1 – Narrow cross-section	Comparable to BAU	3
2 – Wide cross-section	Comparable to BAU	3

Changes in Journey Time – Auto

In Option 1, running the LRT at-grade in a narrow cross section is likely to have significant impacts for auto vehicles and other surface transit routes. Due to the limited width, there will be turning restrictions at a significant number of intersections, as without them, the LRT journey time would be significantly impacted. It should be noted that with this option, there are the same number of general traffic lanes along the corridor as in the Business as Usual case (one lane in each direction).

The impact on auto travel time will be moderate to severe due to the turning restrictions, and will be partially dependent on how many other existing surface transit services (bus and BRT) are removed that operate in the Business as Usual scenario, following the introduction of the LRT.

In Option 2, there will also be turning restrictions at a significant number of intersections, as without them the LRT journey time would be significantly impacted. It should be noted that with this option, there is an additional through traffic lane compared to the number of general traffic lanes along the corridor in the Business as Usual case (two lanes in each direction in this option, one lane in each direction in the BAU).

The impact on auto travel time will be moderate due to the turning restrictions, but flow on the corridor should actually be improved with the addition of an extra running lane. Operation will be partially dependent on how many other existing surface transit services (bus and BRT) are removed that operate in the Business as Usual scenario, following the introduction of the LRT.

Table 9.14: Segment 2 – Transportation: Changes in Journey Time - Auto

Option	Impact	Assessment Score
1 – Narrow cross-section	Slightly worse than Business as Usual	2
2 – Wide cross-section	Comparable to Business as Usual	3

Reliability

Option 1 is on par with the BAU scenario.

In Option 2, even with the wider intersection width, there will be turning restrictions for auto vehicles at a significant number of intersections, as without them the LRT journey time would be significantly impacted. The fact that there are two continuous lanes along the corridor, will improve the storage space available for those making turning movements at the intersections where these are still permitted. This should mean that turning traffic should have limited interaction with the LRT, and so is unlikely to impact on the reliability of the service.

Table 9.15: Segment 2 – Transportation: Reliability

Option	Impact	Assessment Score
1 – Narrow cross-section	Comparable to BAU scenario	3
2 – Wide cross-section	Turning vehicles will have less impact on LRT operations than they did on buses in the BAU scenario	4

Impact of Displaced Traffic and Demand on Parallel Routes

In Option 1, with the large number of the left turns that are banned on this section of the corridor, it is likely that a significant amount of traffic will be forced to re-route locally in order to reach destinations just off the corridor. Demand may also be forced onto parallel routes if the diversions become onerous.

In Option 2, with the large number of the left turns that are banned on this section of the corridor, it is likely that a significant amount of traffic will be forced to re-route locally in order to reach destinations just off the corridor. Demand may also be forced onto parallel routes if the diversions become onerous. The increase of one running lane in this section of the corridor over what was in the BAU (2 lanes vs 1 lane) should, however, help with traffic flow along the corridor.

Table 9.16: MAE 2 – Transportation: Impact of Displaced Traffic and Demand on Parallel Streets

Option	Impact	Assessment Score
1 – Narrow cross-section	With the continued provision of only one travel lane in each direction, diversions to parallel streets are likely	2
2 – Wide cross-section	Addition of a travel lane may keep vehicles from diverting to parallel streets	3

Impact on Parking

In option 1, there would be no change to the BAU scenario in regards to the amount of on-street parking that is impacted.

In option 2, with the wider ROW there could be the potential for off-peak parking along Centre Street similar to the existing on-street parking restrictions. Parking would be restricted where there are left turn bays and stations, but this would be an improvement to the BAU scenario with all on-street parking removed.

Table 9.17: Segment 2 – Transportation: Impact on Parking

Option	Impact	Assessment Score
1 – Narrow cross-section	Currently on street parking is only provided on one side of Centre Street in the off-peak direction	3
2 – Wide cross-section	Only parking will be lost at stations and intersections with left turn lanes	4

9.6 URBAN DEVELOPMENT

NC LRT Project Objective: "A service that support current and future land use and intensification of development along the corridor"

Land Acquisition Impacts

In option 1, land acquisitions are required at station locations and at left turn locations. The narrowest sections in this segment are between 34 Avenue to 32 Avenue and from 40 Avenue to 38 Avenue. In these areas more than 2 metres is required for land acquisition on each side which are predominantly single family homes fronting Centre Street. The remainder of this section south of 42 Avenue will typically require less than 2 metres of land acquisition on either or both sides of Centre Street. This would impact some commercial properties south of 32 Avenue. Closer to McKnight Boulevard the ROW widens to an average of 26 metres which would not impact the adjacent properties.

In option 2, land acquisitions required are more extensive with an additional lane for motor vehicles. Since the ROW varies from 20.12 metres to 27.43 metres more land acquisition would be required. Typically more than 2 metres would be required on each side of Centre Street impacting the adjacent single family homes and commercial properties south of 32 Avenue.

The comparison of land acquisition impacts is shown in Figure 9.1: Land Acquisition Impacts with the narrow cross-section option (top) and the wide cross-section option (bottom).

Table 9.18: Segment 2 – Urban Development: Land Acquisition Impacts

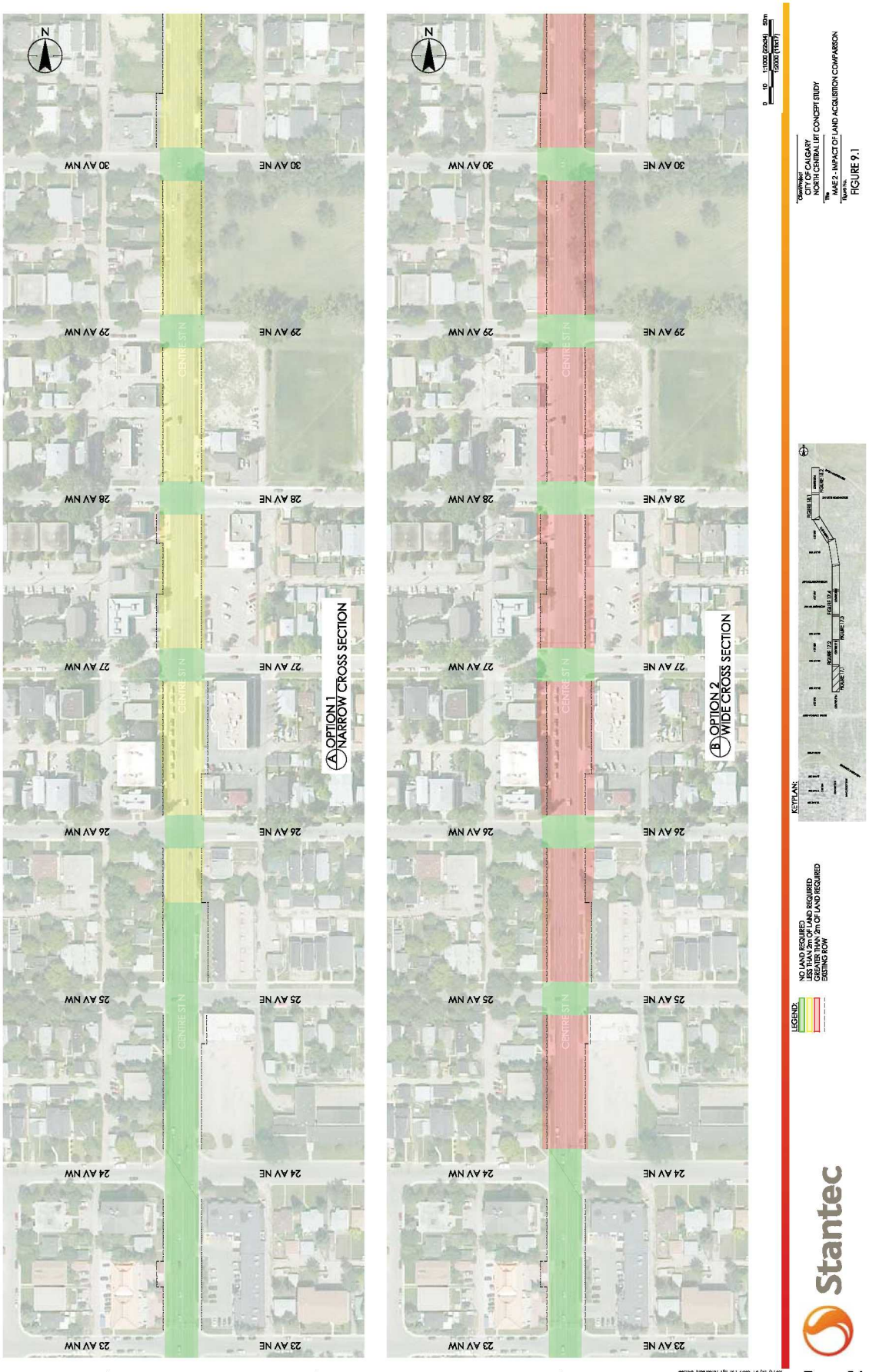
Option	Impact	Assessment Score
1 – Narrow cross-section	With the narrow ROW land acquisition will be required along the entire segment of approximately less than 2 metres except at 32 Avenue and at 38 Avenue	3
2 – Wide cross-section	With the narrow ROW widening the road to 2 vehicle lanes plus the LRT would result in more significant impacts for commercial and residential properties along this segments	2

Contribution to Improved Streetscape and Public Realm

Both options 1 and 2 would be ranked the same with the LRT at-grade. The LRT is assumed to promote more activity than the BAU scenario.

Table 9.19: Segment 2 – Urban Development: Contribution to Improved Streetscape and Public Realm

Option	Impact	Assessment Score
1 – Narrow cross-section	Additional activity encouraged at street level	4
2 – Wide cross-section	Additional activity encouraged at street level	4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30 AV NW
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27 AV NE
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26 AV NE
25 AV NW
25 AV NE
24 AV NW
24 AV NE
23 AV NW
23 AV NE
CENTRE ST N
A OPTION 1
NARROW CROSS SECTION
B OPTION 2
WIDE CROSS SECTION
0 10 1:1000 (22x34) 50m
1:2000 (11x17)
Client/Project
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
MAE2 - IMPACT OF LAND ACQUISITION COMPARISON
Figure No.
FIGURE 9.1
KEYPLAN:
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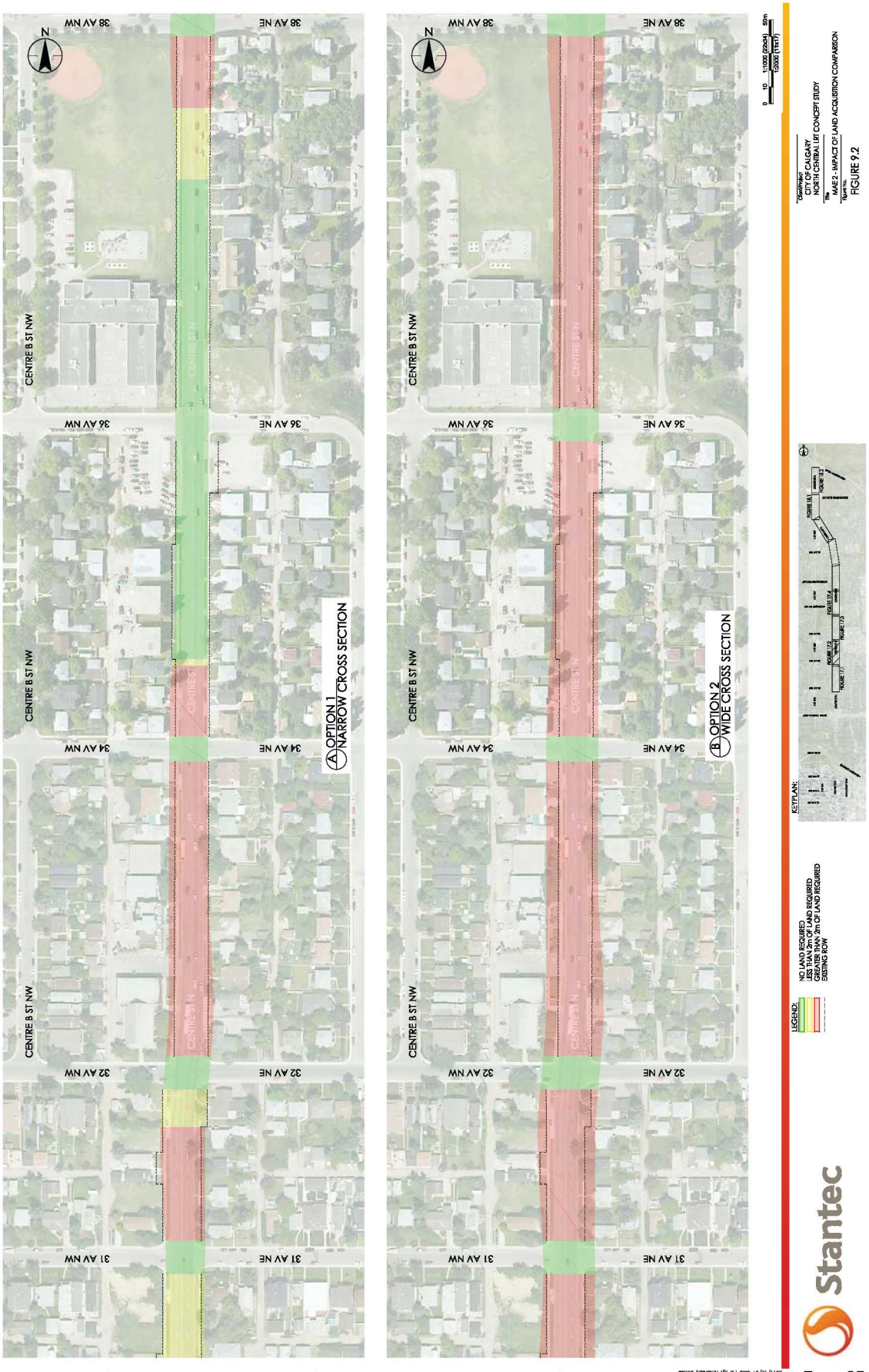
GREATER THAN 10% BUT LESS THAN 20% OF LAND REQUIRED
EXISTING ROW
Stantec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OPTION 2
WIDE CROSS SECTION
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38 AV NE
36 AV NW
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34 AV NW
34 AV NE
32 AV NW
32 AV NE
31 AV NW
31 AV NE
N
LEGEND:
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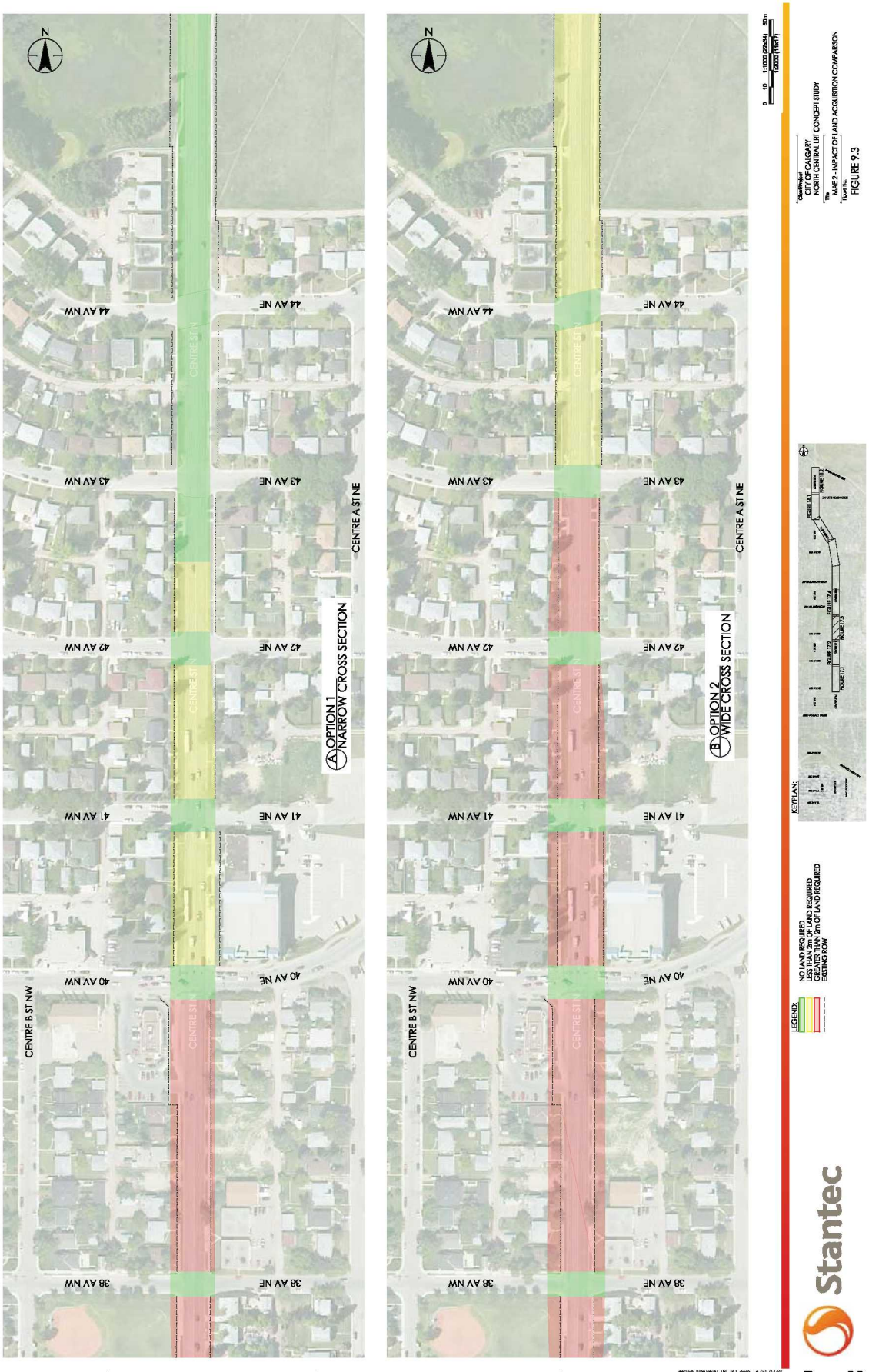
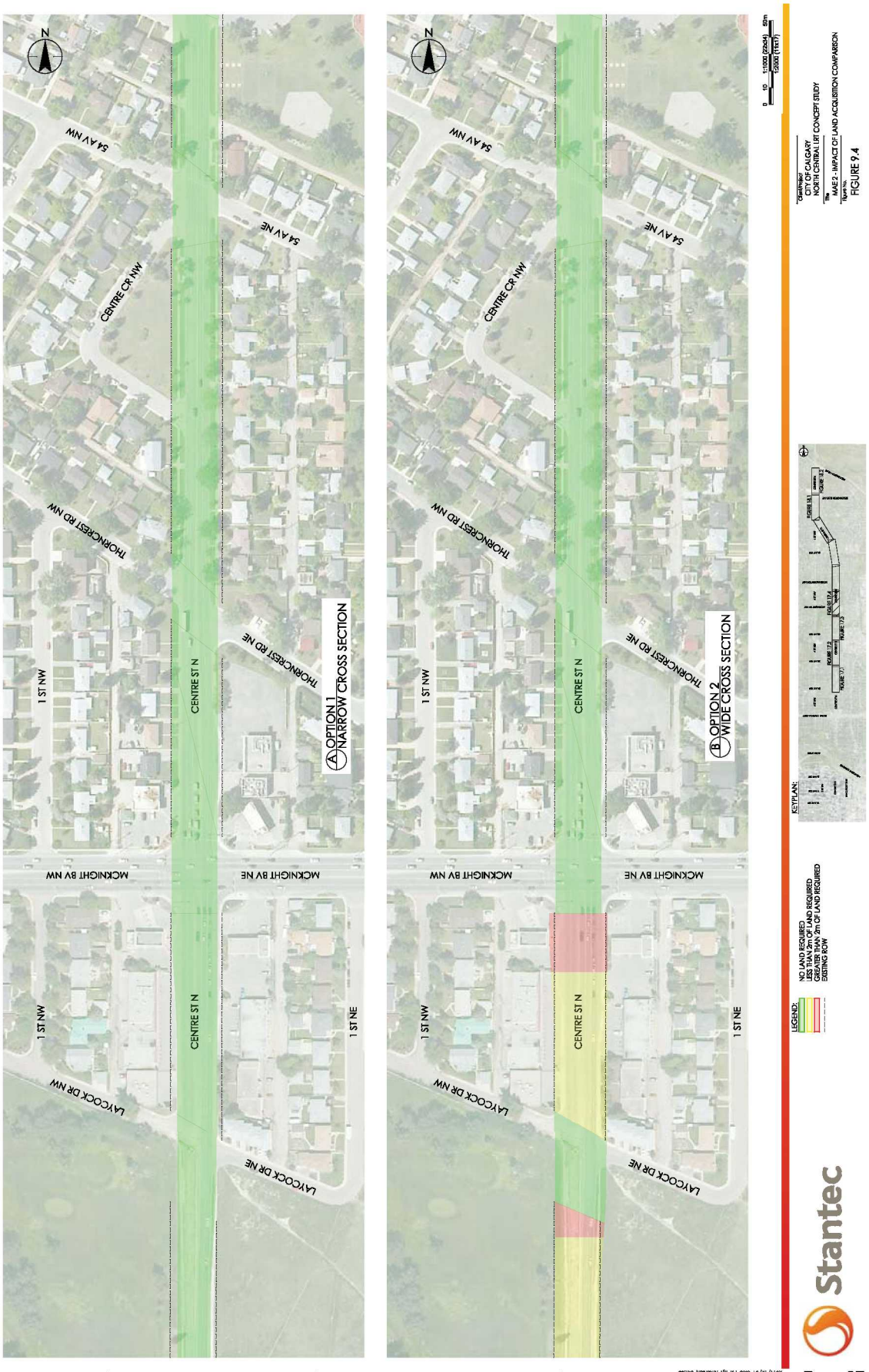
LESS THAN 4m OF LAND REQUIRED
GREATER THAN 4m OF LAND REQUIRED
EXISTING ROW
KEYPLAN:
Stantec
*Client/Project
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
*Title
MAE2 - IMPACT OF LAND ACQUISITION COMPARISON
*Figure No.
FIGURE 9.2


