Highway 11 and 16 Interchange Functional Planning Study

City of Saskatoon
Final Report

June 2017

ISL Engineering and Land Services

ISL Engineering and Land Services Ltd. Is an award-winning full-service consulting firm dedicated to working with all levels of government and the private sector to deliver planning and design solutions for transportation, water, and land projects.

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PROFESSIONAL ENGINEER
S.A. MOULDS
MEMBER 31447
2017 6 27
YR. MN. DAY
SASKATCHEWAN

S Moulds

Shelly Moulds, P.Eng.
Transportation Engineer

Association of Professional Engineers & Geoscientists of Saskatchewan

CERTIFICATE OF AUTHORIZATION

ISL Engineering
and Land Services Ltd.

Number C1096

Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
Civil Engineering, Transportation Planning	31447	S Moulds

Executive Summary

Background

The City of Saskatoon retained ISL Engineering and Land Services to conduct a Functional Planning Study for the Highway 11 and 16 interchange. Serving traffic from both the TransCanada and Circle Drive (the City's ring road), the existing 1960's cloverleaf interchange does not effectively move traffic, and has substandard vertical clearances.

The study objectives, as defined by the City were to:

- Improve overall traffic operations at this junction;
- Short Term: What can we do to keep the interchange operational? How long will it last?
- Long Term: What is needed in the future?
- Reduce collisions and improve safety;
- Add capacity for critical movements;
- Facilitate good interconnections between the two provincial highways;
- Minimize environmental impacts;
- Minimize right-of-way acquisition and impacts to adjacent lands; and
- Optimize costs and benefits.

Traffic Volumes

The future interchange was designed to accommodate traffic for the 500,000 population horizon, approximately 2041. A review of the Ministry of Infrastructure and Highway Travel Demand Model volumes for this time horizon should a significant decrease in the e southbound right turn and eastbound left turn are considerably less than they are at present. This reduction could not be explained, so the project team developed an alternate set of project volumes based on existing volumes and a 2% growth scenario. Both sets of traffic volumes were then tested on the future interchange configurations to ensure that the design was robust, and could handle either scenario.

Stage 1 Improvements

To address the existing operational issues, short-term improvements have been identified based on the assumption that no modifications would be made to the structures themselves. Based on the problem areas identified during traffic analysis, the following Stage 1 improvements are recommended:

- Adding a second lane for the southbound to westbound ramp. This will address the capacity issues on the ramp and improve the southbound through movements as well.
- Constructing the future westbound Collector/Distributor (C/D) Road, including the connection from the westbound exit ramp, a new entrance ramp onto the mainline, and changes to the Preston Avenue off-ramp. This construction will remove the weaving condition from the mainline and allow the weaves to occur at lower speeds.
- Extending the third eastbound auxiliary lane between Preston Avenue and this interchange, allowing vehicles greater time to complete weaves.
- Extending the downstream weave lanes on the cloverleaf past the exit ramp gore to extend the distance for these vehicles to merge into mainline traffic. This allows drivers extra time to merge onto the mainline.
- Include a low-speed high load bypass lane for northbound traffic to prevent the structures from being struck. An upstream sensor at the Vic Boulevard interchange would notify drivers that their loads are too tall to pass under the interchange, and they would be directed to use the bypass lane. Traffic lights on Highway 16 eastbound and westbound would be activated by the sensors to stop traffic to allow the high load to cross the highway.
- Replace the yield signs on the loop ramps with merge signs to alert drivers that they need to find an acceptable gap and proceed. Currently, many drivers are incorrectly treating the yield condition as a stop condition, which has resulted in a high rate of rear-end type collisions.

Lowering the mainline under the bridges to increase the vertical clearance was considered, but ultimately rejected because the long-term plan will be raising the northbound and southbound lanes, and the remaining life of the structures themselves suggests future investment dependent on their lifecycle should not be made.

Ultimate Configuration

An ultimate interchange configuration was developed to support the long-term travel demands in this region. In addition to improving the operations of this location and addressing the low bridge clearance issues that exist today, the new design will provide additional benefits to Saskatoon by reducing fuel use, emissions and reducing delays to the travelling public. Over the life of the interchange, these savings provide significant economic benefits.

It is anticipated that major improvements to the interchange are several years away, and would likely not occur until the existing bridge structures are at or near the end of their service lives which is approximately 10 to 15 years away.

Figure E.2: Rendering of Proposed Interchange, looking south

The main features of the long-term recommended plan are outlined below:

- System interchange maintains free-flow movements in all directions.
    - East-west highway will be approximately 4m higher than existing.
    - North-south highway will be approximately 2m higher than existing.
    - Eastbound to northbound directional and westbound to southbound directional will be approximately 6m below existing ground.

- Collector/Distributor Roads are provided between this interchange and the interchanges at Preston Avenue and Vic Boulevard to accommodate weaving. By separating the weaving volumes from the mainline, and allowing the weaves to occur at lower speeds, the short weave distances will operate acceptably.

- A two-lane exit ramp onto the eastbound Collector/Distributor Roads has been included upstream of the Preston Avenue bridge structure to maximize weaving distances. If the eastbound to northbound volumes are lower than expected, starting the ramp taper immediately after the bridge structure may still provide sufficient weaving space, removing the need for bridge modifications. The exit ramp for Preston Avenue and the eastbound Collector/Distributor Road was combined to obtain proper lane balance. If Circle Drive (west leg) is widened to 6 basic lanes, separate exits would be preferred.

- A two-lane entrance ramp onto Circle Drive (west leg) has been included from the westbound Collector/Distributor Road to accommodate the high volume southbound to westbound movement. Both lanes have fully merged with the westbound lanes prior to the bridge structure; however, if Highway 11 (Circle Drive) is widened to 6 basic lanes and the bridge structure is being widened anyway, the merge lengths can be extended to improve operations. However, for Circle Drive to be widened, the Preston Avenue bridge structure will also need to be widened.

- Loop ramps accommodate the southbound to eastbound and northbound to westbound movements. These are low volume movements which can easily be accommodated on the low speed ramps.

- The new plan will require seven new bridge structures, one bridge widening, two tunnels, and significant amounts of retaining wall and noise wall.

- The northbound to eastbound ramp and the southbound to westbound ramps are moved closer to the centroid of the interchange, maximizing the potential weave distance to the adjacent ramps.

- The northbound to eastbound ramp and the southbound to westbound ramps are shown with tunnels under the east/west highway, and bridges under the north-south highway.

Construction Costs

A Level "C" planning level cost estimate was prepared for each stage of the project. Short-term improvements are estimated to be $5.7M. The long term improvements are estimated to be $280.4M.

Conclusions

This functional planning study has defined the future interchange requirements for the Highway 11 and 16 interchange, based on a 2% growth scenario for the future traffic volumes. It must be stressed that there is a high level of uncertainty in the forecasted volumes, which would have led to two very different interchange configurations. The Project Team chose to be conservative, and develop for the worst case scenario to ensure that traffic can be ultimately accommodated through this interchange. If traffic volumes reduce, as was predicted by the Travel Demand Model, then several of the recommended features should be scaled back at the design stage.

Recommendations

To address the current issues with the existing interchange, the Stage 1 improvements should be implemented, as soon as funding is available, to resolve the operational and vertical clearance issues. These improvements are compatible with the long-term plans, regardless of which traffic scenario materializes.

To address the long-term uncertainty for this project, we have the following recommendations:

- Monitor traffic patterns over the coming years to better understand which traffic volumes are changing;
- Complete further examination of the regional Travel Demand Model to better understand how the forecast volumes were produced and if the TDM growth scenario is valid;
- Update the TDM to reflect the major projects as they come operational and change the network travel patterns; and
- Review the long-term plan every few years to determine if it is still valid based on current travel patterns.

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1.0 Introduction

The City of Saskatoon retained ISL Engineering and Land Services (ISL) to conduct a Functional Planning Study for the Highway 11 and 16 interchange. Serving traffic from both the TransCanada and Circle Drive (the City's ring road), the existing 1960's cloverleaf interchange does not effectively move traffic, has substandard vertical clearances, and a pattern of collisions suggesting insufficient capacity during peak demand.

As part of the study, ISL developed a long-term interchange plan to ensure that this important corridor will once again be free-flow facility, as well as a staging plan to alleviate operational problems in the short-term. Typical interchange solutions are not possible due to the close proximity of adjacent interchanges in all directions, and adjacent residential development along the road right-of-way.

Figure 1.1: Existing Cloverleaf Interchange

1.1 Study Objectives

The study objectives, as defined by the City were to:

- Improve overall traffic operations at this junction;
- Short Term: What can we do to keep the interchange operational? How long will it last?
- Long Term: What is needed in the future?
- Reduce collisions and improve safety;
- Add capacity for critical movements;
- Facilitate good interconnections between the two provincial highways;
- Minimize environmental impacts;
- Minimize right-of-way acquisition and impacts to adjacent lands; and
- Optimize costs and benefits.

1.2 Study Format

The study was organized in the following manner:

- Review of existing conditions;
- Traffic projections
- Development of alternatives;
- Value engineering session;
- Refinement of alternatives;
- Open House #1;
- Development of the Preferred Plan;
- Open House #2;
- Finalization of Recommended Plan; and
- Draft and Final report submissions

Figure 1.2: Existing Interchange Looking West at Preston Avenue

2.0
Existing Conditions

2.1 Roadways

Highway 16 through Saskatchewan is part of the Trans-Canada Yellowhead Highway, and the National Highway System. All highways that make up the National Highway System must be planned to meet the minimum requirements of 90 km/h posted speed, with free flow travel conditions. The north and east legs of the interchange are designated as Highway 16.

Highway 11 (also known **Lois Riel Trail**) is a major arterial highway in Saskatchewan, providing north-south access between Regina, Saskatoon, and Prince Albert. The west and south legs of the interchange are designated as Highway 11.

Circle Drive is the City's ring road, and is cosigned as Highway 11 and Highway 16 for its entire length. The west and north legs of the interchange are designated as Circle Drive.

Preston Avenue is an arterial roadway 1.2 km west of the Highway 11 and 16 interchange. The diamond interchange at Preston Avenue and Circle Drive provide access to the adjacent communities of Eastview and Stonebridge.

Taylor Street is an arterial roadway 1.7 km north of the Highway 11 and 16 interchange. The diamond interchange at Taylor Street and Circle Drive provide access to the adjacent communities of Eastview and Lakeview.

Boychuk Drive is an arterial roadway 2.0 km east of the Highway 11 and 16 interchange. The soon to be constructed diamond with a loop ramp interchange on Highway 16 at Boychuk Drive will provide access to the adjacent communities of Lakeview, Lakeridge, Rosewood, and future development to the south.

Vic Boulevard is an arterial roadway 1.3 km south of the Highway 11 and 16 interchange. The half diamond interchange provides access to the adjacent communities of Stonebridge, and future development to the east.

2.2 City of Saskatoon

The City of Saskatoon is the largest city in the province of Saskatchewan, and serves as the region's cultural and economic hub. Stats Canada reported a population of 295,095 people in 2016, and 262,215 people in 2011, representing an annual increase of 2.5% per year. This grow rate exceeds the national average, and ranks the Saskatoon region as one of the fastest growing regions in the country.

Eastview is a mostly residential neighborhood located in northwest quadrant of the study area. It is a suburban subdivision, consisting of low-density, single detached dwellings, low-rise apartment buildings and semi-detached houses. As of 2007, the area was home to 3,566 residents.

Stonebridge is a mostly residential neighborhood located in the southwest quadrant of the study area, consisting of low-density, single detached dwellings and a mix of medium-density apartment and semi-detached dwellings. As of 2009, the area was home to 994 residents. The area also has significant regional commercial development near Preston Avenue and Clarence Avenue.

Lakeview is a primarily residential neighborhood located in the northeast quadrant of the study area. The majority of its residents live in low-density, single detached dwellings, with a sizeable minority of semi-detached or apartment-style multiple unit dwellings. As of 2011, the area was home to 7,732 residents.

2.3 Regional Municipality of Corman Park

The Regional Municipality (R.M.) of Corman Park is an amalgamation of several smaller communities surrounding the City of Saskatoon. The municipal boundary between the City of Saskatoon and the R.M. sits in the southeast corner of this projects study area. The east leg of Highway 16 is outside of the City limits.

The Corman Park – Saskatoon Planning District identifies the lands southeast of the interchange as D-Agricultural District (DAG1), and the Future Land Use map does not change this usage. If development were to occur on these lands, access of the highway would be restricted to the Vic Boulevard and Boychuk interchanges, and would not directly affect the Highway 11 and 16 interchange; however, traffic volumes would increase, and the weaves between the interchanges would likely become more challenging.

2.4 Collision Analysis

SGI provided collision data for 2010 to 2015. Over the 5 year period, there were 94 collisions involving property damage, 23 collisions involving injuries, and no fatalities. Analysis shows that the number of collisions has increased each year, with no fatalities. Summaries of the findings are shown in the following figures.

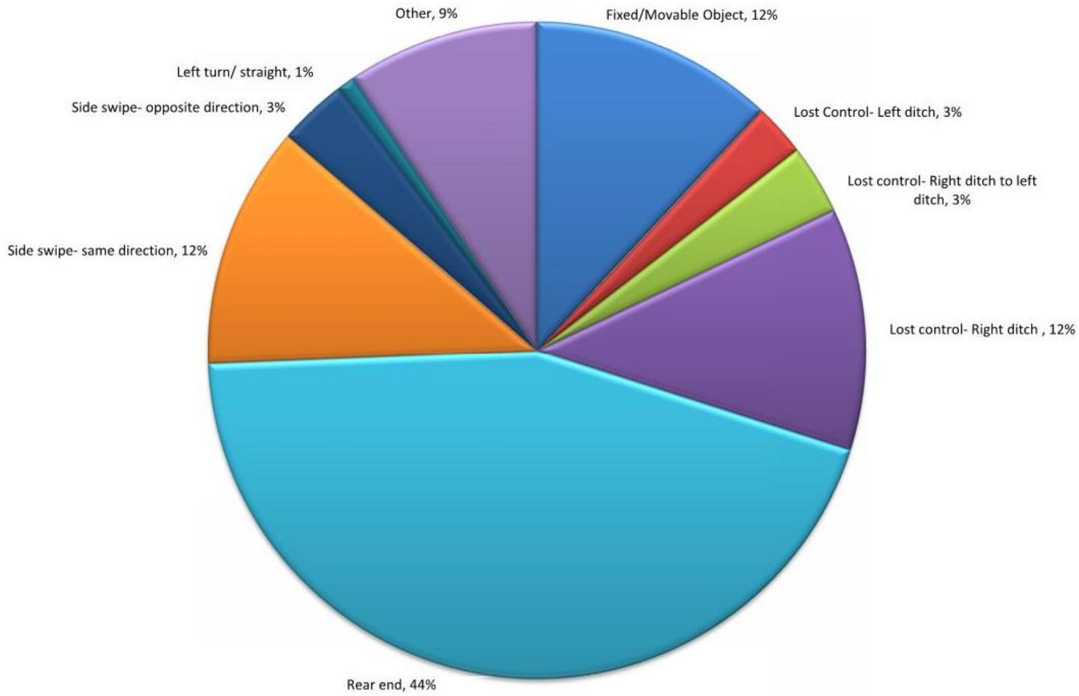


Figure 2.1: Collision Type

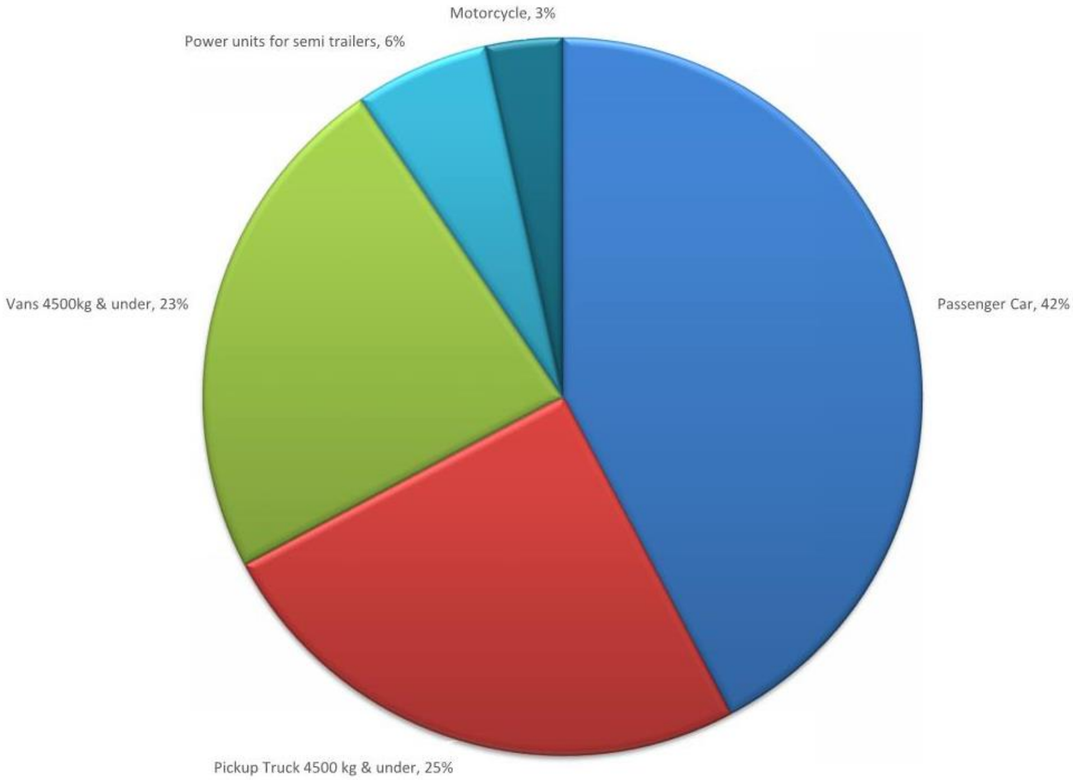


Figure 2.2: Type of Vehicle Involved in Collision

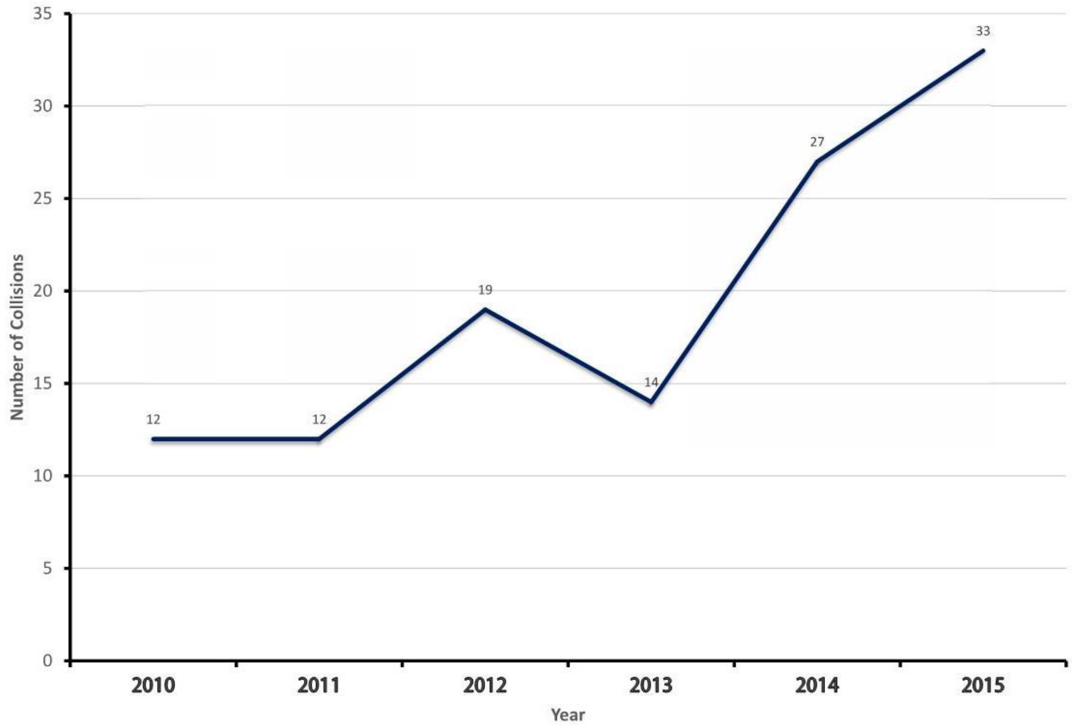


Figure 2.3: Number of Collisions by Year

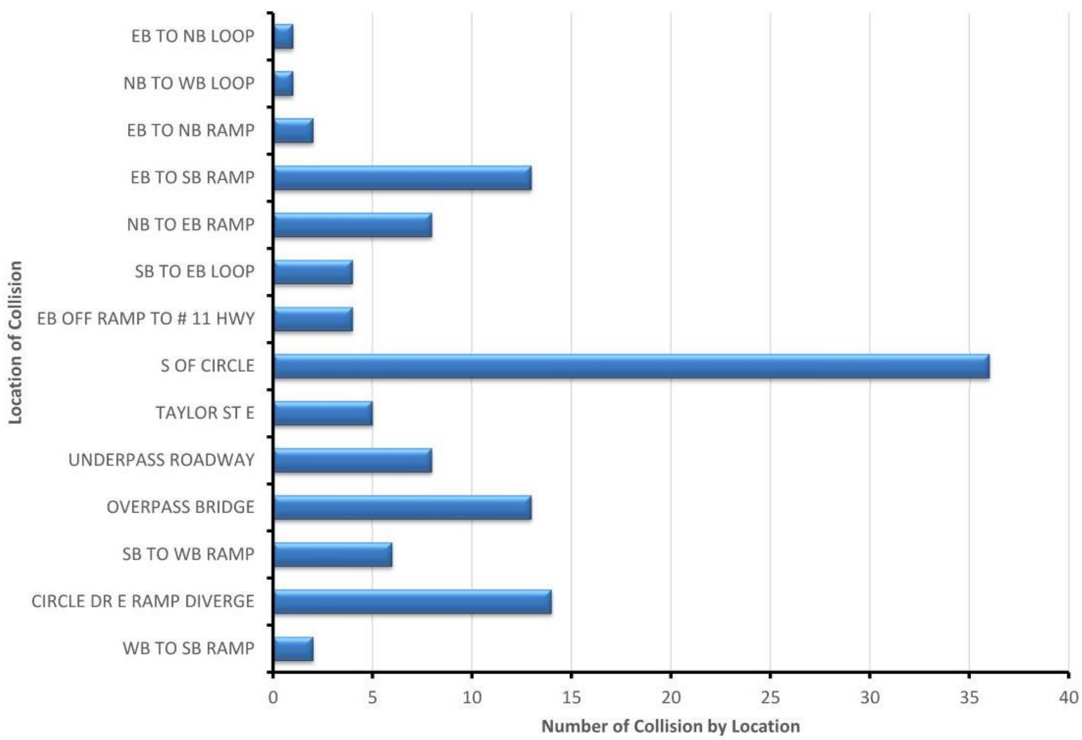


Figure 2.4: Number of Collisions by Location

2.5 Existing Bridge Structures

The interchange has twin overpass bridges on Highway 16 over Highway 11, constructed in 1966. Based on recent inspections, it is estimated that the bridges have between 10 and 15 years of service life remaining. The bridges have 5 spans (10 m, 18.3 m, 16.5 m, 18.3 m, 10 m) totaling approximately 73 m in length.

Currently the bridge has a vertical clearance of 4.7m, and the current standard is 5.6m. Each year the bridge is struck several times by vehicles which is reducing the remaining service life for the structures. Options for increasing the vertical clearance on the existing bridges include:

- **Lowering the roadway under the existing bridges:**
  In order to increase the clearance under the bridge for an interim solution, lowering Highway 11 by about 1.0 m. With a design speed of 110 km/h, the lowered Highway 11 can tie back to existing in approximately 200 m each side with about 1% grades, total of about 400 m-500 m of reconstruction.

  A moment slab barrier will be required for Highway 11 under the bridge in order to provide protection to the bridge piers. These piers were built under 1960's standards and may not meet current crash standard. The moment slabs will provide additional protection to the pier. In order to meet TAC shy line requirement, the design speed would have to be reduced on Highway 11 to 90-100 km/h due to the limited horizontal clearance to the barrier.

- **Raising the bridges and adjusting the profile:**
  Two options are available, and both of these options involve a greater risk associated in dealing with live traffic during the reconstruction. One bridge is reconstructed at a time, using the second bridge for detours and temporary MSE Walls for any staging requirements.
  - Leave existing substructure in place and raise the deck simultaneously by 1.0 m by jacking and adjust the approaching roadway. Piers would need to be cut from the superstructure, pier caps would need to be cast, bearings would need to be installed, abutment seat would need to be modified. The foundation would also need to be checked to ensure it can handle the additional dead load.
  - Replace the existing superstructure and keep the existing foundations raising bridge by 1.2 m. New caps would need to be cast on piers, add supplemental pier foundations as needed, abutment seat reconstruction.

- **Replacing the bridges:**
  A two span bridge would replace each bridge. The new bridges would be 2.0 m– 3.0 m higher than the existing bridge. New foundations are required at abutments and supplement existing pier foundations as deemed appropriate.

All options are feasible, but range in complexity and cost.

2.6 Drainage

The existing interchange system is located at-grade and above grade. The existing drainage patterns of the current interchange site are as per the following original 1966 interchange design drawing: Proposed General Drainage Pattern, Drawing 167-0280-110r001, Intersection of No 16 HWY & No 11 HWY, Government of Saskatchewan of Highways & Transportation, April 28, 1966. The drawings indicate the following:

- that the existing interchange is drained by a roadway ditch and culvert system;
- drainage contributes to the interchange site from Highway 16 to the north, but drains away from the site to the east, west and south; and
- the majority of the interchange footprint (about ¾) drains south along Highway 11, with the bulk of the remaining area draining east along Highway 16 (very little drains west along Highway 11).

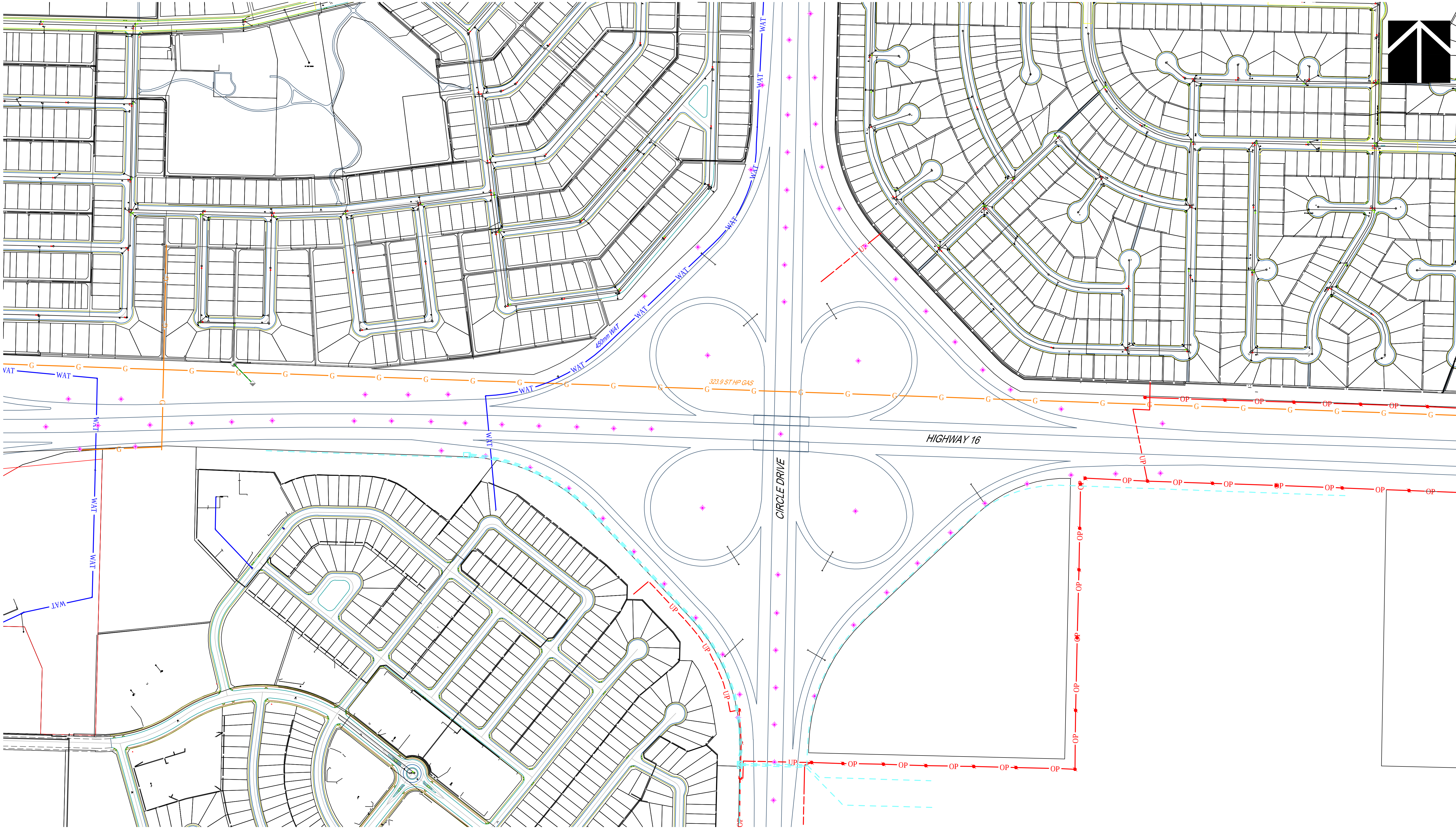
Approximately 800 m south of the east-west mainline the Highway 11 ditch drainage is directed through a storm sewer system west into the Stonebridge neighbourhood where it is routed through the Stonebridge storm sewer system to a stormwater management facility within the neighbourhood. As well, the storm sewer runs below a noise berm. In addition to providing a sound barrier, the noise berm also prevents excess overland flows within the Highway 11 right-of-way from entering the Stonebridge neighbourhood.

The interchange footprint sits on about 34 ha of land. The area of the Highway 11 right-of-way south of the interchange that also contributes runoff to the Stonebridge outlet is about 16 ha. As a result, a total of about 50 ha of highway right-of-way systems drain into Stonebridge. The Stonebridge inlet has a surcharge capacity of about 500 L/s, and a flow-full capacity of about 300 L/s. A lumped computer simulation modelling effort was undertaken using the XPSWMM program to estimate peak runoff from the 50 ha of highway right-of-way during the 1:100 year design event to be about 800 L/s. This means that during the design 1:100 year event the Highway 11 right-of-way would experience ponding water at the outlet location, likely ponding over the highway road surface impacting traffic.

2.7 Utilities

Local utility companies, including SaskPower, SaskEnergy, SaskTel, Shaw Communications, Saskatoon Light and Power, and City of Saskatoon deep utilities, were contacted regarding existing utilities in the area. A summary is shown on Exhibit 2-1.

The major concern SaskEnergy's 323.9 mm high pressure gas line that runs east/west through the center of the north loop ramps.



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LEGEND

GAS	G
WATER	WAT
OVERHEAD POWER	OP
UNDERGROUND POWER	UP
TELECOMMUNICATIONS	
POWER POLE	
LIGHT POLE	

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION

EXISTING UTILITIES

EXHIBIT 2-1

JUNE 2017

3.0
Traffic Volumes and Performance Measures

3.1 Existing Traffic

Existing traffic volumes were collected by the City of Saskatoon in September 2016. For later comparison with forecast model volumes the existing condition reflects a 260,000 population (260k). The AM and PM peak hour survey volumes are shown in Figure 3.1. They show the southbound right turn and eastbound left turn to be the predominant turning movements and are likely to require the most consideration in the development of alternative options.

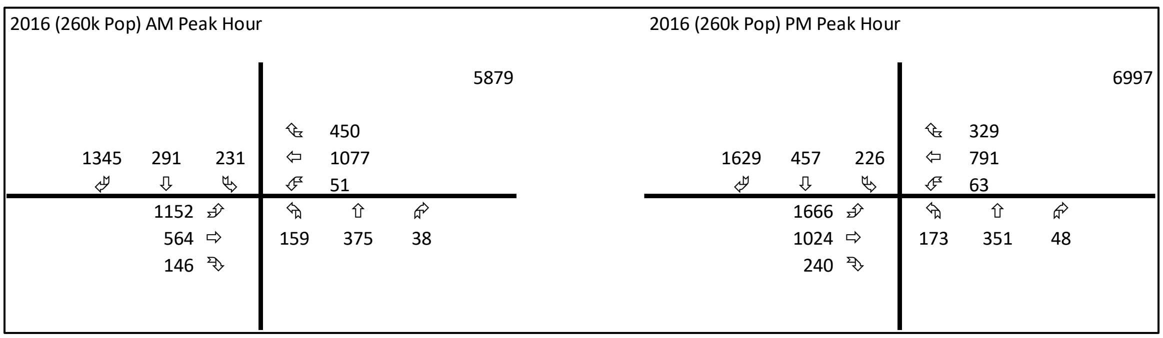


Figure 3.1: AM and PM Peak Hour Existing Traffic Volumes

Overall the interchange has 6.7% trucks, with most trucks entering/exiting the system from the south leg. The largest distribution of trucks is found on the northbound to eastbound ramp (26% during the AM peak), and the westbound to southbound ramp (25% during the AM peak).

