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**FUNCTIONAL PLANNING STUDY**  
**16 AVENUE NE – DEERFOOT TRAIL TO BARLOW TRAIL**  
**ADDITIONAL INFRASTRUCTURE IMPROVEMENT SCENARIOS**  
**OCTOBER 2016**

*Submitted By:*

**PARSONS**

Functional Planning Study 16 Avenue NE –  
Deerfoot Trail to Barlow Trail: Additional Infrastructure  
Improvement Scenarios, October 2016



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## 1.0 INTRODUCTION

As part of the functional planning study for the 16 Avenue NE corridor – Deerfoot Trail to Barlow Trail, several additional infrastructure improvement scenarios in the Barlow Trail and 16 Avenue NE corridors have been identified by the City of Calgary. In order to assist the City of Calgary in determining if any of these infrastructure improvement scenarios should be considered further, analysis was conducted to develop high level estimates of the potential benefits and associated costs for each infrastructure scenario.

This work builds upon a recent assignment to develop free flow interchange concepts for the Barlow Trail interchange component of the recommended interchange plan at 19 Street which also involved modifications to the adjacent interchanges to the east and west of the existing intersection.

The six infrastructure scenarios being considered are listed below:

- Scenario 1: Widening 16 Avenue NE from Four Lanes to Six Lanes
  - From 36 Street N to Stoney Trail
- Scenario 2: Widening Barlow Trail from Four lanes to Six Lanes
  - From Memorial Drive to 16 Avenue N
- Scenario 3: Recommended Plan for 19 Street plus Scenario 1 and Scenario 2
  - Barlow Trail Interchange as a "Diamond" Configuration
  - 19 Street Interchange
  - Deerfoot Trail Interchange Improvements
  - Scenario 1 Additional Infrastructure
  - Scenario 2 Additional Infrastructure
- Scenario 4: New 68 Street NE Interchange at 16 Avenue NE
  - Develop applicable configuration for a new interchange at 68 Street NE
- Scenario 5: Recommended Plan for 19 Street plus Scenario 4
  - Barlow Trail Interchange as a "Diamond" Configuration
  - 19 Street Interchange
  - Deerfoot Trail Interchange Improvements
  - Scenario 4 Additional Infrastructure
- Scenario 6: Recommended Plan for 19 Street with "Free Flow" Interchange at Barlow Trail
  - Barlow Trail Interchange as a "Free Flow" configuration, replacing the "Diamond" configuration included as part of the Recommended Plan.

Exhibits and scope assumptions have been provided for the applicable scenarios listed above, noting that Scenario 3 and Scenario 5 are largely combinations of the elements from the other infrastructure scenarios and the components of the Recommended Plan for the 16 Avenue Corridor between Deerfoot Trail and Barlow Trail.

In addition to developing the potential benefits and cost estimates for each scenario, a "high level" benefit to cost ratio has also been generated in order to provide the City of Calgary with sufficient information to compare the scenarios as well as other potential scenarios involving permutations of the additional infrastructure improvements being considered. The high level implementation costs estimates and benefits were derived using sound methodologies with supporting rationale as described in the following report sections.

# Functional Planning Study 16 Avenue NE – Deerfoot Trail to Barlow Trail: Additional Infrastructure Improvement Scenarios, October 2016



## 2.0 SCENARIO DESCRIPTIONS AND ASSUMPTIONS

As part of the analysis to estimate the benefit and costs for several infrastructure scenarios potentially associated with the Recommended Plan for the 16 Avenue NE corridor between Deerfoot Trail and Barlow Trail, a number of assumptions have been developed to better describe the scope of the scenarios being considered. The scope of each scenario is generally described in the following sections. An exhibit for each applicable scenario has also been developed to graphically illustrate the proposed scenario scope including the extents. For some scenarios, several alternatives have been proposed for consideration by the City of Calgary, however, for cost estimating purposes, only one alternative was selected as described in Section 4.

### 2.1 SCENARIO 1: WIDENING 16 AVENUE FROM FOUR LANES TO SIX LANES

The existing configuration of 16 Avenue between Barlow Trail NE and Stoney Trail consists of four continuous through lanes. Between 52 Street NE and Stoney Trail, an additional auxiliary lane is provided in each direction. In the westbound direction, the auxiliary lane extends from the westbound entrance ramp from Stoney Trail to the westbound exit ramp to 52 Street. In the eastbound direction, the auxiliary lane extends from the westbound entrance ramp from 52 Street to the eastbound to northbound exit ramp to Stoney Trail.

For the proposed widening being considered in Scenario 1, two alternatives have been developed for consideration by the City of Calgary. The following scope assumptions are proposed for Scenario 1 / Alternative 1:

- Maintain the entrance and exit ramps to Stoney Trail as existing, but convert the auxiliary lanes to through lanes beyond the interchange ramps at 52 Street.
- The existing exit and entrance ramp at 52 Street will be converted to merge and diverge ramps.
- In the westbound direction, the additional through lane would end prior to the westbound on-ramp (loop ramp) from 52 Street northbound.
- In the eastbound direction, the additional through lane would begin immediately west of the westbound on-ramp from 52 Street.
- No changes are proposed through the intersection at 68 Street.

The proposed roadway configuration associated with Scenario 1 / Alternative 1 and the above scope assumptions is shown in **Exhibit 1.1**.

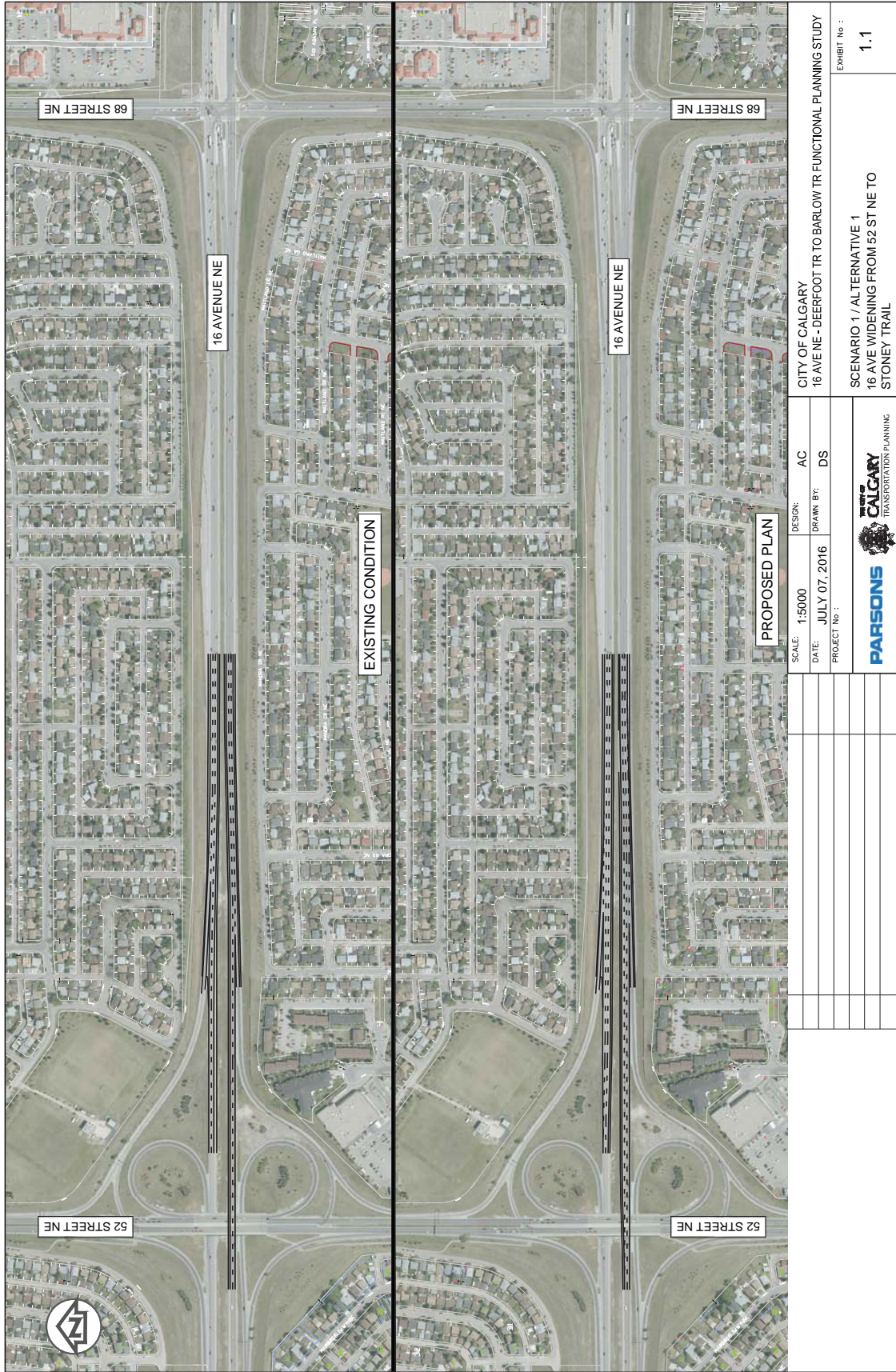
Alternatively, due to the existing condition of successive entrance ramps along 16 Avenue in the westbound direction, the additional third lane may be required to extend further west to 36 Street in order to achieve increased spacing between successive entrance ramps. This scenario alternative includes converting the eastbound entrance ramp from 36 Street to an add lane and the westbound exit ramp to 36 Street to a drop lane. The following scope assumptions are proposed for Scenario 1 / Alternative 2:

- Maintain the entrance and exit ramps to Stoney Trail as existing, but convert the auxiliary lanes to through lanes beyond the interchange ramps at 52 Street.
- The existing exit and entrance ramp at 52 Street will be converted to merge and diverge ramps.
- In the westbound direction, the additional through lane would end prior to the westbound on-ramp (loop ramp) from 36 Street northbound.
- In the eastbound direction, the additional through lane would begin immediately west of the westbound on-ramp from 36 Street.
- The existing east facing ramps at 36 Street will be reconfigured as a drop lane (westbound) and an add lane (eastbound).
- The two westbound on-ramps from 52 Street would merge into the proposed three lane cross section along westbound 16 Avenue.
- The eastbound off-ramp to 52 Street would be configured as a single lane exit.
- No changes are proposed through the intersection at 68 Street.