N
OPTION 1
NARROW CROSS SECTION
OPTION 2
WIDE CROSS SECTION
CENTRE A ST NE
CENTRE B ST NW
CENTRE ST
38 AV NW
38 AV NE
40 AV NW
40 AV NE
41 AV NW
41 AV NE
42 AV NW
42 AV NE
43 AV NW
43 AV NE
44 AV NW
44 AV NE
0 10 1:1000 (22x34) 1:2000 (11x17) 50m
LEGEND:
NO LAND REQUIRED
LESS THAN 10% OF LAND REQUIRED
GREATER THAN 10% OF LAND REQUIRED
EXISTING ROW
KEYPLAN:
Stantec
Drawing:
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
MAE2 - IMPACT OF LAND ACQUISITION COMPARISON
Figure No.
FIGURE 9.3


N
54 AV NW
54 AV NE
CENTRE CR NW
THORNCREST RD NW
THORNCREST RD NE
1 ST NW
CENTRE ST N
A OPTION 1
NARROW CROSS SECTION
MCKNIGHT BV NW
MCKNIGHT BV NE
1 ST NE
LAYCOCK DR NW
LAYCOCK DR NE
B OPTION 2
WIDE CROSS SECTION
0 10 1:1000 (22x34) 50m
1:2000 (11x17)
Client/Logo:
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title:
MAE2 - IMPACT OF LAND ACQUISITION COMPARISON
Figure No.
FIGURE 9.4
KEYPLAN:
LEGEND:
NO LAND REQUIRED
LESS THAN 10% OF LAND REQUIRED
GREATER THAN 10% OF LAND REQUIRED
EXISTING ROW
Stantec

9.7 SUSTAINABLE ENVIRONMENT

NC LRT Project Objective: "A service that facilitates a reduction in GHG emissions while not impacting the City's current biodiversity"

Impact on Existing Natural Environment

With the LRT at-grade for both Option 1 and Option 2 there would be no difference between the options.

Table 9.20: MAE 2 - Sustainable Environment: Impact on Existing Natural Environment

Option	Impact	Assessment Score
1 – Narrow cross-section	Comparable to BAU scenario	3
2 – Wide cross-section	Comparable to BAU scenario	3

Noise Impacts

With the LRT at-grade for both Option 1 and Option 2 there would be no difference between the options based on the noise impacts.

Table 9.21: MAE 2 - Sustainable Environment: Noise Impacts

Option	Impact	Assessment Score
1 – Narrow cross-section	Comparable to BAU scenario	3
2 – Wide cross-section	Comparable to BAU scenario	3

9.8 DELIVERABILITY

NC LRT Project Objective: "A service that is constructible and operable"

Constructability – Technical Constraints

Since both the options would be constructed in the same alignment, in general there are no significant technical constraints that would be "show stoppers" in the construction of these options.

Table 9.22: MAE 2 - Deliverability: Constructability (technical constraints)

Option	Impact	Assessment Score
1 – Narrow cross-section	No significant technical constraints	3
2 – Wide cross-section	No significant technical constraints	3

Construction Impacts

In Option 1, the narrow ROW for the at-grade construction of the LRT will need to be staged in blocks. During construction the road would need to be reduced to one lane in peak hour direction only. This will result in higher traffic impacts during construction. This option would have more noise impacts during construction with the alignment at-grade.

In Option 2, with the wider option (if land acquisitions are considered) the staged construction would maintain one lane in each direction on Centre Street which would be the same as the BAU.

Table 9.23: MAE 2- Deliverability: Construction Impacts

Option	Impact	Assessment Score
1 – Narrow cross-section	Narrower ROW will result in more significant construction impacts including limited access along Centre Street.	2
2 – Wide cross-section	Wider ROW will allow for some access along Centre Street to be maintained.	3

Conformance to CTP & MDP

As previously outlined, options that reduce auto capacity and support an increased mode shift to transit, cycling, and walking would have higher conformance to the CTP and MDP. Additionally, avoiding land acquisition was also considered to conform to the CTP and MDP goals to promote "good urban design". Based on these concepts the options were assessed as shown in the below table.

Table 9.24: MAE 2 - Deliverability: Conformance to CTP & MDP

Option	Impact	Assessment Score
1 – Narrow cross-section	Higher conformance as higher mode split is encouraged and would minimize costs by mitigating land acquisitions.	4
2 – Wide cross-section	Lower conformance as the status quo is maintained for vehicular flow and would incur higher costs with more extensive land acquisitions.	2

Acceptability

In this segment the workshop in April identified stronger preference for two driving lanes with a proposed 30 metre ROW and no on-street parking. However, both the CAG and the City preferred the narrow option.

Positive opinions for Option 1included:

- Lower impact on the community
- Lower acquisition costs
- Will help contribute to complete streets with a narrower road
- Question arose about the incremental cost of tunneling to McKnight if tunneling is an option for the downtown

For option 2, 79% of open house participants in April preferred this option. Positive opinions for this option included a wider street being more positive to creating complete streets.

Table 9.25: MAE 2 - Deliverability: Acceptability

Option	Impact	Assessment Score
1 – Narrow cross-section	Higher conformance as higher mode split is encouraged and would minimize costs by mitigating land acquisitions.	4
2 – Wide cross-section	Lower conformance as the status quo is maintained for vehicular flow and would incur higher costs with more extensive land acquisitions.	2

10.0 EVALUATION RESULTS FOR MAE 3

10.1 OPINION OF PROBABLE CAPITAL COST

Similar to segment 2, the cost difference between Option 1 and Option 2 is due to the added roadworks construction for widening the road to provide a parking and the partial land acquisition costs for Option 2. Since the costs were close in order of magnitude, these options were ranked the same.

Table 10.1: MAE 3 – Opinion of Probable Capital Costs

Option	Opinion of Probable Construction & Land Acquisition Costs **(Appendix G)**	Assessment Score
1 – No Parking within ROW	$40 million	3
2 – Parking within ROW	$50 million	3

10.2 FINANCIAL CAPACITY

NC LRT Project Objective: "An affordable and cost-effective service"

Phasing Possibilities

It is assumed that Segment 3 would be built within a single construction phase, regardless of whether Option 1 or 2 was selected.

Table 10.2: MAE 3 – Financial Capacity: Phasing Possibilities

Option	Impact	Assessment Score
1 – No Parking within ROW	Entire segment would be built in one phase because there is no advantage without a connection to a station north of Beddington Trail	3
2 – Parking within ROW	Entire segment would be built in one phase because there is no advantage without a connection to a station north of Beddington Trail	3

Impact to Existing City Assets

3Similar to segment 2, in segment3 options 1 and 2 both have the same location. City assets in this segment included:

- Park space south of Bergen Drive
- Park space south of the bus trap
- Potential archaeological region throughout the section in MAE 3 (refer to Figure 8.1 shown in section 8.2)

Since both options have the same alignment they could be ranked similarly. However, with option 2 there could be some perceived negatives when park space is used to widen the existing Centre Street ROW which could be seen as a potential negative for option2.

Table 10.3: MAE 3 – Financial Capacity: Impacts to Existing City Assets

Option	Assessment Score
1 – No Parking within ROW	3
2 – Parking within ROW	2

10.3 COMMUNITY WELL BEING

NC LRT Project Objective: "A safe, secure and socially inclusive service that improves access to key community destinations and encourages active travel"

Impact on Community Cohesion: Visual Intrusion

In segment 3, the options are both at-grade and were seen as similar to the BAU.

Table 10.4: MAE 3 – Community Well-Being: Impact on Community Cohesion - Visual Intrusion

Option	Impact	Assessment Score
1 – No Parking within ROW	May be visually intrusive to some but highly subjective as some people may prefer to see the LRT while others may not.	3
2 – Parking within ROW	May be visually intrusive to some but highly subjective as some people may prefer to see the LRT while others may not.	3

Impact on Community Cohesion: Severance

In segment 3, the same ranking was used as segment 2. With the LRT at-grade, all pedestrian crossings would require signalization. This could be seen as a negative compared to the BAU where east-west movements are not restricted. When the ROW is widened to include two driving lanes on each side plus the LRT, the time it takes to cross the road as a pedestrian will introduce added perceptions of severance to the community.

Table 10.5: MAE 3 – Community Well-Being: Impact on Community Cohesion - Severance

Option	Impact	Assessment Score
1 – No Parking within ROW	LRT will be a barrier to crossing the street once every 5 minutes depending on the headways	3
2 – Parking within ROW	LRT will be a barrier to crossing the street once every 5 min depending on the headways The wide ROW will also make the street more of a barrier to cross	2

Safety

In segment 3, with both options at-grade they would represent the same number of conflicts between road users and the LRT. The only added conflict for motor vehicles would be for right turns in the narrow option as the narrow lanes widths of 3.3 metres would require motor vehicles to turn onto the LRT guideway by 0.3 to 1.5 metres.

Table 10.6: MAE 3 – Community Well-Being: Safety

Option	Impact	Assessment Score
1 – No Parking within ROW	More safety concerns with the narrow ROW as vehicles making right turns will need to turn into the LRT guideway increasing the risk of collisions	2
2 – Parking within ROW	Less operational safety concerns with wider ROW as vehicles making right turns do not need to turn into the LRT guideway as with the narrow option	3

Security

For the at-grade options in segment 2, the LRT is considered to increase the sense of personal security along the alignment as there is expected to be more activity on the street compared to the BAU.

Table 10.7: MAE 3 – Community Well-Being: Security

Option	Impact	Assessment Score
1 – No Parking within ROW	Personal perceptions of security are good due to highly visible stations	4
2 – Parking within ROW	Personal perceptions of security are good due to highly visible stations	4

Emergency Access

In segment 3, both the narrow and wide options would not restrict emergency access. These options would be considered the same as the BAU.

Table 10.8: MAE 3 – Community Well-Being: Emergency Access

Option	Impact	Assessment Score
1 – No Parking within ROW	Emergency vehicles will be able to drive along the LRT tracks as the rail will be embedded in-street and separated by a mountable-rolled curb	3
2 – Parking within ROW	Emergency vehicles will be able to drive along the LRT tracks as the rail will be embedded in-street and separated by a mountable-rolled curb	3

User Centered Design / Accessibility

In segment 3, all the options are at-grade and would not have any differences in accessibility compared to the BAU scenario.

Table 10.9: MAE 3 – Community Well-Being: User Centered Design / Accessibility

Option	Impact	Assessment Score
1 – No Parking within ROW	Comparable to the BAU scenario	3
2 – Parking within ROW	Comparable to the BAU scenario	3

10.4 PROSPEROUS ECONOMY

NC LRT Project Objective: "A service that promotes economic development by improving access to employment, without adversely impacting goods movement"

Value Capture

In Segment 3, the station at Beddington Boulevard likely has low demand under normal market conditions for high-rise development, and while the available parcels are large, they are currently being used. The market analysis suggested that demand for development at this site might be enhanced by an underground option that provides shorter travel times and higher reliability for trips to the Centre City. It is assumed that the scoring would not change for the two options in this segment.

Table 10.10: MAE 3 – Prosperous Economy: Value Capture

Option	Impact	Assessment Score
1 – No Parking within ROW	Some land may be available for development at the station in this segment, but the market demand for high density development is low	3
2 – Parking within ROW	Some land may be available for development at the station in this segment, but the market demand for high density development is low	3

Impact on Goods Movement

Segment 3 is not an important link for goods movement. Any trucks traveling to the shopping centre would be able to access it from a point other than along Centre Street. Therefore, it is assumed that there is no difference between the options in terms of goods movement.

Table 10.11: MAE 3 – Prosperous Economy: Impact on Goods Movement

Option	Impact	Assessment Score
1 – No Parking within ROW	Alternative means available for truck access	3
2 – Parking within ROW	No change from Business as Usual.	3

10.5 TRANSPORTATION

NC LRT Project Objective: "A high priority transit service that attracts transit use, walking and cycling as preferred mobility choices for Calgarians and that integrates with, improves customer experience of, and strengthens the regional transit network"

Improvements for Walking and Cycling

Options 1 and 2 would be the same as previously outlined in MAE 2 in section 0.