3.2 Future Traffic Volumes

The City of Saskatoon provided traffic volumes for the 500k population scenario from the Ministry of Highways and Infrastructure Saskatoon Regional Travel Demand Model (TDM). This 500k population is expected to be reached by 2041. Figure 3.2 provides a summary of the TDM volumes.

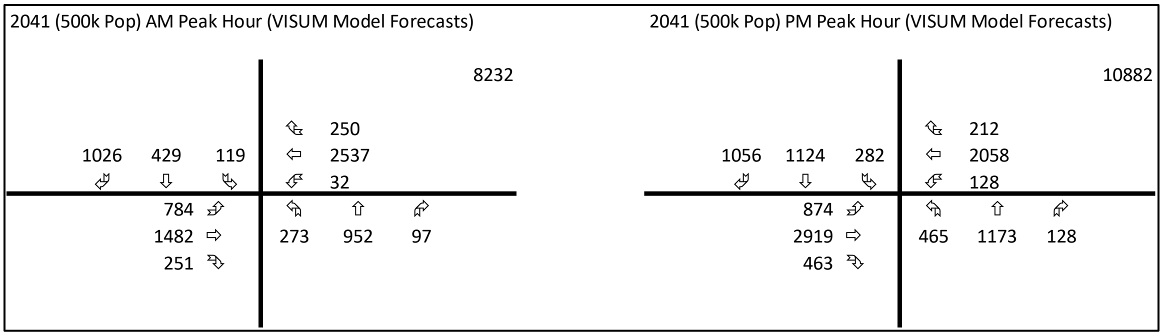


Figure 3.2: AM and PM Peak Hour 2041 TDM Volumes

The TDM volumes show overall growth in traffic through the interchange, however, the volumes for the southbound right turn and eastbound left turn are considerably less than they are at present. This was a concern going forward and the City undertook a review of their model to try and determine the reason for such a reduction in volumes. They were unable to find any conclusive reasons for this reduction on the two predominant movements.

As a test, a second design year scenario was created to reflect a more traditional growth expectation. The existing condition volumes will be increased based upon a universal 2% growth rate per annum up to 2041. Figure 3.3 shows these volumes.

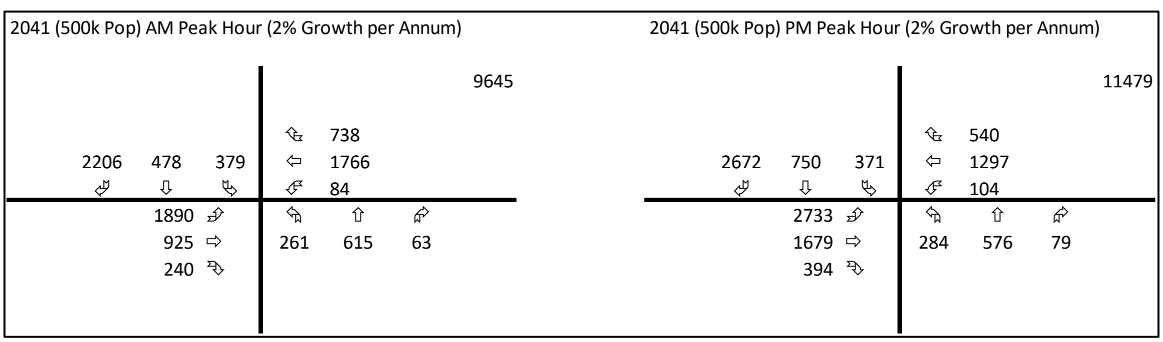


Figure 3.3: AM and PM Peak Hour 2041 2% Growth Rate Volumes

The two sets of future traffic volumes both present difficulties in planning for the future. The TDM model predicts the existing high volume turning movements will be much less than at present, thus the existing interchange may operate more effectively as travel patterns change over time. The 2% growth rate volumes present a very different problem, with those predominant turning movements now much higher and likely requiring two free flow lanes. Subject to upstream lane configurations, it may not even be possible to feed such high volumes onto a double lane ramp.

3.3 Traffic Model and Performance Metrics

The interchange and proposed improvements were assessed using a VISSIM micro-simulation model. VISSIM is a microscopic multi-modal traffic flow simulation software package where each entity (car or truck in this case) is simulated individually. Each vehicle is represented by a corresponding entity in the simulation that interacts with the physical limitations (i.e. curbs and lanes, curves and merges/diverges) and other entities (i.e. maintaining headways, merging into gaps) to accurately represent observed conditions. It provides the flexibility to test many unique configurations and is ideally suited to a study such as this.

The VISSIM model can provide a number of performance metrics which allow us to compare the impacts of different volume scenarios or different interchange types. The following metrics were reviewed:

- **Volume** – The volume data helps us identify where there are capacity issues in the network. If the model does not record all vehicles anticipated to make that movement, it tells us the interchange does not have sufficient capacity. Small variables between the input volume and model output volume are not significant as the model has slight variability programmed into it and is averaged over multiple runs. However large differences are a sign that capacity is insufficient.
- **Delay** – The delay for each movement is measured in seconds from the upstream merge to the downstream diverge and will include any time where a vehicle is travelling below its ideal speed through the network.
- **Travel Time** – The travel time for each movement is measured for the upstream merge to the downstream diverge, thus it includes delays that may occur at the merge areas also, but provides a good overall indication of how this part of the network is operating.

As the Highway 11 and 16 Interchange is a systems interchange, the performance target should essentially be free-flow conditions with minimal delay at merge and diverge locations.

3.4 Existing Configuration Traffic Model

This analysis reflects the conditions observed today (September 2016) at the intersection. It is important that this accurately reflects existing conditions and provides a valid base to test future traffic volumes. If it accurately reflects existing conditions we can have some confidence that when future volumes are tested they provide a reasonable assessment of future operation. The existing condition model was visually compared with on-site observations to confirm it provided a reasonable representation of existing conditions.

To determine the need for future improvements we also tested the existing interchange with forecast future traffic volumes, this is the ‘Do-Nothing’ scenario, and provides an estimate of traffic operation in 2041 should we leave the interchange with its current configuration. This ‘Do-Nothing’ scenario was tested with the 2041 TDM model volumes and 2041 2% Growth volumes.

3.4.1 Existing Configuration – Volumes

In the 2016 and 2041 TDM models, the VISSIM input and output volumes are very similar suggesting little congestion within the model and all intended traffic is making it through the network. In the 2041 2% Growth model, many of the output volumes are much lower than the input volumes. This is to be expected given a single lane can only accommodate approximately 2,000 vehicles. The congestion from the eastbound left and southbound right likely also reduce throughput of adjacent vehicles creating a knock-on effect through the network.

Based on Table 3.1, the 2041 TDM volumes could be expected to accommodate reasonably well by the existing cloverleaf layout due to the change in travel patterns; however, in the next stage of analysis we saw that this is not the case. The 2% growth scenario will require significant changes to provide the appropriate levels of throughput.

In the future scenarios, the major differences between inputs and outputs can be seen in the eastbound left and through, and the southbound through and right movements. Improving these movements will be the focus of the short-term improvements.

Table 3.1: Existing Configuration VISSIM Input and Output Traffic Volumes

Movement	2016 PM		2041 TDM PM		2041 2% PM	
	Input	Output	Input	Output	Input	Output
Eastbound Left	1537	1564	814	761	2521	1750
Eastbound Through	1153	1142	2979	2781	1891	1304
Eastbound Right	240	249	463	434	394	278
Westbound Left	52	56	106	107	86	90
Westbound Through	802	809	2080	2089	1315	1337
Westbound Right	329	329	212	210	540	536
Northbound Left	42	39	303	317	69	66
Northbound Through	482	479	1335	1335	791	797
Northbound Right	48	43	128	124	79	80
Southbound Left	202	207	258	257	332	249
Southbound Through	481	474	1148	1146	789	589
Southbound Right	1629	1607	1056	1029	2672	2048

3.4.2 Existing Configuration – Delays

There are minimal delays in the 2016 existing condition model – small slowdowns for some movements.

In the TDM scenario where the volumes for those high volume turning movements reduce significantly from the existing condition, and contradictory to initial thinking, the delay for the eastbound left increases significantly due to the higher volume of northbound through traffic on the mainline and additional weaving taking place due to the increased northbound left turning traffic. The queues from the eastbound left loop ramp also impact the other eastbound movements and effectively creating congested conditions on the eastbound mainline.

In the 2% growth scenario, where those high volume turning movements become even higher, so high in fact that one lane is not sufficient to accommodate the demand, the delays are considerably higher than existing.

Both future year scenarios suggest the interchange is not capable of accommodating future demand without experiencing congested conditions.

Table 3.2: Existing Configuration VISSIM Traffic Delays (Seconds)

Movement	2016 PM	2041 TDM PM	2041 2% PM
Eastbound Left	18	62	115
Eastbound Through	5	32	52
Eastbound Right	6	42	58
Westbound Left	2	4	3
Westbound Through	1	3	2
Westbound Right	9	9	30
Northbound Left	3	6	4
Northbound Through	2	4	6
Northbound Right	7	29	10
Southbound Left	14	13	64
Southbound Through	2	2	35
Southbound Right	7	5	58

3.4.3 Existing Configuration – Travel Times

Table 3.3 below provides the travel time for each movement and then the percentage increase in travel time between the existing condition and the future condition. We can see the TDM model only sees increases on the eastbound movements and the northbound right. The 2% model sees large increases on many of the movements.

Table 3.3: Existing Configuration VISSIM Travel Times (Seconds)

Movement	2016 PM	2041 TDM PM		2041 2% PM	
	TT	TT	% Inc	TT	% Inc
Eastbound Left	145	189	30%	242	67%
Eastbound Through	102	130	27%	149	46%
Eastbound Right	69	104	51%	121	75%
Westbound Left	149	151	1%	150	1%
Westbound Through	91	93	2%	92	1%
Westbound Right	108	108	0%	129	19%
Northbound Left	121	125	3%	122	1%
Northbound Through	84	85	1%	87	4%
Northbound Right	104	126	21%	108	4%
Southbound Left	179	179	0%	229	28%
Southbound Through	88	88	0%	121	38%
Southbound Right	79	77	-3%	131	66%

3.4.4 Summary

The main traffic operation issue for the existing interchange occurs in the weave sections between the loop ramps. The distance available for weaving varies between 150m and 190m, and while it currently functions reasonably well, it will become an area of concern in future years. The exact nature of concern varies however depending upon the future growth scenario. Using the TDM growth, the weaving volumes reduce significantly, however, through volumes are higher, and there are still capacity issues and disruption to the flow of traffic. In the 2% growth scenario, the weaving volumes are extremely high and cannot be accommodated by the existing configuration. Given both growth scenarios result in disruption to the flow of traffic due to the cloverleaf configuration, alternate solutions that removed the weaving requirement were recommended.

Regardless of the traffic growth scenario that occurs, it is unlikely that the existing interchange configuration will adequately support the traffic demands in the future. The primary area of concern is the eastbound left turn movement that experiences significant delays in both the TDM and 2% growth scenarios. In only the 2% growth scenario the southbound right is also an area of concern.

4.0 Design Standards

The interchange under review is part of the TransCanada Highway and Circle Drive. Based on the importance of these facilities, the following design criterion was adopted for the project:

- The mainline shall be designed as a rural, high speed, free-flow, 4-lane divided, access controlled facility;
- All interchange ramp exits and entrances shall be located on the right-hand side, and no left-hand exit or entrance ramps will be permitted;
- Only one exit ramp per direction shall be provided at all interchanges;
- Lane balance shall be provided;
- The use of combinations of inter-related minimum design criteria is not permitted;
- Transition from rural standards to urban standards (curb and gutter), where applicable, is to occur at the urban end of the interchange ramps connecting to the cross roads;
- Transition lanes and lane-drops shall be provided by dropping the outer lane;

4.1 Mainline Roadway Classification

Rural Freeways and Expressways

4.2 Design Vehicle

All roadways and intersections to accommodate a Transport Truck (WB–20).

4.3 Design and Posted Speeds

	Design
Mainline:	110 km/h
Ramps at gore: 80% of Mainline/crossroad design speed	~88 km/h
Loop Ramp:	40 km/h
Directional Ramp:	80 km/h
Split Ramp:	50 km/h

Mainline posted speed will be 20 km/h less than design speed. All other posted speeds shall be 10 km/h less than design speed.

4.4 Horizontal Radii

All roads as per TAC's Geometric Design Guide Table 2.1.2.6 for 6% Superelevation, rural and high speed urban application.

4.5 Vertical Grades

Mainline .... 4% max
Ramps
    Entrance Ramps .... 6% max
    Exit Ramps :.. 4% max
Bridge Deck: Longitudinal Grade – Maximum 2%; Minimum 0.5%.

A desirable minimum of 0.5% on earth areas such as utility easements.
A desirable minimum of 0.5% on curbed roadway.
A minimum of 1% on graded areas.

4.6 Vertical Curves

K Values: As per TAC's Geometric Design Guide Table's 2.1.3.2M (Crest Curves) and 2.1.3.4M (Sag Curves)

Distance between vertical Points of Intersection ("PI") as per SK Ministry of Highways and Infrastructure SKS 2.1.3-D.

Minimum length of vertical curves be equal to design speed as per TAC's Geometric Design Guide Section 2.1.3.4.

4.7 Superelevation

- As per TAC's Geometric Design Guide Table 2.1.2.6:
- All roads (e max) .... 0.06 m/m
- No bridges shall be on spiral curves or superelevation transitions
- Mainline:...Minimum length of spiral 50 m
- Spirals as per TAC's Geometric Design Guide Section 2.1.2.3

4.8 Entrance and Exit Tapers

- Exit taper design as per TAC's Geometric Design Guide Figure 2.4.8.2 for Single lane ramp and Figure 2.4.8.3 for two lane ramp.
- Entrance taper design as per TAC's Geometric Design Guide Figure 2.4.8.5 for parallel single lane ramp and Figure 2.4.8.6 for parallel two lane ramp.

4.9 Lane Widths

Mainline .... 3.7 m
Loop Ramp
    1 lane .... 5.0 m
Ramps
    1 lane .... 4.0 m
    2 lanes .... 3.6 m

4.10 Shoulder Width

Mainline
    Left (Inside)[1] .... 1.0 m
    Right (Outside)[1] .... 3.0 m
Bridge Structures .... 2.0 m
All Ramps
    Inside (1 lane) .... 1.0 m
    Inside (2 lanes) .... 2.5 m
    Outside .... 2.5 m

[1] Notwithstanding the shoulder widths stated above, wider shoulders may be required to satisfy shy distance requirements or stopping sight distance requirements for bridge structures. In no case shall the shoulder be wider than 3.5 m.

4.11 Median Width

Mainline .... 20.0 m

If median width is less than 20 m, appropriate barriers shall be used to separate opposing traffic flows.

4.12 Vertical Clearances

1. Roadway - underside of roadway superstructure to top of roadway, all bridge vertical clearances shall be a minimum of 5.6 m.
2. Posted vertical clearance to be 0.1 m less than actual vertical clearance
3. Sign structures - roadway surface to underside of sign panel ....6.0 m min.

4.13 Horizontal Clearances

Clear zone and barriers as per TAC's Geometric Design Guide Table 3.1.3.1.

4.14 Passing Sight Distance

As per TAC's Geometric Design Guide Table 1.2.5.5.

4.15 Decision Sight Distance

As per TAC's Geometric Design Guide Table 1.2.5.6.

4.16 Cross Section

- Minimum cross slope 2.5%
- City of Saskatoon: Freeway / Expressway Rural Cross Section Without Drainage Layer (Plan No. 102-0029-003r002)
- (OR) City of Saskatoon: Freeway / Expressway Rural Cross Section With Drainage Layer (Plan No. 102-0029-044r002)

4.17 Right-of- Way (ROW) width

Minimum ROW width: .... 100 m

5.0 Preliminary Interchange Options

5.1 Preliminary Interchange Options

Consideration of All Interchange Configurations

As an initial starting point for the project, ISL conducted a high level evaluation of standard interchanges referenced in well known document such as: the TAC Manual, AASHTO, and the Freeway and Interchange Geometric Design Handbook, to see what options might work in this location. As an initial screening, interchanges with the following features were eliminated:

- Interchange configurations with more or less than 4 legs; and
- Service level interchanges, where some movements have a stop condition – this type of interchange is not suitable for a freeway to freeway junction because it defies driver expectation.

What was left was system level interchanges (all movements are free flow), that accommodated 4 legs of traffic. A summary of this evaluation is shown on Table 5.1.

Options that were deemed possible at this location were considered further at the Value Engineering Session.

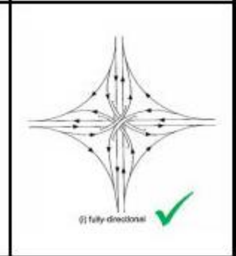
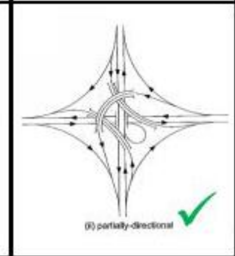
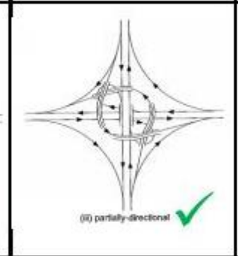
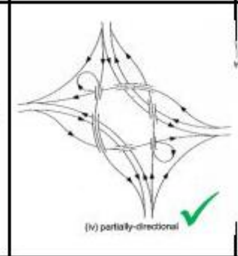
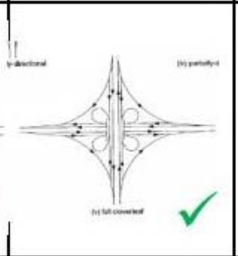
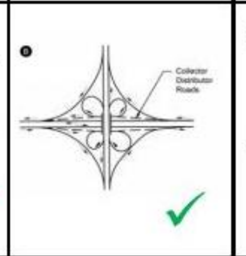
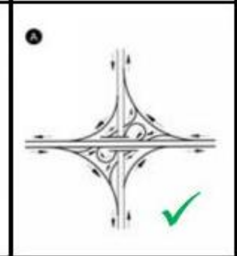
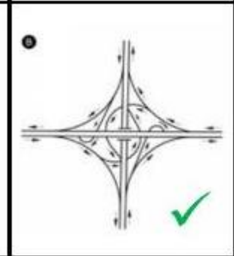
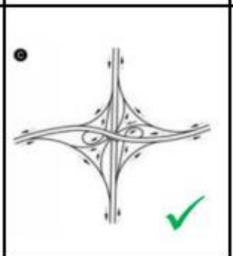
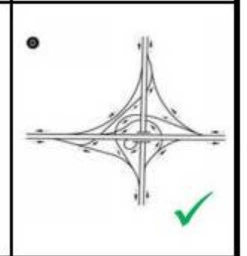
5.2 Value Engineering Session

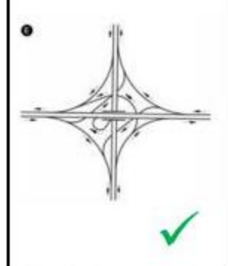
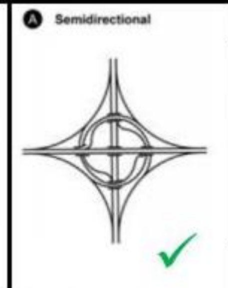
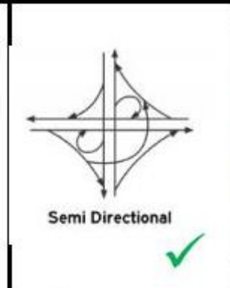
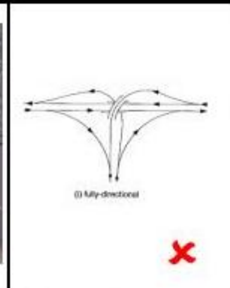
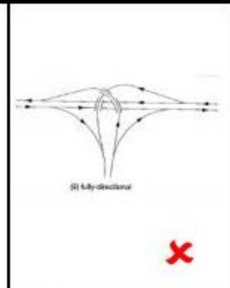
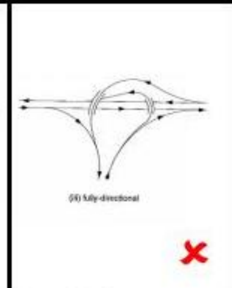
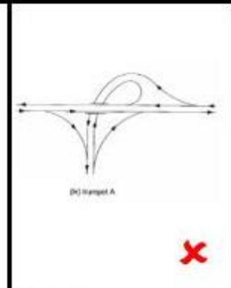
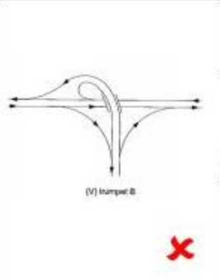
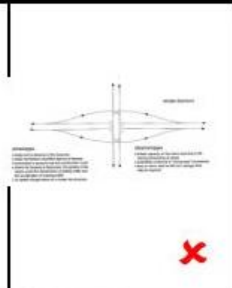
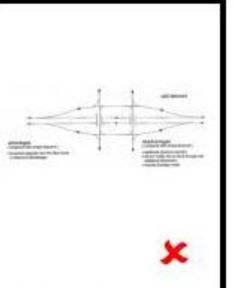
On October 24, 2016 a workshop was held at the Marriott Hotel in Saskatoon (between 12:30pm and 4:30pm) to evaluate potential options for improving the existing interchange. After a brief summary of the existing conditions and constraints by the Project Team, workshop attendees developed an evaluation and ranking system for potential interchange configurations. After some discussion the following criteria was compiled for evaluating each of the potential interchange improvements:

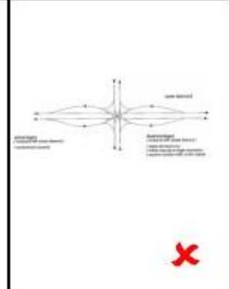
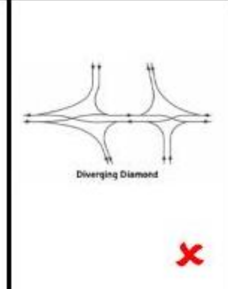
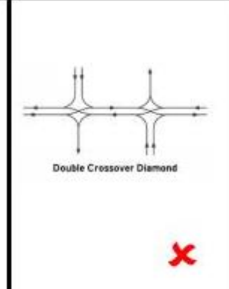
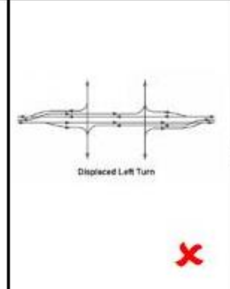
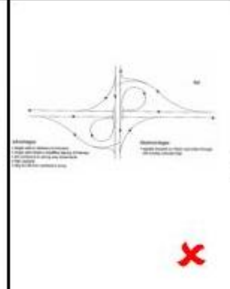
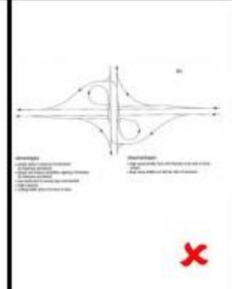
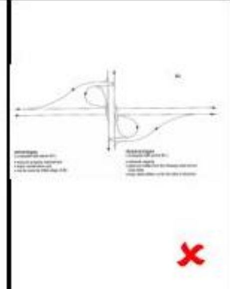
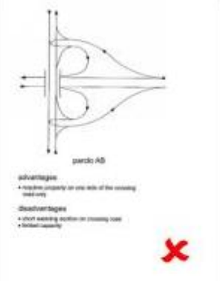
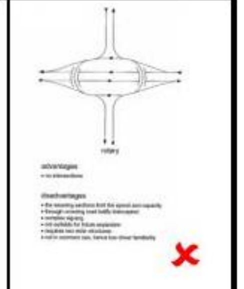
- **Accommodating Oversize Goods Movement** – Corridor must be able to accommodate oversize loads, and facilitate regular sized loads.
- **Improving Weaving** – Weaving lengths for some movements are too short and must be improved
- **Minimizing Resident Impacts** – There should be minimal impacts to existing residents in Stonebridge, Eastview and Lakeview, including visual impacts and noise etc.

Table 5.1: Consideration of All Interchange Configurations

Interchange Configurations Screening (1st Pass, What could work?) Possible configuration for this interchange ✓ Not a possible configuration for this interchange ✗

No.	1	2	3	4	5	6	7	8	9	10
Interchange	Fully Directional	Partially Directional	Partially Directional	Partially Directional	Full Cloverleaf	Cloverleaf + CD Roads	No Weaving	No Weaving	No Weaving	No Weaving
No. of Levels	4	4	4	3	2	2				
Interchange Layout										
TAC ref./Other Ref	Fig 2.4.5.1	Fig 2.4.5.1	Fig 2.4.5.1	Fig 2.4.5.1	Fig 2.4.5.1	AASHTO	AASHTO	AASHTO	AASHTO	AASHTO

No.	11	12	13	13b	14	15	16	17	18	19	20
Interchange	No Weaving	semi-directional	Semi Directional	Proposal Design	Fully Directional	Fully Directional	Fully Directional	Trumpet A	Trumpet B	Simple diamond	Split Diamond
No. of Levels											
Interchange Layout											
TAC ref./Other Ref	AASHTO	AASHTO	FHWA	ISL	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.2	Fig 2.4.5.3	Fig 2.4.5.3

No.	21	22	23	24	25	26	27	28	29	30
Interchange	Point Diamond	Diverging Diamond	Double Crossover	Displaced Left Turn	Parclo A4	Parclo A2	Parclo B4	Parclo B2	Parclo AB	Rotary
No. of Levels										
Interchange Layout										
TAC ref./Other Ref	Fig 2.4.5.3	FHWA	FHWA	FHWA	Fig 2.4.5.4	Fig 2.4.5.4	Fig 2.4.5.5	Fig 2.4.5.5	Fig 2.4.5.6	Fig 2.4.5.6

- **Flexibility for Change in the Future** – Because of uncertainty with the traffic numbers, plans should allow some flexibility for the addition of lanes in future should the traffic numbers warrant it.
- **Meeting Driver Expectations** – Traffic movements should be easy for drivers to understand so that sudden movements and quick decisions are not required
- **Constructability / Traffic Accommodation during Construction** – This interchange cannot be closed during construction and therefore the area must be able to accommodate traffic during this time.

Based on the criteria above, the workshop attendees completed a Paired Comparison Analysis to determine the relative importance of each of the criteria identified above. A summary of the findings is shown in Figure 5.1.

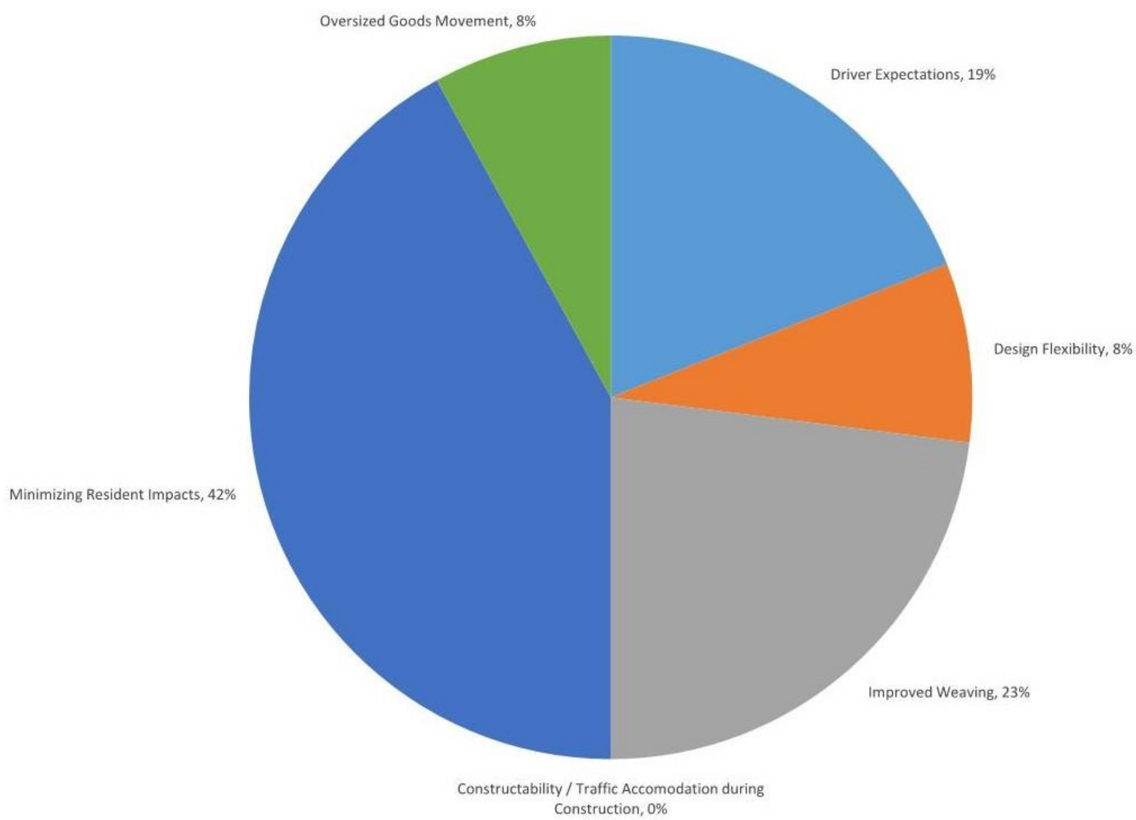


Figure 5.1: Importance of Each Evaluation Criteria

It should be noted that Safety was not included in the evaluation criteria because it is always the top priority, and an unsafe interchange would never be considered.

The members of the workshop were then given the opportunity to create interchange options that would address the issues. In total, eleven interchange options were developed and ranked against the criteria identified above. For more detail on each option, refer to Appendix C.

Following the session, the top three ranked options were refined in more detail to confirm that they work geometrically. One option was rejected and two options were deemed to be viable options. The viable options are shown below.

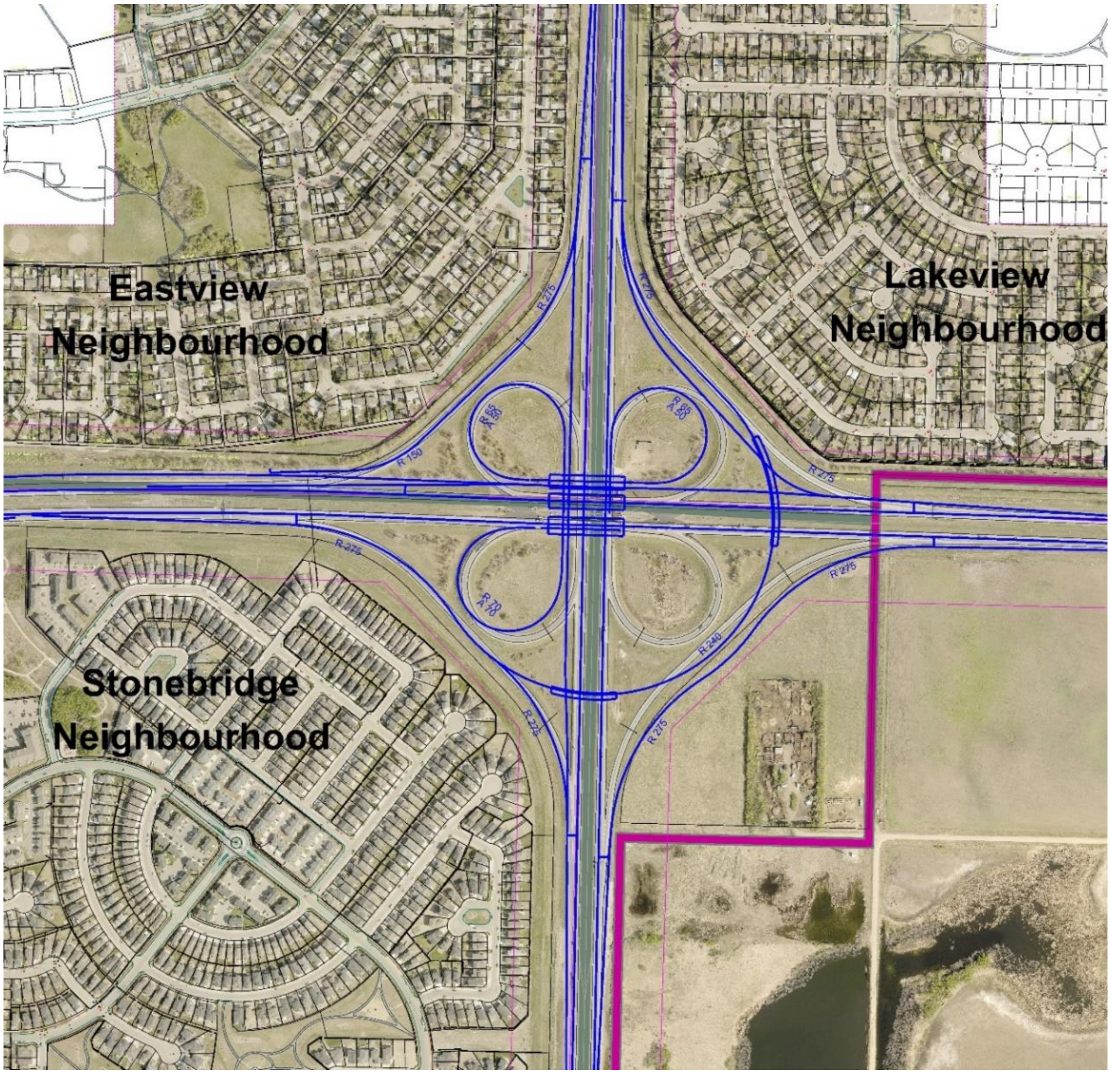


Figure 5.2: Option 1 – Adding an Eastbound to Northbound Directional Ramp

Option 1 removes the eastbound-northbound loop ramp, which is replaced with a high speed directional ramp. Westbound and Southbound collector-distributor roads are also introduced to simplify weaving between adjacent loop ramps.