The proposed roadway configuration associated with Scenario 1 / Alternative 2 and the above scope assumptions is shown in **Exhibit 1.2**.

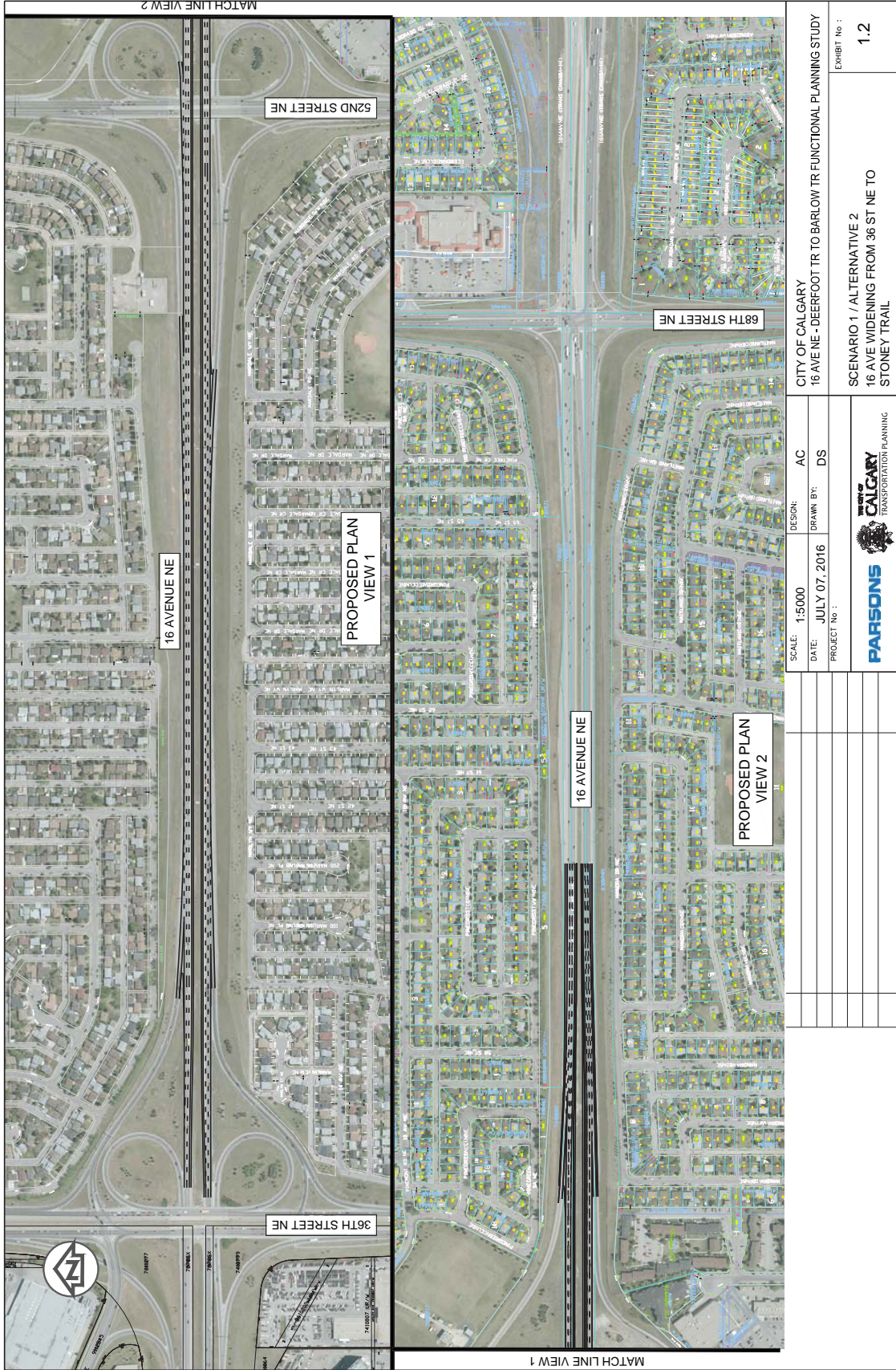


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SCALE: 1:5000	DESIGN: AC	CITY OF CALGARY
DATE: JULY 07, 2016	DRAWN BY: DS	16 AVE NE - DEERFOOT TR TO BARLOW TR FUNCTIONAL PLANNING STUDY
PROJECT No.:		Exhibit No.:
		1.2
		SCENARIO 1 / ALTERNATIVE 2
		16 AVE WIDENING FROM 36 ST NE TO STONEY TRAIL

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## 2.2 SCENARIO 2: WIDENING BARLOW TRAIL FROM 36 STREET NE TO STONEY TRAIL

The existing configuration of Barlow Trail between 16 Avenue and Memorial Drive consists of four continuous through lanes with additional through lanes at select intersections. The existing lane configuration along Barlow Trail is presented on the following page.

This scenario will involve widening Barlow Trail to provide six continuous through lanes between 16 Avenue and Memorial Drive. The widening from four to six lanes will utilize sections of the existing additional / auxiliary lanes at the intersections of Barlow Trail at 7 Avenue NE, Centre Avenue, and the northbound auxiliary lane between Memorial Drive and 2 Avenue SE.

The following scope assumptions are proposed for Scenario 2:

- The additional lanes along Barlow Trail will continue through the Barlow Trail interchange as per the Recommended Plan.
- Between 16 Avenue and 7 Avenue, one lane will be added in each direction along Barlow Trail. The added lane will tie into the existing auxiliary lanes provided at the 7 Avenue intersection in both the northbound and southbound directions. The northbound right lane / shoulder lane will operate as a through / right turn lane. The intersection will be upgraded with new traffic signals.
- Between 7 Avenue and 4 Avenue, one lane will be added in each direction along Barlow Trail. The northbound right lane / shoulder lane will operate as a through / right turn lane. The intersection will be upgraded with new traffic signals.
- Between 4 Avenue and Centre Avenue, one lane will be added in each direction along Barlow Trail. The added lane will tie into the existing auxiliary lanes provided at the Centre Avenue intersection in both the northbound and southbound directions. The northbound and southbound right lanes / shoulder lanes will operate as through / right turn lanes. The intersection at Centre Avenue will be upgraded with new traffic signals.
- Between Centre Avenue and 2 Avenue, one lane will be added in each direction along Barlow Trail. The northbound and southbound right lanes / shoulder lanes will operate as through / right turn lanes at both intersections. Intersection upgrades are included at 2 Avenue and 3 Avenue, complete with new traffic signals.
- The additional lanes on Barlow Trail will be configured to tie into the right turn lanes to / from Memorial Drive.
- All required widening will be located on the outside. Curb and gutter to be replaced throughout length of widening.

The proposed roadway configuration associated with Scenario 2 and the above scope assumptions is shown in **Exhibit 2**.

## 2.3 SCENARIO 3 – ORIGINAL RECOMMENDED PLAN PLUS SCENARIO 1 AND SCENARIO 2

This scenario combines the Recommended Plan from the 16 Avenue - Deerfoot Trail to Barlow Trail Functional Planning Study with the alternatives generated in Scenario 1 and Scenario 2.