Table 10.12: MAE 3 – Transportation: Improvements for Walking and Cycling

Option	Impact	Assessment Score
1 – No Parking within ROW	The narrow ROW results in a tighter space for pedestrians. With the speed of Centre Street reduced the pedestrian space would not feel as constrained.	3
2 – Parking within ROW	Providing a wider ROW gives more space for wider sidewalks at 2 to 2.5 metres.	4

Changes in Journey Time – LRT

In Options 1 and 2, the LRT transit travel time should be faster than existing bus / BRT surface transit and as it is running in its own dedicated lane.

Table 10.13: MAE 3 – Transportation: Changes in Journey Time - LRT

Option	Impact	Assessment Score
1 – No Parking within ROW	A dedicated lane will allow for high speeds	4
2 – Parking within ROW	A dedicated lane will allow for high speeds	4

Changes in Journey Time – Auto

In Option 1, running the LRT at-grade over this section does not impact private vehicle journey times as there are no plans to remove traffic lanes over this section of the route. The fact that there is also no parking along this section means it is less likely there will be any delays to journey time caused by people undertaking parking manoeuvers and blocking the roadway.

The impact on auto travel time will be negligible to minor, and will be partially dependent on how many other existing surface transit services (bus and BRT) are removed that operate in the Business as Usual scenario, following the introduction of the LRT.

In Option 2, running the LRT at-grade over this section does not impact private vehicle journey times as there are no plans to remove traffic lanes over this section of the route. The fact that the wider cross section allows for parking along this section, means there is a small possibility there may be delays to journey time caused by people undertaking parking manoeuvers and blocking the roadway.

The impact on auto travel time will be negligible to minor, and will be partially dependent on how many other existing surface transit services (bus and BRT) are removed that operate in the Business as Usual scenario, following the introduction of the LRT.

Table 10.14: MAE 3 – Transportation: Changes in Journey Time - Auto

Option	Impact	Assessment Score
1 – No Parking within ROW	Journey times for automobiles not expected to change compared to BAU	3
2 – Parking within ROW	Journey times for automobiles not expected to change compared to BAU	3

Reliability

In Option 1, this section of the route would have the same challenges as the narrow cross-section previously discussed in MAE 2. It would be on par with the BAU.

In Option 2, this section of the route appears to have limited issues that would cause unreliability. There is a slight possibility that with parking manoeuvers along this section of the alignment there could be minor interference with the LRT depending on the final cross section. Compared to the BAU, it is considered that reliability will be improved.

Table 10.15: MAE 3 – Prosperous Economy: Reliability

Option	Impact	Assessment Score
1 – No Parking within ROW	The removal of curb-side parking is expected to improve reliability	3
2 – Parking within ROW	The widening of the road is expected to lead to reliability improvements	4

Impact on Displaced Traffic and Demand on Parallel Routes

In Option 1, drivers are expected to continue to use Centre Street if they did in the past, even though parking will not be available. Because the LRT will block most left turns, provisions for U-Turns may be needed or drivers will be expected to use alternative local roads to get back onto Centre Street.

In Option 2, drivers are expected to continue to use Centre Street if they did in the past. Because the LRT will block most left turns,

provisions for U-Turns may be needed or drivers will be expected to use alternative local roads to get back onto Centre Street.

Table 10.16: MAE 3 – Transportation: Impact on Displaced Traffic and Demand on Parallel Routes

Option	Impact	Assessment Score
1 – No Parking within ROW	Centre Street will continue to provide local access	3
2 – Parking within ROW	Centre Street will continue to provide local access	3

Impact on Parking

In option 1, parking in front of the adjacent residences would be removed. The ROW width at 22metres would not provide enough space for a parking lane in addition to a lane for motor vehicles along with the LRT. This would be a reduction in the amount of parking that would be available in the BAU.

In option 2, with the wider ROW additional land would be acquired to provide for a parking lane for the adjacent residences. This option would restore on-street parking to the same conditions as the BAU.

Table 10.17: MAE 3 – Transportation: Impact on Parking

Option	Impact	Assessment Score
1 – No Parking within ROW	Parking in front of adjacent residences removed	2
2 – Parking within ROW	Space for parking lane provided	3

10.6 URBAN DEVELOPMENT

NC LRT Project Objective: "A service that support current and future land use and intensification of development along the corridor"

Land Acquisition Impacts

For option 1, the existing ROW of 21.95metres would provide sufficient space for the LRT and one vehicle lane in each direction. As a result there would not be any anticipated land acquisition required in this segment.

For option 2, since the existing parking in front of adjacent residences would be removed , the parking was added back in to accommodate on-street parking for the adjacent residences. This would result in less than 2 metres of land acquisition required along this section on both sides of Centre Street. This would be considered as an improvement to the BAU with the parking restored on street but with the added impact of acquisition to provide for the on-street parking space.

A comparison of the land acquisition impacts are shown in **Figure 10.1**.

Table 10.18: MAE 3 – Urban Development: Land Acquisition Impacts

Option	Impact	Assessment Score
1 – No Parking within ROW	No acquisition impacts anticipated	3
2 – Parking within ROW	Some acquisition would be required on each side	2

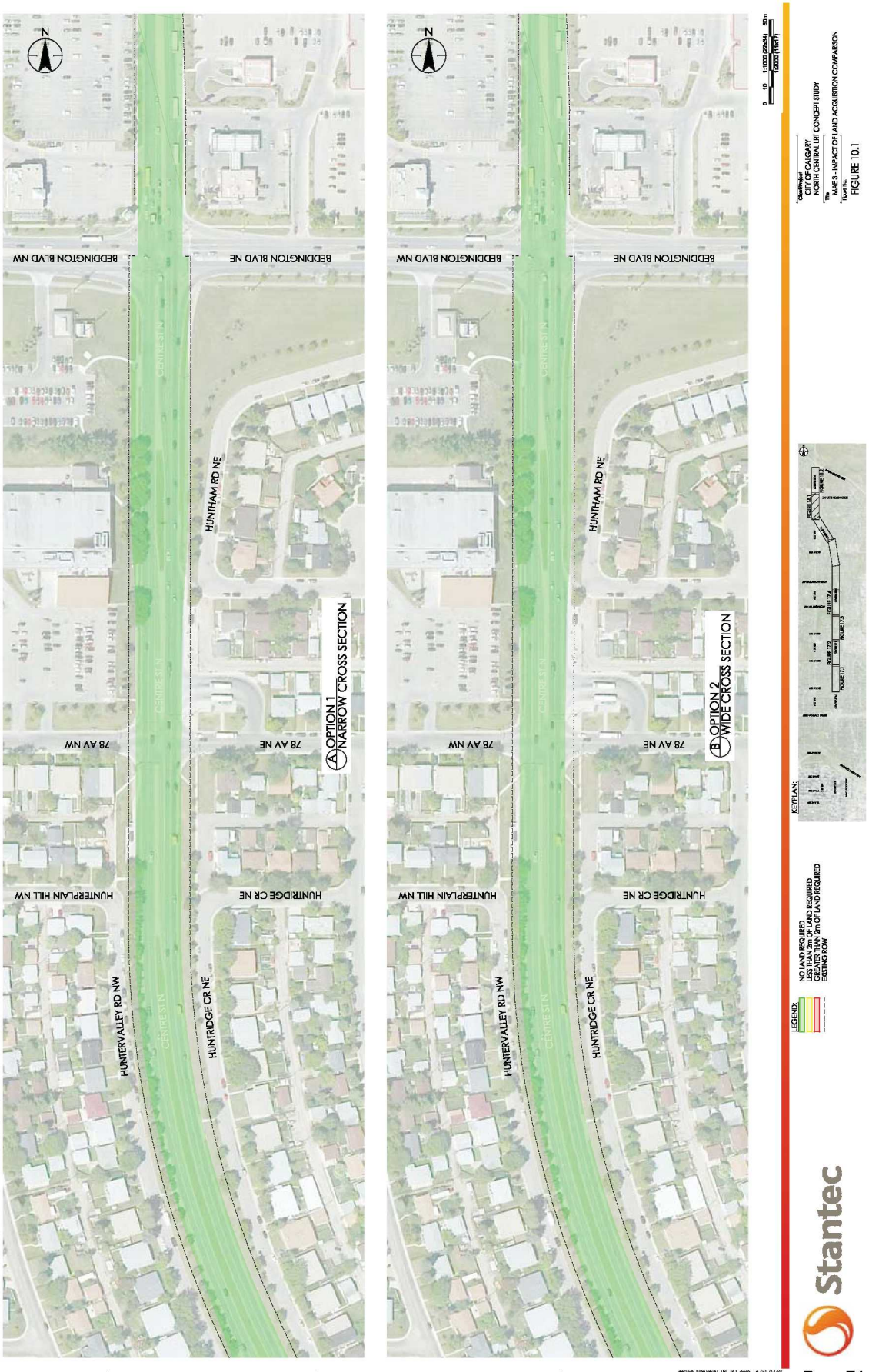
Contribution to Improved Streetscape and Public Realm

Both options 1 and 2 would be ranked the same with the LRT at-grade. The LRT is assumed to promote more activity than the BAU scenario.

Table 10.19: MAE 3 – Urban Development: Contribution to Improved Streetscape and Public Realm

Option	Impact	Assessment Score
1 – No Parking within ROW	Additional activity encouraged at street level	4
2 – Parking within ROW	Additional activity encouraged at street level	4

Figure 10.1: Land Acquisition Impacts for MAE 3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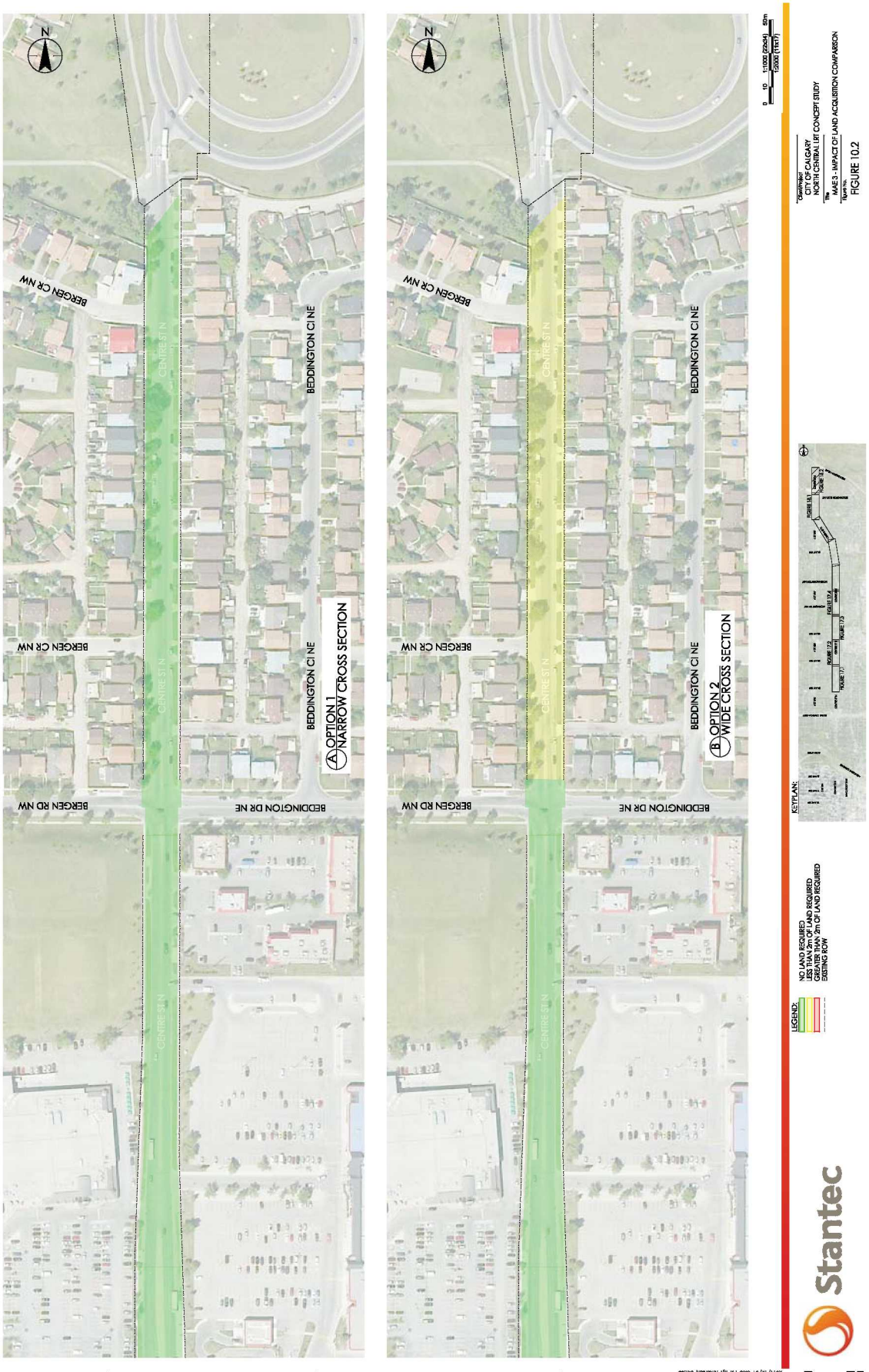
BEDDINGTON BLVD NE
CENTRE ST N
HUNTHAM RD NE
78 AV NW
78 AV NE
HUNTERPLAIN HILL NW
HUNTRIDGE CR NE
HUNTERVALLEY RD NW
HUNTRIDGE CR NE
A OPTION 1
NARROW CROSS SECTION
B OPTION 2
WIDE CROSS SECTION
0 10 1:1000 (ISO-A1) 50m
1:2000 (11x17)
LEGEND:
NO LAND REQUIRED
LESS THAN 10% OF LAND REQUIRED
GREATER THAN 10% OF LAND REQUIRED
EXISTING ROW
KEYPLAN:
Stantec
Drawing:
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
MAE3 - IMPACT OF LAND ACQUISITION COMPARISON
Figure No.
FIGURE 10.1


N
BERGEN CR NW
BEDDINGTON CI NE
CENTRE ST N
BERGEN RD NW
BEDDINGTON DR NE
A OPTION 1
NARROW CROSS SECTION
B OPTION 2
WIDE CROSS SECTION
0 10 1:1000 (22x34) 50m
1:2000 (11x17)
Client/Project
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Title
MAE3 - IMPACT OF LAND ACQUISITION COMPARISON
Figure No.
FIGURE 10.2
KEYPLAN:
LEGEND:
NO LAND REQUIRED
LESS THAN 4m OF LAND REQUIRED
GREATER THAN 4m OF LAND REQUIRED
EXISTING ROW
Stantec

10.7 SUSTAINABLE ENVIRONMENT

NC LRT Project Objective: "A service that facilitates a reduction in GHG emissions while not impacting the City's current biodiversity"

Impact on Existing Natural Environment

With the LRT at-grade for both Option 1 and Option 2 there would be no difference between the options.

Table 10.20: MAE 3 - Sustainable Environment: Impact on Existing Natural Environment

Option	Impact	Assessment Score
1 – No Parking within ROW	Comparable to BAU scenario	3
2 – Parking within ROW	Comparable to BAU scenario	3

Noise Impacts

With the LRT at-grade for both Option 1 and Option 2 there would be no difference between the options based on the noise impacts.

Table 10.21: MAE 3 - Sustainable Environment: Noise Impacts

Option	Impact	Assessment Score
1 – No Parking within ROW	Comparable to BAU scenario	3
2 – Parking within ROW	Comparable to BAU scenario	3

10.8 DELIVERABILITY

NC LRT Project Objective: "A service that is constructible and operable"

Constructability – Technical Constraints

Since both the options would be constructed in the same alignment, in general there are no significant technical constraints that would be "show stoppers" in the construction of these options.

Table 10.22: MAE 3 - Deliverability: Constructability (technical constraints)

Option	Impact	Assessment
1 – No Parking within ROW	No significant technical constraints	3
2 – Parking within ROW	No significant technical constraints	3

Construction Impacts

In Option 1, the narrow ROW for the at-grade construction of the LRT will need to be staged in blocks. During construction the road would need to be reduced to one lane in peak hour direction only. This will result in higher traffic impacts during construction. This option would have more noise impacts during construction with the alignment at-grade.

In Option 2, with the wider option (if land acquisitions are considered) the staged construction would maintain one lane in each direction on Centre Street the same as the BAU.

Table 10.23: MAE 3 - Deliverability: Construction Impacts

Option	Impact	Assessment
1 – No Parking within ROW	Narrower ROW will result in more significant construction impacts including limited access along Centre Street.	2
2 – Parking within ROW	Wider ROW will allow for some access along Centre Street to be maintained.	3

Conformance to CTP & MDP

As previously outlined, options that reduce auto capacity and support an increased mode shift to transit, cycling, and walking would have higher conformance to the CTP and MDP. Additionally, avoiding land acquisition was also considered to conform to the CTP and MDP goals to promote "good urban design". Based on these concepts the options were assessed as shown in the below table.

Since Option 1 would restrict on-street parking it could be seen as an encouragement for fewer vehicles on the road. In general the City of Calgary has been looking to reduce parking outside of private properties. As a result, considering land acquisition in order to provide for parking space could be viewed as lower conformance to CTP and MDP goals.