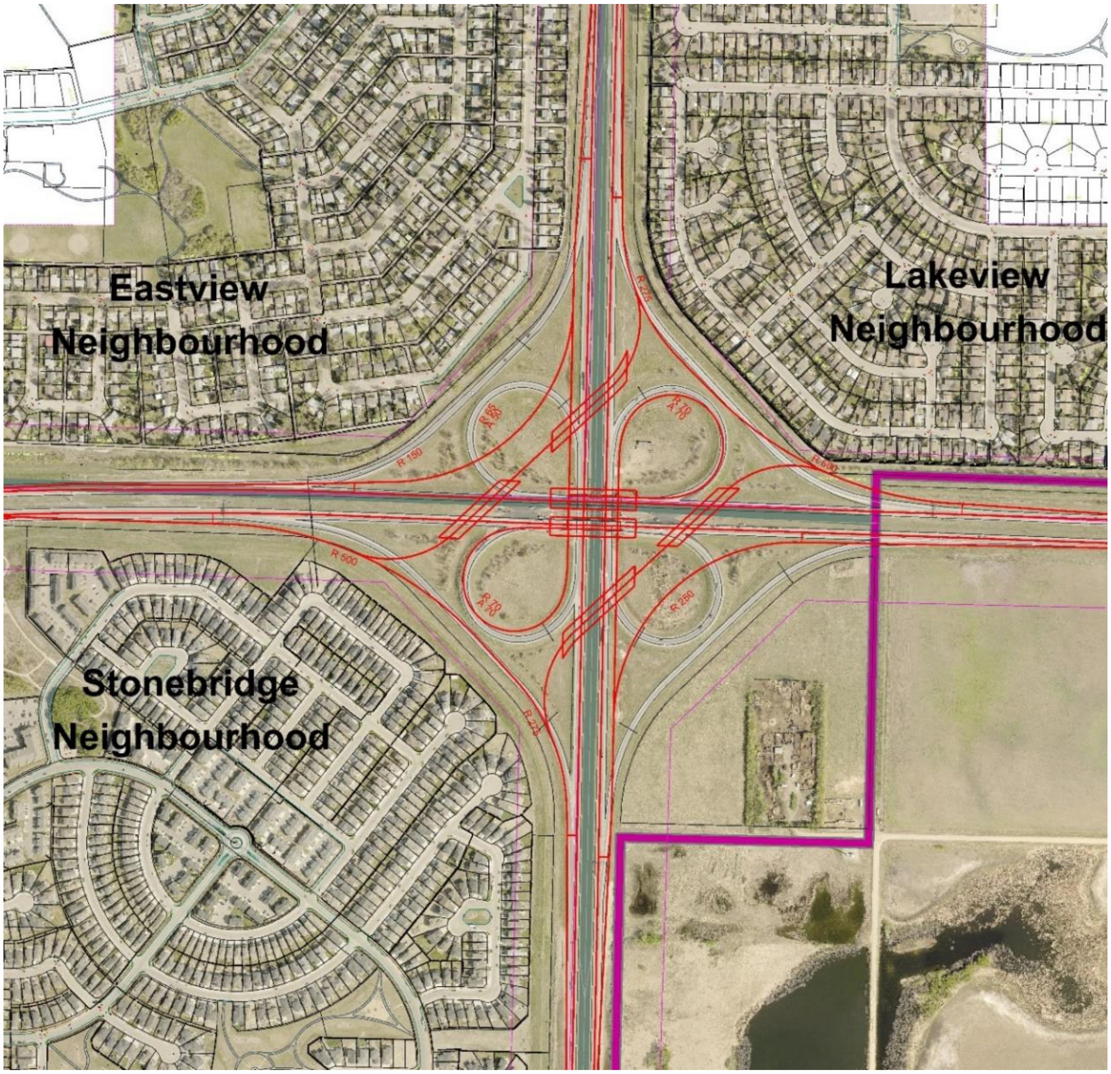


Figure 5.3: Option 2 – Adding Two Directional Ramps

Option removes the eastbound-northbound and westbound-southbound loop ramps, which are replaced with high speed directional ramps. The southbound to southbound-westbound and northbound-eastbound ramps are also relocated closure to the centroid to maximized weaving and reduce proximity to residential areas.

5.3 Public Open House #1

A Public Open House was held on November 28, 2016, to provide area residents and businesses with the opportunity to view project information and discuss their interests and concerns with the project team. The event was held at the Circle Drive Church (3035 Preston Ave South), from 4pm to 8pm.

In preparation for the event, invitations were circulated to City Council and the local community leagues. Invitations were posted on the City website, in the local newspaper, on roadside signs throughout the immediate study area; and the City also used social media to promote the event.

Guests were asked to sign in, and then were given the opportunity to review display boards that showcased the projects progress to date, including: background information and existing constraints, traffic data and projections, interchange configurations that have been rejected (and why), and the two interchange configurations still being considered. A copy of the display boards have been included in Appendix D.

In total, 127 people attended and 32 comments were returned. One additional comment was posted on the Shaping Saskatoon website. There were several reoccurring themes that received in the comment forms:

- Interchange Option B is preferred to Option A (18 to 3) because it removes the weave between the existing loop ramps; seems more intuitive to drivers, it depresses some of the highest volume ramps (helps with noise); and it moves roadways away from the residential areas.
- Traffic safety and operations are an ongoing concerns.
- Local residents are concerned about noise and proximity to their properties.
- Local residents would like the south ramps at Vic Boulevard to be constructed to help address traffic congestion and backtracking, as well as emergency egress.
- Local residents are excited about the recent announcement of the Boychuk interchange.
- Local residents wonder what the impact of the Perimeter Road will have on traffic at this location.
- Local residents are interested in the short-term solutions that will be presented in the spring of 2017.

6.0
Recommended Interchange Plans

An ultimate interchange configuration has been developed to support the long-term travel demands in this region. In addition to improving the operations of this location and addressing the low bridge clearance issues that exist today, the new design will provide additional benefits to Saskatoon by reducing fuel use, emissions and reducing delays to the travelling public. Over the life of the interchange, these savings provide significant economic benefits.

It is anticipated that major improvements to the interchange are several years away, and would likely not occur until the existing bridge structures are at or near the end of their service lives which is approximately 10 to 15 years away.

6.1 Stage 1 Improvements

To address the existing operational issues, short-term improvements have been identified based on the assumption that no modifications would be made to the structures themselves.

A review of the 2041 TDM and 2% growth scenarios on existing interchange configuration model was completed to identify the areas that would benefit the most from these improvements. The following problem areas were identified:

- Southbound right – volumes exceed the capacity of a single lane ramp
- Southbound through (north of the interchange) – there is delay caused by the high volume of weaving vehicles and the high volumes of southbound right turns waiting for the exit ramp
- Eastbound through, southbound left – there is delay caused by the high volume of weaving vehicles between the loop ramps
- Eastbound left – high volumes exceed the capacity of this low speed ramp plus a short weave distance

Based on the problem areas identified above, the following Stage 1 improvements are recommended:

1. Adding a second lane for the southbound to westbound ramp. This will address the capacity issues on the ramp and improve the southbound through movements as well.
2. Constructing the future westbound Collector/Distributor road, including the connection from the westbound exit ramp, a new entrance ramp onto the

mainline, and changes to the Preston Avenue off-ramp. A Collector/Distributor road will remove the weaving condition from the mainline and allow the weaves to occur at lower speeds.
3. Extending the third eastbound auxiliary lane between Preston Avenue and this interchange, allowing vehicles greater time to complete weaves.
4. Extending the downstream weave lanes on the cloverleaf past the exit ramp gore to extend the distance for these vehicles to merge into mainline traffic. This allows drivers extra time to merge onto the mainline.
5. Include a low-speed, high-load bypass lane for northbound traffic to prevent the structures from being struck. An upstream sensor at the Vic Boulevard interchange would notify drivers that their loads are too tall to pass under the interchange, and they would be directed to use the bypass lane. Traffic lights on Highway 16 eastbound and westbound would be activated by the sensors to stop traffic to allow the high load to cross the highway.
6. Replace the yield signs on the loop ramps with merge signs, to alert drivers that they need to find an acceptable gap and proceed. Currently, many drivers are incorrectly treating the yield condition as a stop condition, which has resulted in a high rated of year end type collisions.

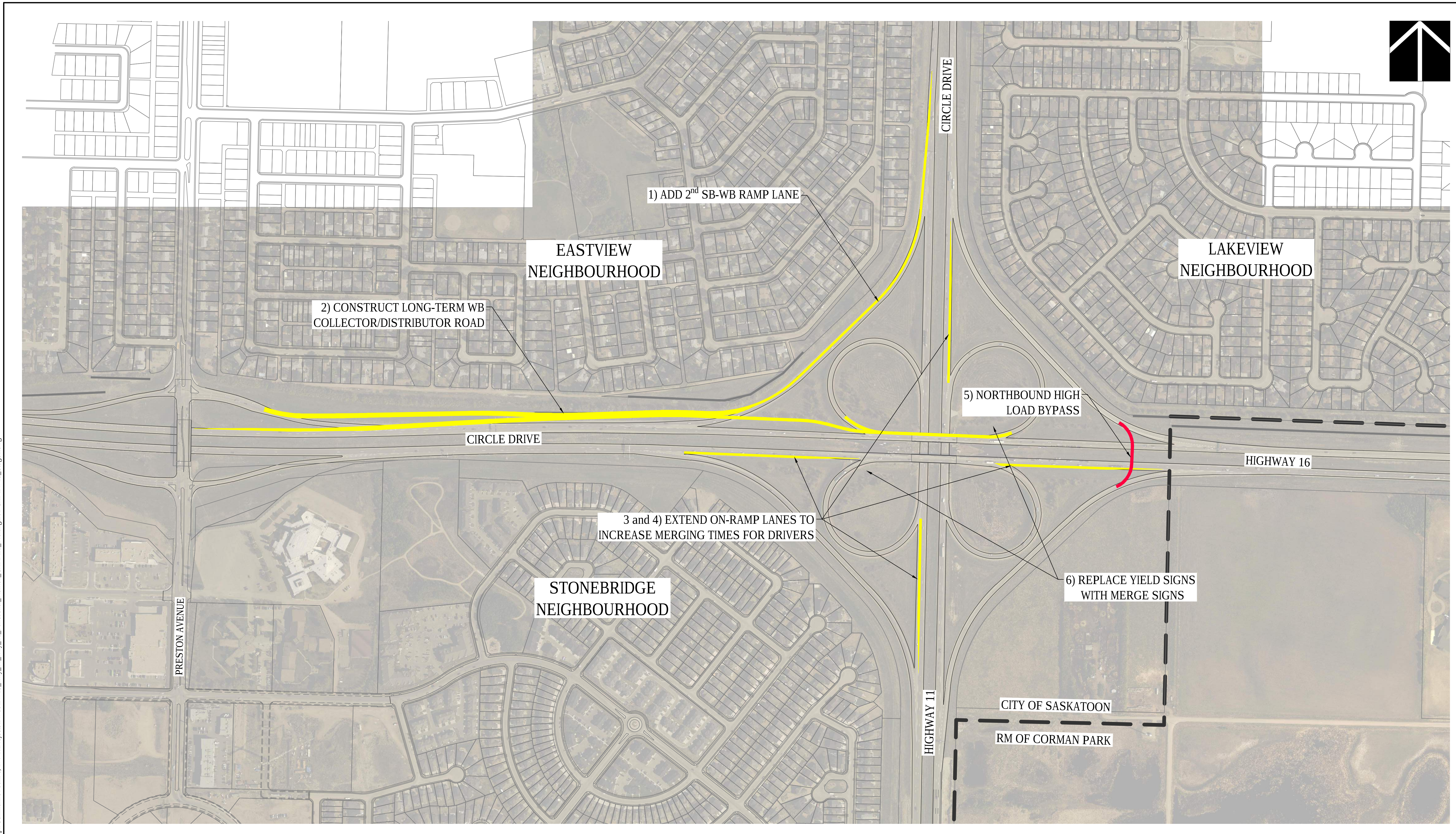
Refer to Exhibit 6.1 for the Stage 1 Recommendations.

Lowering the mainline under the bridges to increase the vertical clearance was considered, but ultimately rejected because the long-term plan will be raising the northbound and southbound lanes, and the remaining life of the structures themselves suggests future investments dependent on their lifecycle should not be made.

6.2 Ultimate Configuration

The main features of the long-term recommended plan are outlined below:

- System interchange maintains free-flow movements in all directions.
- East-west highway will be approximately 4 m higher than existing.
- North-south highway will be approximately 2 m higher than existing.
- Eastbound to northbound directional and westbound to southbound directional will be approximately 6 m below existing ground. The following options were also considered, but ultimately rejected:
    - Keeping all levels above existing ground was considered, but rejected due to the impacts that it would have on the adjacent neighbourhoods. Although the amount of retaining walls is reduced as the cuts are minimized, the fill



Ralph Schimanke / Jun. 6, 17 / T:\Projects\14700\14719_Hwy_11_Hwy_16_Functional_Plan\02_CADD\20_Drafting\201-CAD\14719_Stage1.dwg

ISL Engineering and Land Services

City of Saskatoon

LEGEND

NEW PAVEMENT

TRUCK BYPASS

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

STAGE 1 IMPROVEMENTS

1:3000

EXHIBIT 6-1

JUNE 2017

limits expand, which would ultimately require either the purchase of residential homes, or retaining walls to minimize impacts.

- Having the directional ramps at the top level was considered to remove the expensive directional ramp tunnels; however, the vertical profiles would not work due to the constrained space. The option resulted in vertical grades that exceed the 6% maximum. Depressing the highest volume movement also helps with noise suppression, minimizing the noise wall requirements.
- Having the directional ramps at-grade was also considered, but that would make the vertical grades on the loop ramps too steep as they would have to make a two 8 m level changes.

- Collector/Distributor Roads are provided between this interchange and the interchanges at Preston Avenue and Vic Boulevard to accommodate weaving. By separating the weaving volumes from the mainline, and allowing the weaves to occur at lower speeds, the short weave distances will operate acceptably.
- A two-lane exit ramp onto the eastbound Collector/Distributor Road has been included upstream of the Preston Avenue bridge structure to maximize weaving distances. If the eastbound to northbound volumes are lower than expected, starting the ramp taper immediately after the bridge structure may still provide sufficient weaving space, removing the need for bridge modifications. The exit ramp for Preston Avenue and the eastbound Collector/Distributor Road was combined to obtain proper lane balance. If Circle Drive (west leg) is widened to 6 basic lanes, separate exits would be preferred.
- The option of changing the eastbound on-ramp from Preston Avenue to a loop ramp was considered to expand the weave distance on the Collector/Distributor Road. The current right-of-way will allow for a R50 loop ramp in the southwest quadrant of the Preston Avenue interchange (shown in the sketch below), which would increase the weave distance by approximately 300 m. At the detailed design stage, traffic volumes should be reviewed to determine if the additional weave distance is required.

Figure 6.1: Preston Avenue Interchange Option with Loop Ramp

- The option of creating a basket weave between the Preston Avenue eastbound on-ramp and the eastbound Collector/Distributor Road off-ramp was also considered, shown on the sketch below. This option would remove the eastbound weave condition completely, but would require an additional bridge structure and retaining walls parallel to the westbound mainline. Due to the increase in costs and right-of-way impacts on the local church, this option is not recommended unless it is operationally required.

Figure 6.2: Preston Avenue Interchange Option with a Basket Weave

- A two-lane entrance ramp onto Circle Drive (west leg) has been included from the westbound Collector/Distributor Road to accommodate the high volume southbound to westbound movement. Both lanes have fully merged with the westbound lanes prior to the bridge structure; however, if Highway 11 is

widened to 6 basic lanes and the bridge structure is being widened anyway, the merge lengths can be extended to improve operations. However, for Circle Drive to be widened, the Preston Avenue bridge structure will also need to be widened.

- Loop ramps accommodate the southbound to eastbound and northbound to westbound movements. These are low volume movements which can easily be accommodated on the low speed ramps.
- The new plan will require seven new bridge structures, one bridge widening, two tunnels, and significant amounts of retaining wall and noise wall.
- The northbound to eastbound ramp and the southbound to westbound ramps are moved closer to the centroid of the interchange, maximizing the potential weave distance to the adjacent ramps.
- The northbound to eastbound ramp and the southbound to westbound ramps are shown with tunnels under the east/west highway, and bridges under the north-south highway. The decision to use bridges under the north/south highway was made to reduce construction costs by approximately $12M. It is possible that the tunnels under the east-west highway could also be replaced with bridges, however, there would be significantly more earthwork to waste on the project, and noise attenuation would need to be reassessed.

For detailed plan and profiles, refer to Appendix A; and for detailed cross-sections refer to Appendix B.

The following issues still need to be addressed at the design stage, or by other studies:

- Since the final design at Boychuk Drive was not available at the time of this report, the weaving to/from that interchange should also be reviewed at the design stage. Additional Collector/Distributor roads may be required.
- West of Clarence Avenue Circle Drive (west leg) has 6 basic lanes, tapering down to 4 basic lanes immediately east of the bridge structure. Based on the design volumes developed for this project, it is very likely that the 6 basic lanes will need to be extended to the east. Unfortunately, the Preston Avenue bridge design does not appear to accommodate this widening, and major bridge work will be needed.

  As this study also requires bridge widening at Preston Avenue (to accommodate the double lane exit ramp to the eastbound Collector/Distributor Road), future design work should accommodate both requirements at the same time. Once the eastbound mainline is expanded to 6-lanes, consecutive exit ramps should be considered.

If the Preston Avenue bridge is widened to accommodate 6 basic lanes on Circle Drive, the design of the 2-lane on-ramp from the westbound Collector/Distributor Road should be reviewed and preferably extended to allow for additional merge time.

- A two-lane entrance ramp from the eastbound to northbound directional ramp has been included to accommodate the high volume anticipated for this movement. Downstream, the plans show the four lanes diverge, with a double exit ramp to Taylor Street, and three lanes continuing straight (tapers to two lanes prior to the bridge structure). While this design achieves lane balance, the City is concerned that the lane configuration will be confusing to local drivers. If Circle Drive is not expanded to 6 basic lanes, this area should be reviewed at the design stage to see if other options are possible. It does not appear that the Taylor Street interchange was designed to accommodate future widening of Circle Drive in the future.

6.3 Traffic Operations

The recommended interchange was modelled in VISSIM, confirming that the interchange would operate successfully for both scenarios. The model found:

- the proposed design is capable of accommodating the high volumes projected using the 2% growth scenario and the TDM scenario;
- delays are greatly reduced in the ultimate configuration for both growth scenarios;
- travel times are similar or lower than what is experienced today, with the greatest improvements seen on the movements accommodated by the directional ramps; and
- travel times are consistent across all traffic volume scenarios tested, indicating the ultimate configuration will provide greater reliability in travel times.

Refer to Appendix E for more details.

6.4 Construction Staging

For the purpose of this report, a construction staging plan was developed to confirm that the project can be constructed. The construction staging plan shown in Table 6.1 is one of several options that may be implemented. Refer to Appendix J for more details.

Table 6.1: Potential Construction Staging Sequence

Stage	Under Construction	Removals	Traffic Detours
1	• Reconstruct the WB-NB ramp.	• WB-NB ramp	• WB-NB ramp would share NB-WB ramp abutment
2	• Reconstruct the WB mainline and related bridge structures. • Reconstruct part of the NB-WB loop ramp. • Construct the EB Collector/Distributor Road. • Construct the SB Collector/Distributor Road, south of the interchange.	• WB-SB loop ramp	• WB mainline would share existing EB lanes, with transitions across the median before and after the construction zones. • On the EB mainline, a temporary signal would be installed with temporary ramp connection to accommodate the NB-WB movement. • WB-SB movements would be diverted through the Preston Avenue interchange.
3	• Reconstruct the EB and SB mainlines and related bridge structures. • Reconstruct the SB-WB ramp and SB-EB loop ramp. • Reconstruct the NB-EB ramp. • Construct the SB off-ramp to Vic Boulevard.	• EB-NB loop ramp	• EB mainline would share the new WB lanes, with transitions across the median before and after the construction zones. • SB mainline would share existing NB lanes, with transitions across the median before and after the construction zones. • On the EB mainline a temporary signal would be installed with a temporary ramp connection to accommodate the EB-NB movement. • SB-EB and WB-SB movements would be diverted through the Preston Avenue interchange.
4	• Reconstruct the NB mainline and related bridge structures.	• Remove original NB-EB ramp.	• NB mainline would share the new SB lanes, with transitions across the median before and after the construction zone. • On the WB mainline a temporary signal would be installed with a temporary ramp connection to accommodate the EB-NB movement. • On the SB mainline and Collector/Distributor Road temporary signals would be installed with a temporary ramp connection to accommodate the NB-WB movement on to the long-term SB-WB ramp. • WB-SB movements would be diverted through the Preston Avenue interchange.
5		• Remove temporary connections. • Remove original SB-WB ramp.	

6.5 Public Open House #2

A Public Open House was held on April 12, 2017 to provide area residents and businesses with the opportunity to view project information and discuss their interests and concerns with the project team. The event was held at the Circle Drive Church (3035 Preston Avenue South), from 4pm to 8pm.

In preparation for the event, invitations were circulated to City Council and the local community leagues. Invitations were also posted on the City website, in the local newspaper, and on roadside signs throughout the immediate study area; and the City used social media to promote the event.

Guests were asked to sign in, and then were given the opportunity to review display boards that showcased the projects progress to date, including: background information and existing constraints, a summary from Open House #1, the short- and long-term recommendations (including impacts on the environment, noise attenuation, utilities and stormwater management), and the opinion of probable costs. A copy of the display boards have been included in Appendix D.

Figure 6.3: Rendering of Proposed Interchange, looking south

In total, 98 people attended, and 6 comment forms were returned with the following comments:

- Seems like a total overkill just raise the existing overpasses or lower the road. Since they didn't include off ramps out of Stonebridge to Regina and back into Stonebridge from Regina all that traffic ends up in the cloverleaf now. Those ramps should have been built.
- Before you do anything get some left turn arrows on Preston and Taylor so a person can turn off to the left without a 20 minutes wait.
- Consideration given to: snow removal?, flooding?
- Way too many roads, way too many bridges, the merging speeds increased. Accidents will be more serious. These limited resources could be used much more effectively. Boychuk approach is excellent!
- Curious how the aquifer 35m deep is impacted or impacts on this construction. I imagine the two tunnels are very expensive – what part of the total $258M are they? $258M seems a lot when there are some aspects of the interchange that are not likely to be exchanged appreciably.
- The west bound ramp to the C.D. road on the west bound lanes looks very tight and uncomfortable to drive while approaching a merge. This is a very expensive option. Is there nothing less expensive?

7.0 Geotechnical Overview

A Geotechnical Desktop Screening was completed by Golder Associates for this project. The entire report is located in Appendix F. In general, the geology in this region comprises of surficial stratified deposits overlying a thick stratum of clayey glacial tills, overlying clay shale deposits (bedrock). Groundwater levels have been recorded between 1.5 m and 6 m below the surface.

Recommendations for Embankments and Roadways:

- Consideration should be given to the potential for encountering poorly graded silty sand which is highly frost susceptible or clean poorly graded sands which may require stabilization. Silts are highly frost susceptible and can cause significant movements in roadway and interchange embankments in Saskatchewan's climate. Frost action in silt subgrades can be mitigated by subgrade excavation and replacement with free draining granular material and by providing subgrade drainage. However, silts are not recommended for subgrade or embankment construction.
- When using clay fill for the embankments, it is important to monitor pore water pressures which can increase and then dissipate slowly over an extended time period due to the low hydraulic conductivity of the soil. Consolidation of the clay soil material only occurs after the excess pore water pressure dissipates and stress is transferred to the soil structure. If pavement structures are constructed on clay embankments before most of the consolidation has occurred, the structures may crack and shift as the embankment settles. Dewatering measures to lower possible high groundwater tables may be required and placement of fill embankments well in advance of construction should be considered to expedite consolidation of the subgrade materials and reduce settlement damage. Instrumentation to monitor pore water pressures, settlement, and lateral deformation may be required in any approach embankments.
- According to the SaskWater well database, glacial till can be up to 40 m or greater below surface; however, it would be uneconomical to excavate to these depths for borrow material. Utilizing low to medium plastic cohesive glacial tills to construct the roadway and interchange embankments will provide good consistent subgrade support and will reduce the thickness of pavement structure required to support the anticipated traffic loading. Glacial tills are also superior to clay for the construction of interchange embankments.

- Construction through any wetlands created by the water channels and sloughs would likely require dewatering, excavation of organic materials, and backfilling with more stable materials. Road grade construction through these types of areas may require use of geotextile materials to reduce the extent of subgrade excavation and backfill.

Recommendations for the foundations for structures and sideslopes:

- Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site.
- Cast-in-place piles within the silt, sand and gravel surficial deposits may require sleeving.
- Boulders are commonly found at random or in layers within the Saskatchewan glacial tills.
- The Forestry Farm Aquifer is about 35 m below surface and should be considered when determining pile lengths, excavations and cuts.
- Concrete in contact with the soil should be produced with sulphate resistant Portland cement.
- The current study area would not be expected to have any existing slopes that may cause issues; however, slopes within trenches, excavations and cuts may become unstable over time depending on ground moisture conditions, fluctuations in the groundwater table and changes to surface drainage patterns.

8.0 Environmental and Heritage Overviews

A Desktop Environmental Screening was completed by Golder Associates for this project. The entire report is located in Appendix G.

8.1 Heritage Resources

According to the Developers' Online Screening Tool (Ministry of Parks, Culture and Sport 2017), five quarter sections overlapping the proposed Project are potentially heritage sensitive lands, including the E ½ 11, SE 15, and the S ½ 14-36-05 W3M. A review of the Project activities on the potentially heritage sensitive lands should be submitted to the Heritage Conservation Branch to determine if an Heritage Resources Impact Assessment is required to be completed.

8.2 Terrains and Soils

The project is located within the Saskatoon Plain Landscape Area within the Moist Mixed Grassland Ecoregion. The Saskatoon Plain is a gently undulating glaciolacustrine and eroded glacial till plain with elevations ranging from 500 to 520 m near the South Saskatchewan River. Historical soil survey data for the Project footprint indicates that terrain in the upland outside of the South Saskatchewan River valley is typically undulating to hummocky with slopes between 0.5% and 10%.

Recommendations for handling soils on site include:

- Topsoil should be stripped and stored separately from subsoils to prevent admixing.
- Saturated, potentially saline, soils are associated with wetlands. Topsoil in these areas should be stripped and stored separately to prevent admixing with subsoils.
- Salvaged topsoil should be replaced on graded back slopes or recontoured slopes once construction is complete.
- Seeding should occur on disturbed areas where topsoil is replaced.
- Equipment should arrive on-site clean and free of soil and plant material (i.e. weed seeds).

8.3 Surface Water

The following wetlands were identified in the immediate study area:

- Class IV semi-permanent wetland located in 13U 390025 5772401, north of the interchange. The majority of the wetland is regularly mowed during the growing season.
- Class IV semi-permanent wetland is located in the southeast loop of the interchange and is typically not mowed.
- Class IV semi-permanent wetland is located at 13U 391085 5772124, south of Highway 16 in SW 13-36-05 W3M.
- Class III seasonal wetland is located between the southeast loop of the Interchange and the Highway 11 off ramp to the east at 13U 390096 5771924.
- Three Class IV semi-permanent wetlands occur east of Highway 11 in the NE 11-36-05 W3M at 13U 390119 5771658, 13U 390080 5771334, and 13U 390170 5771147. Another large Class IV wetland occurs in this quarter section, but further east from the Project.
- Additionally, there are several runoff storage ponds that have been constructed by the City. These storage ponds often act as semi-permanent or permanent wetlands, including:
    - Class V wetland located at 13U 391512 5772100, immediately south of Highway 16 in SE 13-36-05 W3M;
    - Pond located 380 m west of Highway 11 in the N ½ 11-36-05 W3M; and
    - Pond located 550 m east of Highway 11 in the NW 13-36-05 W3M.

An Aquatic Habitat Protection Permit (AHPP) may be required from MOE for the crossing or alteration of wetlands.

Recommendations for construction near these wetlands include:

- Erosion and sediment control practices should be implemented where appropriate and excavated topsoil and subsoil has been stored in such a manner as to avoid sediment transfer into the wetlands crossed by or adjacent to the Project.
- Equipment should be inspected for leaks prior to entry into the Project area, and throughout the duration of construction.
- Equipment will be limited to working within the Highway and Interchange right-of-way and staging areas.

- Spill response equipment should be on-site during construction, and any spills will be isolated and cleaned up immediately, to minimize the potential of a release into the wetland crossed by or adjacent to the Project.
- Stationary equipment such as water pumps should have secondary containment to prevent fluids from entering water bodies in the event of a spill or leak.
- Fuel for equipment and water pumps should be stored 100 m from wetlands.
- Hydraulic hose changes, oil changes, or maintenance activities on equipment should be kept to a minimum area and oils, greases, and fuels should be contained so as not to contaminate soil or wetlands in the area.

8.4 Vegetation

The project is located within an existing disturbance corridor; as such, the habitat crossed by the project has a low to moderate potential to support listed plant species. Based on the literature review, there are no federally listed plant species under COSEWIC and/or SARA within the 3 km of the Interchange. Within the same area, there are 11 provincially listed plant species, shown in Table 8.1.

Table 8.1: Listed Plant Species within 3km of the Interchange

Species	SK Provincial Listing
American bugseed (Corispermum americanum var. americanum)	S3 – Rare / uncommon
Blue wild rye (Elymus glaucus ssp. glaucus)	S3 – Rare / uncommon
Bristly gooseberry (Ribes oxyacanthoides ssp. setosum)	S2 – Rare
Columbia needlegrass (Achnatherum nelsonii ssp. dorei)	S3 – Rare / uncommon
Hairy bugseed (Corispermum villosum)	S2 – Rare
Hooker's bugseed (Corispermum hookeri var. hookeri)	S2 – Rare
Longstem water-wort (Elatine triandra)	S2 – Rare
Mucronate blue-eyed grass (Sisyrinchium mucronatum)	S3 – Rare / uncommon
Pallas' bugseed (Corispermum pallasii)	S2 – Rare
Red-stemmed cinquefoil (Potentilla rubricaulis)	S3 – Rare / uncommon
Tall blue lettuce (Lactuca biennis)	S3 – Rare / uncommon

Wild Blue Rye

Recommendations for construction include:

- Localized clearing of trees and tall shrubs may be required, but should be kept to the minimum amount necessary.
- Weed species likely occur within the existing roadside ditches, so appropriate vegetation management should be considered to prevent seed production and to mitigate the transfer and spread of these species.
- Pre-construction listed plant surveys should occur in and adjacent to the Project footprint.
- If any listed plants are found in the Project footprint, MOE should be contacted to discuss mitigation measures. Activity restriction guidelines for sensitive plant and wildlife species are provided in Appendix A of the Environmental Report.

8.5 Wildlife

Although most of the project area has been extensively modified for residential and transportation corridor development, suitable wildlife habitat remains, including nesting habitat. Based on the literature review, there are no federally or provincially listed species in the study area, and there are no suitable fish habitat is located with the project area. However, twenty-eight (28) federally and/or provincially listed species have potential to occur within the project area based on available habitat types. The species and their ranking status is listed below in Table 8.2.