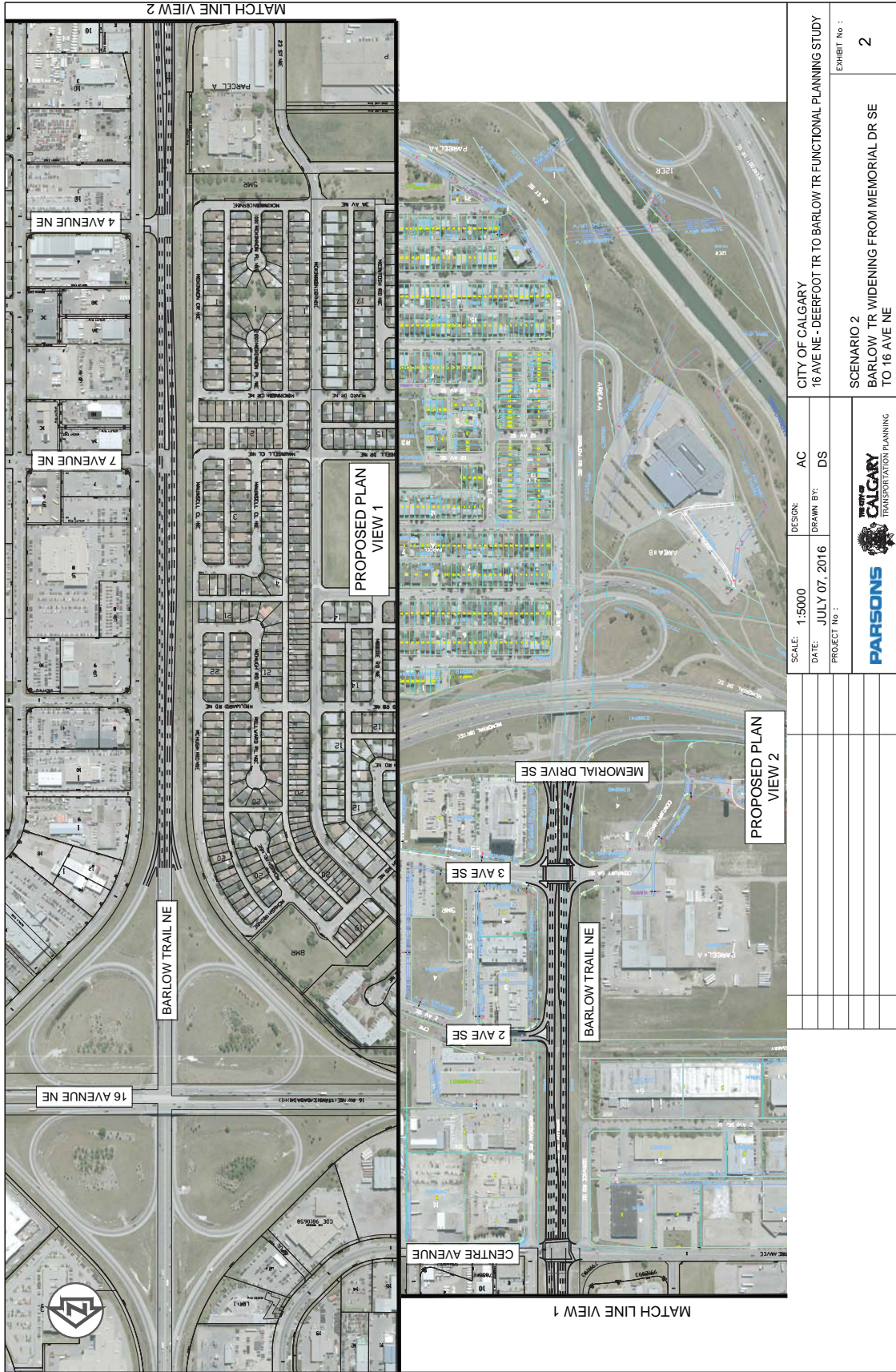
## 2.4 SCENARIO 4: NEW INTERCHANGE AT 68 STREET NE & 16 AVENUE

An interchange is contemplated in this scenario at the location of the existing major intersection along 16 Avenue at 68 Street. A full movement interchange is assumed to replace the existing at-grade intersection. This intersection is located within 500 metres of the ramp terminals connecting 16 Avenue to Stoney Trail. Typically the distance between these two junctions is too close to develop conventional interchanges. If a conventional interchange is located at 68 Street, significant weaving operations would be created between the various ramps from the Stoney Trail interchange and the proposed east facing ramps for the 68 Street interchange.

To mitigate the operational issues associated with closely spaced interchanges, several interchange configurations were developed with specialized treatments (basket weave structures) for the ramps located between 68 Street and Stoney Trail. The four potential interchange alternatives for this location are shown below in **Exhibits 3.1 to 3.4** as single line sketches.



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CITY OF CALGARY 16 AVE NE - DEERFOOT TR TO BARLOW TR FUNCTIONAL PLANNING STUDY	DESIGN: AC	EXHIBIT No : 2
SCENARIO 2 BARLOW TR WIDENING FROM MEMORIAL DR SE TO 16 AVE NE	DRAWN BY: DS	

SCALE: 1:5000	DESIGN: AC
DATE: JULY 07, 2016	DRAWN BY: DS
PROJECT No :	
<b>PARSONS</b>	<b>CITY OF CALGARY</b> TRANSPORTATION PLANNING



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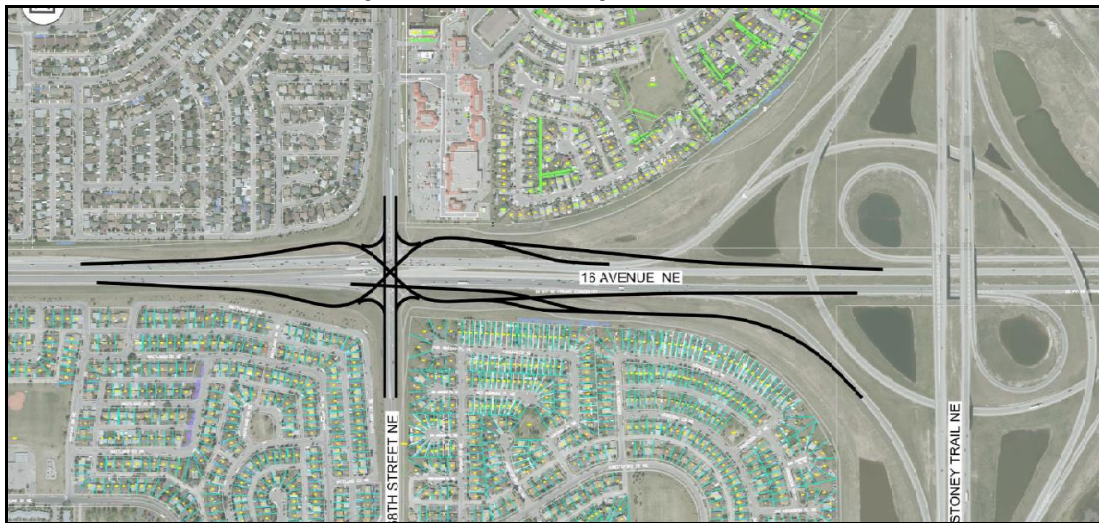


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*Exhibit 3.1: Diamond Interchange with Basket Weave Structures*



*Exhibit 3.2: Single Point Diamond Interchange with Basket Weave Structures*



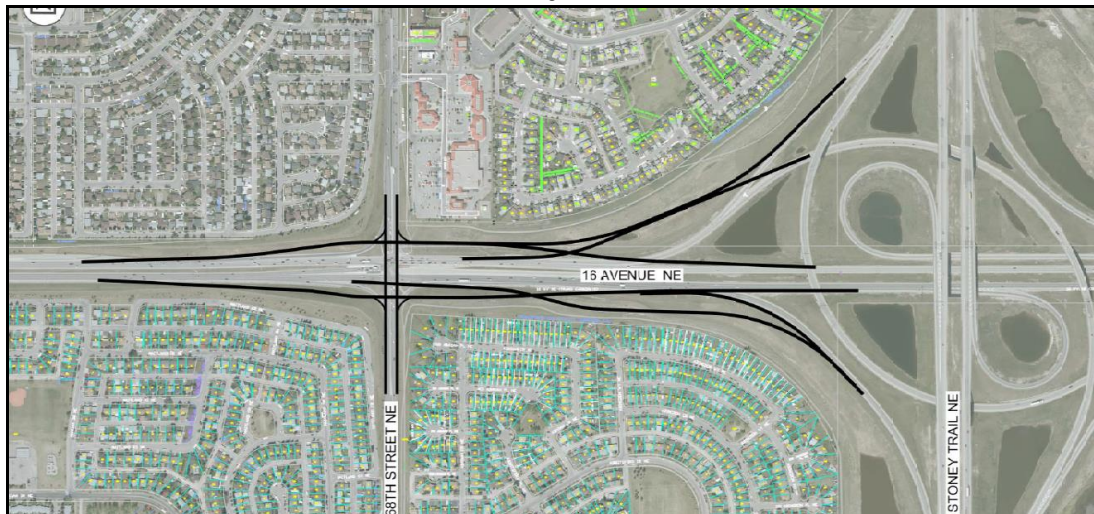


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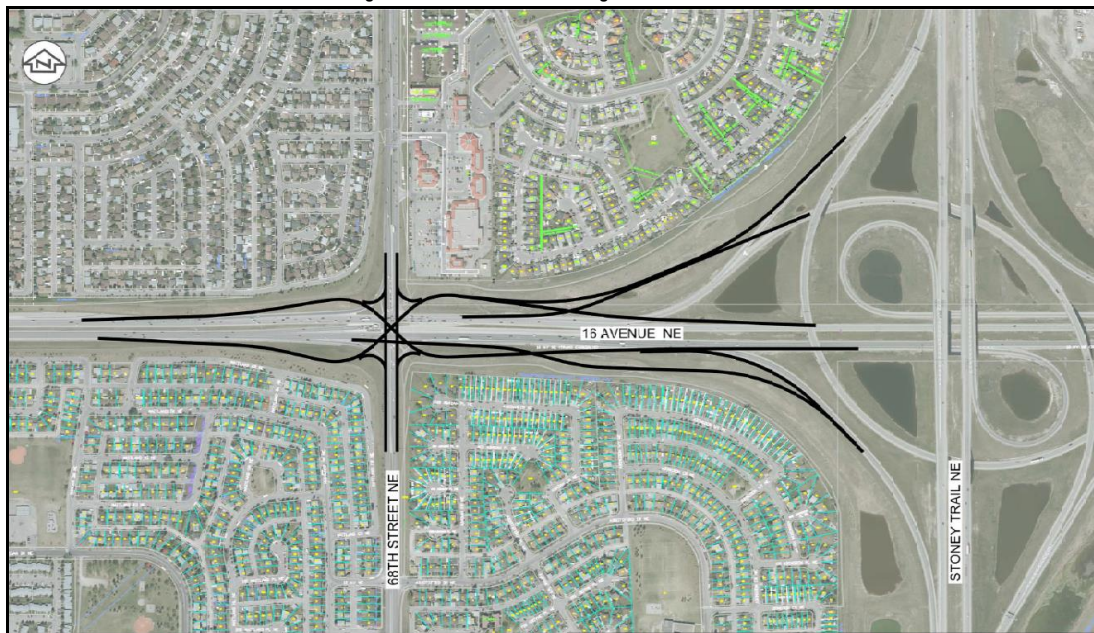