Table 10.24: MAE 3 - Deliverability: Conformance to CTP and MDP

Option	Impact	Assessment
1 – No Parking within ROW	Higher conformance to the CTP and MDP but would be comparable to the BAU scenario.	3
2 – Parking within ROW	Lower conformance as the status quo is maintained for vehicular flow and would incur higher costs with more extensive land acquisitions.	2

Acceptability

In this segment 41 % of workshop participants and 67 % of open house participants preferred Option 2; having one vehicle lane in each direction and have a parking lane in each direction. Option 1 was considered less preferable as parking would need to be relocated to back lanes which are already in use.

Table 10.25: MAE 3 - Deliverability: Acceptability

Option	Impact	Assessment
1 – No Parking within ROW	Lower acceptance with no on-street parking provided.	0
2 – Parking within ROW	Would be comparable to the BAU scenario for the public.	3

11.0 EVALUATION SUMMARY

The MAE sets out the criteria to compare and evaluate options for configuring the LRT alignment from the Center City north across the Bow River and along Centre Street to Beddington Trail. The criteria used to compare the options were selected by the project team in consultation with the public and the City's project Steering Committee. The results of the evaluation show how the options for the LRT alignment in any one segment compare to one another, and identify the key differences that can be used to distinguish one option over another in any one segment.

The following discussion summarizes the key trade-offs or factors that differentiate the options in each segment of the NC LRT alignment.

MAE 1 – Downtown to 9 Avenue N

In MAE 1, the key trade-off is financial cost. If cost is a major deciding factor in selecting a preferred option, then placing LRT on the Centre Street Bridge is the best option from a cost perspective. However, the analysis also shows that the higher cost for the Full Tunnel option provides important benefits including:

- Less impact on City assets (land, Centre Street Bridge, infrastructure)
- Less impact on communities and therefore more public support
- Greater reliability and less prone to conflicts with traffic and potential delays
- Less impact on the natural environment and the Bow River
- More travel time savings into the Center City

The Centre Street Bridge option may cost less, but it has greater transportation impacts. LRT on the Bridge will compete with other street traffic, potentially resulting in congestion, travel time delays and impact to goods movement. This option also has the potential to create a physical barrier along Centre Street severing communities. The Tunnel option avoids these potential impacts but at a higher cost.

The option of building a New Bridge across the Bow River is less costly than the tunnel, but more so than the Centre Street Bridge option. However, the New Bridge option impacts Princess Island Park, the pedestrian/cycling pathway and the Bow River natural environment. These impacts could result in public opposition making it less desirable than other options within this segment. Placing the LRT at grade from 2 Avenue into the downtown will also result in traffic impacts and additional travel time compared to the tunnel.

MAE 2 – 24 Avenue N to McKnight Boulevard

LRT options in this segment compare a Wide option (2 lanes of traffic each way plus LRT) with a narrow option (1 lane of traffic each way plus LRT). The major difference between these two options is cost and reliability. The wide option has higher costs to acquire land to accommodate 2 lanes of traffic in each direction plus LRT, which contributes to transportation reliability due to reduced potential for traffic conflicts.

However, the wide option does not address the priority to reduce the use of single occupant vehicles into the Centre City and the priority for transit identified in the CTP.

The narrow option had the support of the Community Advisory Group (CAG) while the Wide option was more supported by the general public.

MAE 3 – Beddington Boulevard to Beddington Trail

The narrow option is slightly preferred over the wide option due to lower property acquisition costs and less overall impact to the community. The Narrow option maintains the existing width of the street making it easier and safer for pedestrians and cyclists to cross the street compared to the Wide option.

The narrow option, however, removes all on-street parking. For some residents, the loss of parking was a major factor leading to higher public acceptance of the Wide option.

The wide option is less desirable because of the impact to individual properties, higher costs and the creation of a much wider street corridor for people to cross.

The initially preferred alternative will move forward with at-grade over the Centre Street Bridge from downtown to 24 Avenue (MAE 1 Option 2) with further consideration for the TBM tunnel (MAE 1 Option 3). The alignment will continue with the narrow cross section between 24 Avenue N to McKnight Boulevard (MAE 2 Option 1) to minimize land impacts. With the existing wide ROW between McKnight Boulevard and Beddington Boulevard, the LRT will continue with a wide cross section with minimal land impacts. Lastly, between Beddington Boulevard to Beddington Trail the wide cross section (MAE 3 Option 2) will be proposed to provide parking for the adjacent residences. The full recommended alignment is shown in Figure 11.1. A summary of the full end-to-end costs and travel time of the recommended options is shown in Table 11.1.

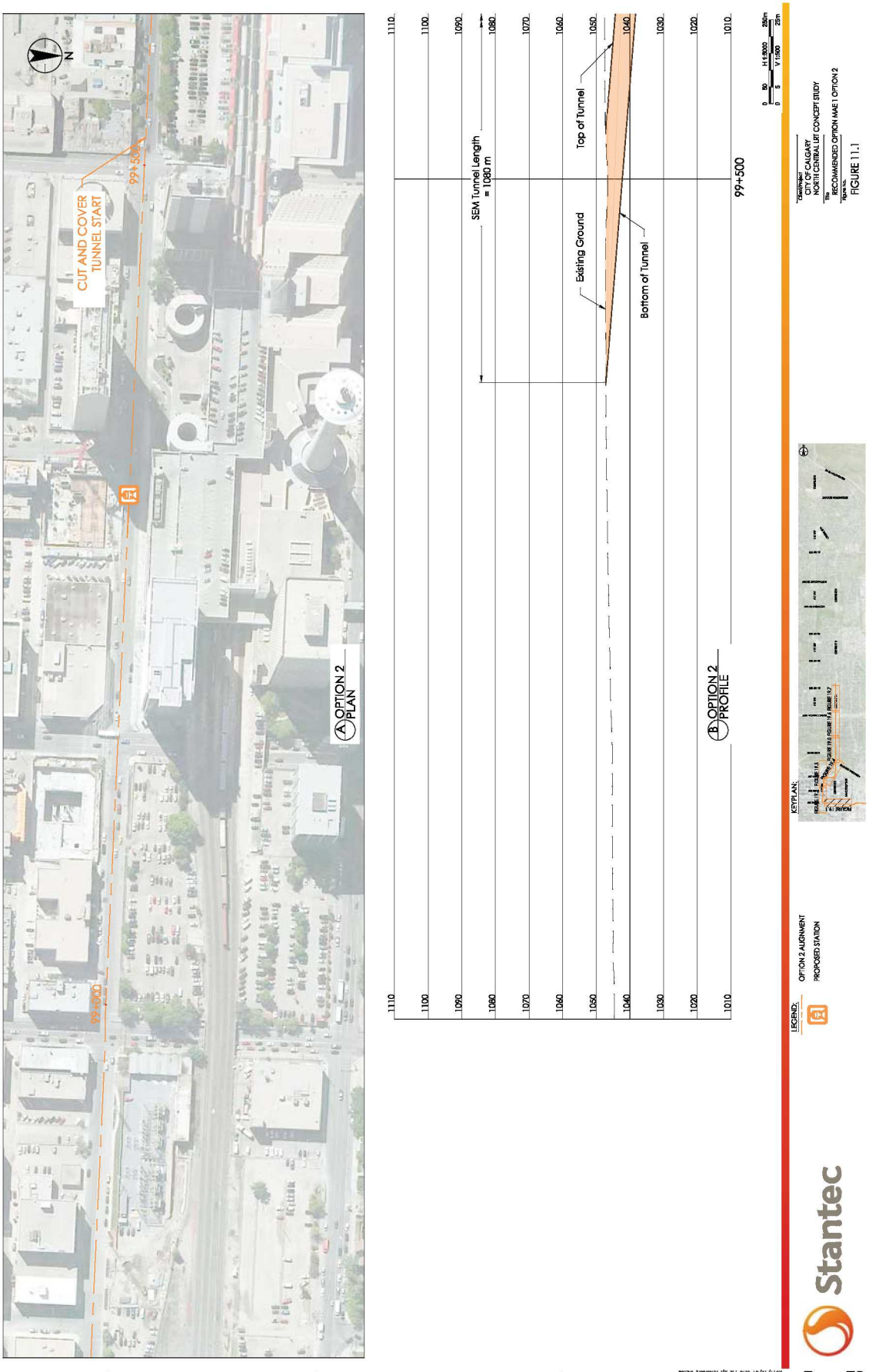
Table 11.1: Preferred Option Summary

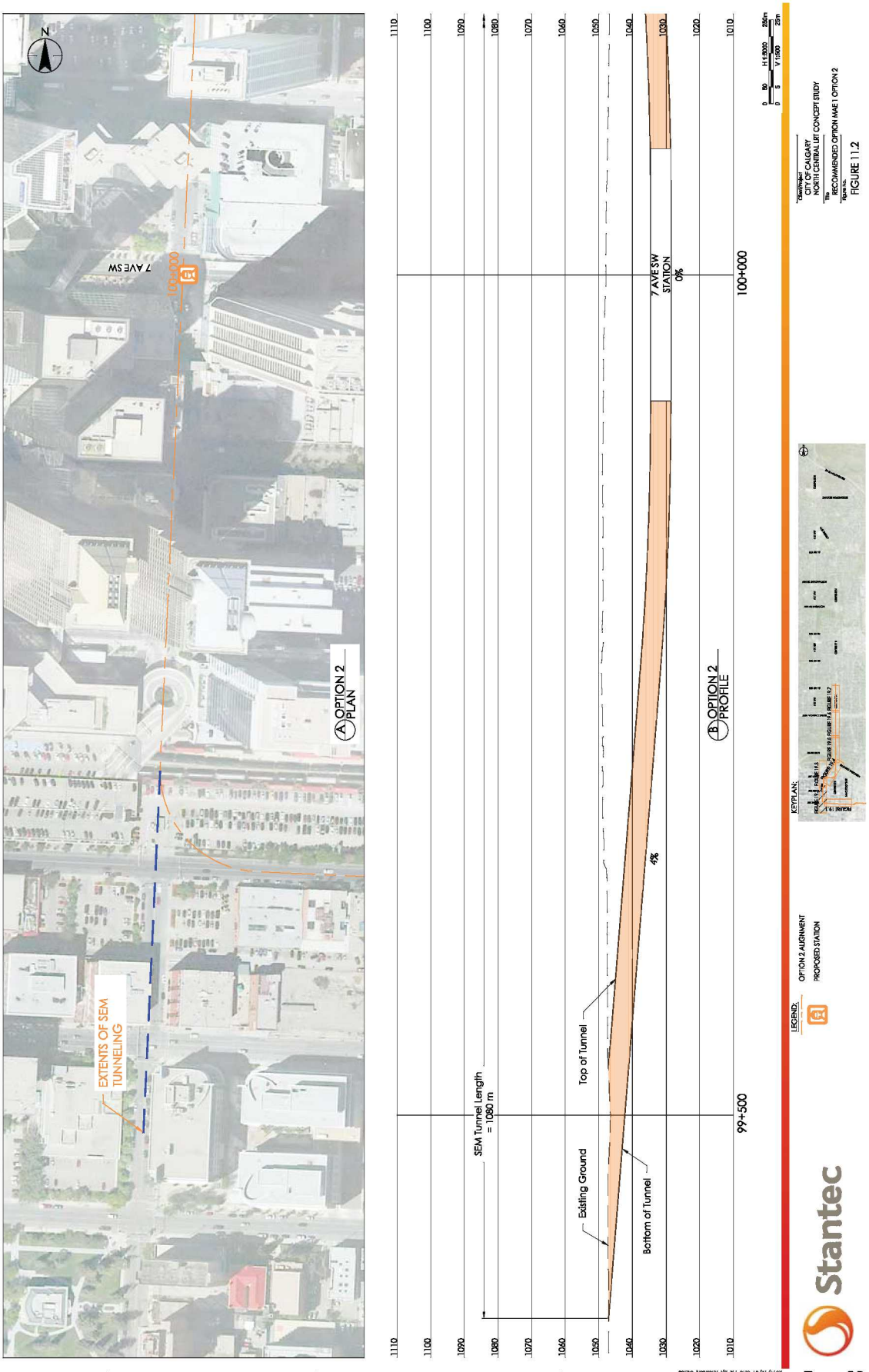
Option	Estimated Range of OPCC from Downtown to North Pointe Station	Estimated Average Travel Times from Downtown to North Pointe Station
BAU	N/A	35 minutes
Initially Preferred Alternative: At-grade over the Centre Street Bridge (MAE 1 Option 2)	$0.9 to 1.1 Billion	33 to 35 minutes
Further consideration: TBM tunnel from downtown to 24 Avenue (MAE 1 Option 3)	$1.6 to 2.0 Billion	28 to 30 minutes

Table 11.2 Detailed MAE Evaluation Summary

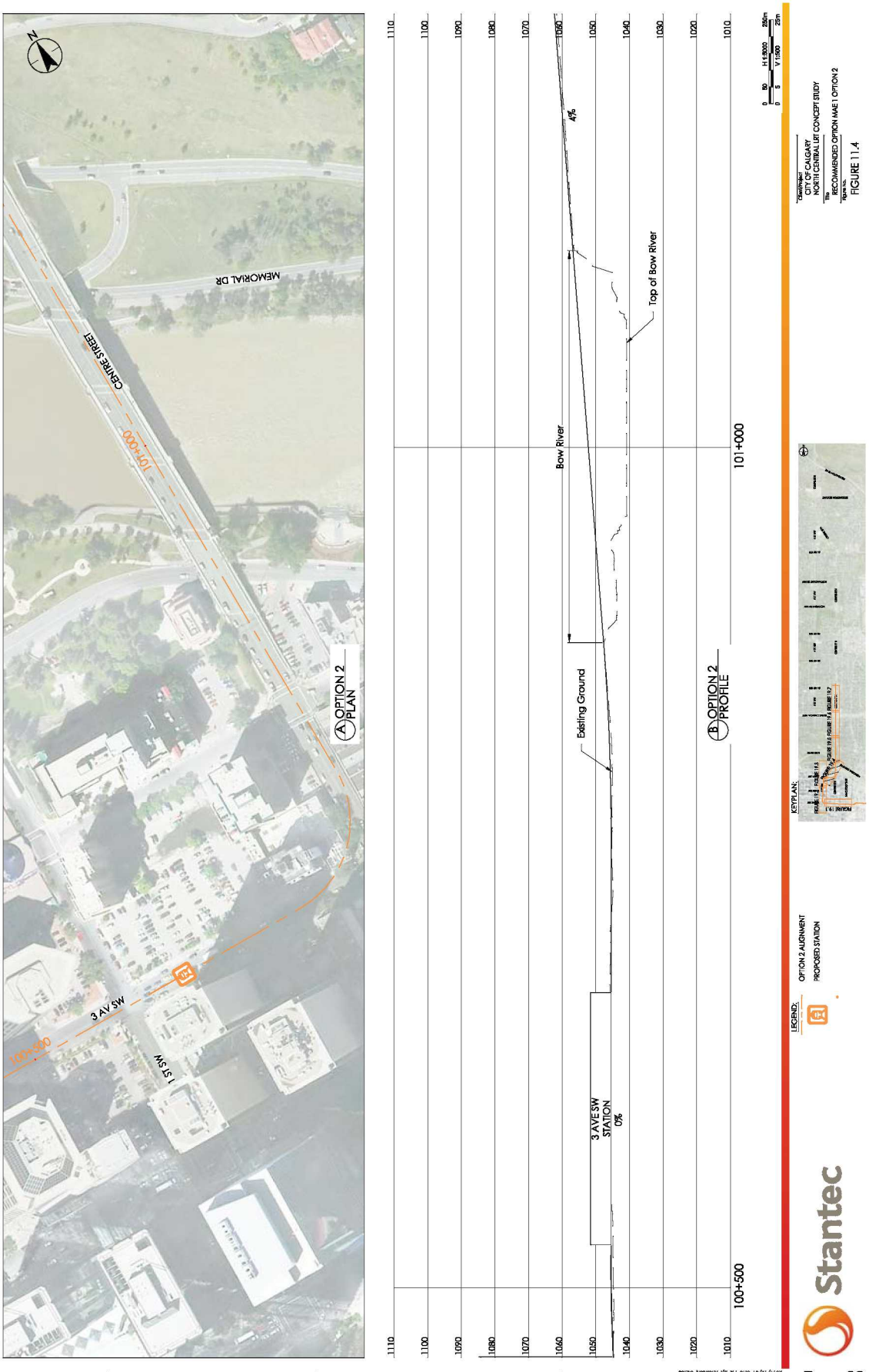
MAE Accounts	Criteria	Expanded Description	MAE 1: Downtown to 9 Ave New bridge over Bow River and partial tunnel	MAE 1: Downtown to 9 Ave At-grade over existing Centre Street bridge	MAE 1: Downtown to 9 Avenue Full tunnel	MAE 2: 24 Ave to McKnight Blvd Narrow	MAE 2: 24 Ave to McKnight Blvd Wide	MAE 3: Beddington Blvd to Beddington Tr Narrow	MAE 3: Beddington Blvd to Beddington Tr Wide
Financial Capacity / Sustainable Corporation	Capital cost	Like for like comparison of full costs to construct the options based on the latest cost estimates	◑ $760 M (to 24 Ave)	◕ $660 M (to 24 Ave)	○ $1,300 M (to 24 Ave)	◑ $200 M	◔ $300 M	◑ $40 M	◑ $50 M
			3	4	1	3	2	3	3
	Phasing Possibilities	Consideration if the potential staging / phasing options make the project more cost-effective / affordable	◑	◑	○	◑	◑	◑	◑
	Impact on existing City assets e.g. land	Depending on alignments, route may impact on existing City assets or facilities with implications	○	○	◕	◑	◔	◑	◔
			2.0	2.0	2.5	3.0	2.5	3.0	2.5
Community Well-Being	Impact on community cohesion: Visual Intrusion	Options can impose different levels of severance and visual intrusion - consideration of number of restricted locations for pedestrians, vehicles and bikes & visual impact on neighbouring properties	◔	◑	●	◑	◑	◑	◑
	Impact on community cohesion: Sevrance	Options can impose different levels of severance and visual intrusion - consideration of number of restricted locations for pedestrians, vehicles and bikes & visual impact on neighbouring properties	◕	◑	●	◑	◑	◑	◑
	Safety	Safety of the system includes both operational safety (ie collisions) as well as personal security of using the system (real and perceived)	◕	◔	●	◔	◑	◔	◑
	Security	Safety of the system includes both operational safety (ie collisions) as well as personal security of using the system (real and perceived)	◔	◕	◔	◕	◕	◕	◕
	Emergency access	Consideration of number of restricted locations for emergency access and implemented mitigation	◔	◑	○	◑	◑	◑	◑
	User Centered design / Accessibility	Consideration of physical access to the system	◔	◑	○	◑	◑	◑	◑
			2.7	3.0	3.2	3.0	3.2	3.0	3.2
Prosperous Economy	Value Capture	Consideration of the potential for each of the different alignments to generate additional (alignment specific) income through mechanisms such as development of City owned property, special taxation districts or development charges	◕	●	●	◑	◑	◑	◑
	Impact on Goods movement	This includes impacts on road space and traffic lanes, restricted movements at intersections and the removal or restriction on loading and servicing along the different routes	◕	◔	◕	◔	◕	◑	◑
			4.0	3.5	4.5	2.5	3.5	3.0	3.0
Transportation	Improvements for walking & cycling	Review of planned impact on pedestrian and bike movements and infrastructure	◕	◑	◑	◑	◕	◑	◕
	Changes in journey time LRT	Depending on the route alignment and level of segregation, the time savings over existing	◕	◔	◕	◑	◑	◕	◕
	Changes in journey time AUTO	Depending on the route alignment and level of segregation, the time savings over existing	◑	○	◑	◔	◑	◑	◑
	Reliability	Depending on levels of route segregation, and the existing and forecast levels of traffic on the routes, the journey times may vary significantly over the day, creating uncertainty for users	◕	◑	◕	◔	◕	◑	◕
	Impact of displaced traffic and demand on parallel routes	Vehicle operating cost and accident reduction savings, offset against potential increases in journey time	◕	◔	◕	◔	◑	◑	◑
	Impact on parking	Depending on the alignment and segregation of the options, there may be an impact on the availability and location of parking on the routes	◑	◑	◑	◑	◕	◔	◑
			3.7	2.3	3.5	2.5	3.5	3.0	3.5
Urban Development / Urban Realm	Land acquisition impacts	Quantity and types of land use impacted by alignments e.g. brownfield vs existing residential	◑	◕	◔	◑	◔	◑	◔
	Contributes to improved streetscape & public realm	Consideration of the planned improvements for each of the alignments	◔	◕	◔	◕	◕	◕	◕
			2.5	4.0	2.0	3.5	3	3.5	3
Sustainable Environment	Route impact on existing natural environment	Options may impact differently on biodiversity and environment and during operation & construction	○	◑	◑	◑	◑	◑	◑
	Noise Impacts	Different options may have different noise and vibration impacts during operation and construction and may impact on different numbers of people	◔	◔	●	◑	◑	◑	◑
			1.5	2.5	4.0	3.0	3.0	3.0	3.0
Deliverability	Constructability - technical constraints	Generally a review of 'show-stoppers' including geotechnical, archaeological, environmental remediation measures and physical challenges (gradients, physical constraints, system expandability, etc.) that would make building / operating an option overly difficult. This also includes non-environmental construction impacts	○	◑	○	◑	◑	◑	◑
	Construction Impacts	Impacts to the surrounding environment during construction including noise impacts from construcion and traffic impacts	○	◔	◔	◔	◑	◔	◑
	Confromance to CTP & MDP	Review of how the options fit with existing public policies and how they may help in achieving the goals and targets set	◔	◑	◔	◕	◔	◑	◔
	Acceptability	Description of the likely public response to the option (often gauged through outreach process)	○	◑	●	◑	◕	○	◑
			1.3	2.8	2.5	3.0	3.0	2.3	2.8
	TOTAL with Capital Cost	TOTAL with Capital Cost	20.6	24.1	23.2	23.5	23.7	23.8	23.9
	TOTAL without Capital Cost	TOTAL without Capital Cost	17.6	20.1	22.2	20.5	21.7	20.8	20.9