Short Eared Owl


Monarch Butterfly


Common Nighthawk


Peregrine Falcon

Table 8.2: Listed Species with some Potential to Occur within the Study Area

Species	Species at Risk Act	COSEWIC	SK Provincial Listing
Amphibians and Reptiles			
Great plains toad (Bufo cognatus)	Special Concern - Schedule 1	Special Concern	S3
Northern leopard frog (Lithobates pipiens)	Schedule 1	Special Concern	S3
Birds			
Western grebe (Aechmophorus occidentalis)	No Status or Schedule	Special Concern	S3B / S3M
Baird's sparrow (Ammodramus bairdii)	No Status or Schedule	Special Concern	S4B
Sprague's pipit (Anthus spragueii)	Threatened - Schedule 1	Threatened	S3B / S3M
Short-eared owl (Asio flammeus)	Special Concern - Schedule 1	Special Concern	S3B / S2N / S3M
Burrowing owl (Athene cunicularia)	Endangered - Schedule 1	Endangered	S2B / S2M
Ferruginous hawk (Buteo regalis)	Threatened - Schedule 1	Threatened	S3
McCown's longspur (Calcarius mccownii)	Special Concern - Schedule 1	Threatened	S3B
Chestnut-collared longspur (Calcarius ornatus)	Threatened - Schedule 1	Threatened	S3B
Red knot (Calidris canutus rufa)	Endangered, Schedule 1	Endangered	S2M
Piping plover (Charadrius melodus)	Endangered - Schedule 1	Endangered	S3B
Common nighthawk (Chordeiles minor)	Threatened - Schedule 1	Threatened	S4B / S4M
Olive-sided flycatcher (Contopus cooperi)	Threatened - Schedule 1	Threatened	S4B / S4M
Yellow rail (Coturnicops noveboracensis)	Special Concern - Schedule 1	Special Concern	S3B / S3M
Bobolink (Dolichonyx oryzivorus)	No Status	Threatened	S4B / S4M

Species	Species at Risk Act	COSEWIC	SK Provincial Listing
Rusty blackbird (Euphagus Carolinus)	Special Concern - Schedule 1	Special Concern	S3B / SUN / S3M
Peregrine falcon (Falco peregrinus anatum)	Special Concern - Schedule 1	Special Concern	S1B / SNRM
Whooping Crane (Grus Americana)	Endangered – Schedule 1	Endangered	SXB / S1M
Barn swallow (Hirundo rustica)	No Status	Threatened	S5B / S5M
Loggerhead shrike (Lanius ludovicianus excubitorides)	Threatened - Schedule 1	Threatened	S2B / S2M
Long-billed curlew (Numenius americanus)	Special Concern - Schedule 1	Special Concern	S3B / S4M
Horned grebe (Podiceps auritus)	No Status	Special Concern	S5B / S5M
Bank swallow (Riparia riparia)	No Status	Threatened	S4B / S5M
Mammals			
Little brown bat (Myotis lucifugus)	Endangered - Schedule 1	Endangered	S4
Northern myotis (Myotis septentrionalis)	Endangered - Schedule 1	Endangered	S3
American badger (Taxidea taxus taxus)	No Status or Schedule	Special Concern	S3
Arthropods			
Monarch Butterfly (Danaus plexippus)	Special Concern - Schedule 1	Endangered	S2B

- Provincial Rank Definitions S1 Critically Imperiled – Very high risk of extinction or extirpation;
- S2 Imperiled – A high risk of extinction or extirpation;
- S3 Vulnerable – Moderate risk of extinction or extirpation;
- S4 Apparently Secure – Uncommon, but not rare;
- S5 Secure – Demonstrably secure under present conditions.
- B – for a migratory species, rank applies to the breeding population in the province.
- M – for a migratory species, rank applies to the transient population in the province.
- N – for a migratory species, rank applies to the non-breeding population in the province.

The South Saskatchewan River, approximately 5 km from the study area, is a Migratory Bird Concentration Site (MBCS). This MBCS is considered locally significant for staging geese including 1,000 to 5,000 snow geese and Ross' geese, and 1,000 to 3,000 Canada Geese, and greater white-fronted geese. The study area maybe used by these birds during their migration. Additionally, all migratory bird species and their nests, eggs, and young are protected by the Migratory Birds Convention Act (1994).

Recommendations for construction include:

- Disturbance to wildlife habitat may occur, specifically the clearing of woodlands, removal of low vegetation cover, and alteration or removal of wetlands.
- Disturbance to nesting migratory bird species is possible, depending on timing of construction. Pre-construction nest surveys may be required considering construction will occur within the nesting periods (between April 15 and August 15) for most avian species (Environment and Climate Change Canada 2016).
- Active nests should be avoided by buffer distances determined by either MOE or Environment and Climate Change Canada.

9.0 Structures

9.1 Short-term Improvements

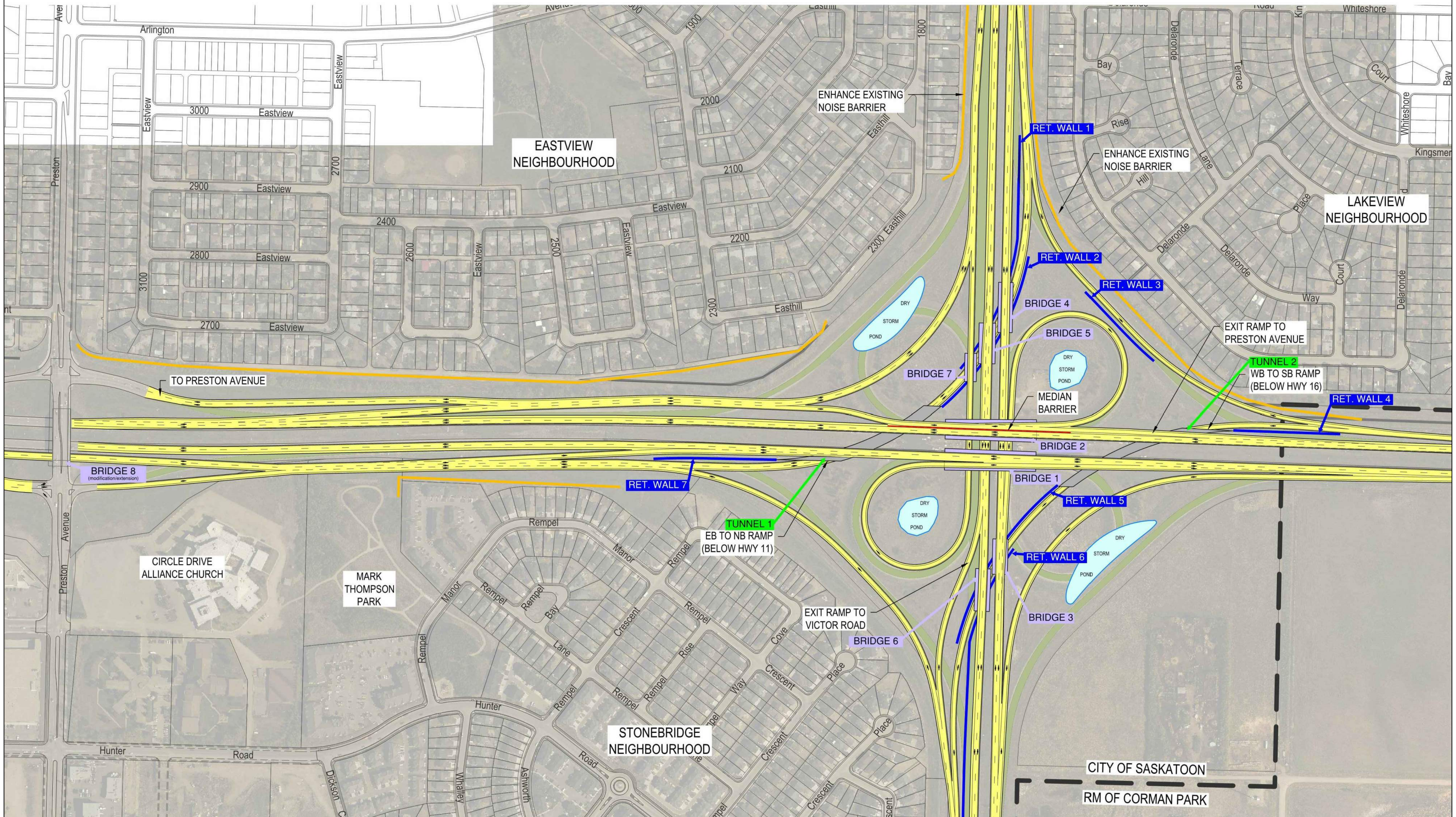
The bridge structures were constructed in 1966, and despite being fifty years old it would seem they are structurally sound and with some rehabilitation could last another 25 years. Some rehabilitation was completed in 1989, but the level of repairs to the deck is unknown at this time. There is minimal concrete cover on the rebar in the deck and the testing at that time indicated that chlorides are at or very near the bar level, meaning corrosion induced deterioration is at an early stage of occurrence in the deck. Based on the testing completed in 2012, the expectation is that there would be 2 phases of work to prolong the life of the structures:

- The first phase of work occurred in 2015 and focused on completing repairs to the expansion joints, abutments and piers. The City invested a significant amount of money to take the joints out and convert the abutments from conventional to semi-integral abutments.
- The second phase of work would focus on the deck, which is expected to occur between 2018 and 2032 with the most likely year for rehab being 2025. This would be a major rehabilitation and it is expected to include removal/replacement of the asphalt wearing surface and waterproofing membrane along with 100 mm of concrete deck thickness. The barriers/railing would also be replaced as part of the major deck rehabilitation; however, the barriers are in very poor condition already, and may accelerate repair timelines.

9.2 Long-Term Improvements

The recommended interchange configuration requires nine new structures, one bridge modification and a significant number of retaining walls. The location of each bridge and retaining wall is shown on Exhibit 9.1.

- Eastbound mainline bridge (Bridge 1);
- Westbound mainline bridge (Bridge 2);
- Eastbound to northbound directional ramp structures:
    - Tunnel structure under eastbound and westbound mainline (Tunnel 1);
    - Bridge carrying northbound mainline (Bridge 4);
    - Bridge carrying southbound mainline (Bridge 5);
    - Bridge carrying southbound to eastbound traffic (Bridge 7);



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION

LOCATION OF STRUCTURES

SCALE: AS NOTED

EXHIBIT 9-1

JUNE 2017

- Westbound to southbound directional ramp structures:
  - Tunnel structure under eastbound and westbound mainline (Tunnel 2);
  - Bridge carrying northbound mainline (Bridge 3);
  - Bridge carrying southbound mainline (Bridge 6);
- Preston Avenue bridge modification to accommodate eastbound off-ramp exit to Collector/Distributor Road (Bridge 8).

Design parameters are evaluated and discussed in this section for each structure to ensure that they meet acceptable standards.

Golder Associates Ltd. (Golder) provided a Geotechnical Desktop Screening Report for this project (draft version dated March 15, 2017). In the report, Golder states that driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site. A geotechnical test drilling investigation is recommended in order to provide specific recommendations for this project. At a minimum, the following items need to be addressed in the detailed design investigation to the interchange:

- structural test holes for bridge foundations;
- confirm underlying soils in the footprint of the fills; and
- confirm slope stability requirements for headslopes.

From there, foundation types and headslopes will be reviewed and a preferred method will be selected at the detailed design stage.

9.2.1 Eastbound Mainline Bridge

Proposed Bridge 1 (On Square)

The proposed structure is based on a preliminary out to out length of 101.5 m on square associated with the proposed lane arrangement for the northbound and southbound traffic as well as the SB-EB loop ramp and the NB-WB loop ramp movements. A two span structure with spans of 51 m and 40 m is being proposed at this early stage. A tentative structure depth of 2.5 m may be used for preliminary design purposes and appears to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 1 Section

The bridge will accommodate 2-3.7 m lanes, a gore, 1-5.0 m ramp lane, shoulders as well as bridge barriers. With a design speed of 110 km/h, the shy line offset distance is 2.8 m which creates 2.8 m shoulders on the structure. Refer to Exhibit 9.2 for more details.

Clear Zone

Following TAC's Design Guide with an AADT greater than 6,000 under the structure the clear zones are found to be:

- 6.0 m using 80 km/h design speed for the SB-EB loop ramp
- 9.0 m using 110 km/h for the mainline
- 6.5 m using 88 km/h for the NB-WB loop ramp

Clear zones below the bridge structure are adequate to the abutments due to the 2:1 headslope. The 9.0 m clear zone to the pier cannot be achieved and will require barrier protection. These barrier details are to be verified in detailed design.

Deck Drainage

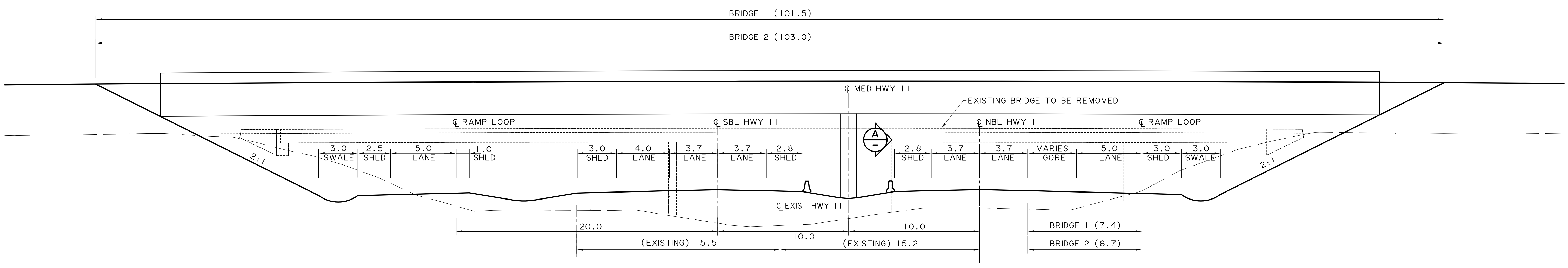
The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. Since the soils in this general area have supported 2:1 headslopes with fills, the preliminary out to out of structure length is based on 2:1 headslopes. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills and soil stability analysis should be undertaken during the detailed design phase to verify assumptions.

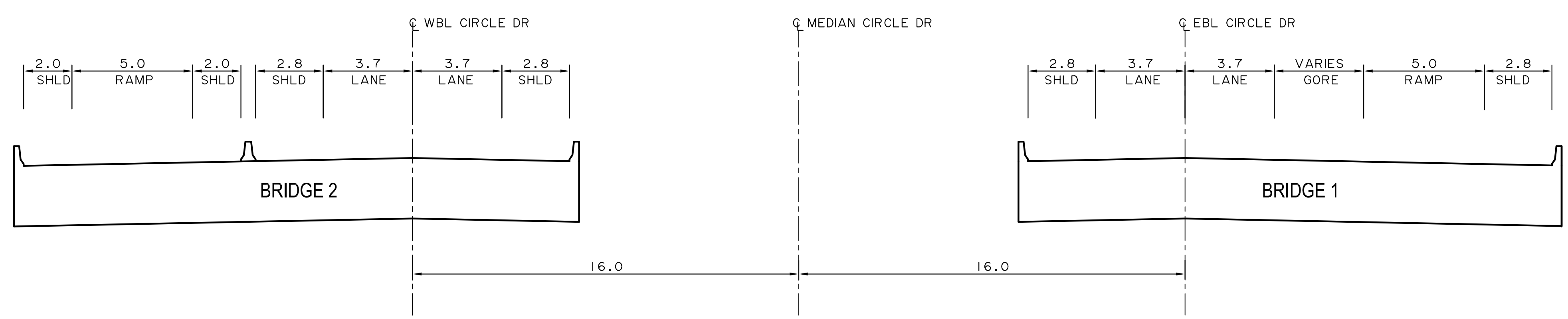
Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $10.3M before contingency and engineering fees. This cost is based on 2017 dollars, and incorporates 2:1 bridge headslopes adjacent to the northbound and southbound mainlines.



BRIDGE 1 & 2

LOOKING NORTH 1:300



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION

BRIDGE 1 & 2 LAYOUTS

SCALE: AS NOTED

EXHIBIT 9-2

JUNE 2017

9.2.2 Westbound Mainline Bridge

Proposed Bridge 2 (On Square)

The proposed structure is based on a preliminary out to out length of 103 m on square associated with the proposed lane arrangement for the northbound and southbound traffic as well as the SB-EB loop ramp and the NB-WB loop ramp movements. A two span structure with spans of 52 m and 41 m is being proposed at this early stage. A tentative structure depth of 2.5 m may be used for preliminary design purposes and appears to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 2 Section

The bridge will accommodate 2-3.7 m lanes, a 2.0 m separation barrier, 1-5.0 m ramp lane, shoulders as well as bridge barriers. With a design speed of 110 km/h, the shy line offset distance is 2.8 m and with a design speed of 80 km/h the shy line offset distance is 2.0 m which make up the shoulders on the structure. Refer to Exhibit 9.2 for more details.

Clear Zone

Following TAC's Design Guide with an AADT greater than 6,000 under the structure the clear zones are found to be:

- 6.0 m using 80 km/h design speed for the SB-EB loop ramp
- 9.0 m using 110 km/h for the mainline
- 6.5 m using 88 km/h for the NB-WB loop ramp

Clear zones below the bridge structure are adequate to the abutments due to the 2:1 headslope. The 9.0 m clear zone to the pier cannot be achieved and will require barrier protection. These barrier details are to be verified in detailed design.

Deck Drainage

The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. Since the soils in this general area have supported 2:1 headslopes with fills, the preliminary out to out of structure length is based on 2:1 headslopes. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills and soil stability analysis should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $11.4M before contingency and engineering fees. This cost is based on 2017 dollars, and incorporates 2:1 bridge headslopes adjacent to the northbound and southbound mainlines.

9.2.3 EB-NB Directional Ramp Tunnel under EB and WB mainline

Proposed Tunnel 1

Due to the elevation difference in excess of 14 m between the road profiles at this location, a tunnel structure is proposed to eliminate retaining walls with excessive height. The proposed structure is based on a preliminary tunnel length of 273 m. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Tunnel 1 Section

The tunnel will accommodate 2-3.6 m lanes, a 2.0 m maintenance sidewalk, ventilation, and underpass barriers. A vertical clearance of 5.6 m is provided following the minimum requirement. Due to the length of the tunnels emergency escape locations will need to be provided. Refer to Exhibit 9.3 for more details.

Horizontal Clearance

The tunnel will provide horizontal clearance for the design speed of 80 km/h as required by TAC at bridges on urban freeway underpasses.

Drainage

Drainage details within the tunnel will need to be explored in detailed design. The structure is on a vertical sag curve and drainage will need to be verified in the detailed design stage to ensure adequate drainage through the structure.

Geotechnical

Tunnel construction is assumed to be open cut. A further geotechnical assessment should be undertaken during the detail design phase to verify existing soil conditions and construction slope stability.

Estimated Construction Costs

Structure cost for the proposed tunnel structure is estimated to be $36.9M before contingency and engineering fees based on 2017 dollars.

9.2.4 Bridge carrying NB Mainline over EB-NB Ramp

Proposed Bridge 4

The proposed structure is based on a preliminary out to out length of 42.6 m on a right hand forward skew with retaining walls associated with the proposed two 3.6 m lane arrangement for the EB-NB directional ramp. A single span structure and a tentative structure depth of 2.1 m may be used for preliminary design purposes. These proposed parameters appear to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 4 Section

The bridge will accommodate 2-3.7 m lanes, shoulders, as well as bridge barriers. With a design speed of 110 km/h, the shy line offset distance is 2.8 m which creates 2.8 m shoulders on the structure. Refer to Exhibit 9.3 for more details.

Clear Zone

Following TAC's Design Guide, based on the design speed of 80 km/h and an AADT greater than 6,000 under the structure, a 6.0 m clear zone is required on the inside of the curve from the edge of the travelled lane to the face of the retaining wall. This 6.0 m clear zone is greater than the lateral clearance (5.4 m) required for stopping sight distance on the inside of the curve. The outside of the curve requires a horizontal curve adjustment and based on the radius and design speed, a 7.8 m clear zone to the retaining walls is required. Both of these clear zones have been used to calculate the out to out length of the proposed structure.

Deck Drainage

The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $2.7M before contingency and engineering fees. This cost is based on 2017 dollars, and is based on the use of retaining walls at the abutments.

9.2.5 Bridge carrying SB Mainline over EB-NB Ramp

Proposed Bridge 5

The proposed structure is based on a preliminary out to out length of 37.2 m on a right hand forward skew with retaining walls associated with the proposed two 3.6 m lane arrangement for the EB-NB directional ramp. A single span structure and a tentative structure depth of 1.9 m may be used for preliminary design purposes. These proposed parameters appear to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 5 Section

The bridge will accommodate 2-3.7 m lane, 1-3.7 m ramp lane, shoulders, as well as bridge barriers. With a design speed of 110 km/h, the shy line offset distance is 2.8 m which creates 2.8 m shoulders on the structure. Refer to Exhibit 9.3 for more details.

Clear Zone

Following TAC's Design Guide, based on the design speed of 80 km/h and an AADT greater than 6,000 under the structure, a 6.0 m clear zone is required on the inside of the curve from the edge of the travelled lane to the face of the retaining wall. This 6.0 m clear zone is greater than the lateral clearance (5.4 m) required for stopping sight distance on the inside of the curve. The outside of the curve requires a horizontal curve adjustment and based on the radius and design speed, a 7.8 m clear zone to the retaining walls is required. Both of these clear zones have been used to calculate the out to out length of the proposed structure.

Deck Drainage

The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $3.0M before contingency and engineering fees. This cost is based on 2017 dollars, and is based on the use of retaining walls at the abutments.

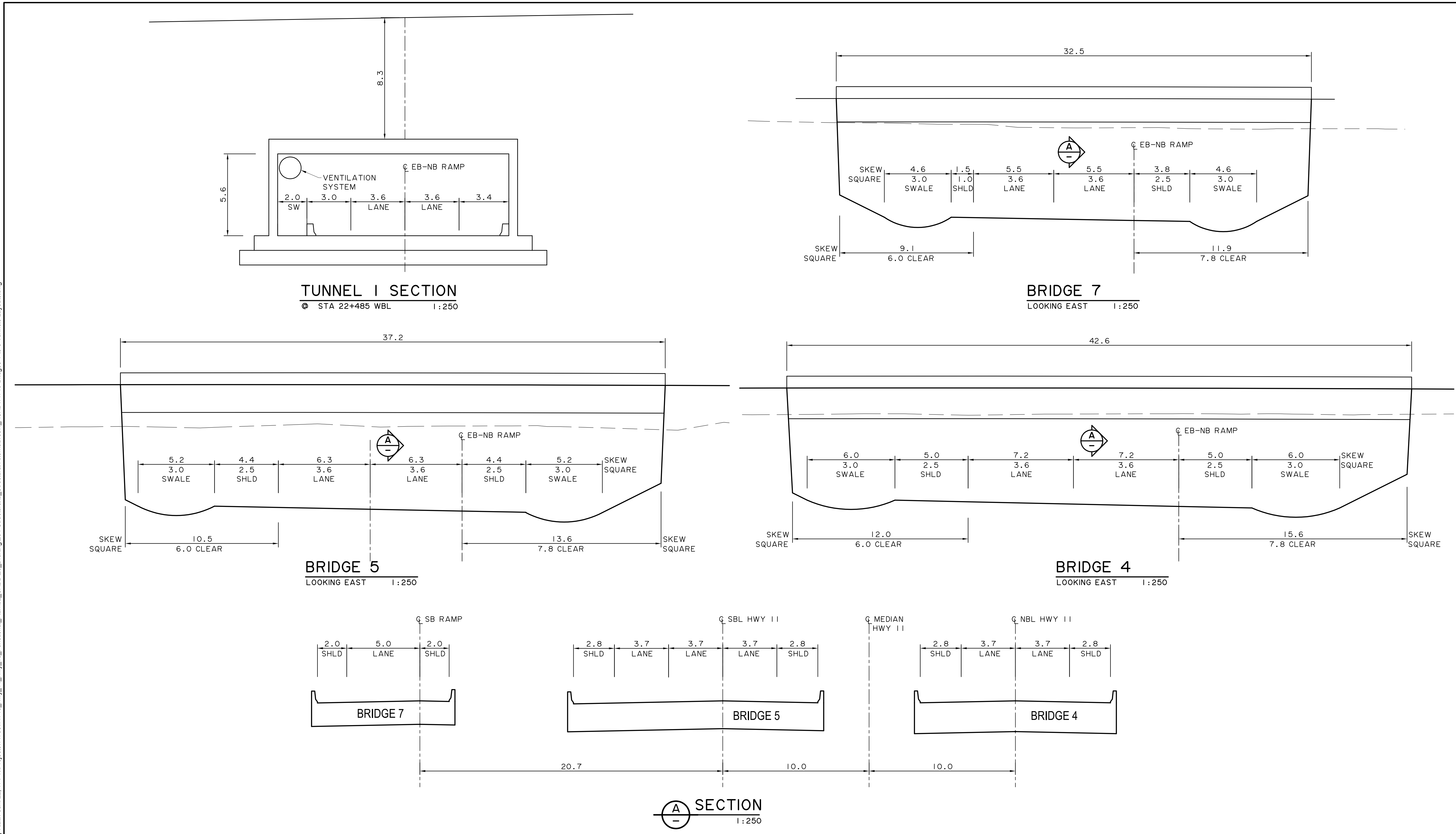
9.2.6 Bridge carrying SB to EB Traffic over EB-NB Ramp

Proposed Bridge 7

The proposed structure is based on a preliminary out to out length of 32.5 m on a right hand forward skew with retaining walls associated with the proposed two 3.6 m lane arrangement for the EB-NB directional ramp. A single span structure and a tentative structure depth of 1.9 m may be used for preliminary design purposes. These proposed parameters appear to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 7 Section

The bridge will accommodate a 5.0 m lane, shoulders, as well as bridge barriers. With a design speed of 80 km/h, the shy line offset distance is 2.0 m which creates 2.0 m shoulders on the structure. Refer to Exhibit 9.3 for more details.



ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION

TUNNEL 1, BRIDGE 7, 5, & 4 LAYOUTS

SCALE: AS NOTED

EXHIBIT 9-3

JUNE 2017

Clear Zone

Following TAC's Design Guide, based on the design speed of 80 km/h and an AADT greater than 6,000 under the structure, a 6.0 m clear zone is required on the inside of the curve from the edge of the travelled lane to the face of the retaining wall. This 6.0 m clear zone is greater than the lateral clearance (5.4 m) required for stopping sight distance on the inside of the curve. The outside of the curve requires a horizontal curve adjustment and based on the radius and design speed, a 7.8 m clear zone to the retaining walls is required. Both of these clear zones have been used to calculate the out to out length of the proposed structure.

Deck Drainage

The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $1.4M before contingency and engineering fees. This cost is based on 2017 dollars, and is based on the use of retaining walls at the abutments.

9.2.7 WB-SB Directional Ramp Tunnel under EB and WB Mainline

Proposed Tunnel 2

Due to the elevation difference in excess of 14 m between the road profiles at this location, a tunnel structure is proposed to eliminate retaining walls with excessive height. The proposed structure is based on a preliminary tunnel length of 265 m. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Tunnel 2 Section

The tunnel will accommodate 1-4.0 m lane, a 2.0 m maintenance sidewalk, ventilation, and underpass barriers. A vertical clearance of 5.6 m is provided following the minimum requirement. Due to the length of the tunnels emergency escape locations will need to be provided. Refer to Exhibit 9.4 for more details.

Horizontal Clearance

The tunnel will provide horizontal clearance for the design speed of 80 km/h as required by TAC at bridges on urban freeway underpasses.

Drainage

Drainage details within the tunnel will need to be explored in detailed design. The structure is on a vertical sag curve and drainage will need to be verified in the detailed design stage to ensure adequate drainage through the structure.

Geotechnical

Tunnel construction is assumed to be open cut. A further geotechnical assessment, should be undertaken during the detail design phase to verify existing soil conditions and construction slope stability.

Estimated Construction Costs

Structure cost for the proposed tunnel structure is estimated to be $35.8M before contingency and engineering fees based on 2017 dollars.

9.2.8 Bridge carrying NB Mainline over WB-SB Ramp

Proposed Bridge 3

The proposed structure is based on a preliminary out to out length of 32.4 m on a right hand forward skew with retaining walls associated with the proposed two 3.6 m lane arrangement for the EB-NB directional ramp. A single span structure and a tentative structure depth of 1.6 m may be used for preliminary design purposes. These proposed parameters appear to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 3 Section

The bridge will accommodate 2-3.7 m lanes, a varied width lane, shoulders and bridge barriers. With a design speed of 110 km/h, the shy line offset distance is 2.8 m which creates 2.8 m shoulders on the structure. Refer to Exhibit 9.4 for more details.

Clear Zone

Following TAC's Design Guide, based on the design speed of 80 km/h and an AADT within the 750-1,500 range under the structure, a 6.0 m clear zone is required on the inside of the curve from the edge of the travelled lane to the face of the retaining wall. This 6.0 m clear zone is greater than the lateral clearance (4.5 m) required for stopping sight distance on the inside of the curve. The outside of the curve requires a horizontal curve adjustment and based on the radius and design speed, a 5.85 m clear zone to the retaining walls is required. Both of these clear zones have been used to calculate the out to out length of the proposed structure.

Deck Drainage

The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $2.1M before contingency and engineering fees. This cost is based on 2017 dollars, and is based on the use of retaining walls at the abutments.

9.2.9 Bridge carrying SB Mainline over WB-SB Ramp

Proposed Bridge 6

The proposed structure is based on a preliminary out to out length of 32.4 m on a right hand forward skew with retaining walls associated with the proposed two 3.6 m lane arrangement for the EB-NB directional ramp. A single span structure and a tentative structure depth of 1.9 m may be used for preliminary design purposes. These proposed parameters appear to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary length may be revised during the design phase of the project upon completion of the final design gradeline and structural parameters.

Bridge 6 Section

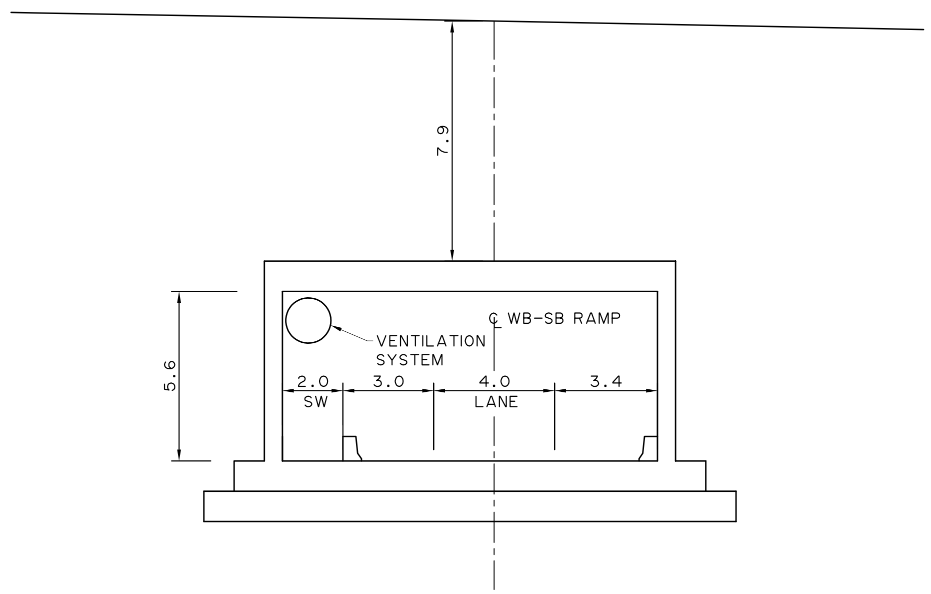
The bridge will accommodate 2-3.7 m lanes, shoulders and bridge barriers. With a design speed of 110 km/h, the shy line offset distance is 2.8 m which creates 2.8 m shoulders on the structure. Refer to Exhibit 9.4 for more details.

Clear Zone

Following TAC's Design Guide, based on the design speed of 80 km/h and an AADT within the 750-1,500 range under the structure, a 6.0 m clear zone is required on the inside of the curve from the edge of the travelled lane to the face of the retaining wall. This 6.0 m clear zone is greater than the lateral clearance (4.5 m) required for stopping sight distance on the inside of the curve. The outside of the curve requires a horizontal curve adjustment and based on the radius and design speed, a 5.85 m clear zone to the retaining walls is required. Both of these clear zones have been used to calculate the out to out length of the proposed structure.

Deck Drainage

The structure is on a vertical crest curve and deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.