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*Exhibit 3.3: Diamond Interchange with Basket Weave Structures*



*Exhibit 3.4: Single Point Diamond Interchange with Basket Weave Structures*



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## FUNCTIONAL PLANNING STUDY 16 AVENUE NE – DEERFOOT TRAIL TO BARLOW TRAIL Additional Infrastructure Improvement Scenarios

For the purposes of this assignment, the single point diamond interchange configuration depicted in **Exhibit 3.2** seems to be applicable in addressing all movements currently provided by the existing intersection. The following scope assumptions are proposed for the single point diamond interchange configuration being considered to replace the 68 Street intersection in Scenario 2:

- A new single lane off-ramp will be constructed between 16 Avenue westbound and 68 Street. This new ramp will be grade separated from the westbound on-ramps from Stoney Trail. A slip lane from the Stoney Trail westbound on-ramps to 16 Avenue will be provided to connect with the 16 Avenue westbound off-ramp in order to provide access to 68 Street from Stoney Trail.
- The eastbound single lane on-ramp from 68 Street will be constructed to merge into 16 Avenue eastbound and to provide access to Stoney Trail northbound. This new eastbound on-ramp will be grade separated from the eastbound off-ramp from 16 Avenue to Stoney Trail. The eastbound off-ramp from 16 Avenue to Stoney Trail will be reconstructed such that the exit is located further west. A single lane slip lane is required from the 16 Avenue eastbound to Stoney Trail ramp to provide access to Stoney Trail northbound. The current exit ramp from 16 Avenue to Stoney Trail will be removed at the connection to 16 Avenue. An additional single lane slip lane will be constructed between the 68 Street eastbound on-ramp and the 16 Avenue eastbound off ramp to Stoney Trail in order to provide access from 68 Street to Stoney Trail southbound.
- Single lane west facing exit and entrance ramps from 68 Street will be provided.
- The 68 Street facility will be constructed as a six lane arterial facility with urban cross section (curb and gutter) and sidewalk / multi-use pathway on both sides. This six lane cross section on 68 Street will extend to the first intersection north and south of 16 Avenue.
- Dual left turn movements are anticipated for all movements at the interchange junction. Traffic signals will be required for all movements.
- The interchange structure will span at least six lanes over 16 Avenue plus the depressed median.

### 2.5 SCENARIO 5: ORIGINAL RECOMMENDED PLAN PLUS SCENARIO 4

This scenario combines the Recommended Plan from the 16 Avenue – Deerfoot Trail to Barlow Trail Functional Planning Study with the recommended option developed in Scenario 4.

### 2.6 SCENARIO 6: BARLOW TRAIL FREE FLOW INTERCHANGE CONCEPT

A total of three shortlisted scenarios were identified in a preceding study to investigate various means of providing a free-flow interchange at the Barlow Trail / 16 Avenue NE junction. All three concepts, complete with the previously prepared high level cost estimates, will be taken forward for inclusion in the benefit cost comparison.

In Concept 1, shown in **Exhibit 4.1**, the configuration is similar to the existing configuration where free flow loop ramps are located in all four quadrants. However in this concept, separate weaving lanes between the successive loop ramps have been added along 16 Avenue in both directions of travel to minimize the impacts to traffic operations in the through lanes. No separate weaving lanes were provided along Barlow Trail. To accommodate the 19 Street eastbound movement to 16 Avenue eastbound and Barlow Trail northbound, a single lane elevated directional ramp was provided.

Concept 2, shown in **Exhibit 4.2**, represents a modification of a typical cloverleaf configuration to avoid the need for physically separating the weaving lanes between the successive loop ramps along 16 Avenue. In this configuration, free flow loop ramps are provided in the northeast and southwest quadrants. However, to accommodate the westbound to southbound and the eastbound to northbound movements, separate directional ramps are provided with loop ramp connections to Barlow Trail. These separate ramps also accommodate the eastbound movements from 19 Street to 16 Avenue and the Barlow Trail northbound as well as from 16 Avenue westbound to 19 Street.

Lastly in Concept 2, shown in **Exhibit 4.3**, free flow loop ramps are provided in the northeast and southwest quadrants to accommodate the northbound to westbound movement and the southbound to eastbound movement. Single lane directional ramps are provided for the remaining movements including elevated ramps for the 19 Street movements to 16 Avenue eastbound and Barlow Trail northbound.

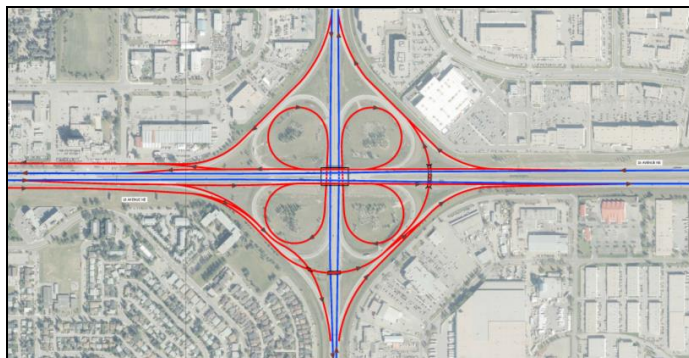


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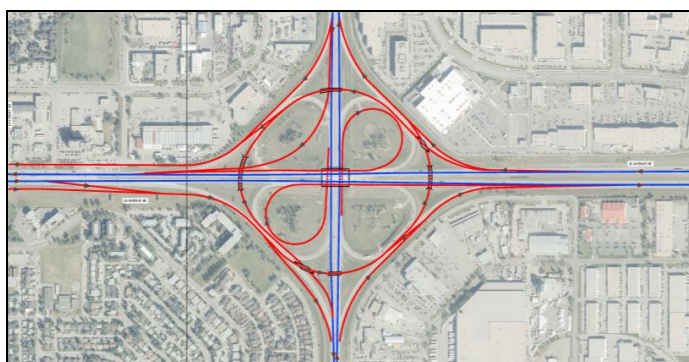


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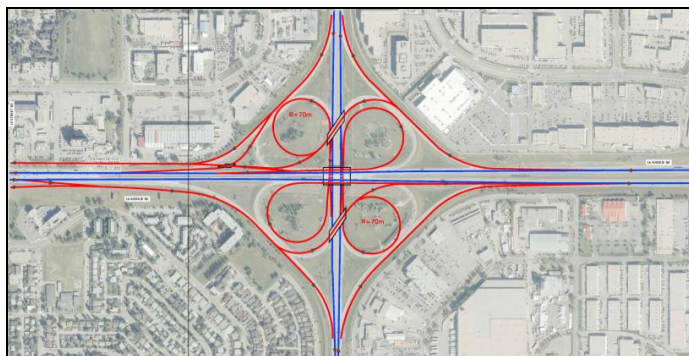
*Exhibit 4.1: Scenario 6 (1) – Cloverleaf Configuration at Barlow Trail (Concept 1)*



*Exhibit 4.2: Scenario 6 (2) – Parclo Configuration at Barlow Trail (Concept 2)*



*Exhibit 4.3: Scenario 6 (3) – Modified Cloverleaf Configuration at Barlow Trail (Concept 3)*





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## 3.0 SCENARIO BENEFIT ANALYSIS

To develop the potential benefits for each of the additional infrastructure improvement scenarios, traffic analysis using the Synchro and HCS software was conducted with a focus on generating travel time savings. These travel time savings are associated with a reduction in intersection delay for either improved intersection operations (such as road widening) or removal of an intersection (such as a new interchange). For the free flow interchange concept in Scenario 6, travel time savings were estimated based on the elimination of the proposed signalized ramp terminal intersections for the Barlow Trail interchange component in the Recommended Plan from the 16 Avenue NE – Deerfoot Trail to Barlow Trail Functional Planning Study.

For inputs in the traffic analysis, existing turning movement counts, current base (2012) and future base (2039) traffic forecasts from the City's travel demand forecasting model, as well as existing signal timing plans were obtained from the City of Calgary. To estimate the future traffic volumes, growth factors between the current and future base volumes from the forecasting model were applied to the existing turning movement counts. The only exception was Scenario 6, where the existing and future traffic volumes generated in the Functional Planning Study were used.

As mentioned, travel time savings were assumed to represent the potential benefits for each scenario. Travel time savings, typically a major contributor of benefits which can be monetized, other typical benefits also include vehicle operating cost savings and traffic safety improvements in the form of collision reduction. In only using travel time savings, the simplified approach used in this study should therefore be considered conservative as other potential benefits have not been captured.

### 3.1 GENERAL ANALYSIS APPROACH

For **Scenario 1**, the travel time savings estimation was carried out using the Highway Capacity Software (HCS). Vehicle speeds were determined for merge, diverge, and mainline operations over specific segments of the 16 Avenue corridor which were then used to calculate a total travel time. The difference between the "No Build" and "Build" alternatives were calculated by analyzing the "No Build" freeway segments (basic, merge and diverge) with two mainline lanes in each direction whereas in the "Build" scenario, the freeway segments (basic, merge and diverge) were analyzed with three mainline lanes in each direction.

For **Scenarios 2 and 4**, a Synchro model representing the base case (no improvement) and a separate model representing the scenario (with improvement) were developed. The calculations were performed for 2012 and 2039, for both the AM and PM Peak Hours. In Scenario 2, the through lanes on Barlow Trail were increased from two lanes in each direction to three lanes in each direction – which affected the performance at each signalized intersection. In Scenario 4, the existing 16 Avenue / 68 Street traffic signal that controls all movements was replaced with one Single Point Urban Interchange (SPUI) ramp terminal intersection that controls all movements except for the large through movements on 16 Avenue which are grade separated.