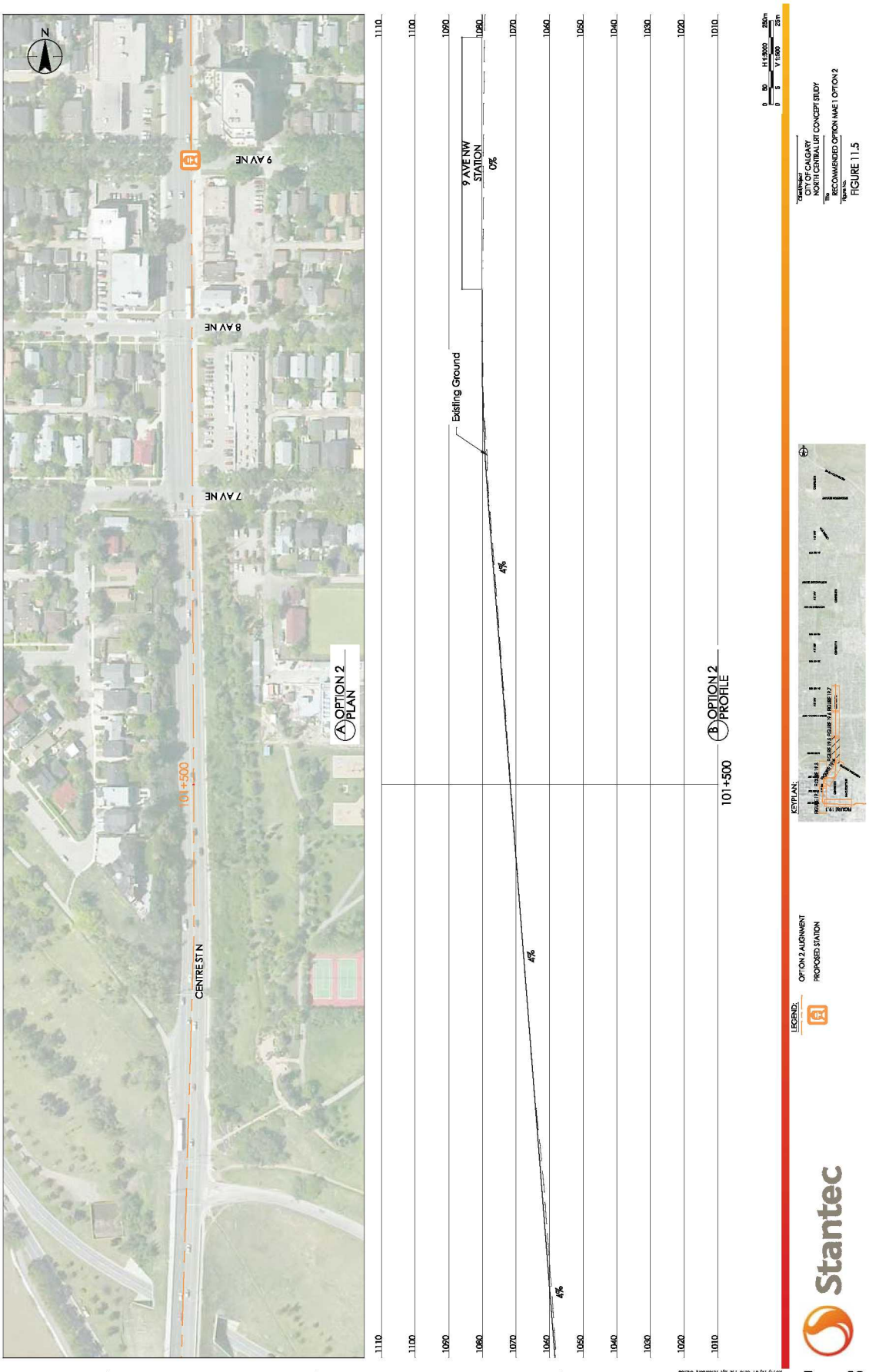
Ranking Legend: ● 5 ◕ 4 ◑ 3 ◔ 2 ○ 1

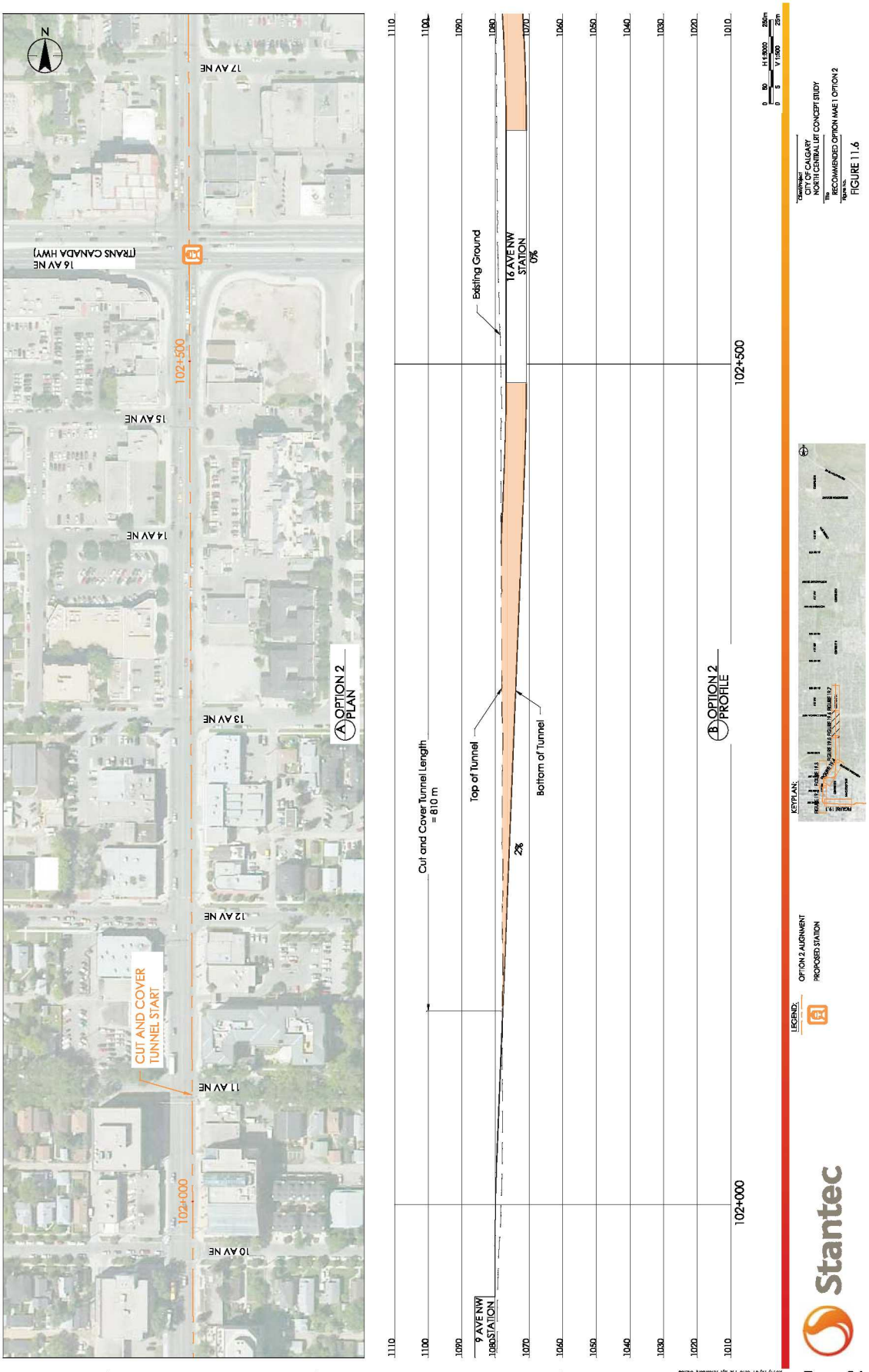

N
CUT AND COVER TUNNEL START
99+500
99+000
A OPTION 2 PLAN
B OPTION 2 PROFILE
SEM Tunnel Length = 1080 m
Top of Tunnel
Existing Ground
Bottom of Tunnel
99+500
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
KEYPLAN:
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.1

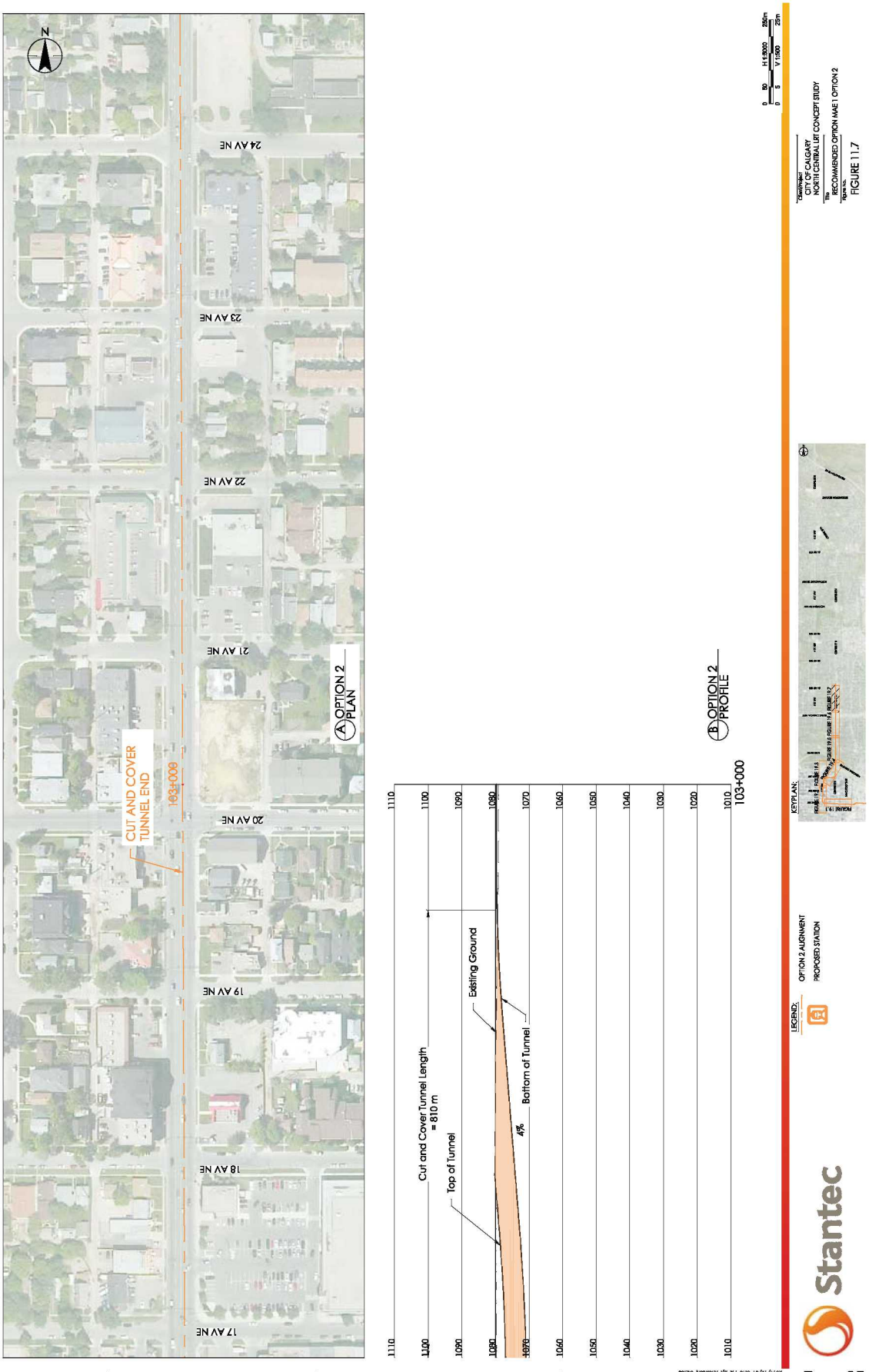

N
7 AVE SW
100+000
EXTENTS OF SEM TUNNELING
A OPTION 2 PLAN
B OPTION 2 PROFILE
SEM Tunnel Length = 1080 m
Top of Tunnel
Existing Ground
Bottom of Tunnel
4%
7 AVE SW STATION
0%
100+000
99+500
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
KEYPLAN:
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.2