TUNNEL 2 SECTION
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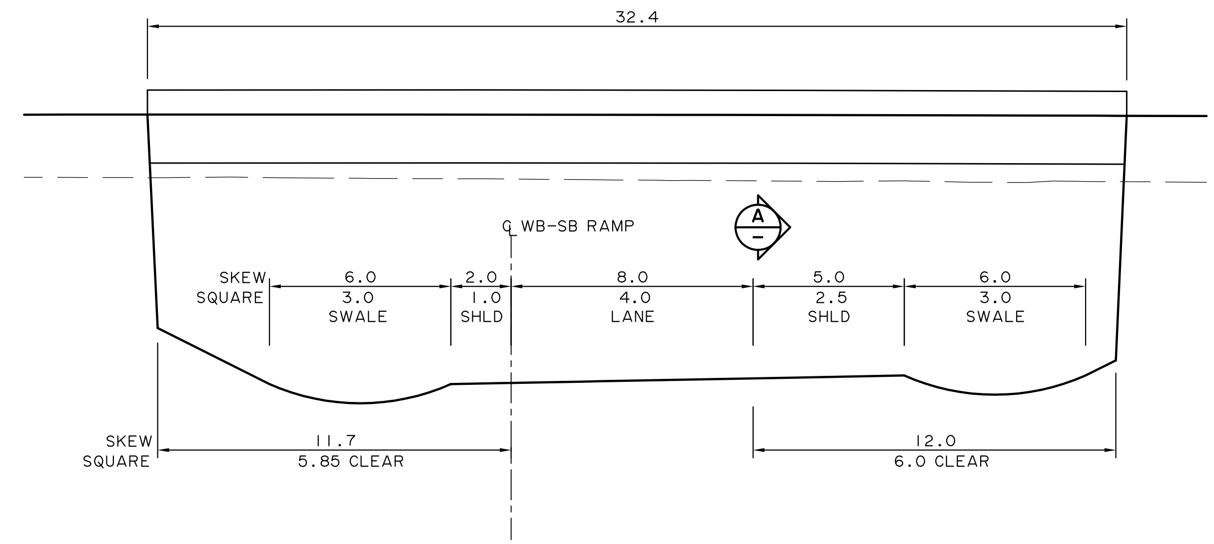
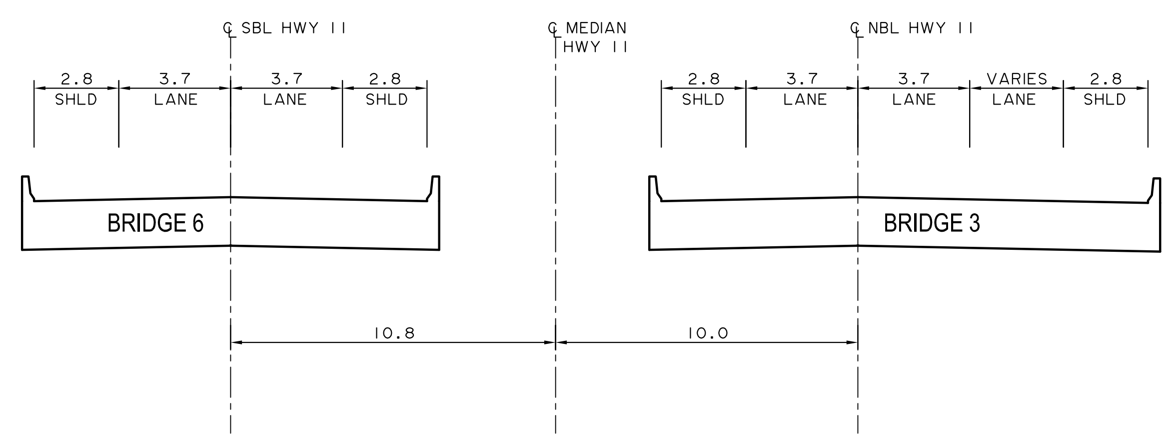


BRIDGE 3 & 6
LOOKING EAST 1:250



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION

TUNNEL 2, BRIDGE 3 & 6 LAYOUTS

SCALE: AS NOTED

EXHIBIT 9-4

JUNE 2017

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

Structure cost for the proposed bridge structure is estimated to be $2.1M before contingency and engineering fees. This cost is based on 2017 dollars, and is based on the use of retaining walls at the abutments.

9.2.10 Preston Avenue Bridge Modification

Proposed Structure

The existing bridge will need to be modified in order to accommodate the eastbound lanes to Highway 11 southbound and Highway 16 northbound. The proposed structure will demolish the existing south abutment in order to introduce a pier to accommodate the new 19.4 m span associated with the proposed lane arrangement for the eastbound lanes to Highway 11 and Highway 16 northbound. These proposed parameters appear to exceed the minimum 5.6 m requirement for vertical clearance. The preliminary span length may be revised during the design phase upon completion of the final design gradeline and structural parameters.

Bridge Section

The bridge section is to match the existing Preston Avenue bridge. This involves 4-3.6 m lanes, one turning lane, median, shoulders, sidewalk, and bridge barriers. Refer to Exhibit 9.5 for more details.

Clear Zone

Following TAC's Design Guide, based on the design speed of 80 km/h and an AADT greater than 6,000 under the structure, a 6.0 m clear zone is required from the edge of the travelled lane to the face of the retaining wall or pier. These clear zones have been used to calculate the new span length.

Deck Drainage

Deck drainage will need to be verified in the detailed design stage to ensure adequate positive drainage across the structure.

Geotechnical

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site according to Golder's report. A further geotechnical assessment including structural test holes for bridge foundations, confirmation of underlying soils in the footprint of the fills should be undertaken during the detail design phase to verify assumptions.

Estimated Construction Costs

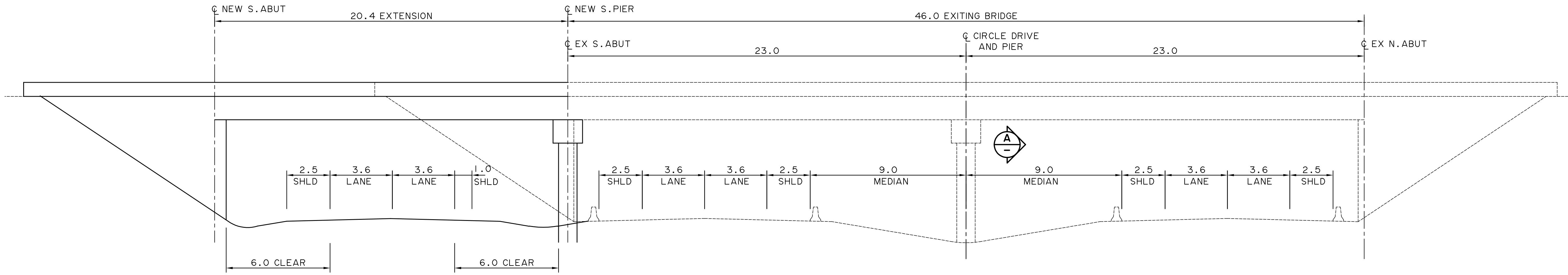
Structure cost for the proposed modification to the bridge structure is estimated to be $4.0M before contingency and engineering fees. This cost is based on 2017 dollars, and is based on the use of a retaining wall at the abutment.

9.2.11 Retaining Walls

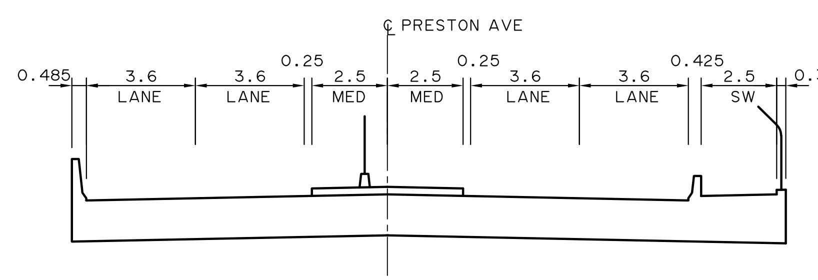
In conjunction with the proposed bridge structures, varying height retaining walls are used to reduce the bridge length required, and limit the need for additional right of way. Exhibit 9.1 shows the location of the retaining walls. Costs below do not include engineering and contingencies.

Table 9.1: Retaining Wall Requirements

Description	Length (m)	Surface Area (m^2)	Estimated Cost
Retaining Wall 1	317	2,667	$4.0M
Retaining Wall 2	202	1,867	$2.8M
Retaining Wall 3	129	1,067	$1.6M
Retaining Wall 4	222	1,133	$1.7M
Retaining Wall 5	202	1,667	$2.5M
Retaining Wall 6	297	2,133	$3.2M
Retaining Wall 7	278	1,533	$2.3M
Total			**$18.1M**



BRIDGE 8
LOOKING EAST 1:250



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION
EXISTING BRIDGE 8 MODIFICATIONS

SCALE: AS NOTED

EXHIBIT 9-5

JUNE 2017

9.2.12 Summary of Proposed Structures

Costs below do not include engineering and contingencies.

Table 9.2: Costs for Structures and Retaining Walls

Structure	Description	Proposed Structure	Est. Cost
1	Eastbound Mainline Bridge	100 m out-to-out 2 span	$10.3M
2	Westbound Mainline Bridge	102 m out-to-out 2 span	$11.4M
3	Bridge carrying northbound traffic over WB-SB ramp	32.3 m out-to-out Single span	$2.1M
4	Bridge carrying northbound mainline traffic over EB-NB ramp	42.6 m out-to-out Single span	$2.7M
5	Bridge carrying southbound mainline traffic over EB-NB ramp	37.2 m out-to-out Single span	$3.0M
6	Bridge carrying southbound traffic over WB-SB ramp	32.4 m out-to-out Single span	$2.1M
7	Bridge carrying southbound to eastbound traffic over EB-NB ramp	32.5 m out-to-out Single span	$1.4M
8	Preston Avenue bridge modification	Modification and 20.4 m additional span	$4.0M
Tunnel 1	EB-NB ramp tunnel under Hwy 11	273 m	$36.9M
Tunnel 2	WB to SB ramp tunnel under Hwy 16	265 m	$35.8M
	Retaining walls where required.	1647 m	$18.1M
Total			**$127.8M**

10.0 Stormwater Management

10.1 Proposed Redevelopment

The proposed redeveloped interchange will include:

- dropping the directional ramps about 6 m below grade;
- locating the north-south mainline about 2 m above grade; and
- locating the east-west mainline about 10 m above grade.

This will result in portions of the interchange lands sloping towards the directional ramp low points. The existing grade is at an approximate elevation of about 513 m. As a result, the directional ramp low points elevation will be approximately 507 m, with an adjacent ditch elevation of about 506 m.

10.2 Proposed Servicing Goals

The current performance of the existing interchange and downstream highway drainage systems is less than what it would be if they were designed to today's standards. This redevelopment project provides an opportunity to improve the level of service up to current design standards, minimizing the risk of flooding during the rare extreme events.

The proposed servicing goals for this redevelopment therefore include the following:

- provide for gravity drainage – there is to be no pumping of stormwater runoff;
- there must be no ponding on roadway surfaces during the 1:100 year design event;
- the downstream Stonebridge neighbourhood drainage system must not be overloaded during the 1:100 year design event;
- sediment management must be provided for reduce operations and maintenance of local and downstream drainage systems; and
- water quality treatment must be provided to protect downstream natural ecosystems from contaminants found in urban runoff.

10.3 Proposed Servicing Concept

The proposed stormwater management servicing concept consists of the following:

- minimize the area of the interchange site that will contribute runoff to the directional ramp low points in an uncontrolled manner;
- provide dry pond stormwater management facilities (SWMFs) within the ramp areas to control runoff from the majority of the 34 ha interchange site;
- install a new storm sewer to drain the directional ramp low points south into the Stonebridge neighbourhood storm sewer system by gravity;
- drain the interchange dry ponds at a controlled rate into the new storm sewer;
- oversize the new storm sewer to provide storage to control the uncontrolled flows from its directly contributing area, and discharge the new storm sewer at a controlled rate into the downstream Stonebridge system; and
- develop surface storage within the ditch system of Highway 11 as it extends south from the interchange site, and discharge at a controlled rate into the new interchange storm sewer.

Maximum System Discharge Rate

For purposes of this functional plan we have established an approximate maximum discharge rate of 6 L/s/ha during the 1:100 year design event that should be directed from the 50 ha of interchange and Highway 11 right-of-way contributing area into the Stonebridge neighbourhood. This is based on matching the current flow-full capacity of the existing system of about 300 L/s. This value should be further considered and refined during detailed design with the aim of ensuring adequate capacity in the downstream existing neighbourhood drainage system.

Approximate Storage Requirements

Based on the lumped XPSWMM modelling effort and the maximum unit discharge rate of 6 L/s/ha, the following approximate storage volumes will be required:

- 11,000 m^3 – interchange area; and
- 4,000 m^3 – Highway 11 right-of-way ditch storage.

Assuming a small portion of the interchange area will drain uncontrolled to the directional ramp low points, then the storm pipe would need to be oversized to provide storage in addition to some conveyance capacity.

Discharge rates from the three main storage elements (interchange dry ponds, new storm pipe and Highway 11 right-of-way ditch storage) may be refined during detailed design to optimize costs of the design, as long as the total combined discharge rate does not overload the downstream Stonebridge storm system.

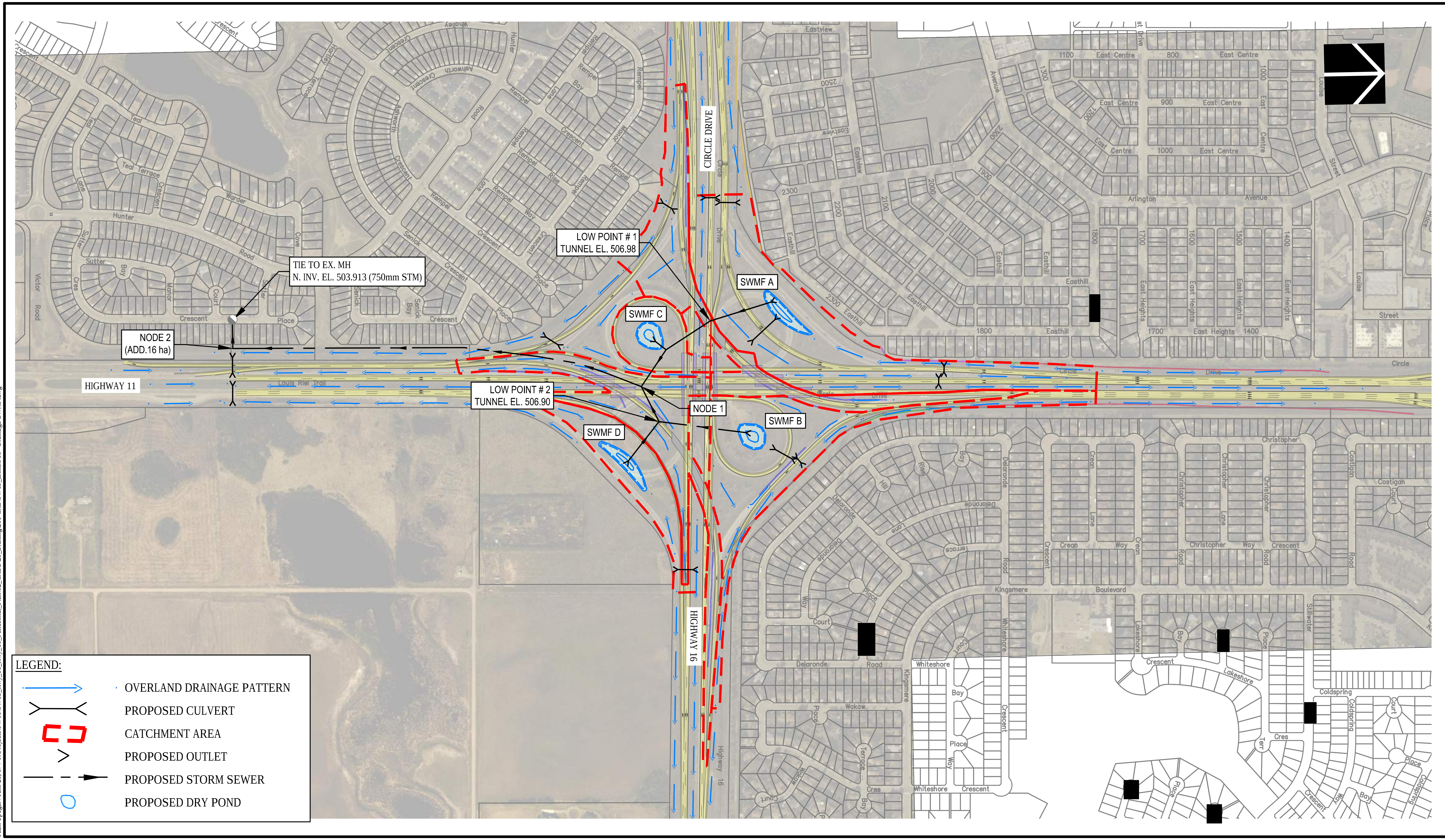
Proposed Conceptual Design

The proposed conceptual design is shown on Exhibit 10.1. It is comprised of:

- drainage of the majority of the interchange lands to 4 stormwater management dry pond facilities within the ramp areas that release at a controlled rate based on 6 L/s/ha into a new local storm sewer system;
- drainage of the two underground ramp areas uncontrolled into the new local sewer system;
- the new local sewer system will drain about 800 m south then west into the existing Stonebridge neighbourhood drainage system;
- the new storm sewer running south from the interchange for about 800 m will be oversized to store the uncontrolled runoff from the two low ramp areas such that the total discharge west into Stonebridge is controlled to 6 L/s/ha; and
- the existing storm sewer system running west into Stonebridge from Highway 11 will be replaced with a new deeper system that will convey runoff from the new interchange storm sewer as well as runoff inflows from the adjacent local Highway 11 catchment area.

Table 10.1: Conceptual pond design information

SWMF	Design Elevations (m)			Surface Areas (m^2)		Storage Capacity (m^3)	Design	
	Ground	HWL	Pond Bottom	HWL	Bottom		Catch. Area (ha)	Required Storage (m^3)
A	512.0	511.5	509.0	2200	400	3250	9.65	3130
B	512.1	511.6	509.1	1550	150	2125	6.21	2020
C	512.4	511.9	509.4	520	20	675	1.87	610
D	511.9	511.4	508.9	810	50	1075	3.28	1070
Totals:						**7125**	**21.0**	**6830**



Juan Upegui / Jun. 21, 17 / T:\Projects\14700\14719_Hwy_11_Hwy_16_Functional_Plan\02_CADD\20_Drafting\201-CAD\14719_Exhibit 10 - Drainage SWMP.dwg

ISL Engineering and Land Services

City of Saskatoon

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HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

STORMWATER MANAGEMENT PLAN

STORM SYSTEM

EXHIBIT 10.1

JUNE 2017

Table 10.2: Conceptual pipe design information

U/S MH	D/S MH	U/S Area (ha)	Design Flow (L/s)	U/S Inv (m)	D/S Inv (m)	Slope (%)	Length (m)	Dia (mm)	Capacity (L/s)
Pond A	Low Pt 1	9.65	58	511.09	505.68	4.70	115	300	210
Low Pt 1	Pond C	14.83	89	505.53	505.43	0.10	105	450	90
Pond C	Node 1	16.7	100	505.35	505.27	0.10	85	525	136
Pond B	Low Pt 2	6.21	37	511.68	505.60	3.80	160	300	189
Pond D	Low Pt 2	3.28	20	509.83	505.60	4.70	90	300	210
Low Pt 2	Node 1	14.94	90	505.38	505.30	0.10	75	300	136
Node 1	Node 2	31.64	190	504.77	503.97	0.10	800	2 @ 1650	190
Node 2	Ex. MH	47.64	286	503.97	503.91	0.10	55	750	352

Notes:

1. The data in the above two tables was developed at a conceptual level for purposes of understanding the general configuration of the recommended drainage system and developing a planning level cost estimate. Every aspect of the design must be confirmed during preliminary engineering design.
2. The pipe between Nodes 1 and 2, in addition to conveyance, it must provide storage for the uncontrolled runoff that will enter the below grade ramp areas. Discharges from this pipe into the downstream pipe must be controlled to the rate of 6 L/s/ha.
3. The pipe between Node 2 and the existing manhole will take controlled flows from the pipe between Node 1 and Node 2, as well as controlled flows from the Highway 11 adjacent contributing area – ditch storage will be required along Highway 11 to provide controlled discharges.

Lastly, flows on the immediate subdivision side of the noise berm (west side) currently contribute from a back-of-lot swale system into the existing drainage system. This local drainage service will need to maintained with the proposed design.

10.4 Water Quality

Sediment Management

Roadway sediment should be controlled within the roadway ditch systems and the bottom of the dry ponds to prevent sediment movement into the downstream storm sewer system in order to minimize operation and maintenance needs including sewer cleaning. This can be achieved through the installation of small check dams to slow flows and encourage settlement of suspended sediments. Collected sediments should be removed annually (typically each spring) to maintain effectiveness of these stormwater Best Management Practices (BMPs).

Water Quality Treatment

For this project there are two important stormwater BMP measures that will provide a reasonable level of water quality treatment to prevent urban contaminants from passing to downstream natural ecosystems (in this case the river):

- on-site sediment capture BMPs, including check dams within roadway ditches and along the bottoms of the interchange dry ponds – this is considered an important contaminant removal method as many urban contaminants attach themselves to sediment; and
- the downstream Stonebridge wet pond type of SWMF – provides a high level on contaminant removal.

11.0 Utilities

The following utilities will be affected by the long-term plan improvements.

11.1 TransGas

SaskEnergy has a 323.9mm high pressure gas line that runs along the along the northern boundary of the Highway 11 west / Highway 16 east corridor. The line will be in direct conflict with several excatation portions of the long-term plan and will need to be relocated. Costs to directionally drill a new section of line is estimated at $2M.

11.2 City of Saskatoon Water

A City of Saskatoon Water line runs along the western edge of Highway 16, from Taylor Drive to Highway 11, where it crosses and enters the Stonebridge neighbourhood. Approximately 160 m of the watermain will need to be lowered across Circle Drive as part of the long-term plan. Costs are estimated to be in the order of $0.5M.

11.3 Saskatoon Light and Power

The proposed interchange will be fully illuminated along the mainlines and all ramps. Costs are estimated to be in the order of $3M.

12.0 Noise Attenuation

In 2015, ACI Acoustical Consultants Inc. conducted a Noise Modelling Study on behalf of the City of Saskatoon on Circle Drive between Highway 16 and Taylor Street. Noise modelling for the 2014 existing conditions reached 69.1 dBa L_{dn}, exceeding the City's criteria of 65 dBa L_{dn}. In order to suppress the noise levels under the 65 dBa L_{dn} criteria, noise attenuation walls were recommended on both the east and west sides of Circle Drive. The City has since installed the noise walls as recommended.

A Noise Modelling Study was also completed by ACI for this project for the future condition (400k population) based on the proposed interchange configuration. The entire report is located in Appendix H. The maximum modeled noise level was 69.6 dBa L_{dn} without any noise mitigation. In order to achieve future noise levels below 65 dBA Ldn throughout the entire study area, noise barriers are required for almost all of the northeast and northwest areas (with the exception of the existing earth berm located directly northwest of the Interchange) as well as for a small portion of the southwest area. The new noise barrier heights range from 1.83 m (6 ft) to 4.0 m. The total running length of the new noise barriers is approximately 3,760 m. The recommendations are shown on Figure 12.1 to 12.3.

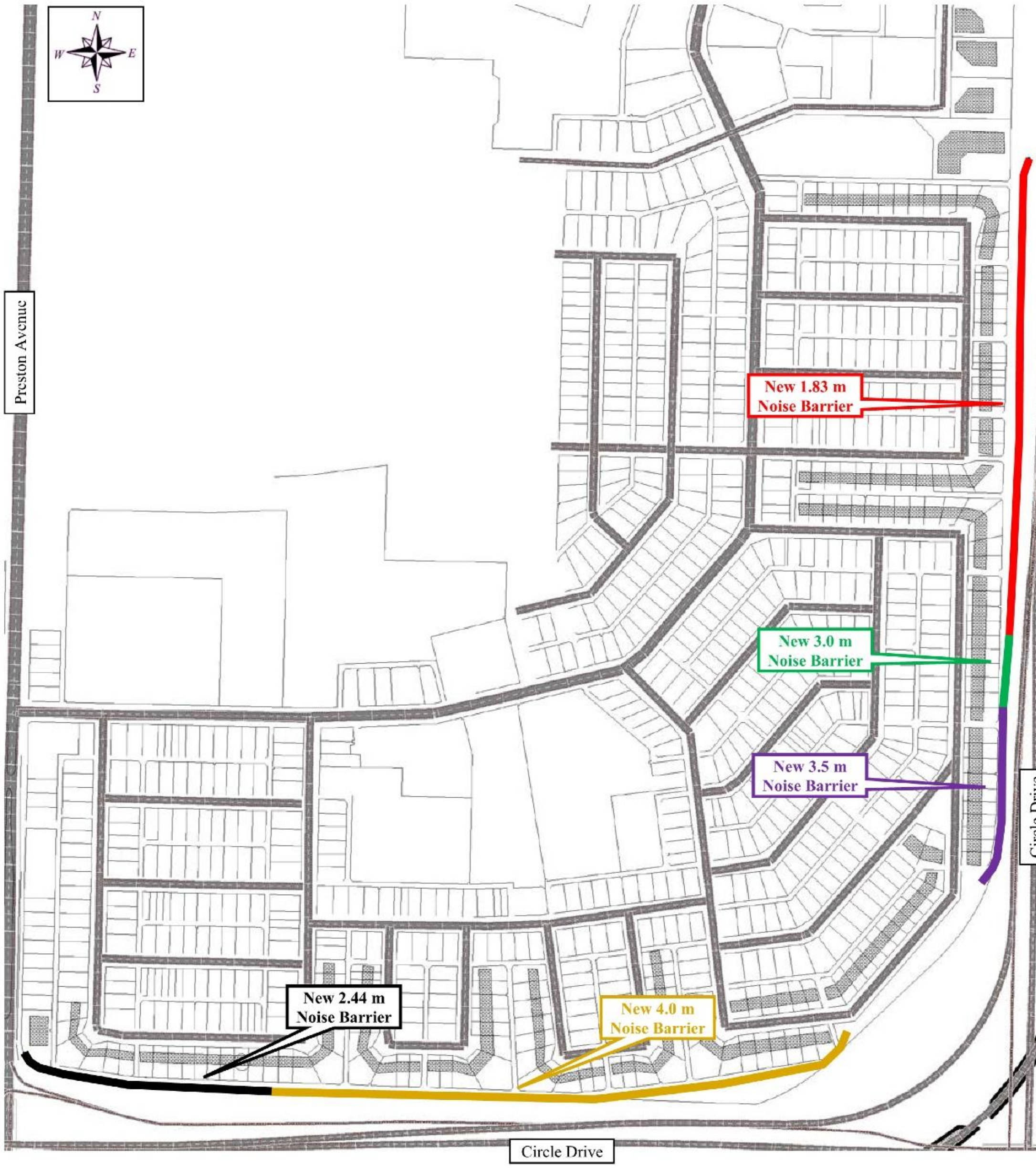


Figure 12.1: Northwest Mitigation Recommendations

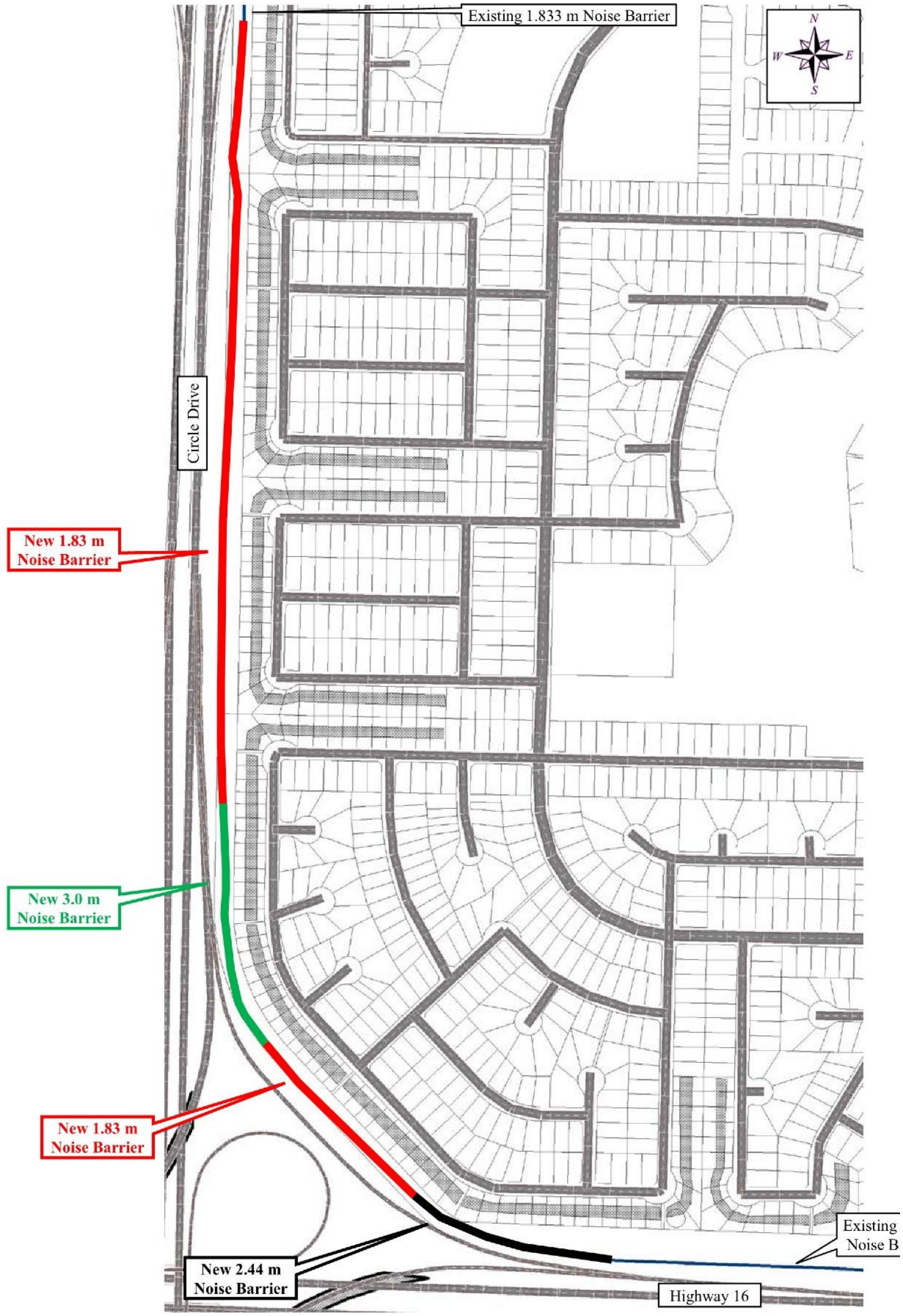


Figure 12.2: Northeast Mitigation Recommendations

Figure 12.3: Southwest Mitigation Recommendations

13.0 Right-of-way Requirements

The majority of the long-term interchange is contained within the existing highway right-of-way parcels (62SO6532, 65S24296, and 66S18127), and municipal buffer lots:

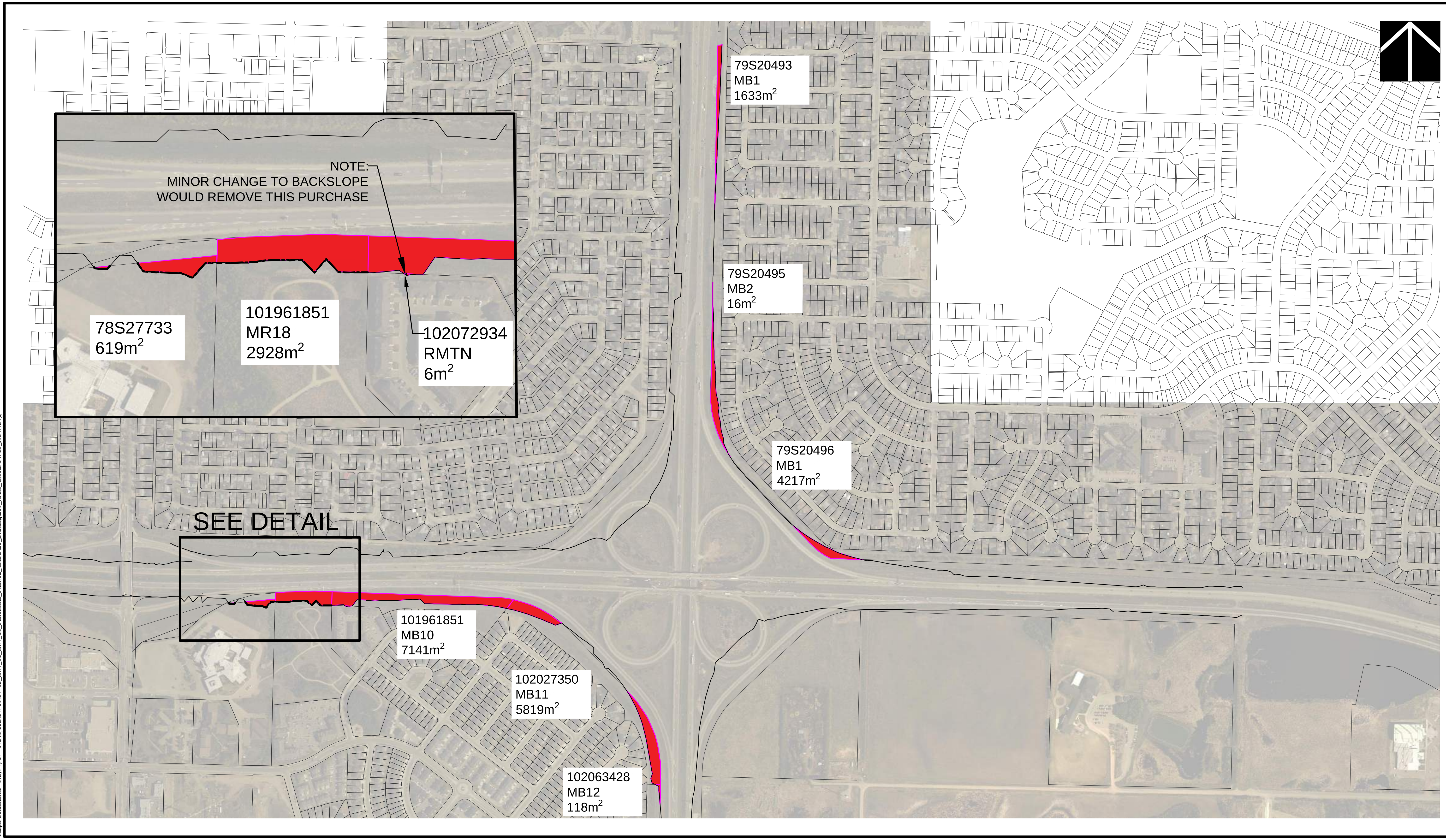
- 1633 m^2 (0.40 acres) in 79S20493 MB1;
- 16 m^2 (0.004 acres) in 79S20495 MB2;
- 4217 m^2 (1.04 acres) 79S20496 MB1
- 118 m^2 (0.03 acres) in 102063428 MB12;
- 5819 m^2 (1.44 acres in 102027350 MB11; and
- 7141 m^2 (1.76 Acres) in 101961851 MB10.