For **Scenarios 3 and 5** which include the Recommended Plan, the travel time savings associated with the Recommended Plan as documented in the previous Functional Planning Study were used. The generated benefits from Scenarios 1 and 2, and / or Scenario 4 were added as appropriate.

For **Scenario 6**, the travel time savings were approximated assuming the free flow interchange concept for the Barlow Trail interchange will not result in any travel delay. The Synchro model estimated the potential travel delay associated with the two ramp terminal intersections that are included as part of the "Diamond" configuration at the Barlow Trail interchange. In assuming a free flow interchange concept, the delay associated with the two ramp terminal intersections in the "Diamond" configuration of the Barlow Trail interchange component in the Recommended Plan would be eliminated.

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## 3.2 BENEFIT CALCULATIONS

To convert the estimated peak hour travel time savings into monetary benefits, the same assumptions as used in the previous Functional Planning Study were applied, which included:

- Weekday travel time savings were assumed to be the sum of the AM and PM peak period (each comprising of three hours) travel time savings estimates only (an additional factor of 2.5 was applied to estimate the three-hour peak period savings from the single peak hour savings).
- Weekend day travel time savings were assumed to be represented by the AM peak period travel time savings only.
- 250 weekdays per year.
- 100 weekend days per year.
- Annual estimates equal the sum of weekdays and weekends.
- Single occupant, carpools, and trucks were the identified vehicle types. A factor of 2.25 was used for the average occupancy level for carpools.
- Approximate values of time:
  - Driver / passenger ~ \$16.00 / hr; and
  - Truck Driver ~ \$50.00 / hr.

Using the assumptions listed above, annual travel time savings (for the three vehicle classes) were calculated for each scenario for 2012 and 2039. For the years between 2012 and 2039, as well as after 2039, a constant linear trend was assumed to provide the annual savings for the period from 2012 to 2041. Extending to 2041 allows a 25-year analysis period assuming that construction will not be completed until 2017 (assumption continued in this analysis such that there remains consistency between the benefit analysis in this assignment and the benefits derived in the Functional Planning Study).

The annual travel time savings for the 25-year analysis period are presented in 2014 Present Value (PV) in **Table 3.1**, using a discount rate of 6%.

**Table 3.1: Potential Travel Time Benefits**

Scenario	Improvement	Travel Time Savings (2014 PV)		
		Base (Recommended Plan)	New Scenario	Total Scenario
1	Widening 16 Ave NE		\$2,600,000	\$2,600,000
2	Widening Barlow Trail		\$10,500,000	\$10,500,000
3	Recommended Plan + Scenario 1 + Scenario 2	\$198,580,000	\$10,650,000	\$209,230,000
4	New 68 St NE Interchange		\$49,450,000	\$49,450,000
5	Recommended Plan + Scenario 4	\$198,580,000	\$49,450,000	\$248,030,000
6	Free flow interchange at Barlow Trail (1)		\$10,150,000	\$10,150,000
	Free flow interchange at Barlow Trail (2)		\$10,150,000	\$10,150,000
	Free flow interchange at Barlow Trail (2)		\$10,150,000	\$10,150,000

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## 4.0 SCENARIO COST ESTIMATES

High level construction costs estimates were prepared for each scenario and then compared to the benefits derived in the previous section to obtain the benefit cost ratio. The assumptions used in developing the cost estimates and the results of the benefit cost analysis is presented below.

### 4.1 SCENARIO COST ESTIMATES

For the construction cost estimates for each option, planning level unit costs for the roadways (grading and paving) of \$2200 / linear metre and \$5000 / square metre of deck area for the structures were applied. For the roadway widening (e.g. Scenario 1 and Scenario 2), it was assumed that no significant reconstruction of the existing shoulders is required and that the widening width would be primarily related to the actual width of the new lane. No repaving (milling and paving) of the existing roadway lanes was included in the cost estimates. The approximate extent of the proposed works for each option is included in **Appendix A**.

Other typical costs were considered in developing the overall cost estimates including provisions for utility impacts / relocations, intersection traffic signals, signing, and other road side treatments. To allow for these anticipated costs, a 20% provision was applied to the roadway costs.

Based on the conceptual plans, it is assumed that all new work would be constructed within the existing right-of-way, therefore, no property acquisition costs were generated.

Contingency of 30% was applied to all of the above costs which is consistent with that used in the previous Functional Planning Study.

The high level cost estimates for each scenario are shown in **Table 4.1**.

**Table 4.1: Scenario Cost Estimates**

Scenario	Improvement	Base (Recommended Plan)	New Scenario	Total Scenario
1	Widening 16 Ave NE		\$9,200,000	\$9,200,000
2	Widening Barlow Trail		\$5,500,000	\$5,500,000
3	Recommended Plan + Scenario 1 + Scenario 2	\$201,000,000	\$14,700,000	\$215,700,000
4	New 68 St NE Interchange		\$51,500,000	\$51,500,000
5	Recommended Plan + Scenario 4	\$201,000,000	\$51,500,000	\$252,500,000
6	Free flow interchange at Barlow Trail (1)		\$31,000,000	\$31,000,000
	Free flow interchange at Barlow Trail (2)		\$43,000,000	\$43,000,000
	Free flow interchange at Barlow Trail (3)		\$34,000,000	\$34,000,000

In Scenario 3 and Scenario 5 above, the full cost of the Recommended Plan is shown. However, other less costly scenario permutations could be considered if one of more of the proposed implementation stages of the Recommended Plan were combined with the other infrastructure scenarios, namely Scenario 1, Scenario 2, and Scenario 4. The four implementation stages proposed for the Recommended Plan and the associated costs of each are listed below:

Stage 1: Construct south half of reconfigured Barlow Trail Interchange	\$12.0 M
Stage 2: Completion of the Barlow Trail Interchange	\$23.0 M
Stage 3: Construction of the 19 Street Interchange	\$37.0 M
Stage 4: Construction of the additional structure and ramps at the Deerfoot Trail Interchange	\$131.0 M

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## 4.2 BENEFIT COST ANALYSIS

When calculating the benefit to cost ratio using the benefits and costs from **Table 3.1** and **Table 4.1** respectively, the following B/C ratios for each option are derived as shown in **Table 4.2** below.

**Table 4.2: Scenario Benefit / Cost Ratios**

Scenario	Improvement	B/C
1	Widening 16 Ave NE	0.28
2	Widening Barlow Trail	1.91
3	Recommended Plan + Scenario 1 + Scenario 2	0.97
4	New 68 St NE Interchange	0.96
5	Recommended Plan + Scenario 4	0.98
6	Free flow interchange at Barlow Trail (1)	0.33
	Free flow interchange at Barlow Trail (2)	0.24
	Free flow interchange at Barlow Trail (3)	0.30

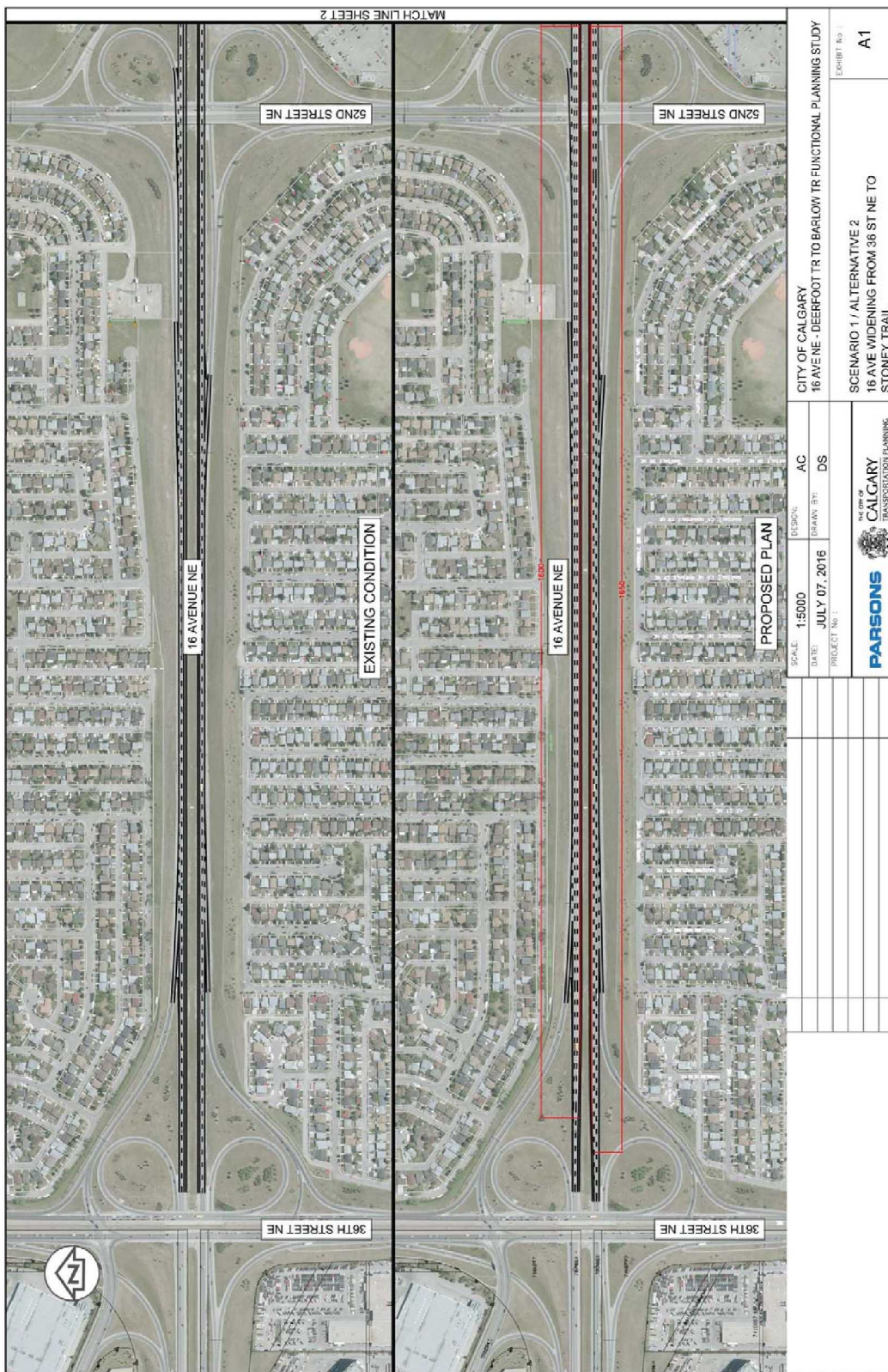
When comparing the additional costs associated with providing a full free flow interchange at Barlow Trail (Scenario 6) as part of the Recommended Plan, significant infrastructure improvement options elsewhere along 16 Avenue (Scenario 1) or along Barlow Trail (Scenario 2) are shown to provide a better value at less cost. For example, when combining Scenario 1 and Scenario 2, a benefit cost ratio of 0.89 is generated at an overall cost of \$14.7 M. This combined cost for these two additional infrastructure scenarios is significantly less than the additional costs associated with any of the three free flow Barlow Trail interchange options, and none of the free flow interchange options possesses a benefit to cost ratio exceeding 0.33.