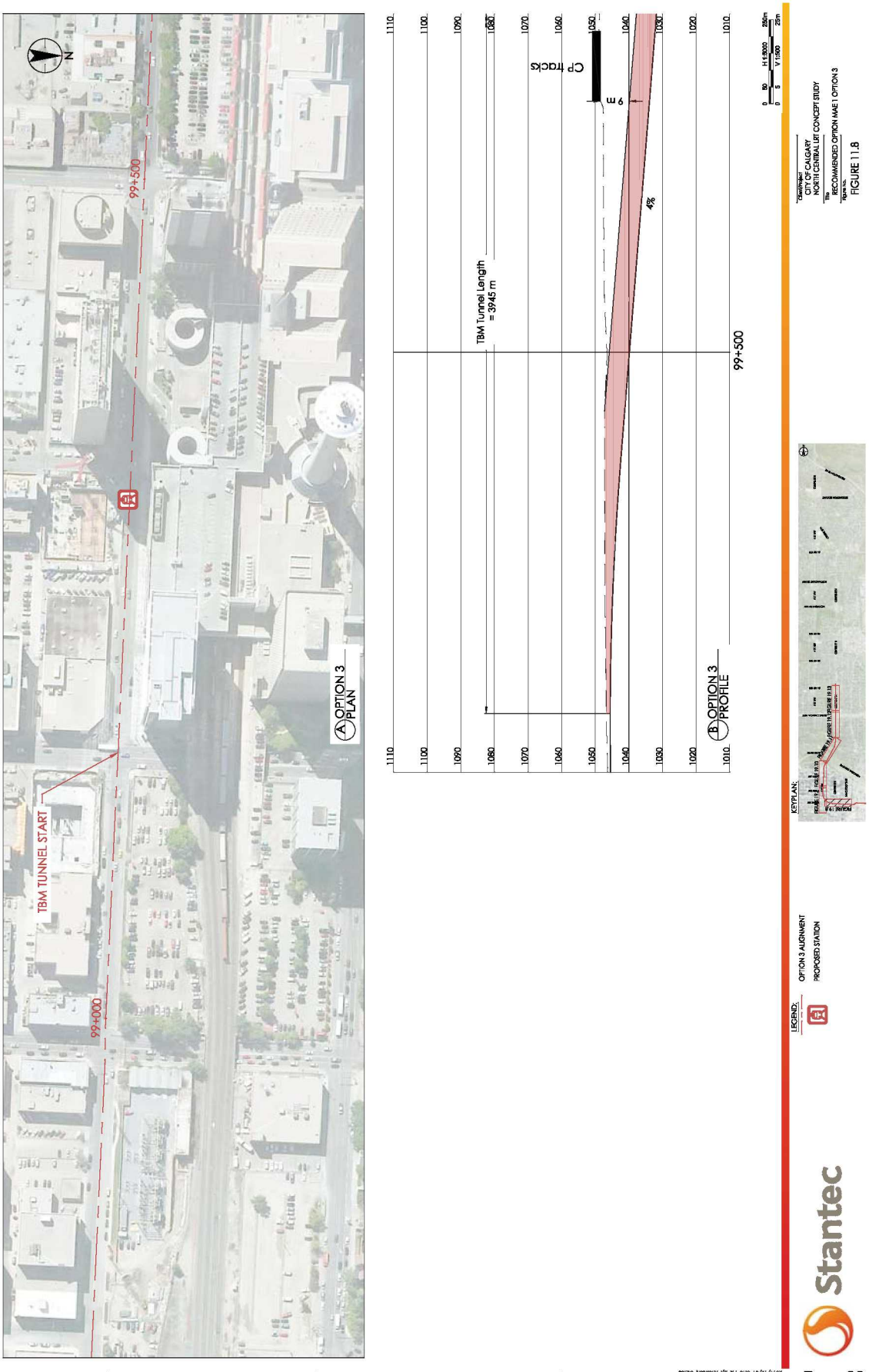

N
EXTENTS OF SEM TUNNELING
2 AVE SW
2 ST SW
CUT AND COVER TUNNEL END
A OPTION 2 PLAN
B OPTION 2 PROFILE 100+500
3 AVE SW STATION 0%
Existing Ground
SEM Tunnel Length = 1080 m
Top of Tunnel
Bottom of Tunnel
6%
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
KEYPLAN:
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.3

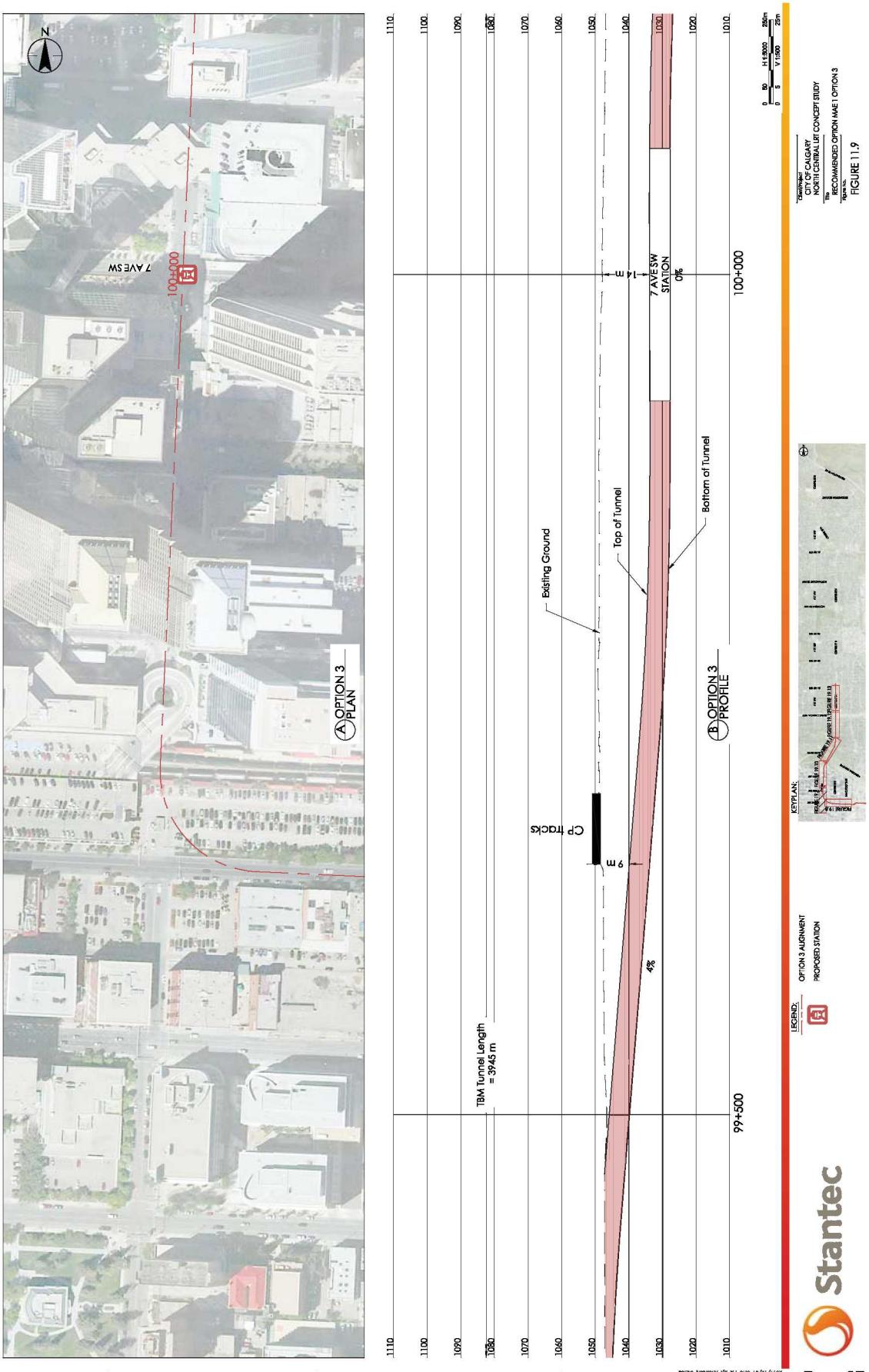

N
MEMORIAL DR
CENTRE STREET
10A+000
3 AV SW
1 ST SW
100+500
A OPTION 2 PLAN
B OPTION 2 PROFILE
Bow River
Existing Ground
Top of Bow River
3 AVE SW STATION
0%
4%
101+000
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
KEYPLAN:
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.4

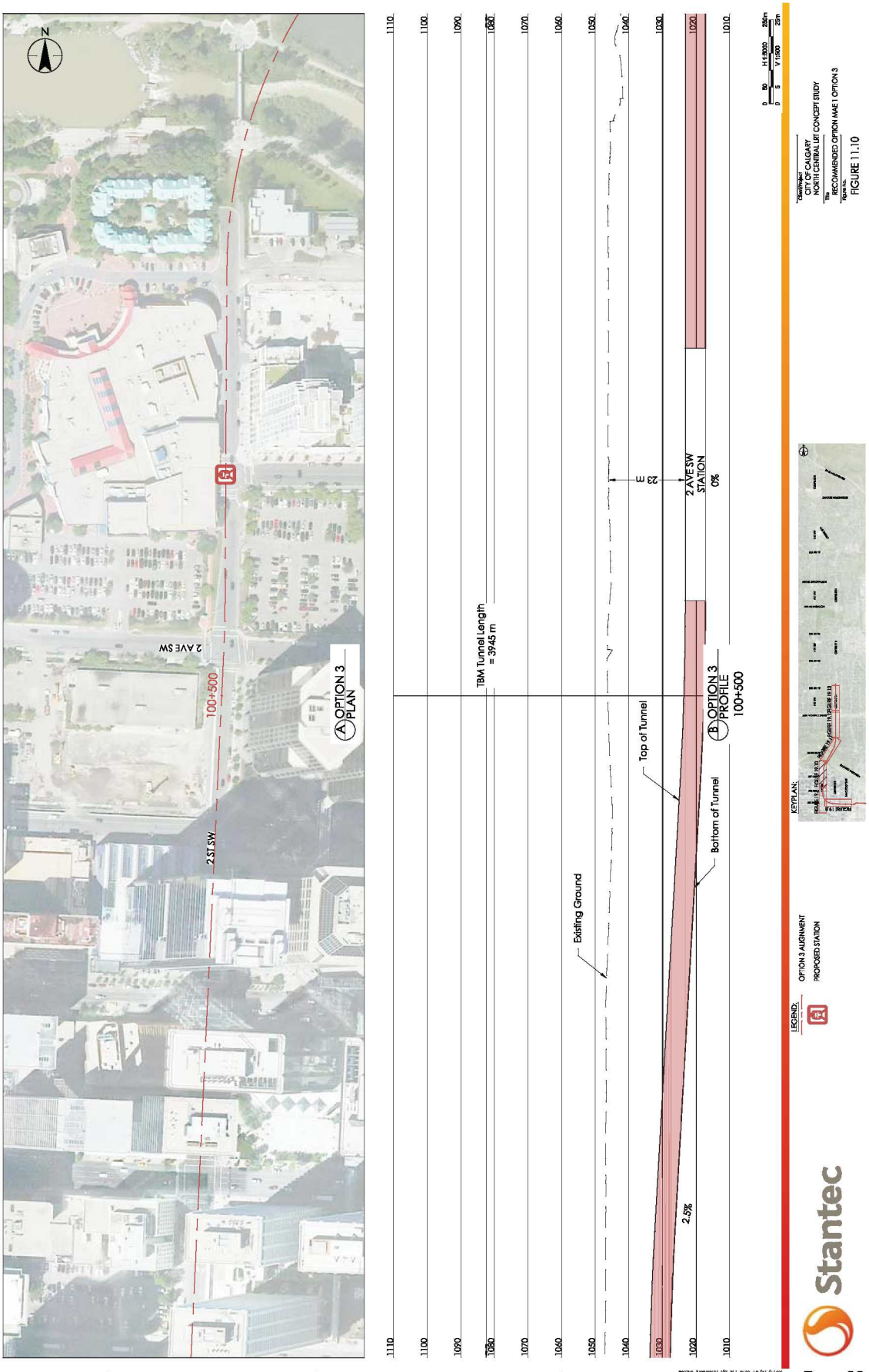

N
9 AV NE
8 AV NE
7 AV NE
CENTRE ST N
101+500
A OPTION 2 PLAN
9 AVE NW STATION
0%
Existing Ground
4%
4%
4%
B OPTION 2 PROFILE
101+500
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
KEYPLAN:
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.5

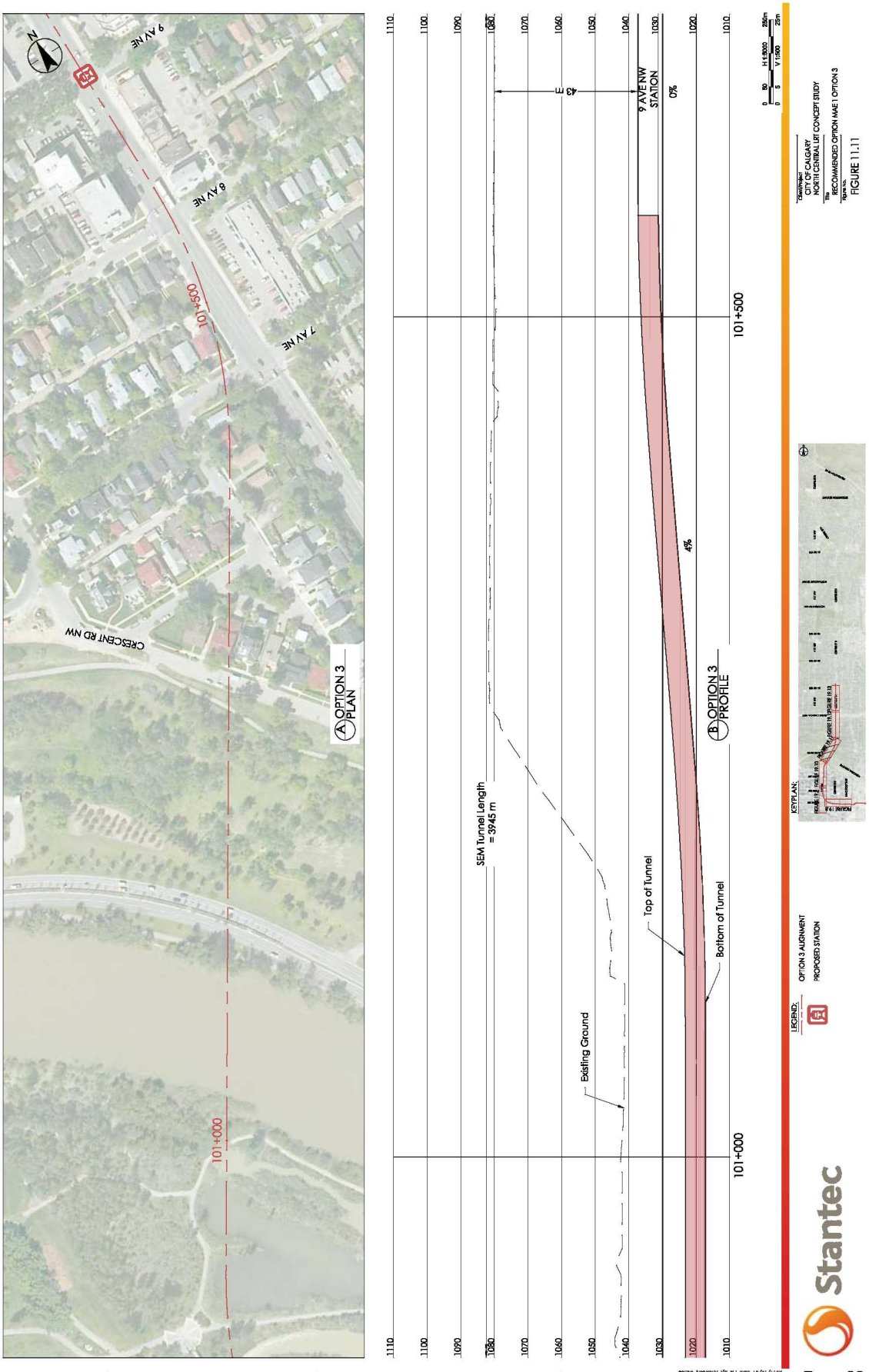

N
17 AV NE
16 AV NE (TRANS CANADA HWY)
15 AV NE
14 AV NE
13 AV NE
12 AV NE
11 AV NE
10 AV NE
102+500
102+000
CUT AND COVER TUNNEL START
A OPTION 2 PLAN
B OPTION 2 PROFILE
Cut and Cover Tunnel Length = 810 m
Top of Tunnel
Bottom of Tunnel
Existing Ground
2%
9 AVE NW STATION
16 AVE NW STATION
0%
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
KEYPLAN:
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.6