The lots directly effected are:

- 619 m^2 (0.15 acres) from the northeast corner of the Circle Drive Alliance Church lot (78S27733);
- 2928 m^2 (0.72 acres) along the north boundary of the Mark Thompson Park (101961851 MR18); and
- 6 m^2 (0.001 acres) along the northern boundary of the condos along Rempel Manor (102072934 RMTN). However, a modest change to the sideslope in this area would remove this right-of-way requirement.

The total cost for right-of-way is $460,000.

The recommended property lines are shown on Exhibit 13.1.



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ISL Engineering and Land Services

City of Saskatoon

LEGEND

CONSTRUCTION LIMITS

RECOMMENDED RIGHT-OF-WAY

REQUIRED RIGHT-OF-WAY

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

RIGHT-OF-WAY REQUIREMENTS

1:8000 EXHIBIT 13.1

MAY 2017

14.0
Opinion of Probable Costs

A Level "C" planning level cost estimate was prepared for each stage of the project, and are included in Appendix I. Short-term improvements are estimated to be $5.7M. The long-term improvements are estimated to be $280.4M.

Based on different funding stream opportunities, the cost estimate has been broken down into the zones shown in Figure 14.1. Table 14.1 shows a summary of the costs by zone.

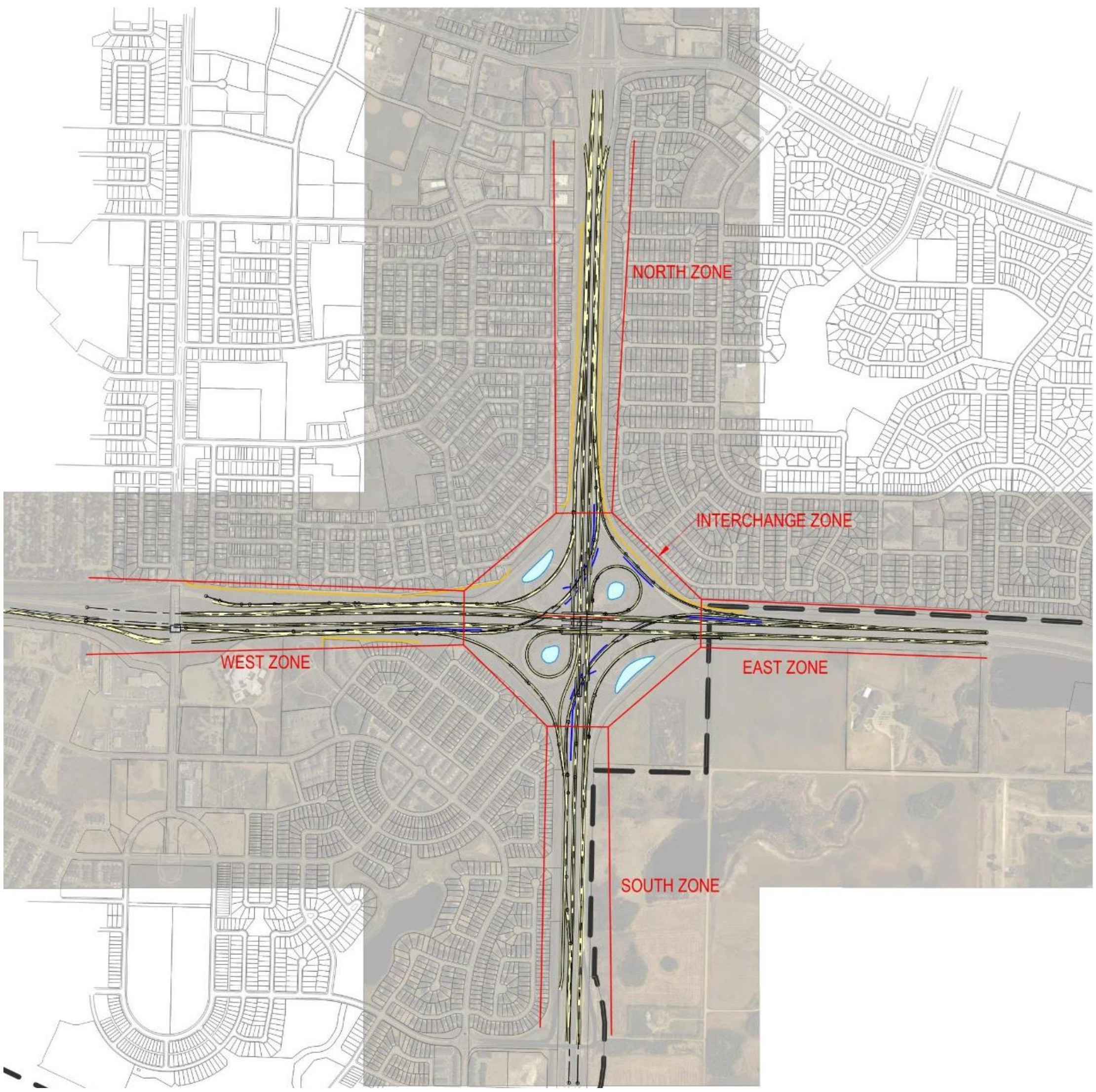


Figure 14.1: Cost Estimate Zones

Table 14.1: Summary of Long-Term Costs

	Costs in $M by Zone					Total
	West	South	East	North	Interchange	
Roadways	$5.4M	$2.8M	$2.8M	$9.4M	$25.2M	$45.6M
Noise Barrier Walls	$1.0M	–	–	$1.6M	$2.1M	$4.7M
Retaining Walls	–	–	–	–	$18.2M	$18.2M
Bridges	$4.0M	–	–	–	$33.1M	$37.1M
Tunnels	–	–	–	–	$72.7M	$72.7M
Utilities	$0.6M	$0.6M	$0.6M	$0.6M	$3.1M	$5.5M
Storm Water Management	$0.06M	$0.06M	$0.06M	$0.06M	$0.09M	$2.5M
Landscaping	$0.06M	$0.06M	$0.03M	$0.06M	$0.09M	$2.5M
Detours	$0.2M	$0.2M	$0.2M	$0.2M	$0.2M	$1.0M
Right-of-way	$0.5M	–	–	–	–	$0.5M
Zone Subtotal	$11.7M	$3.6M	$3.7M	$11.8M	$156.8M	$187.6M
15% Engineering	$1.8M	$0.5M	$0.5M	$1.8M	$23.5M	$28.1M
30% Contingency	$3.9M	$1.3M	$1.3M	$4.1M	$54.1M	$64.7M
Zone Total	**$17.4M**	**$5.4M**	**$5.5M**	**$17.7M**	**$234.4M**	**$280.4M**

Note: Columns may not sum due to rounding.

15.0 Conclusions and Recommendations

15.1 Conclusions

This functional planning study has defined the future interchange requirements for the Highway 11 and 16 interchange, based on a 2% growth scenario for the future traffic volumes. It must be stressed that there is a high level of uncertainty in the forecasted volumes, which would have led to two very different interchange configurations. The Project Team chose to be conservative, and develop for the worst case scenario to ensure that traffic can be ultimately accommodated through this interchange. If traffic volumes reduce, as was predicted by the TDM, then several of the recommended features should be scaled back at the design stage.

Based on the 2% traffic demand scenario, existing constraints, and input from stakeholders, the recommended plan (shown in Appendix A) was developed:

- System interchange which maintains free-flow movements in all directions.
- East-west highway will be approximately 4 m higher than existing.
- North-south highway will be approximately 2 m higher than existing.
- Eastbound to northbound directional and westbound to southbound directional will be approximately 6m below existing ground.
- Collector/Distributor Roads are provided between this interchange and the interchanges at Preston Avenue and Vic Boulevard to accommodate weaving. By separating the weaving volumes from the mainline, and allowing the weaves to occur at lower speeds, the short weave distances will operate acceptably.
- A two-lane exit ramp onto the eastbound Collector/Distributor Road has been included upstream of the Preston Avenue bridge structure to maximize weaving distances.
- A two-lane entrance ramp onto Circle Drive (west leg) has been included from the westbound Collector/Distributor Road to accommodate the high volume southbound to westbound movement.

- Loop ramps accommodate the southbound to eastbound and northbound to westbound movements. These are low volume movements which can easily be accommodated on the low speed ramps.
- The new plan will require seven new bridge structures, one bridge widening, two tunnels, and significant amounts of retaining wall and noise wall.
- The northbound to eastbound ramp and the southbound to westbound ramps are moved closer to the centroid of the interchange, maximizing the potential weave distance to the adjacent ramps.

15.2 Recommendations

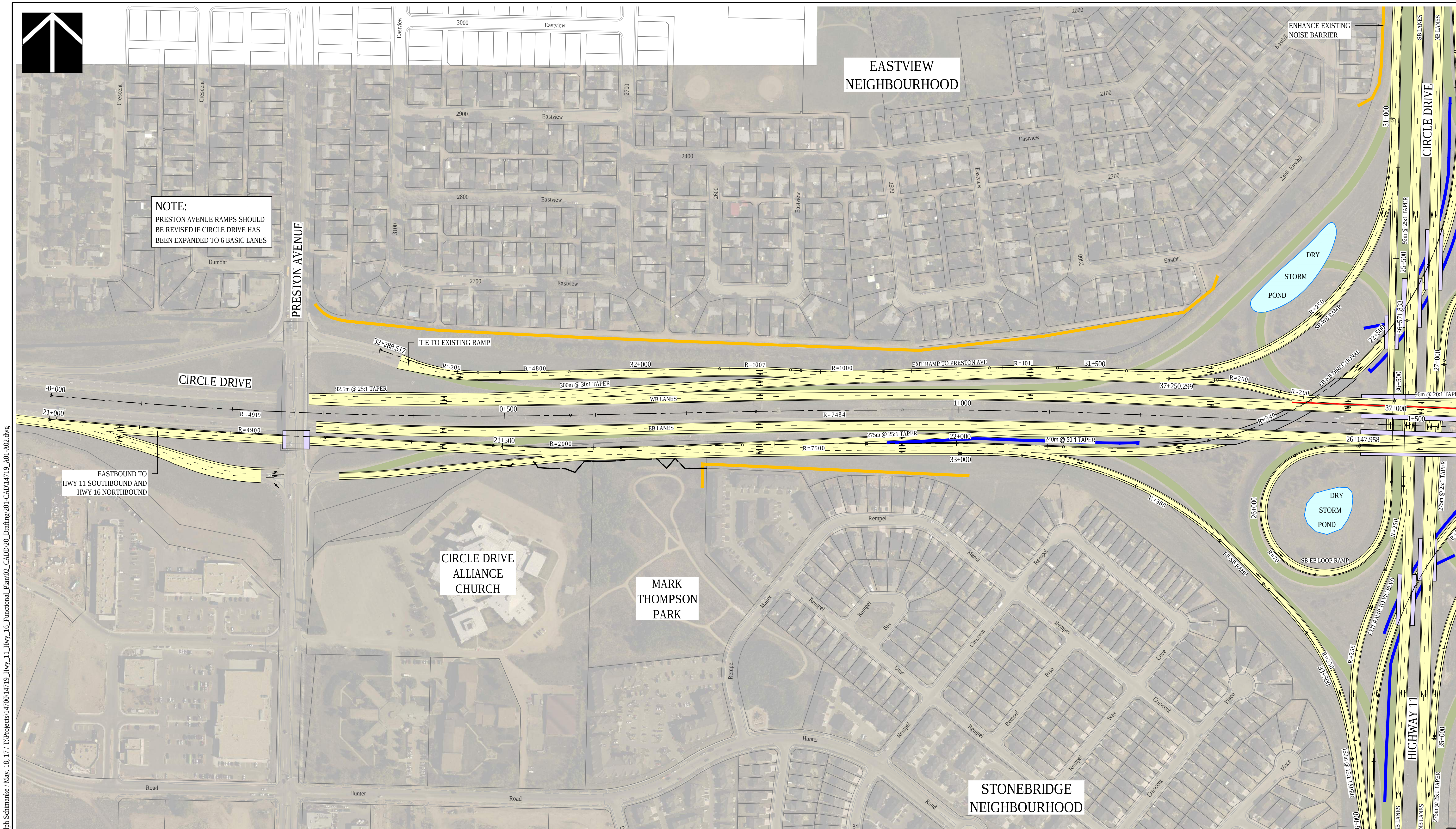
To address the current issues with the existing interchange, the Stage 1 improvements should be implemented, as soon as funding is available, to resolve the operational and vertical clearance issues. These improvements are compatible with the long-term plans, regardless of which traffic scenario materializes.

To address the long-term uncertainty for this project, we have the following recommendations:

- Monitor traffic patterns over the coming years to better understand which traffic volumes are changing;
- Complete further examination of the regional Travel Demand Model to better understand how the forecast volumes were produced and if the TDM growth scenario is valid;
- Update the TDM to reflect the major projects as they come operational and change the network travel patterns; and
- Review the long-term plan every few years to determine if it is still valid based on current travel patterns.

Appendix A

Long-Term Recommended Plan and Profiles



LEGEND

- NEW HIGHWAY ALIGNMENT
- TUNNEL
- BRIDGE
- REMOVE EXISTING PAVEMENT
- RETAINING WALL
- NOISE BARRIER WALL
- MEDIAN BARRIER
- NEW PROPERTY LINE
- DRY STORM POND
- CITY LIMITS

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City of Saskatoon

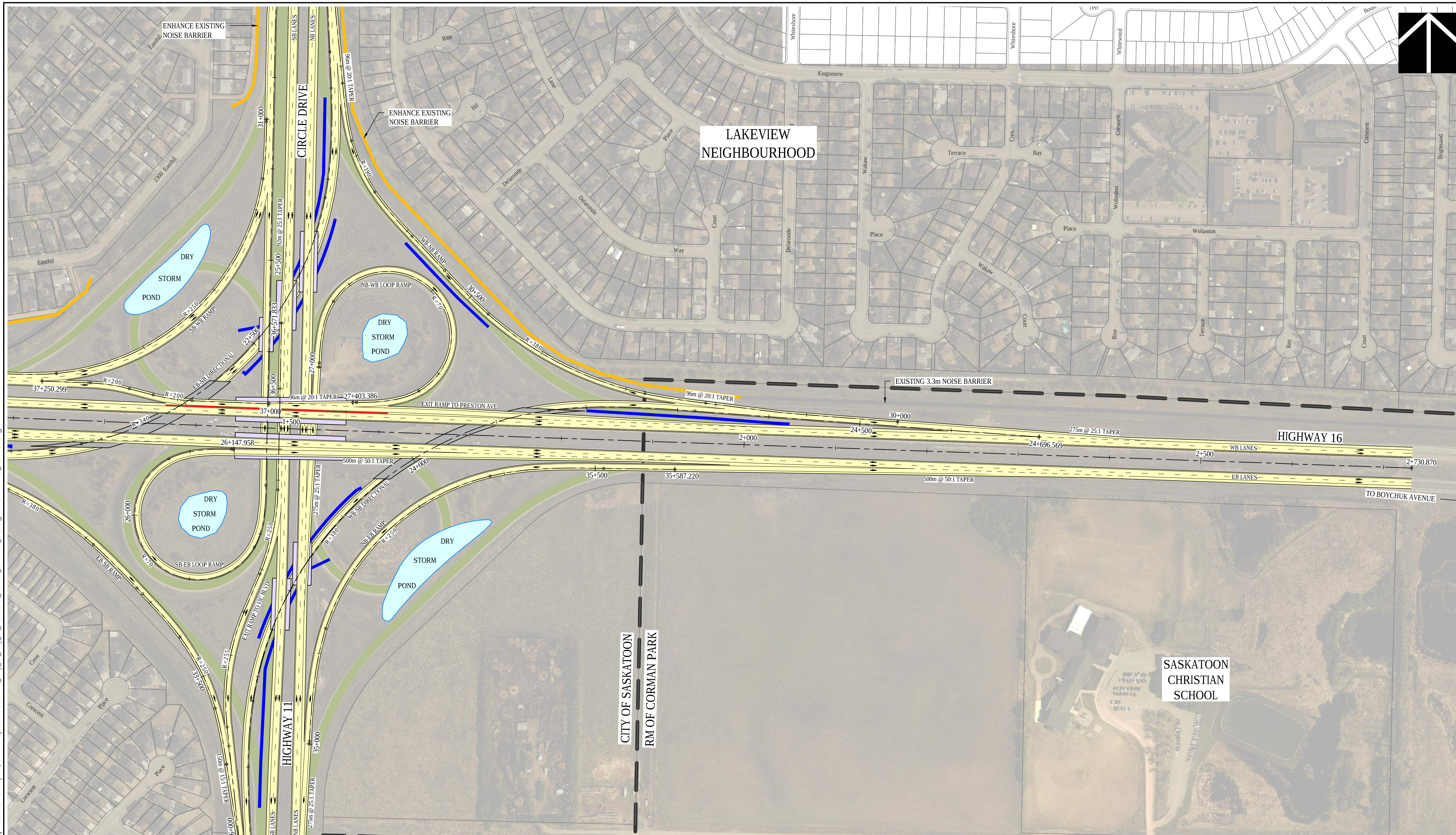
HORZ 0 40 80 120 160m
1:4000

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PLAN
WEST QUADRANT

Appendix A01

JUNE 2017



LEGEND

- NEW HIGHWAY ALIGNMENT
- TUNNEL
- BRIDGE
- REMOVE EXISTING PAVEMENT
- RETAINING WALL
- NOISE BARRIER WALL
- MEDIAN BARRIER
- NEW PROPERTY LINE
- DRY STORM POND
- CITY LIMITS

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HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PLAN

EAST QUADRANT

HORZ 1:4000 0 40 80 120 160m

Appendix A02

JUNE 2017

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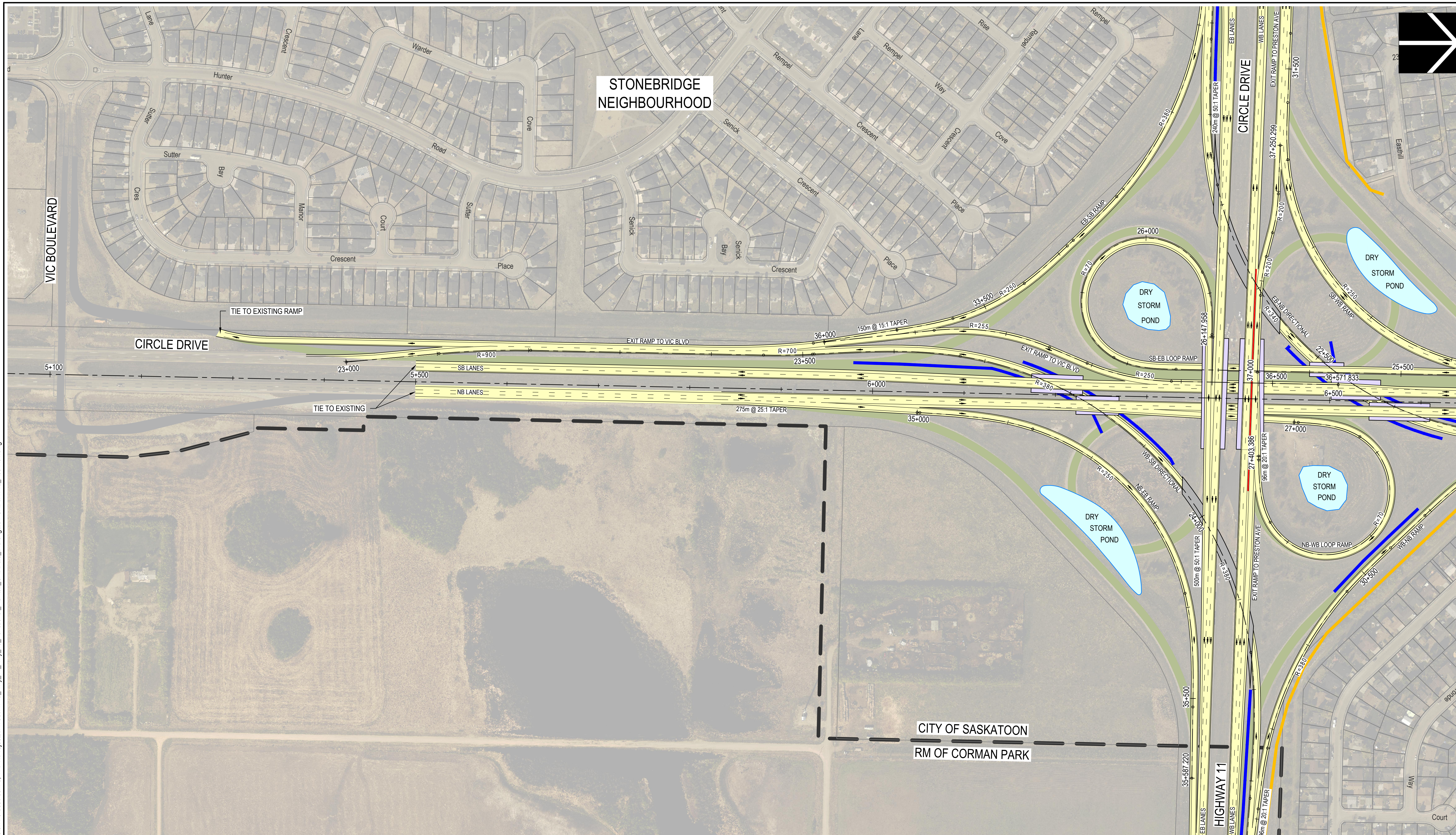

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LEGEND

- NEW HIGHWAY ALIGNMENT
- TUNNEL
- BRIDGE
- REMOVE EXISTING PAVEMENT
- RETAINING WALL
- NOISE BARRIER WALL
- MEDIAN BARRIER
- NEW PROPERTY LINE
- DRY STORM POND
- CITY LIMITS

HORZ 1:4000 0 40 80 120 160m

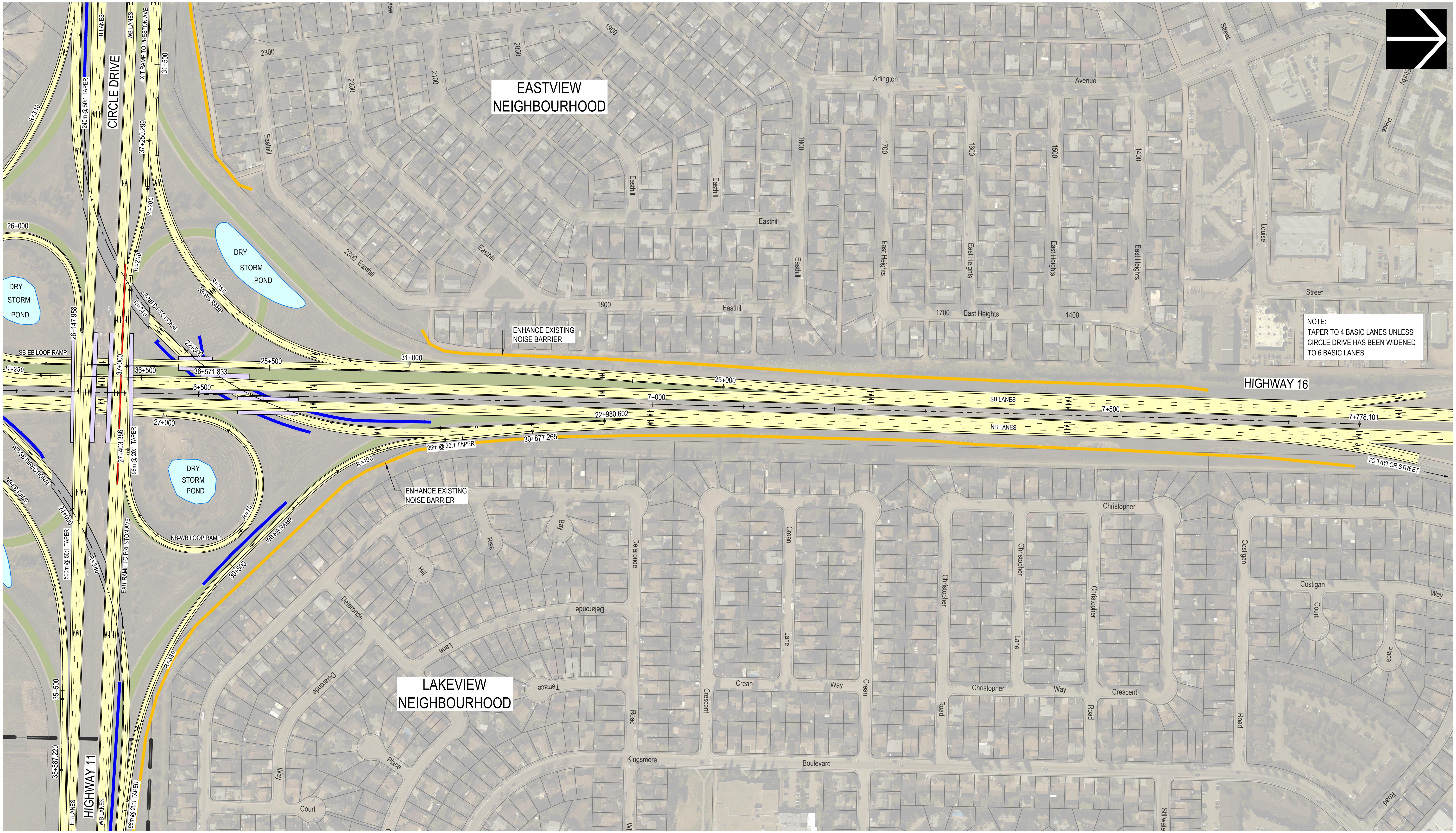
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PLAN

SOUTH QUADRANT

Appendix A03

JUNE 2017



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LEGEND

- NEW HIGHWAY ALIGNMENT
- TUNNEL
- BRIDGE
- REMOVE EXISTING PAVEMENT
- RETAINING WALL
- NOISE BARRIER WALL
- MEDIAN BARRIER
- NEW PROPERTY LINE
- DRY STORM POND
- CITY LIMITS

HORZ 0 40 80 120 160m
1:4000

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PLAN
NORTH QUADRANT

Appendix A04

JUNE 2017

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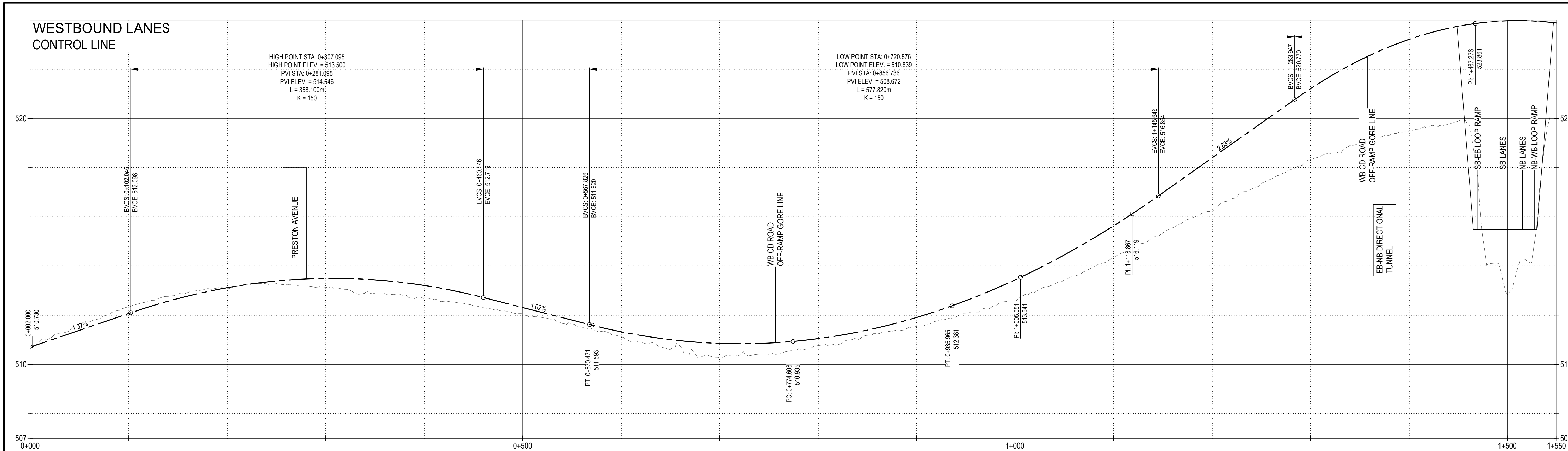