# APPENDIX A

## *Cost Estimate Widening Assumptions*

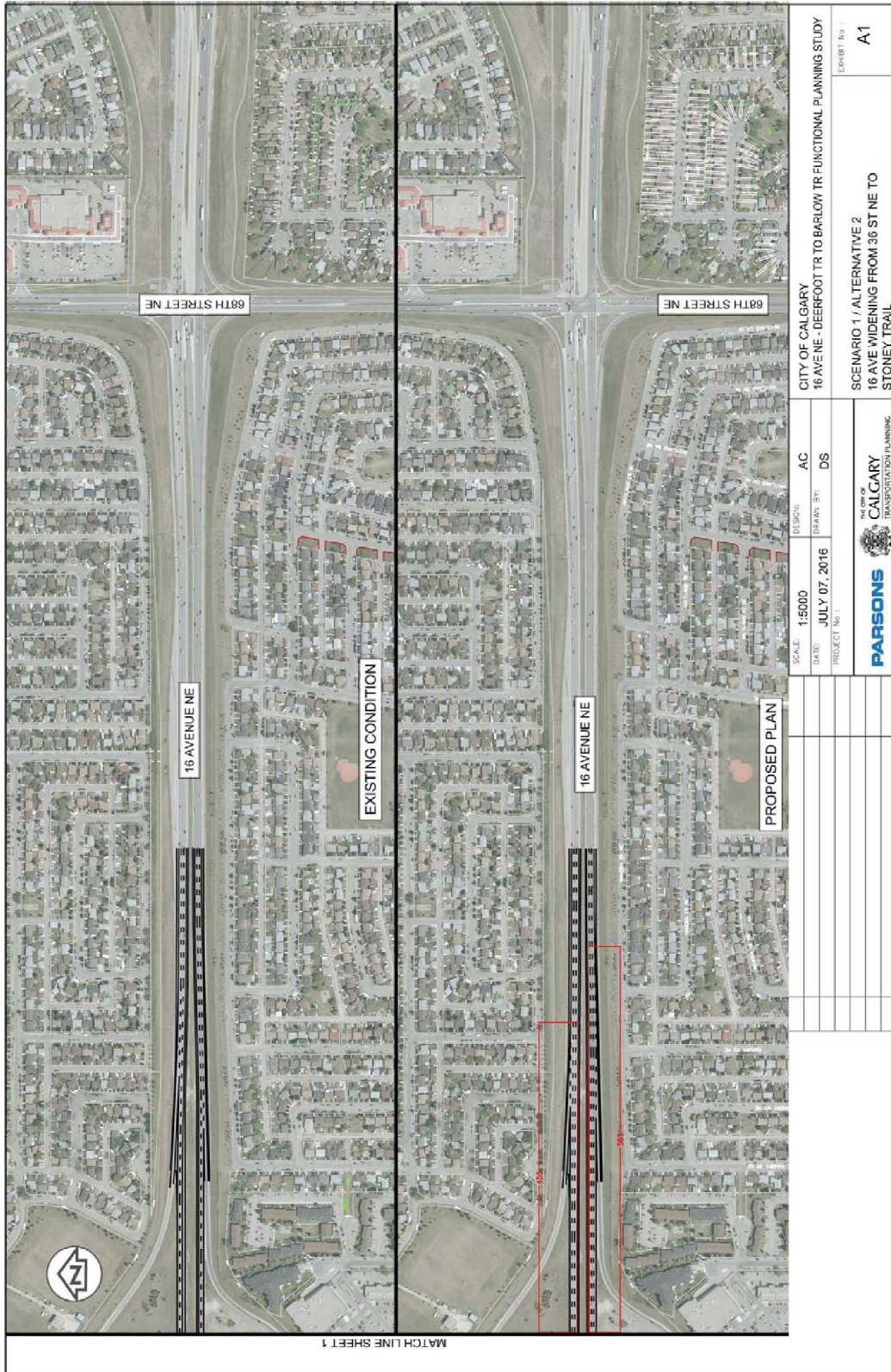


Functional Planning Study 16 Avenue NE –  
 Deerfoot Trail to Barlow Trail: Additional Infrastructure  
 Improvement Scenarios, October 2016





Functional Planning Study 16 Avenue NE –  
Deerfoot Trail to Barlow Trail: Additional Infrastructure  
Improvement Scenarios, October 2016

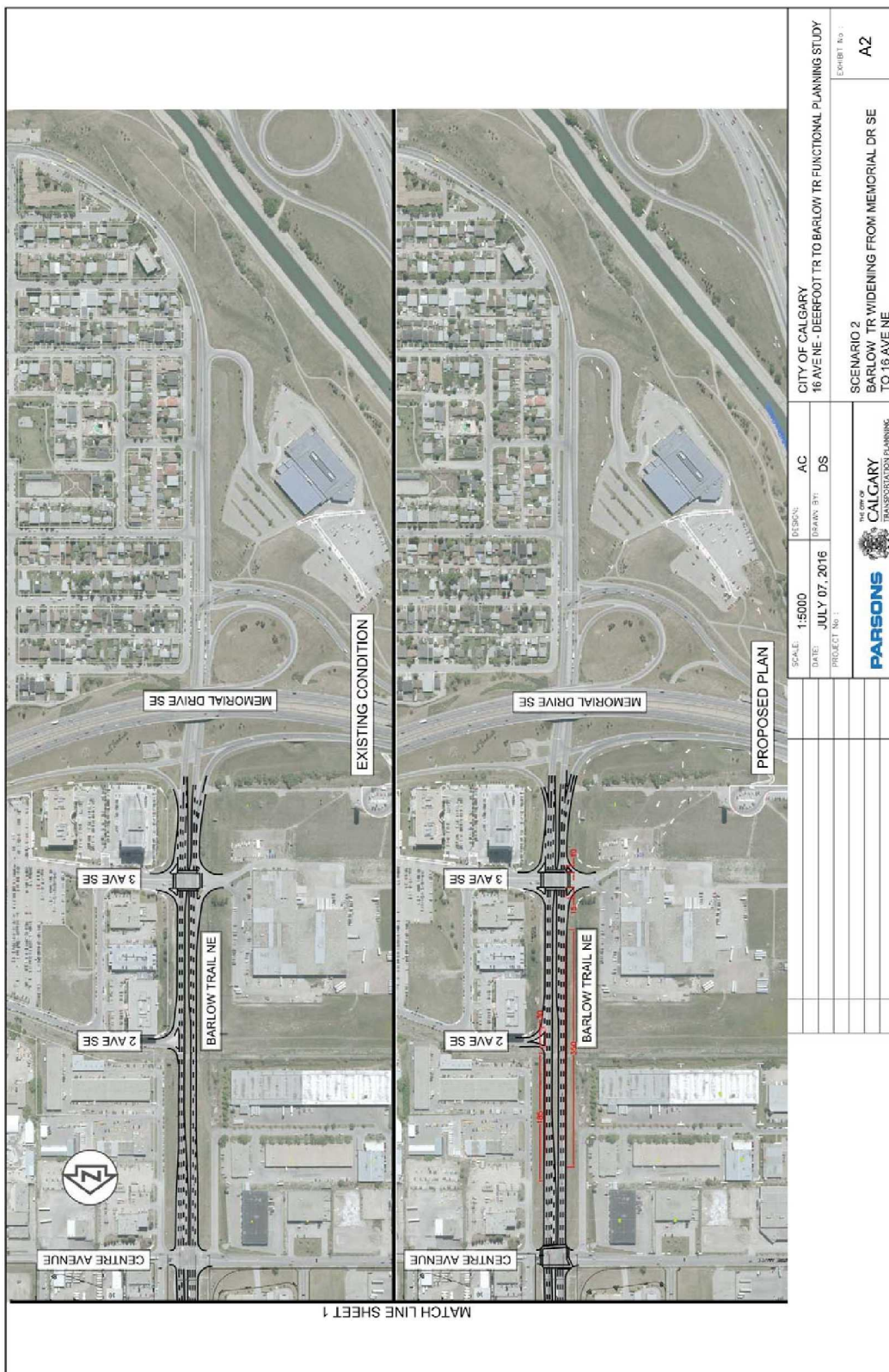








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Improvement Scenarios, October 2016