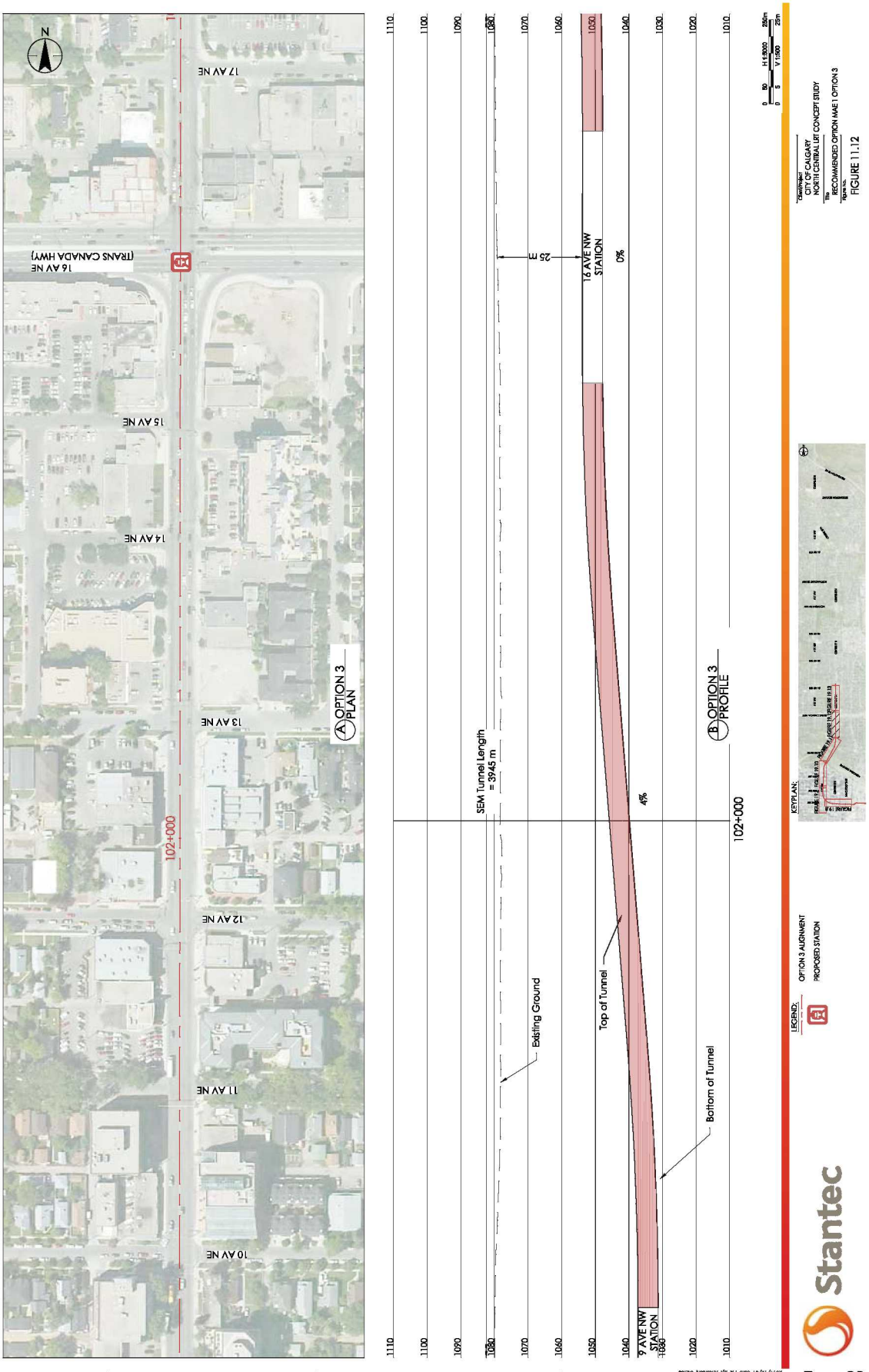

N
24 AV NE
23 AV NE
22 AV NE
21 AV NE
20 AV NE
19 AV NE
18 AV NE
17 AV NE
CUT AND COVER TUNNEL END
103+000
A OPTION 2 PLAN
B OPTION 2 PROFILE
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
103+000
Cut and Cover Tunnel Length = 810 m
Top of Tunnel
Existing Ground
4%
Bottom of Tunnel
KEYPLAN:
LEGEND:
OPTION 2 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 2
FIGURE 11.7

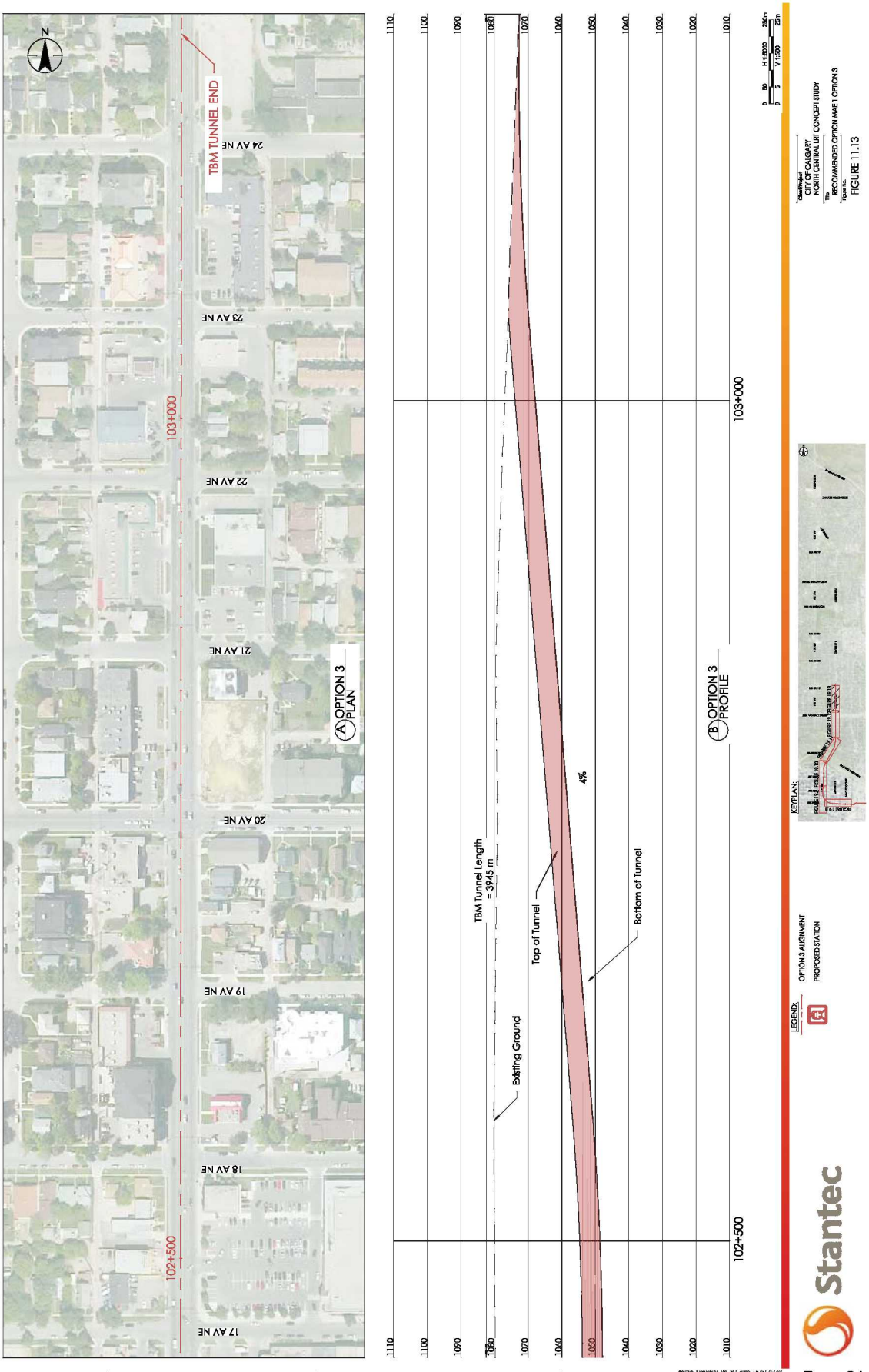

N
99+500
99+000
TBM TUNNEL START
A OPTION 3 PLAN
TBM Tunnel Length = 3945 m
CP tracks
9 m
4%
99+500
B OPTION 3 PROFILE
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
KEYPLAN:
LEGEND:
OPTION 3 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 3
FIGURE 11.8


N
7 AVE SW
100+000
A OPTION 3 PLAN
B OPTION 3 PROFILE
Existing Ground
Top of Tunnel
Bottom of Tunnel
CP tracks
9 m
4%
TBM Tunnel Length = 3945 m
7 AVE SW STATION
0%
3 m
1.4 m
99+500
100+000
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
LEGEND:
OPTION 3 ALIGNMENT
PROPOSED STATION
KEYPLAN:
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 3
FIGURE 11.9

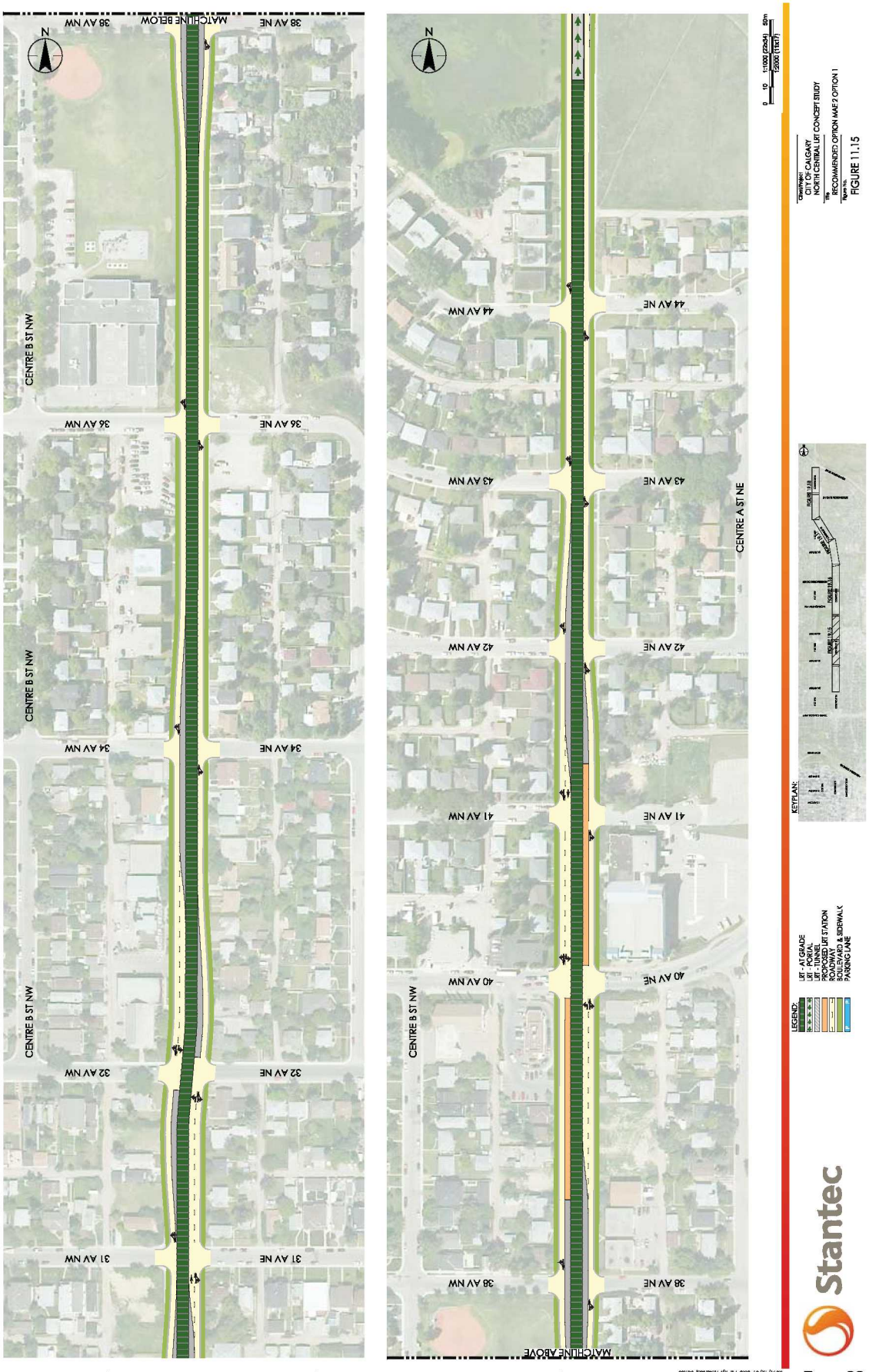

N
2 AVE SW
2 ST SW
100+500
A OPTION 3 PLAN
TBM Tunnel Length = 3945 m
Existing Ground
Top of Tunnel
Bottom of Tunnel
2.5%
3
2 AVE SW STATION
0%
B OPTION 3 PROFILE 100+500
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
LEGEND:
OPTION 3 ALIGNMENT
PROPOSED STATION
KEYPLAN:
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 3
FIGURE 11.10

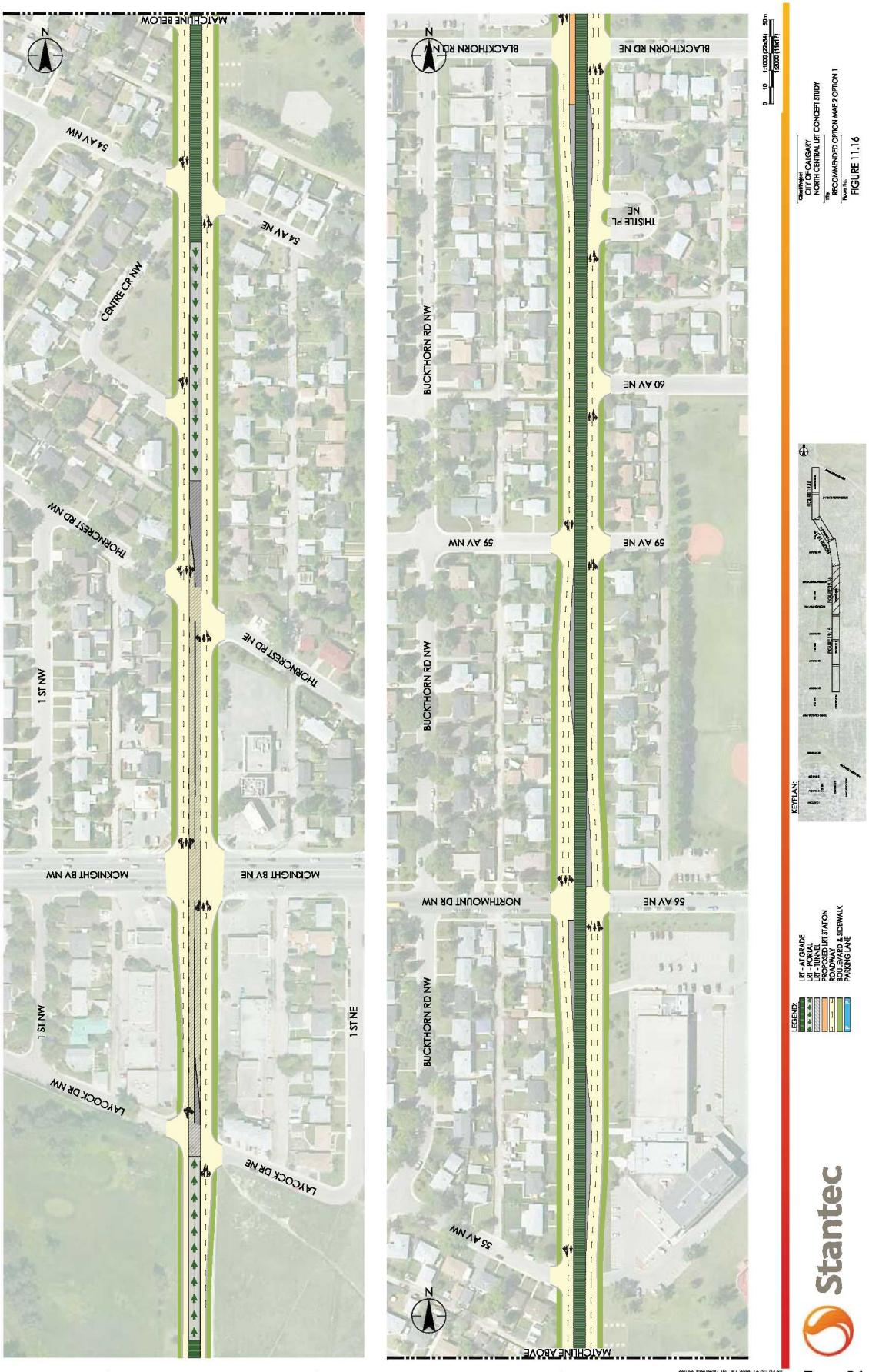

N
9 AV NE
8 AV NE
7 AV NE
CRESCENT RD NW
101+500
101+000
A OPTION 3 PLAN
B OPTION 3 PROFILE
SEM Tunnel Length = 3945 m
Existing Ground
Top of Tunnel
Bottom of Tunnel
9 AVE NW STATION
43
4%
0%
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
LEGEND:
OPTION 3 ALIGNMENT
PROPOSED STATION
KEYPLAN:
Stantec
Client/Project
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
RECOMMENDED OPTION MAE1 OPTION 3
Figure No.
FIGURE 11.11