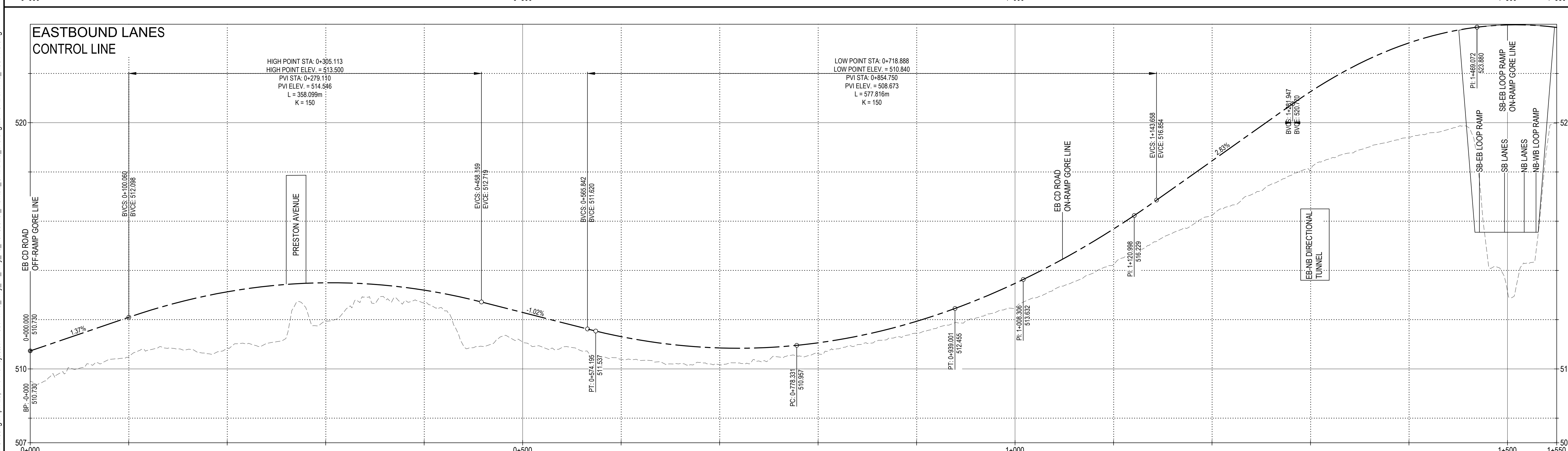

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LEGEND

— - — - — PROFILE CONTROL LINE

- - - - - - EXISTING GROUND

VERT 1:160 — 0 1.6 3.2 4.8 6.4m

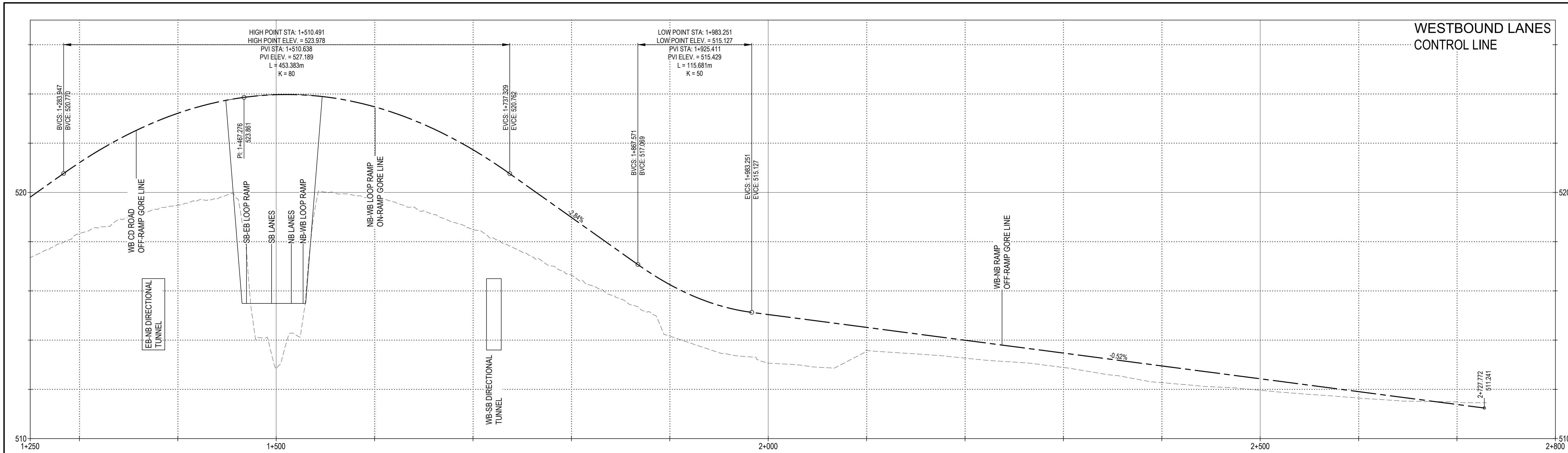
HORZ 1:4000 — 0 40 80 120 160m

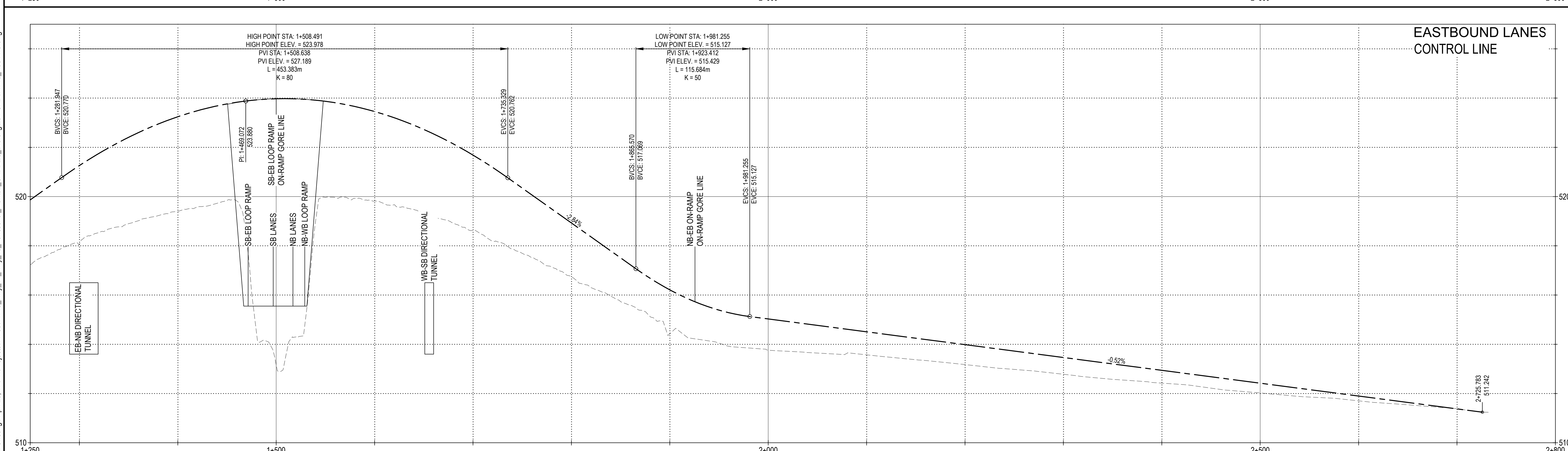
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PROFILES
WESTBOUND AND EASTBOUND MAINLINE

Appendix A05

MAY 2017





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City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:160 — 0 1.6 3.2 4.8 6.4m

HORZ 1:4000 — 0 40 80 120 160m

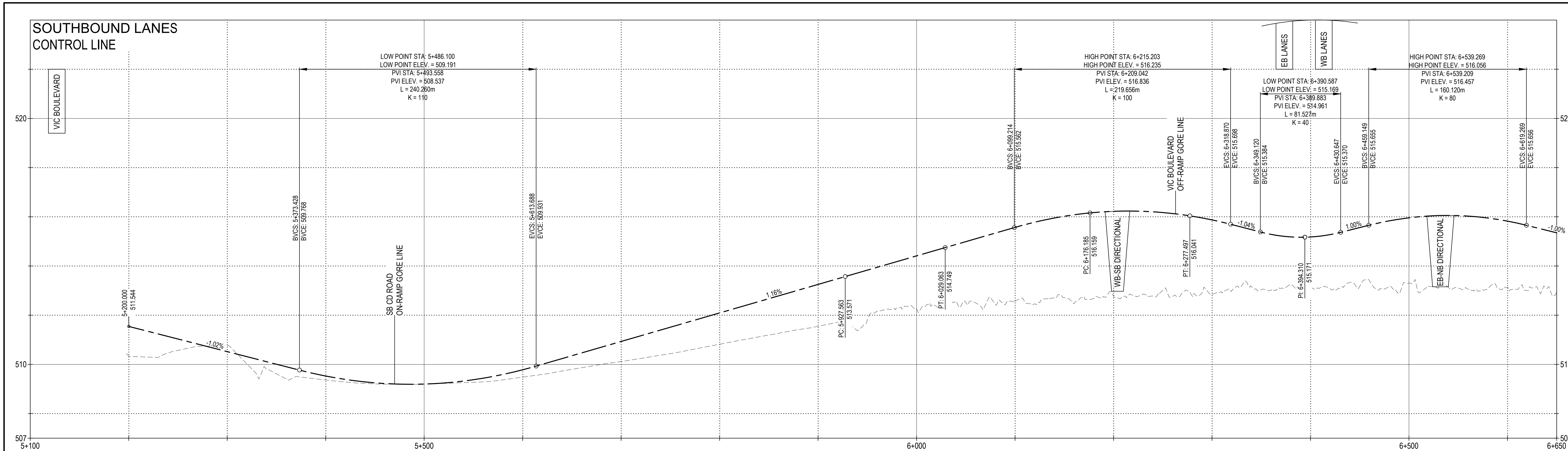
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

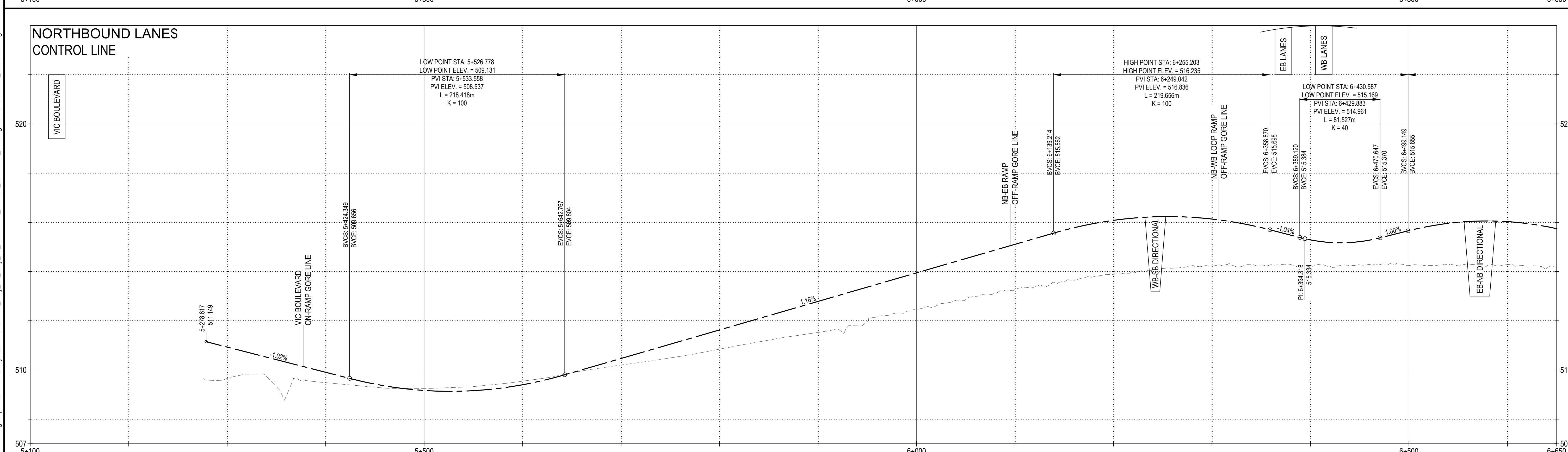
LONG TERM RECOMMENDED PROFILES

WESTBOUND AND EASTBOUND MAINLINE

Appendix A06

MAY 2017





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City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:160 — 0 1.6 3.2 4.8 6.4m

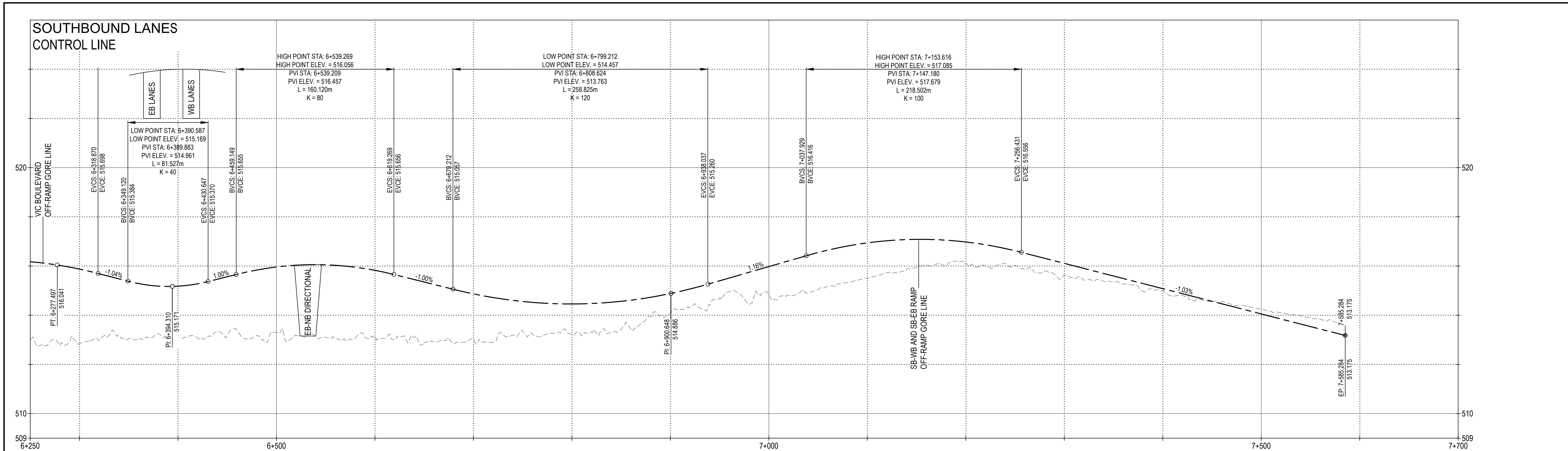
HORZ 1:4000 — 0 40 80 120 160m

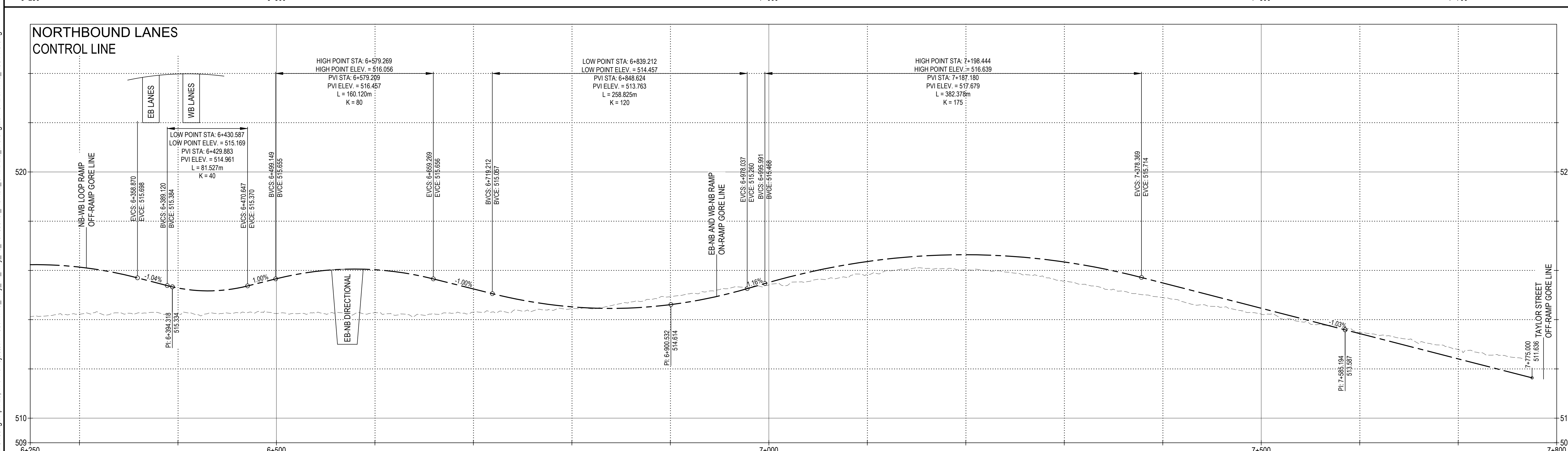
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PROFILES
SOUTHBOUND AND NORTHBOUND MAINLINE

Appendix A07

MAY 2017





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City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:80 — 0 0.8 1.6 2.4 3.2m

HORZ 1:4000 — 0 40 80 120 160m

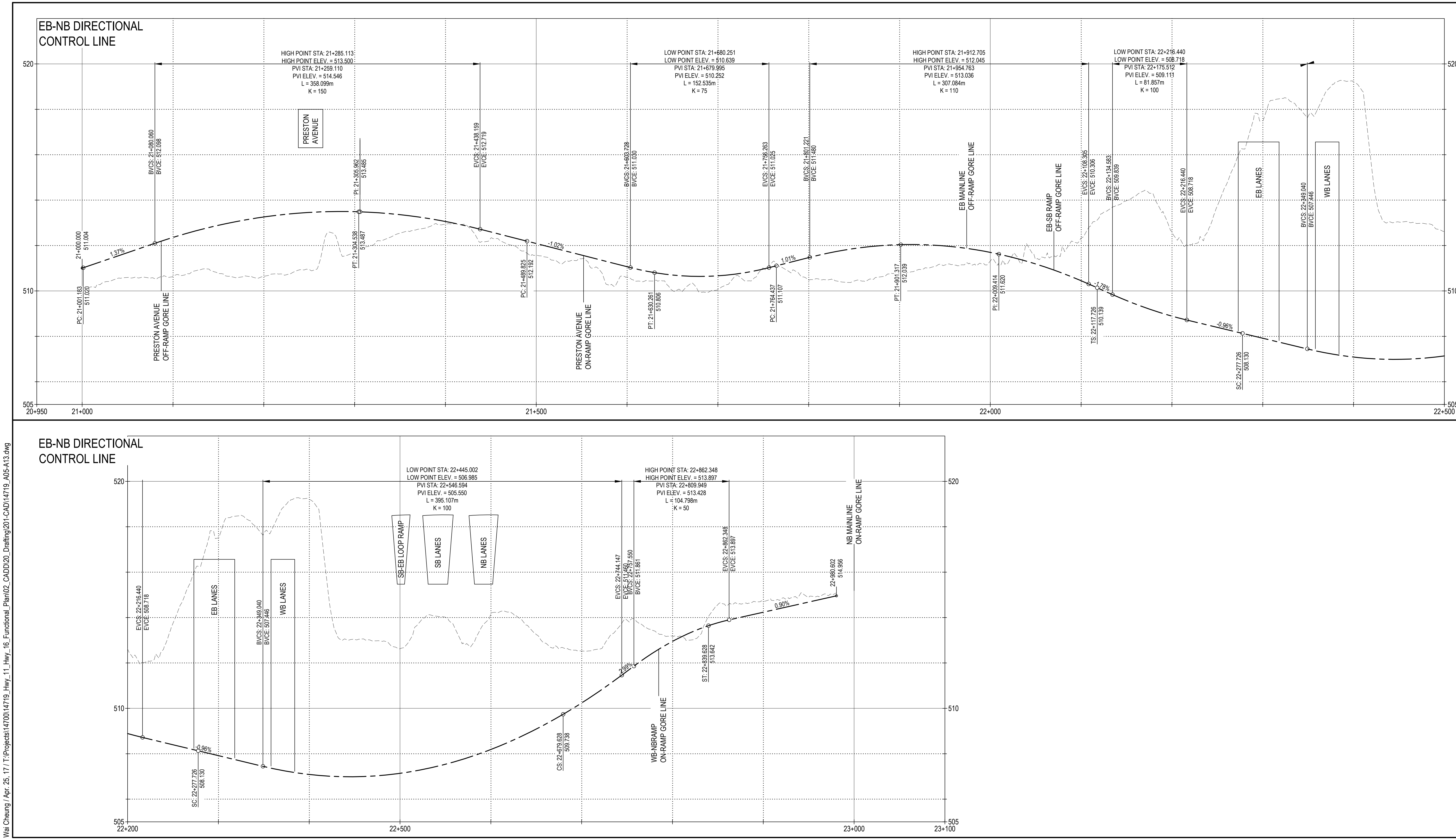
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PROFILES

SOUTHBOUND AND NORTHBOUND MAINLINE

Appendix A08

MAY 2017



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City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:160 — 0, 1.6, 3.2, 4.8, 6.4m

HORZ 1:4000 — 0, 40, 80, 120, 160m

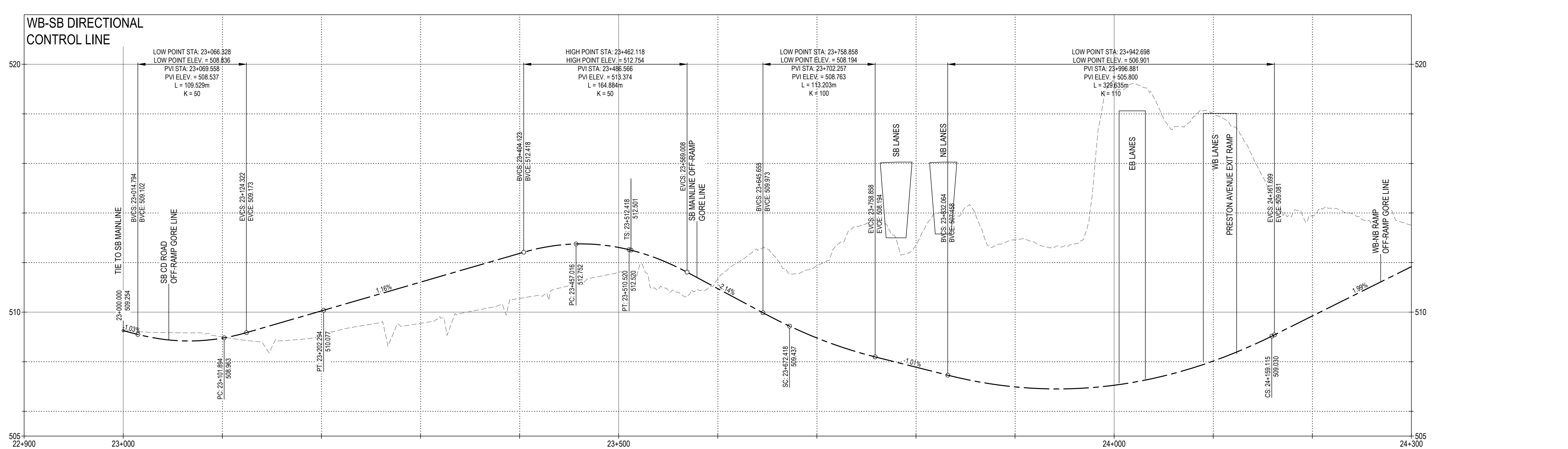
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

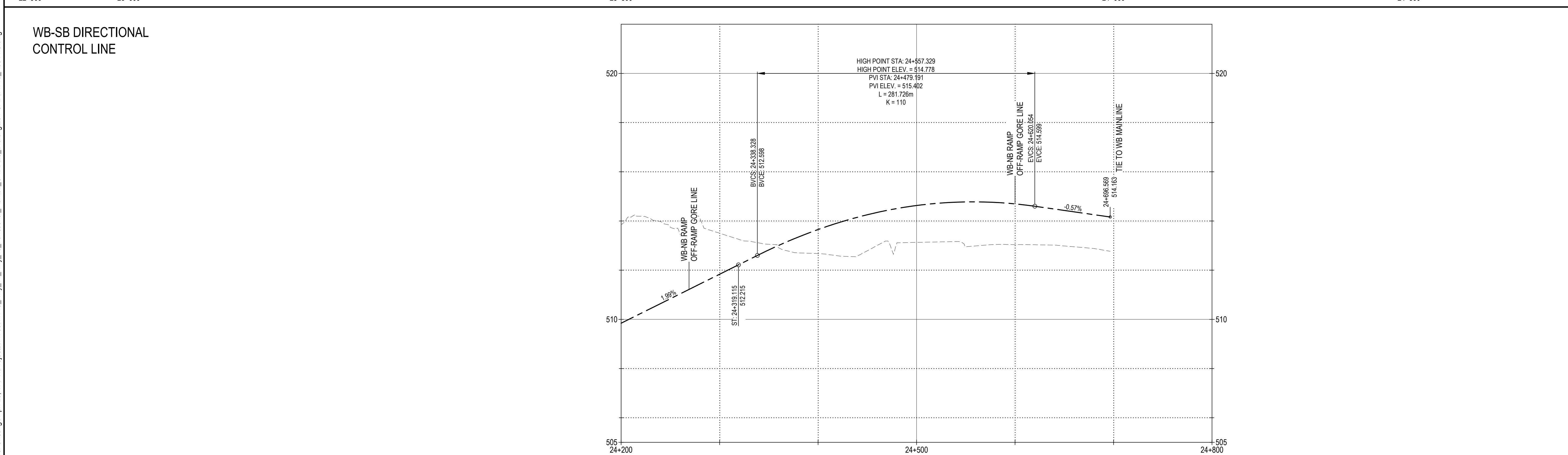
LONG TERM RECOMMENDED PROFILES

EB-NB DIRECTIONAL RAMP

Appendix A09

MAY 2017





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City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:160 — 0, 1.6, 3.2, 4.8, 6.4m

HORZ 1:4000 — 0, 40, 80, 120, 160m

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

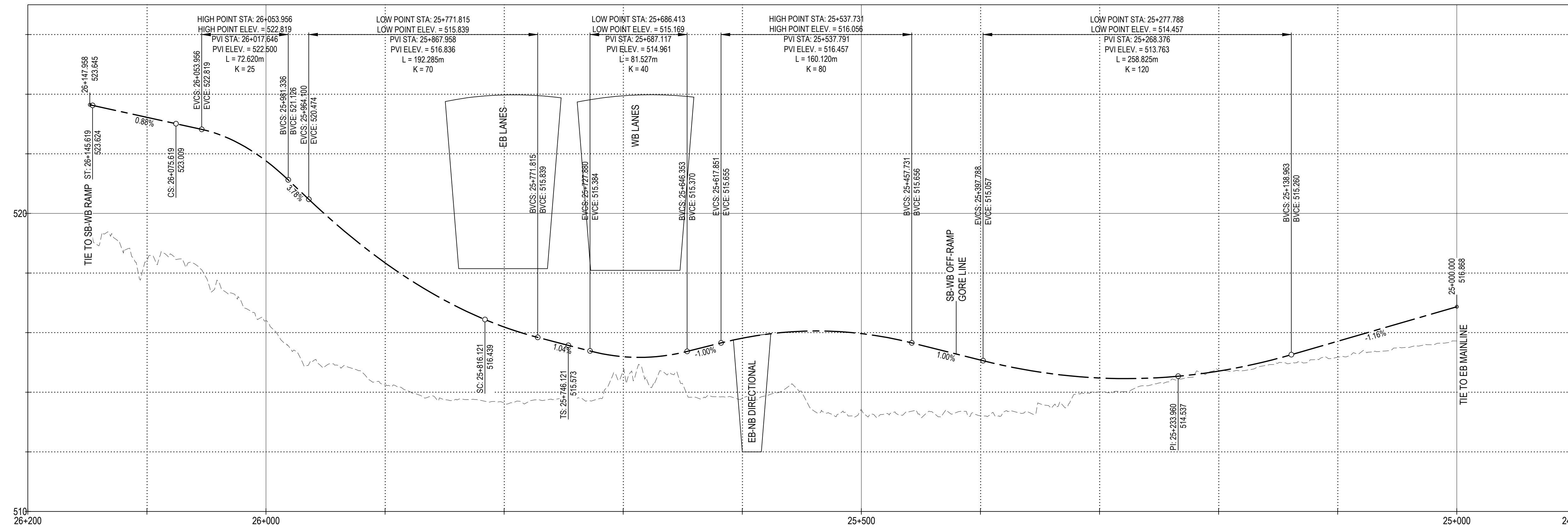
LONG TERM RECOMMENDED PROFILES

WB-SB DIRECTIONAL RAMP

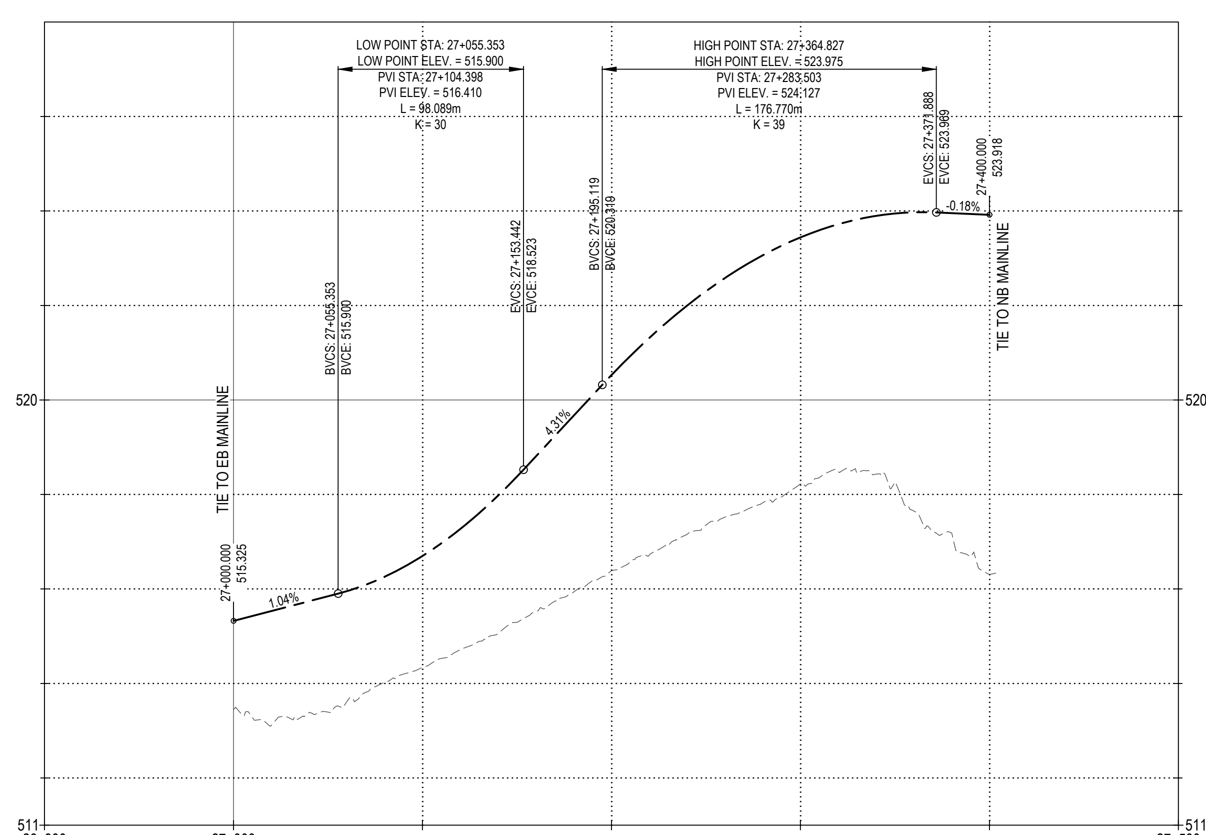
Appendix A10

MAY 2017

SB-EB LOOP RAMP CONTROL LINE



NB-WB LOOP RAMP CONTROL LINE



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City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:160 — 0 1.6 3.2 4.8 6.4m

HORZ 1:4000 — 0 40 80 120 160m

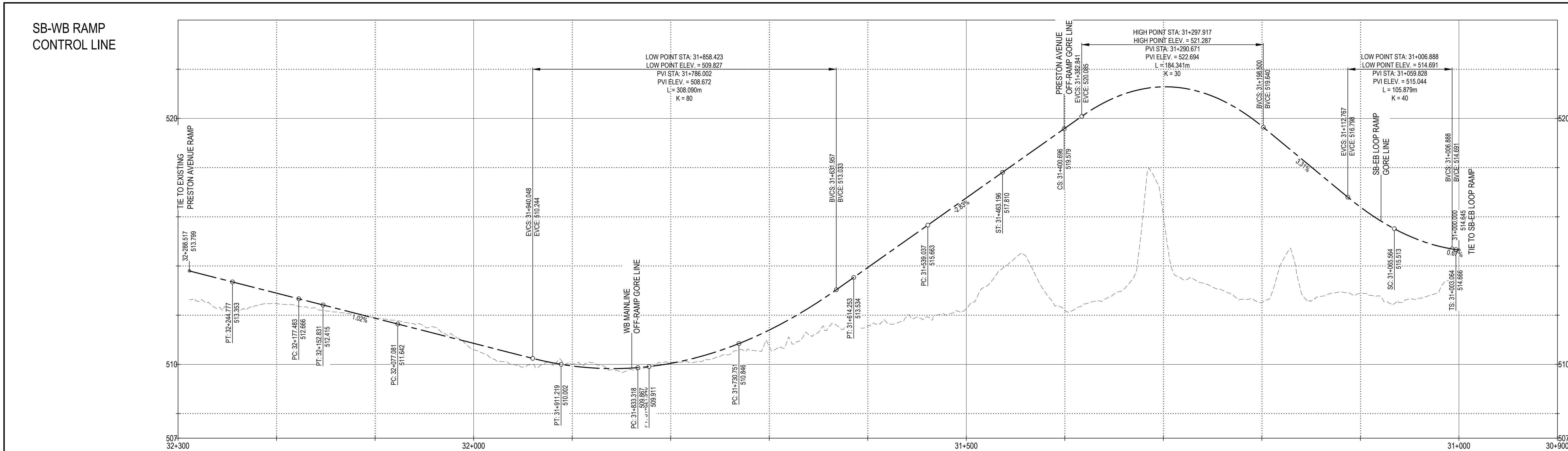
HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