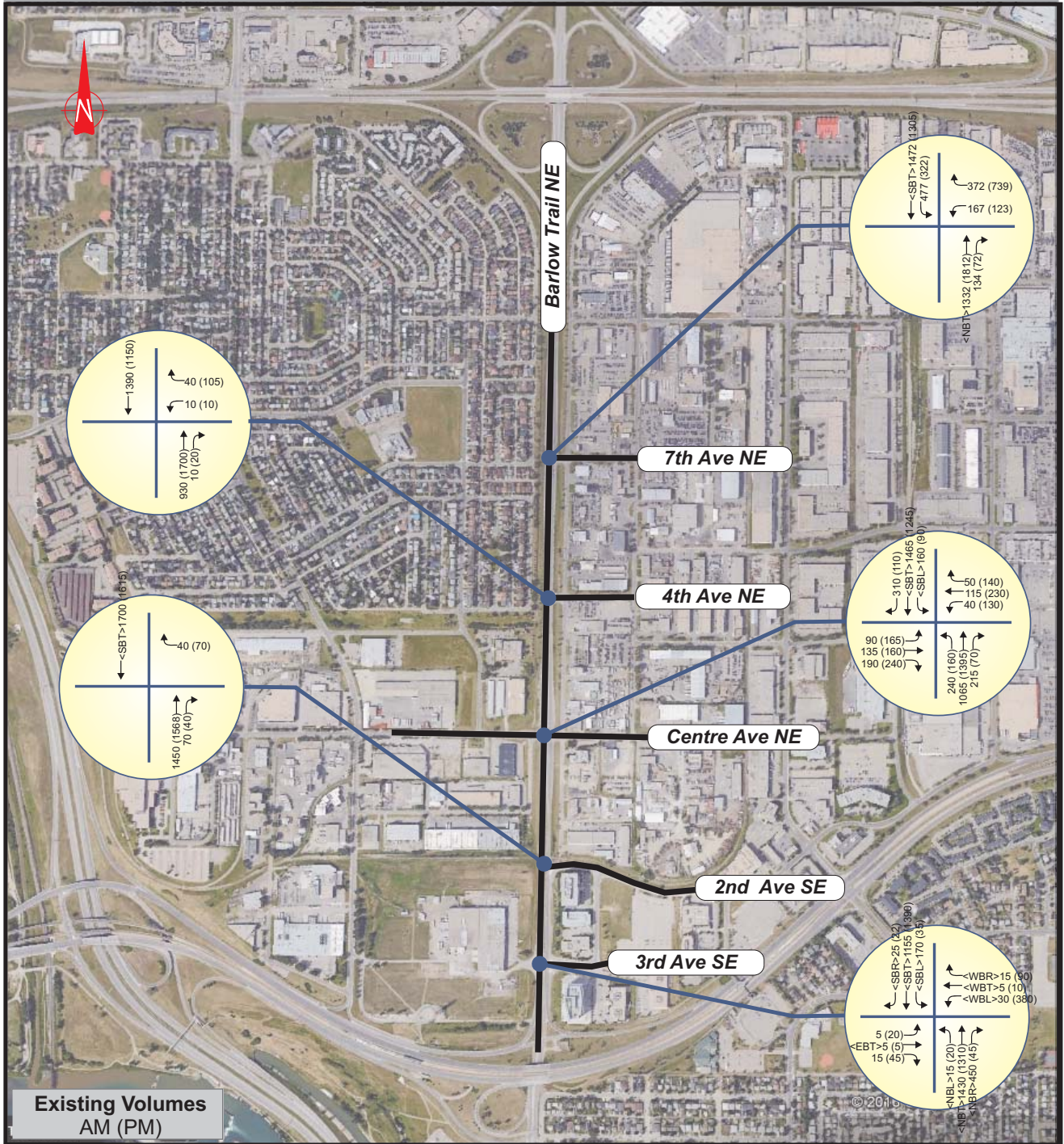


# APPENDIX B

## *Traffic Volumes*

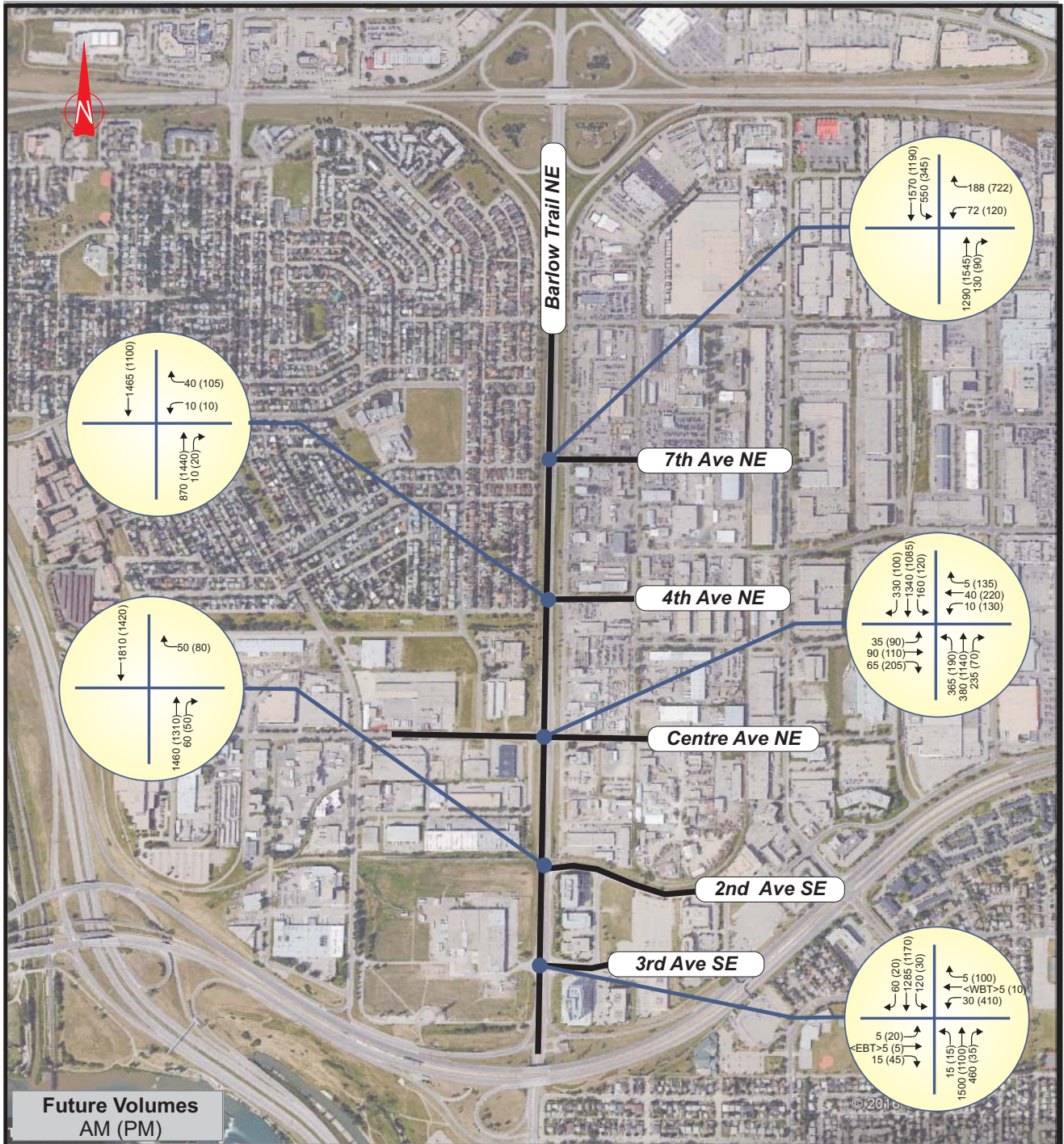


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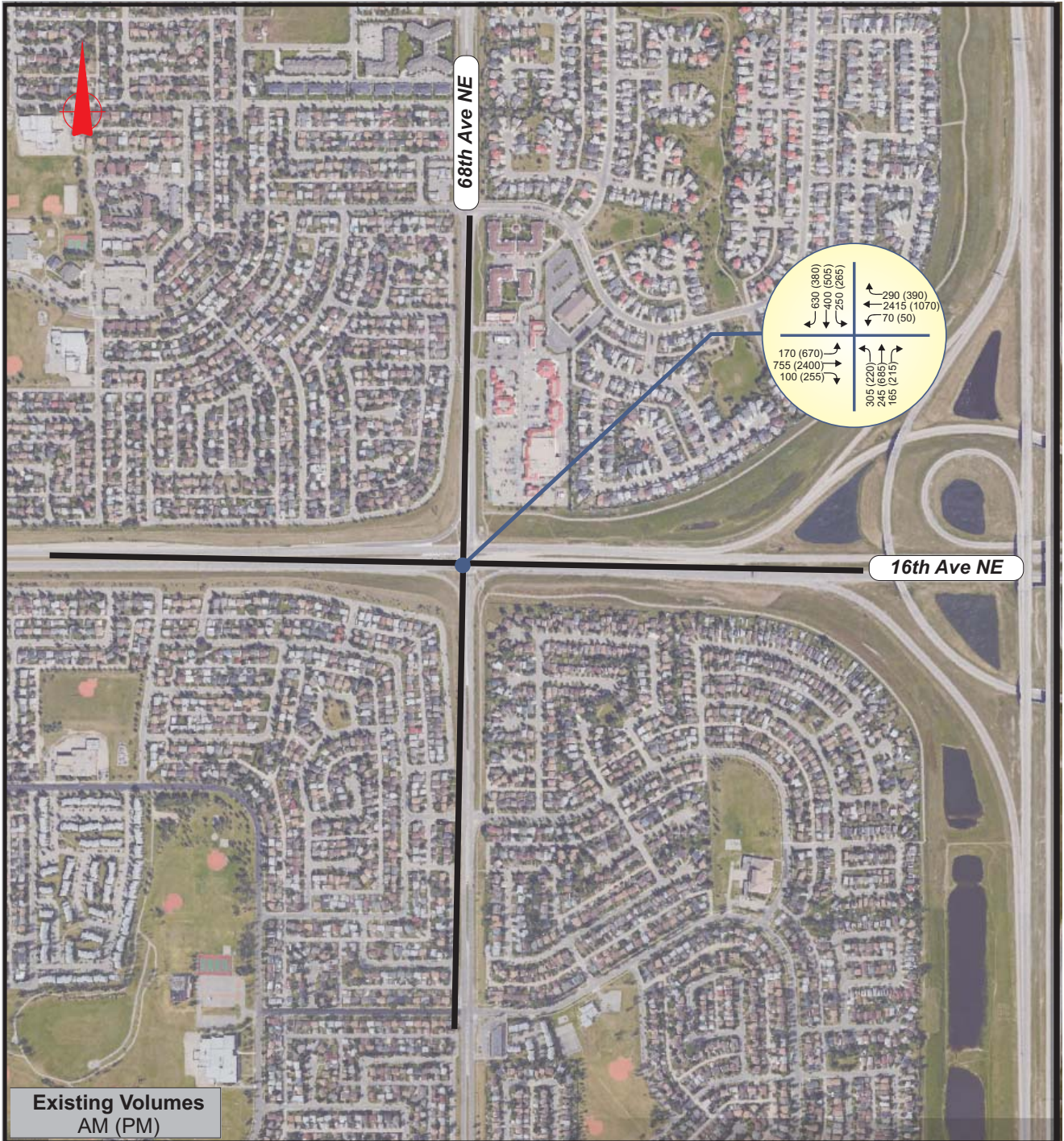