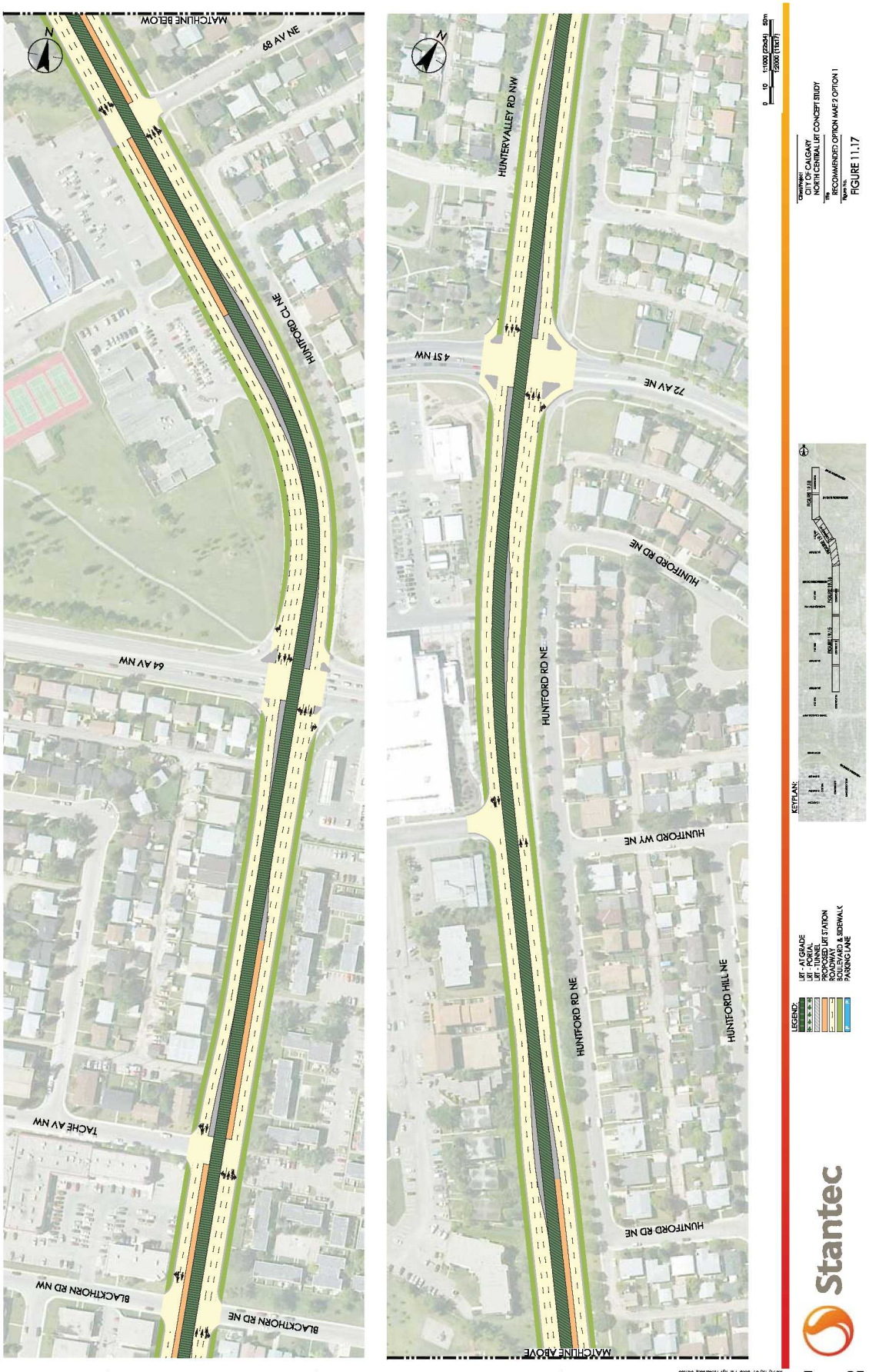

A OPTION 3 PLAN
B OPTION 3 PROFILE
17 AV NE
16 AV NE (TRANS CANADA HWY)
15 AV NE
14 AV NE
13 AV NE
12 AV NE
11 AV NE
10 AV NE
102+000
SEM Tunnel Length = 3945 m
Existing Ground
Top of Tunnel
Bottom of Tunnel
9 AVE NW STATION
16 AVE NW STATION
4%
0%
25
KEYPLAN:
LEGEND:
OPTION 3 ALIGNMENT
PROPOSED STATION
Stantec
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 3
FIGURE 11.12

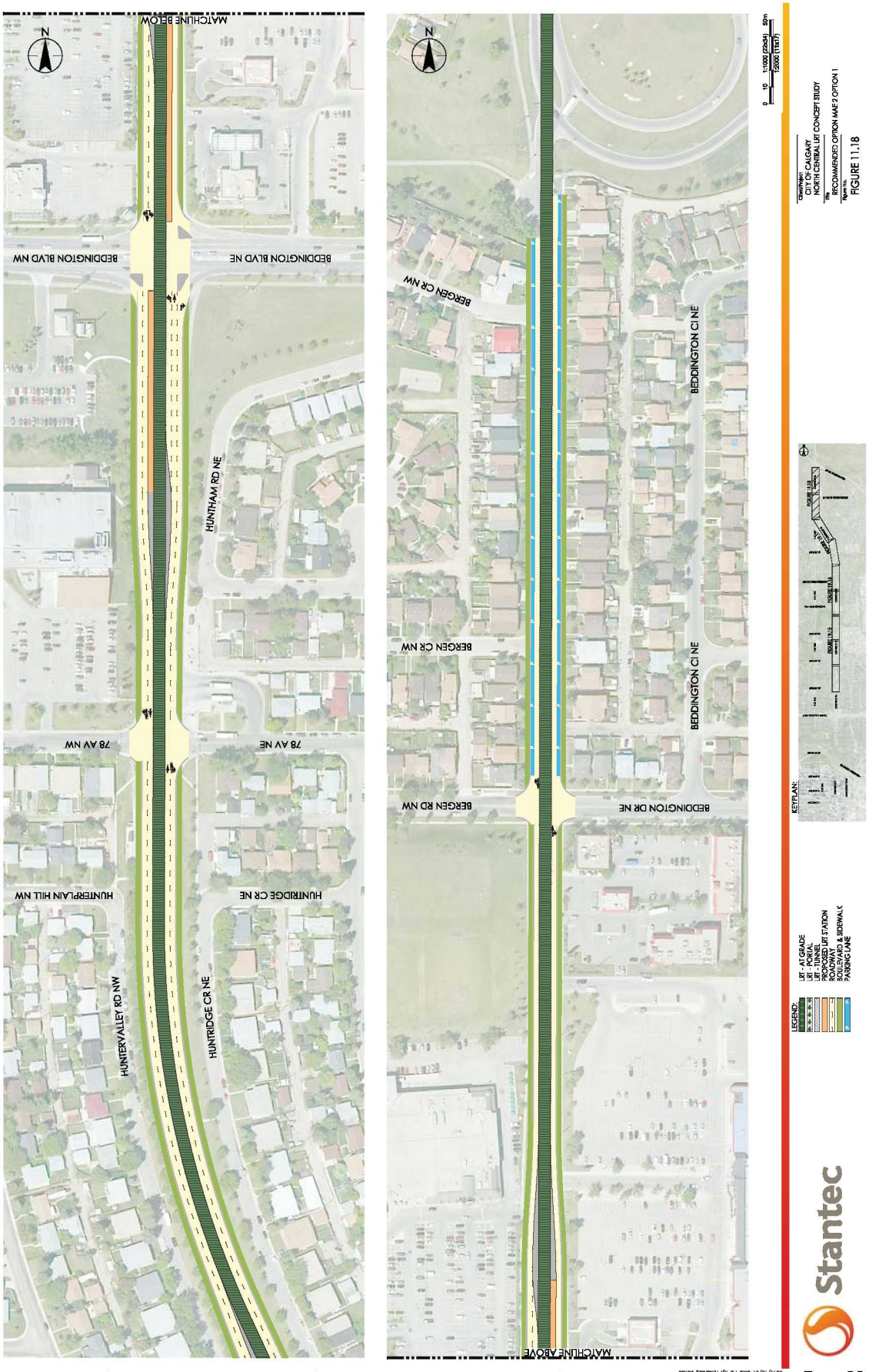

N
TBM TUNNEL END
24 AV NE
23 AV NE
22 AV NE
21 AV NE
20 AV NE
19 AV NE
18 AV NE
17 AV NE
102+500
103+000
A OPTION 3 PLAN
B OPTION 3 PROFILE
TBM Tunnel Length = 3945 m
Existing Ground
Top of Tunnel
Bottom of Tunnel
4%
1110
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
LEGEND:
OPTION 3 ALIGNMENT
PROPOSED STATION
KEYPLAN:
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
RECOMMENDED OPTION MAE1 OPTION 3
FIGURE 11.13
Stantec


N
30 AV NW
30 AV NE
29 AV NW
29 AV NE
28 AV NW
28 AV NE
27 AV NW
27 AV NE
26 AV NW
26 AV NE
25 AV NW
25 AV NE
24 AV NW
24 AV NE
23 AV NW
23 AV NE
0 10 1:1000 (22x34) 50m
1:2000 (11x17)
Developer
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
RECOMMENDED OPTION MAE2 OPTION 1
Figure No.
FIGURE 11.14
KEYPLAN:
LEGEND:
LRT - AT GRADE
LRT - PORTAL
LRT - TUNNEL
PROPOSED LRT STATION
ROADWAY
BOULEVARD & SIDEWALK
PARKING LANE
Stantec


MATCHLINE BELOW
38 AV NW
38 AV NE
CENTRE B ST NW
36 AV NW
36 AV NE
34 AV NW
34 AV NE
32 AV NW
32 AV NE
31 AV NW
31 AV NE
CENTRE A ST NE
44 AV NW
44 AV NE
43 AV NW
43 AV NE
42 AV NW
42 AV NE
41 AV NW
41 AV NE
40 AV NW
40 AV NE
38 AV NW
38 AV NE
MATCHLINE ABOVE
N
0 10 1:1000 (A3=A) 50m
1:2000 (11x17)
Client/AE: CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title: RECOMMENDED OPTION MAP 2 OPTION 1
Figure No. FIGURE 11.15
KEYPLAN:
LEGEND:
LRT AT GRADE
LRT - TUNNEL
LRT - ELEVATED
PROPOSED LRT STATION
ROADWAY
ROADWAY AND 4.5 SIDEWALK
PARKING LANE
Stantec


MATCHLINE BELOW
54 AV NW
54 AV NE
CENTRE CR NW
THORNCREST RD NW
THORNCREST RD NE
1 ST NW
MCKNIGHT BV NW
MCKNIGHT BV NE
1 ST NW
1 ST NE
LAYCOCK DR NW
LAYCOCK DR NE
BLACKTHORN RD NW
BLACKTHORN RD NE
THISTLE PL NE
BUCKTHORN RD NW
60 AV NE
59 AV NW
59 AV NE
BUCKTHORN RD NW
NORTHMOUNT DR NW
56 AV NE
BUCKTHORN RD NW
55 AV NW
MATCHLINE ABOVE
KEYPLAN:
LEGEND:
LRT - AT GRADE
LRT - TUNNEL
LRT - ELEVATED
PROPOSED LRT STATION
ROADWAY
ROADWAY AND SIDEWALK
PARKING LANE
Stantec
Client/Project
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
RECOMMENDED OPTION MAE 2 OPTION 1
Figure No.
FIGURE 11.16


MATCHLINE BELOW
68 AV NE
HUNTCROFT CL NE
64 AV NW
TACHE AV NW
BLACKTHORN RD NW
BLACKTHORN RD NE
HUNTERVALLEY RD NW
4 ST NW
72 AV NE
HUNTFORD RD NE
HUNTFORD WY NE
HUNTFORD RD NE
HUNTFORD HILL NE
HUNTFORD RD NE
MATCHLINE ABOVE
N
0 10 1:1000 (22x34) 50m
1:2000 (11x17)
LEGEND:
LRT - AT GRADE
LRT - TUNNEL
PROPOSED LRT STATION
ROADWAY
BIKE LANE AND SIDEWALK
PARKING LANE
KEYPLAN:
Stantec
Client/Project
CITY OF CALGARY
NORTH CENTRAL LRT CONCEPT STUDY
Title
RECOMMENDED OPTION WAE2 OPTION 1
Figure No.
FIGURE 11.17


MATCHLINE BELOW
BEDDINGTON BLVD NW
BEDDINGTON BLVD NE
HUNTHAM RD NE
78 AV NW
78 AV NE
HUNTERVALLEY RD NW
HUNTRIDGE CR NE
HUNTERPLAIN HILL NW
HUNTRIDGE CR NE
BERGEN CR NW
BEDDINGTON CI NE
BERGEN RD NW
BEDDINGTON DR NE
MATCHLINE ABOVE
LEGEND:
LRT - AT GRADE
LRT - TUNNEL
LRT - ELEVATED
PROPOSED LRT STATION
ROADWAY
ROADWAY WITH BIKE LANE & SIDEWALK
PARKING LANE
KEYPLAN:
Stantec
RECOMMENDED OPTION MAE 2 OPTION 1
FIGURE 11.18

12.0 CONCLUSION

12.1 RECOMMENDATIONS

The North Central LRT Concept Study resulted in a confirmation that LRT along Centre Street is best aligned with the vision and objectives of The City of Calgary. This new LRT line that will ultimately connect to the SELRT will implement low-floor vehicles that will allow for better integration into the adjacent communities. The City's desire is to build LRT along Centre Street in such a way that land acquisitions are minimized. Given the current roadway widths, this allows for only one lane of general traffic in each direction if LRT is constructed in the median of Centre Street. However, land use analysis carried out in this study suggests that a large number of parcels will still need to be acquired in locations where there are stations and/or left turn lanes. It should also be noted that while the recommended cross section for at-grade portions of the LRT results in a significant decrease in roadway capacity as compared to today for vehicular traffic, The City is planning to build exclusive bus lanes in the near future (North Central Transitway). It will be the North Central Tansitway project that the vehicular traffic capacity is significantly reduced within the corridor, and therefore the introduction of the LRT into the roadway at a future date would not result in a significant change in capacity.

The study team arrived at the recommendation for at-grade LRT in a narrow Centre Street alignment through a multi-step process known as a Multiple Account Evaluation (MAE). Firstly, a high-level MAE identified at-grade LRT along Centre Street and Edmonton Trail as having the most benefits compared to eight other options that included options along 4th Street SW, Centre Street, Edmonton Trail, and Nose Creek. Secondly, Centre Street was compared directly to Edmonton Trail, and based on information available, Centre Street was shown to be the more attractive location for LRT.

The recommended alignment north of 16 Avenue NE was generally established through the completion of this study, however the final resolution the alignment connecting the Centre City to points north of the Bow River is recommended for further study. Three alternatives were considered for the crossing of the Bow River: an at-grade crossing of the LRT over the existing Centre Street Bridge, a tunneled alternative below the Bow River and a new bridge over the Bow River that would allow for a shallower tunnel on the north side of the Bow River. The three options developed indicated that there are trade-offs between cost, visual impacts, and reliability. However, based on the findings of this study we are recommending that the at-grade and tunnel alternatives be brought forward for further analysis to establish a better understanding of the geological conditions and costs of the two preferred alternatives.

The NCLRT line will likely not be built until at least the northern half of the SELRT is built, due to the need for vehicle storage and maintenance facility located along the SE portion of this alignment for the new style of LRT vehicles proposed for this LRT corridor.

Regardless of the option selected for the Centre City connection, the recommended alignment will be vastly different from one in the original Nose Creek alignment. An at-grade LRT in a narrow cross section along Centre Street will keep the built form of communities intact, support walking access to transit, improve connections to existing bus routes, and increase the person carrying capacity on an already popular transit corridor.

12.2 NEXT STEPS

With a more developed understanding of what LRT will look like in North Central Calgary in the future, a next step is to start designing a transitway along Centre Street that can further build ridership and make a future conversion to LRT more acceptable, while providing a near-term benefit for transit riders. This design work is scheduled to start in early 2015. Key decisions in the design may include station locations, land acquisitions, transit signal priority, pedestrian improvements, turning restrictions, and other considerations that should be linked to the long-term plans for the corridor.

Land acquisitions will be a major component, and potentially a politically contentious part of building LRT in a relatively narrow corridor like Centre Street south of McKnight Boulevard. A land acquisition strategy is needed to identify a process for notifying owners and tenants of the NC Transitway/NCLRT projects and the possible implications on their properties, assessing the market value of properties, and carrying out any purchase or relocations. Plans for consolidating parcels and either developing them or selling them to developers will also have to be developed. In addition, if the TBM alternative is chosen, then financial consideration could be given to extending the tunneling alternative further to the north within the area of constrained ROW.

To build the LRT in Centre Street corridor, in exclusive ROW, restrictions to vehicular turning movements will be required to limit interference with LRT operation (and minimize land acquisition). The limitations to automobile mobility will have to be further explored and consideration will need to be given to enhancements that can be made within the corridor as well as enhancements to vehicular capacity on alternative corridors. This may involve the design of signage tailored to the corridor, public education, and roadway improvements. Pedestrian and bicycle movement within the corridor will also need to be reviewed and enhanced as the design is progressed.

Public Consultation Process
December 1, 2014

Appendix A

PUBLIC CONSULTATION PROCESS

Appendix B

MODELLING

Appendix C

TOD REPORTS

Appendix D

HIGH LEVEL MAE

Downtown Reports
December 1, 2014

Appendix E

DOWNTOWN REPORTS

Centre Street Vs. Edmonton Trail
December 1, 2014

Appendix F

CENTRE STREET VS. EDMONTON TRAIL

Opinion of Probable Cost
December 1, 2014

Appendix G

OPINION OF PROBABLE COST