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Functional Planning Study 16 Avenue NE –  
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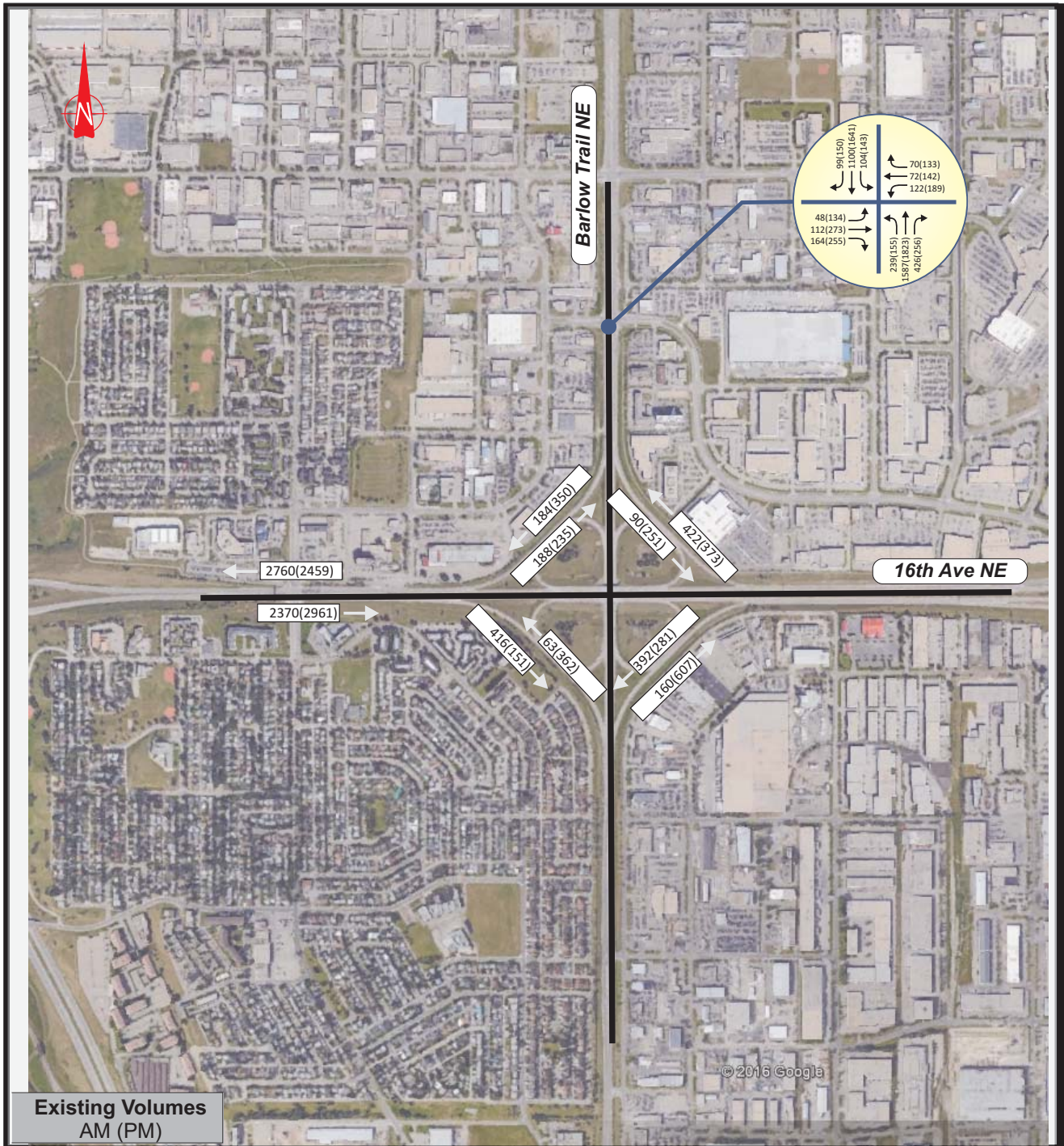


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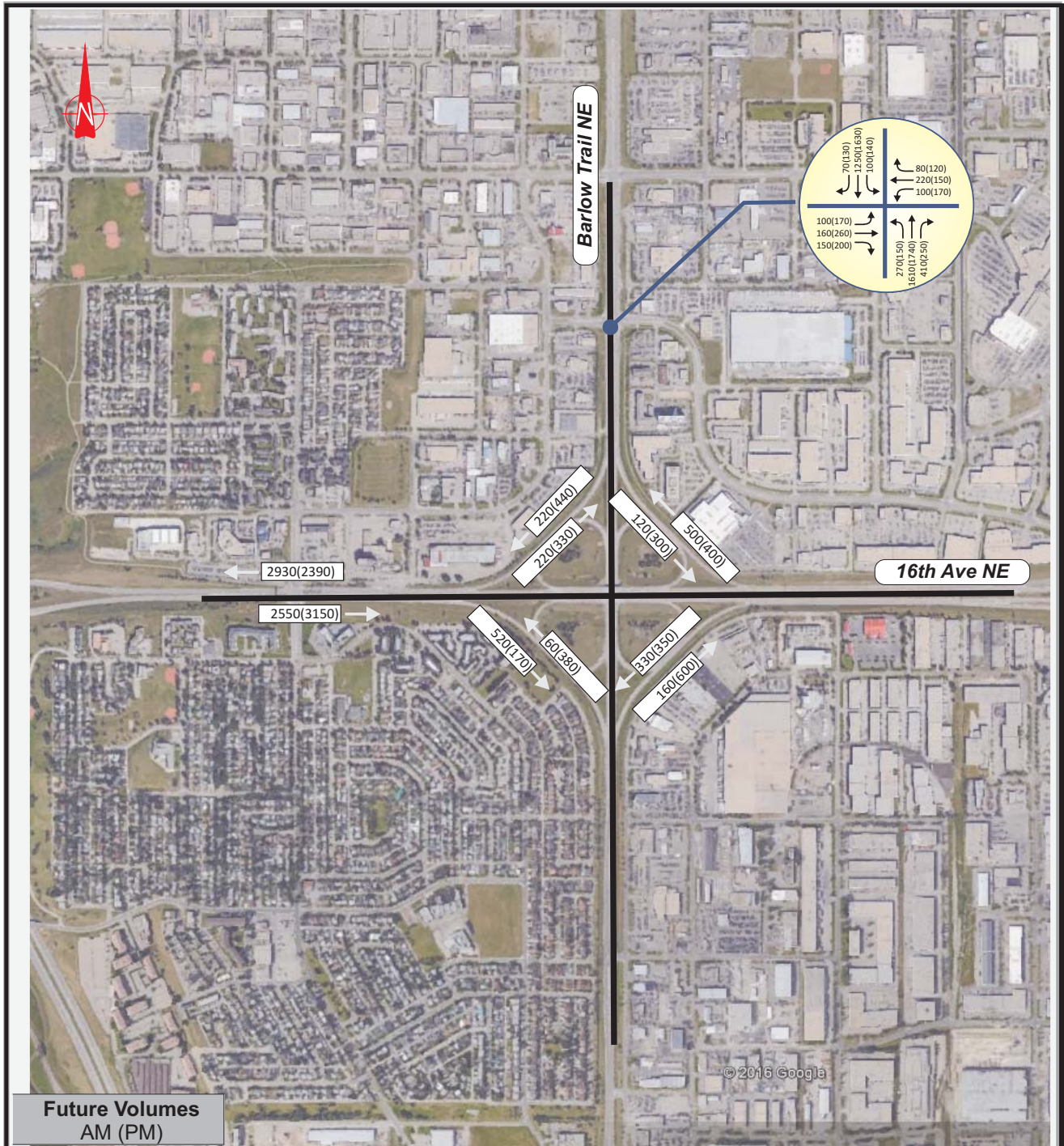


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