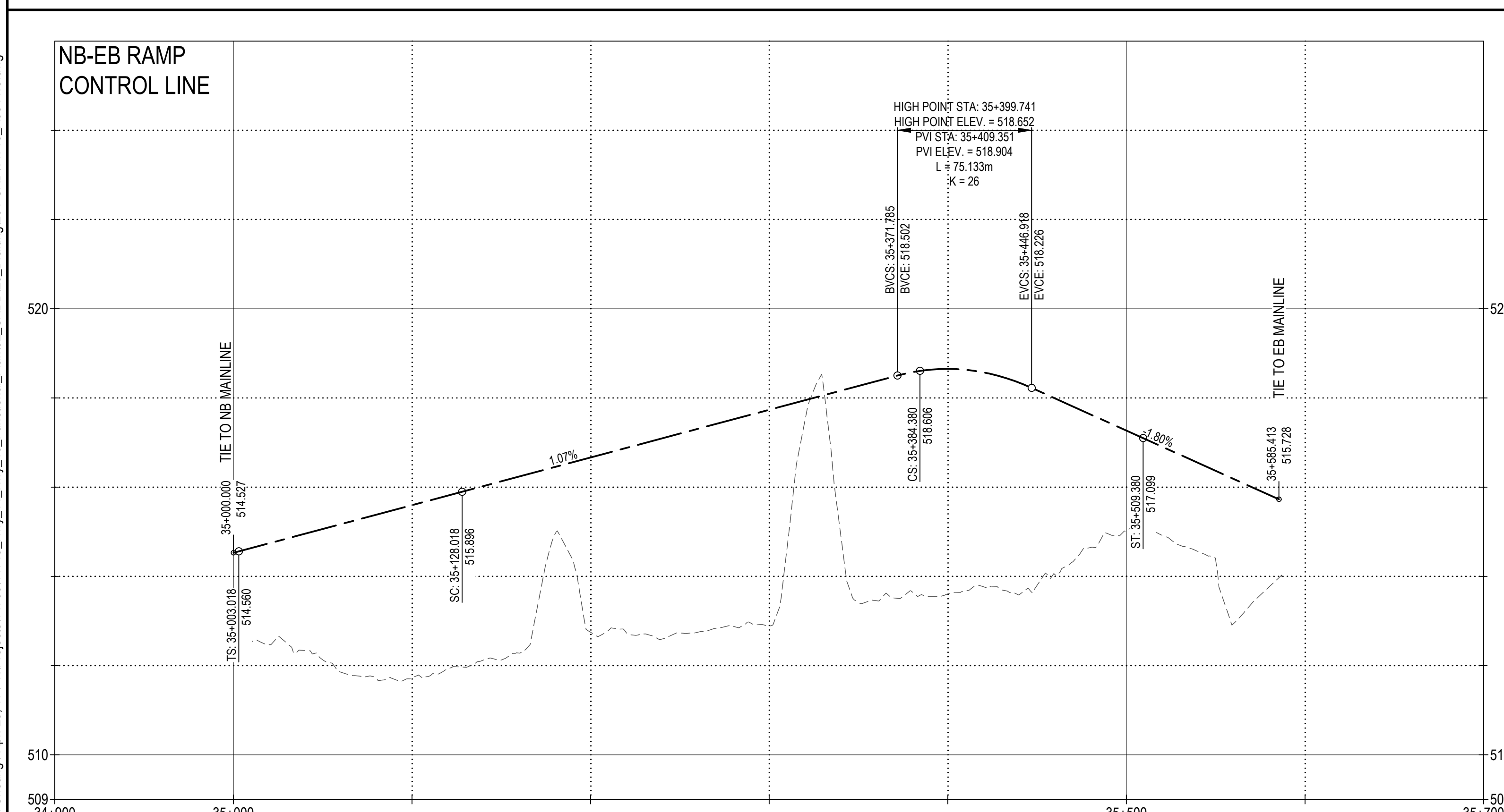
LONG TERM RECOMMENDED PROFILES

SB-EB LOOP RAMP AND NB-WB LOOP RAMP

Appendix A11

MAY 2017





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ISL Engineering and Land Services

City of Saskatoon

LEGEND

PROFILE CONTROL LINE

EXISTING GROUND

VERT 1:160 0 1.6 3.2 4.8 6.4m

HORZ 1:4000 0 40 80 120 160m

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

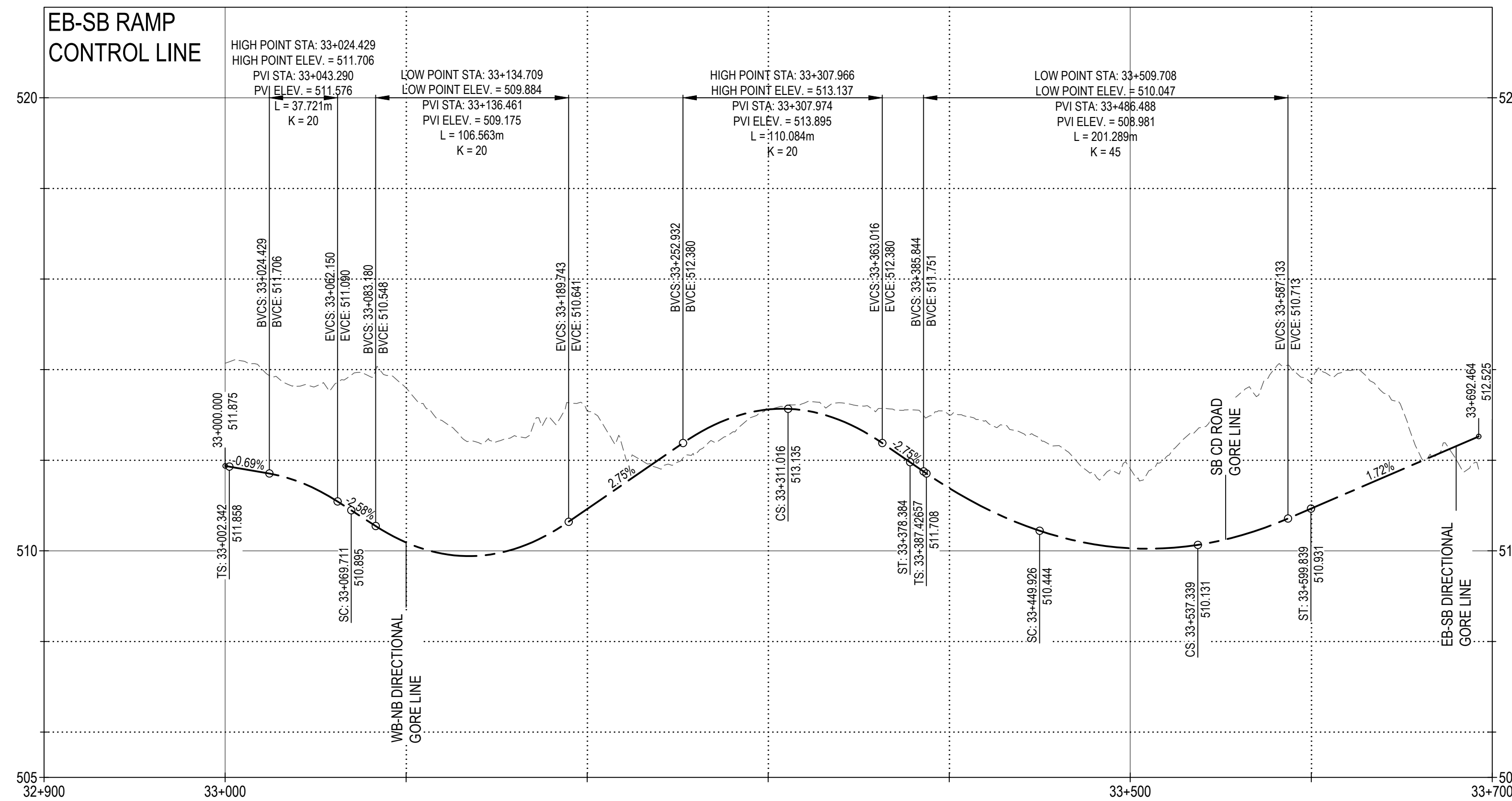
LONG TERM RECOMMENDED PROFILES

SB-WB RAMP AND NB-EB RAMP

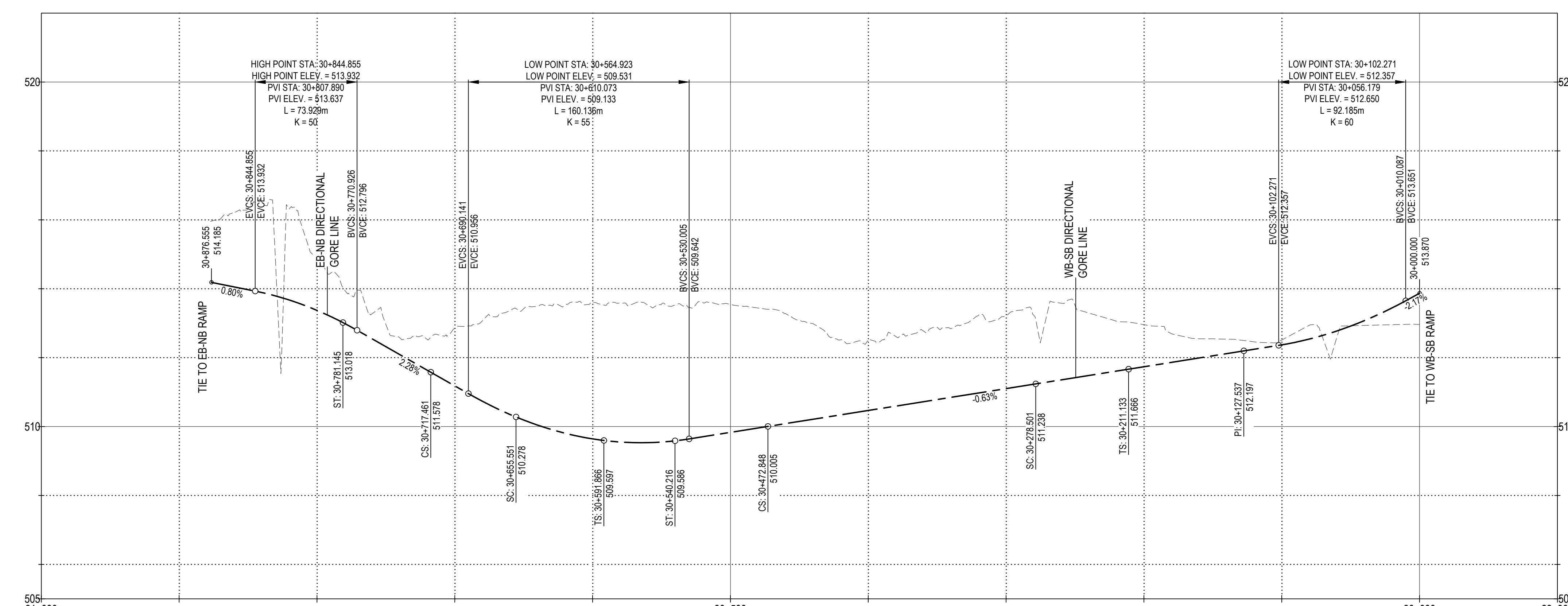
Appendix A12

MAY 2017

EB-SB RAMP
CONTROL LINE



WB-NB RAMP
CONTROL LINE



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City of Saskatoon

LEGEND

PROFILE CONTROL LINE
EXISTING GROUND

VERT 1:160 — 0, 1.6, 3.2, 4.8, 6.4m
HORZ 1:4000 — 0, 40, 80, 120, 160m

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED PROFILES

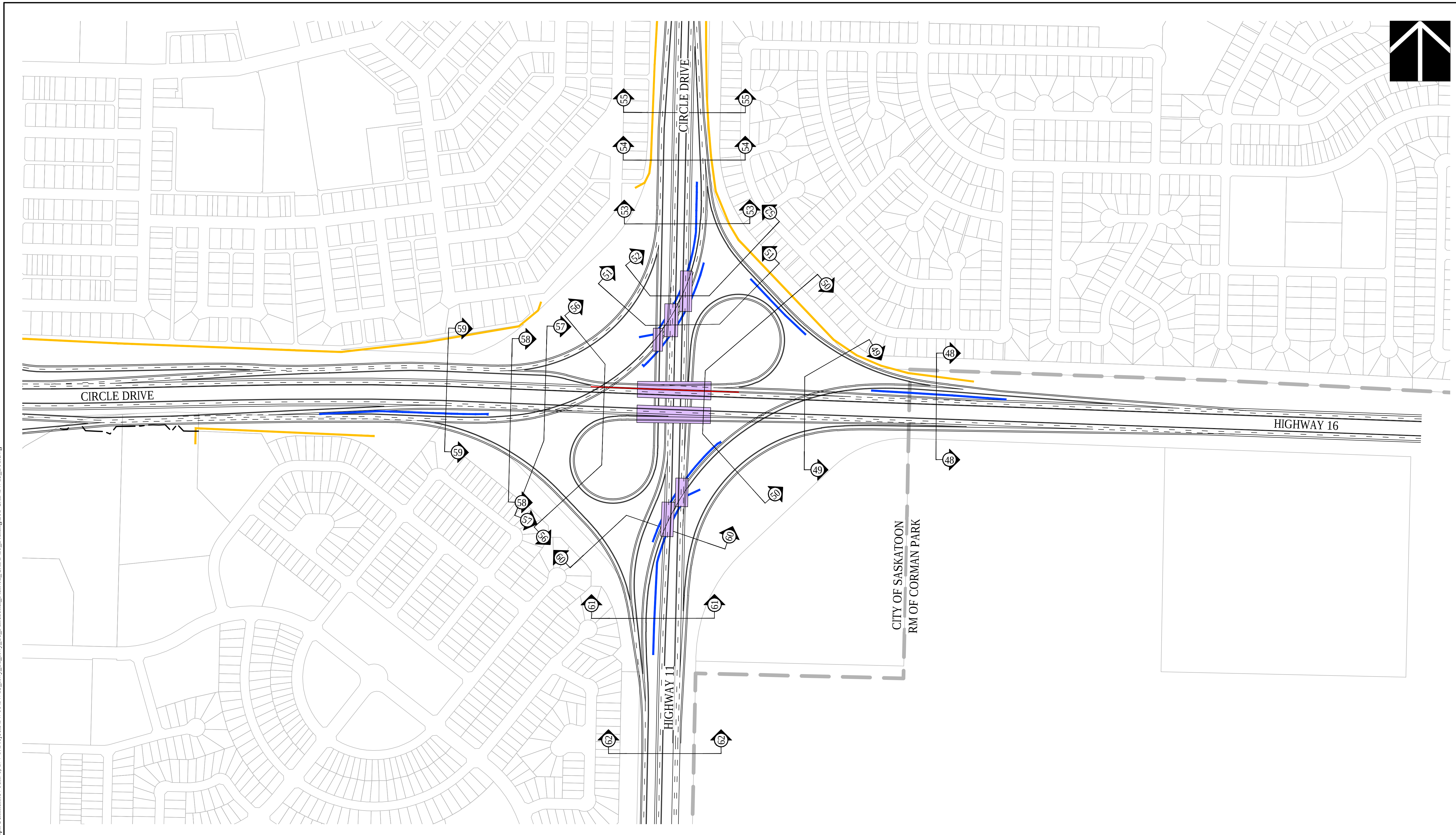
SB-WB RAMP AND NB-EB RAMP

Appendix A13

MAY 2017

Appendix B

Detailed Cross-Sections



ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

LONG TERM RECOMMENDATION

CROSS-SECTION LOCATION PLAN

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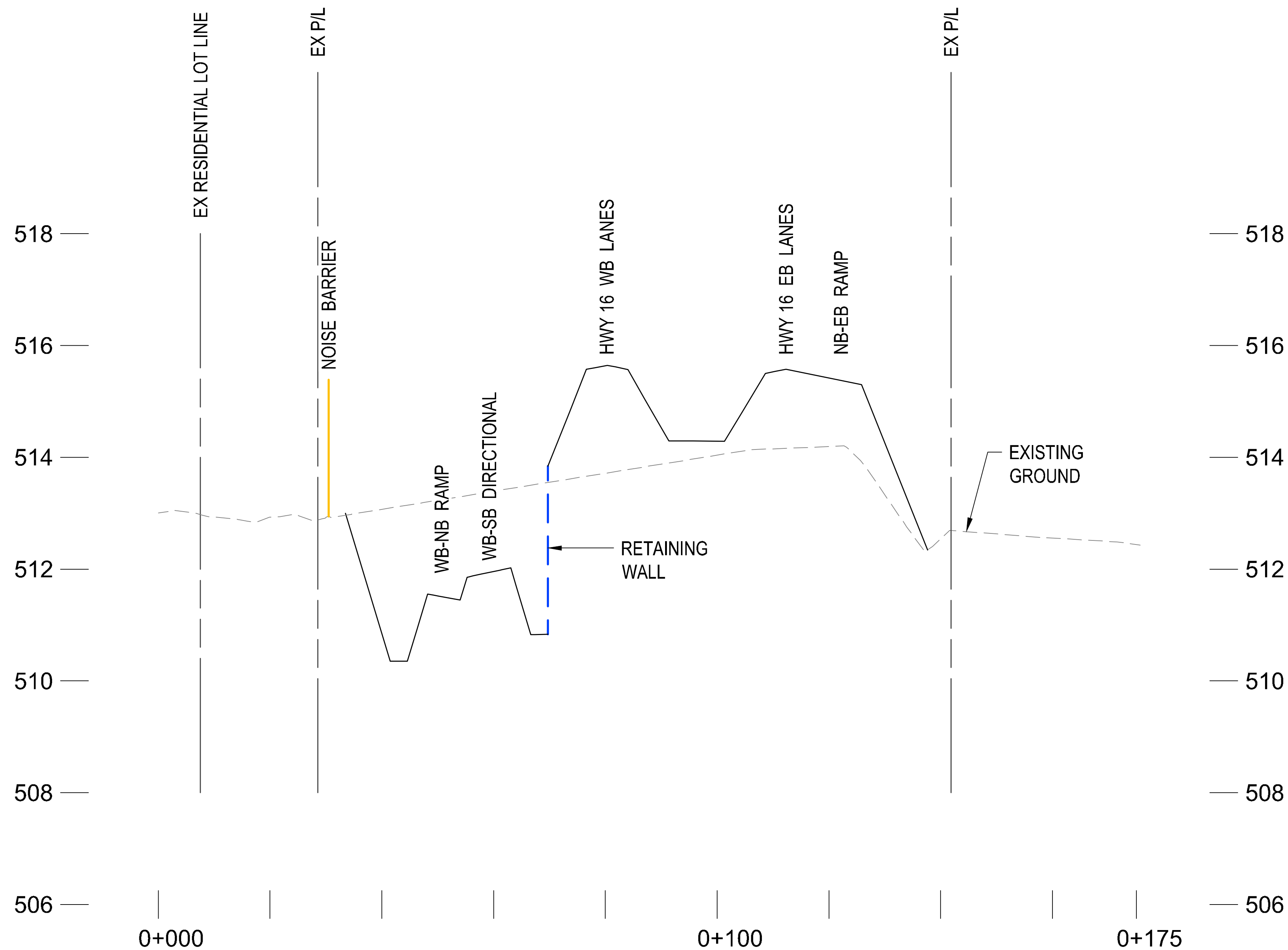
Appendix B01

JUNE 2017



LOCATION 48

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

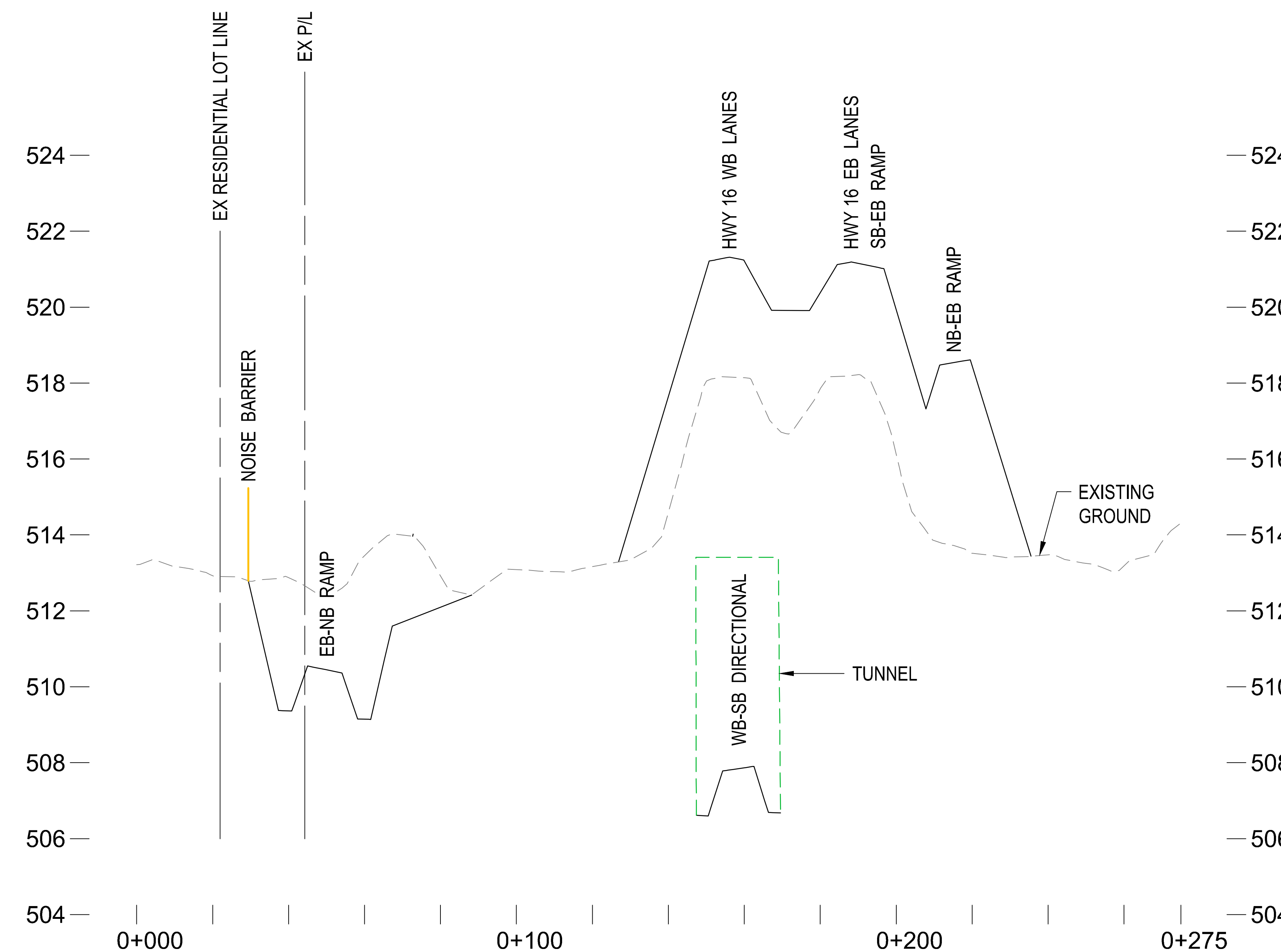
LOCATION 48

VERT 1:100 0 1 2 3 4m

HORZ 1:1000 0 10 20 30 40m

Appendix B02

MAY 2017



LOCATION 49

ISL Engineering and Land Services

City of Saskatoon

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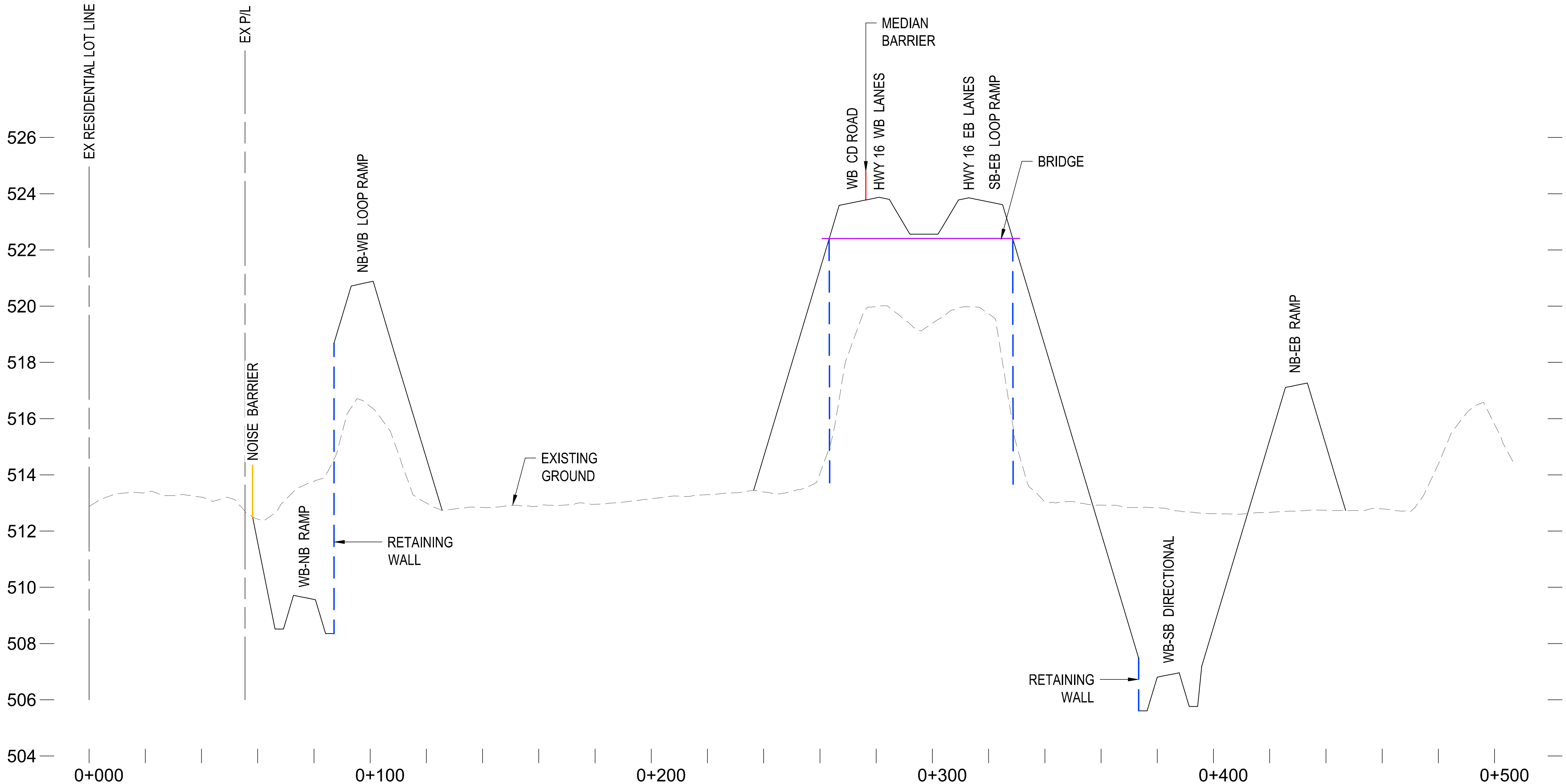
HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 49

Appendix B03

MAY 2017



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 50

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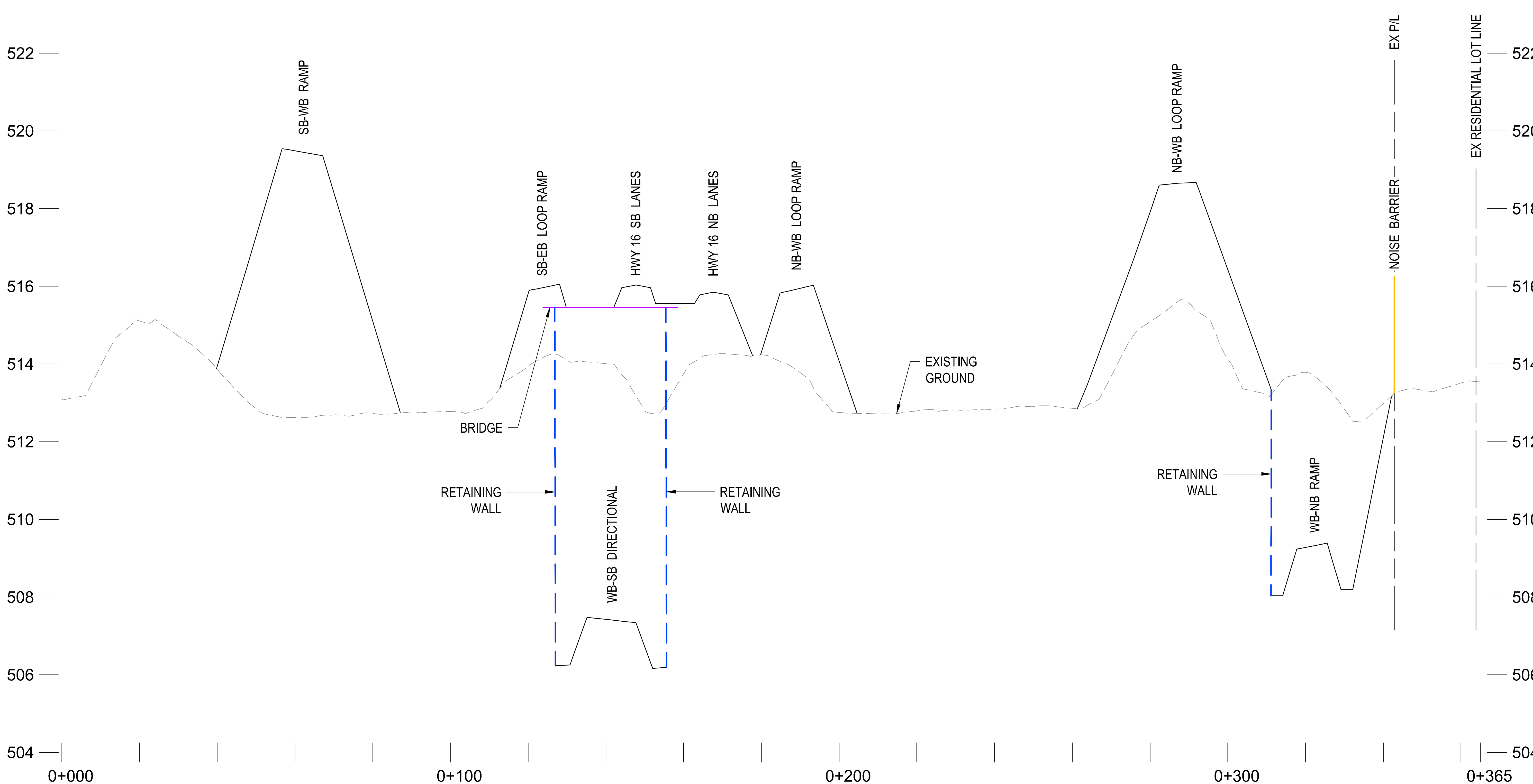
Appendix B04

MAY 2017



LOCATION 51

ISL Engineering and Land Services

City of Saskatoon

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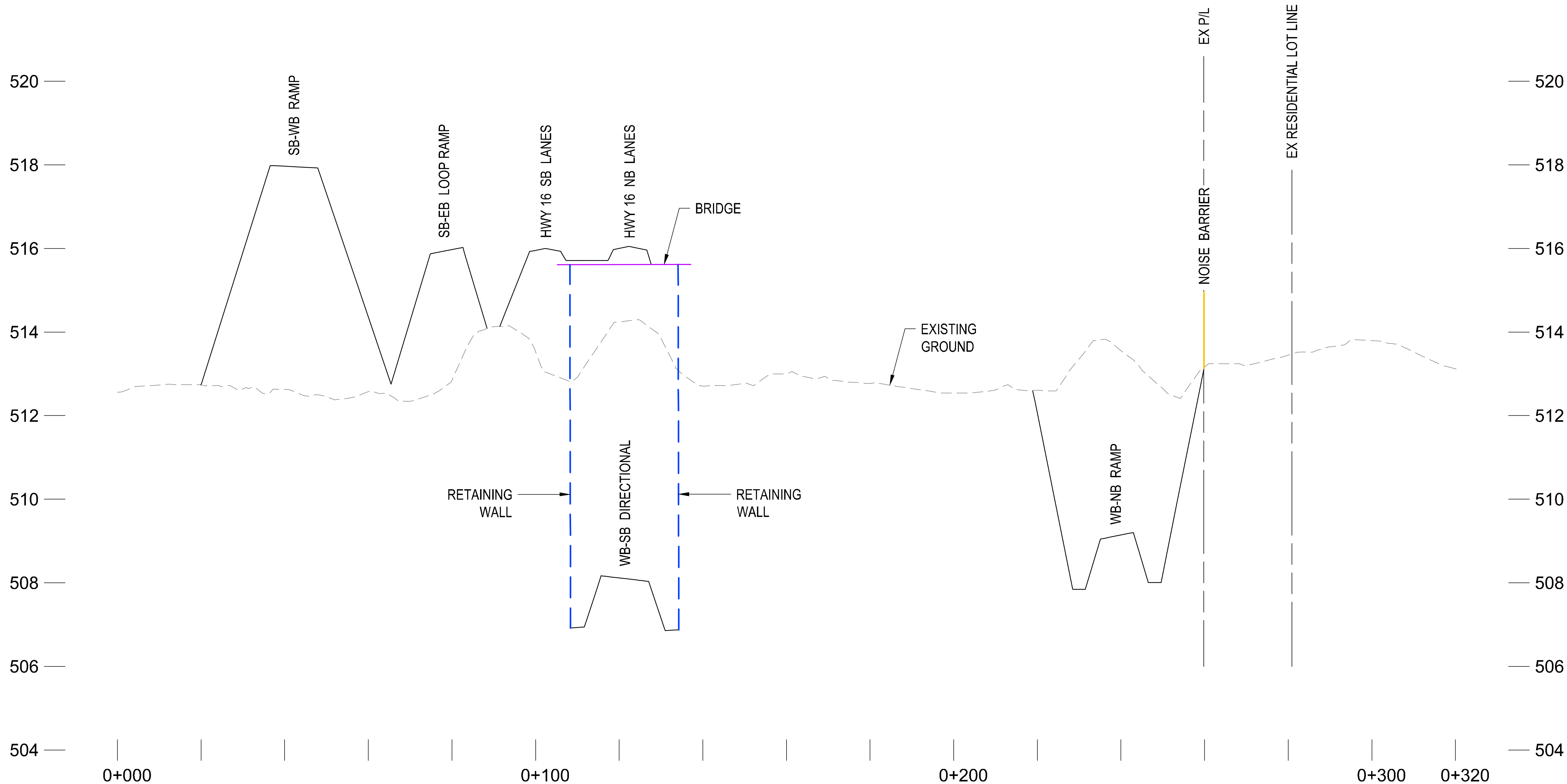
HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 51

Appendix B05

MAY 2017



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 52

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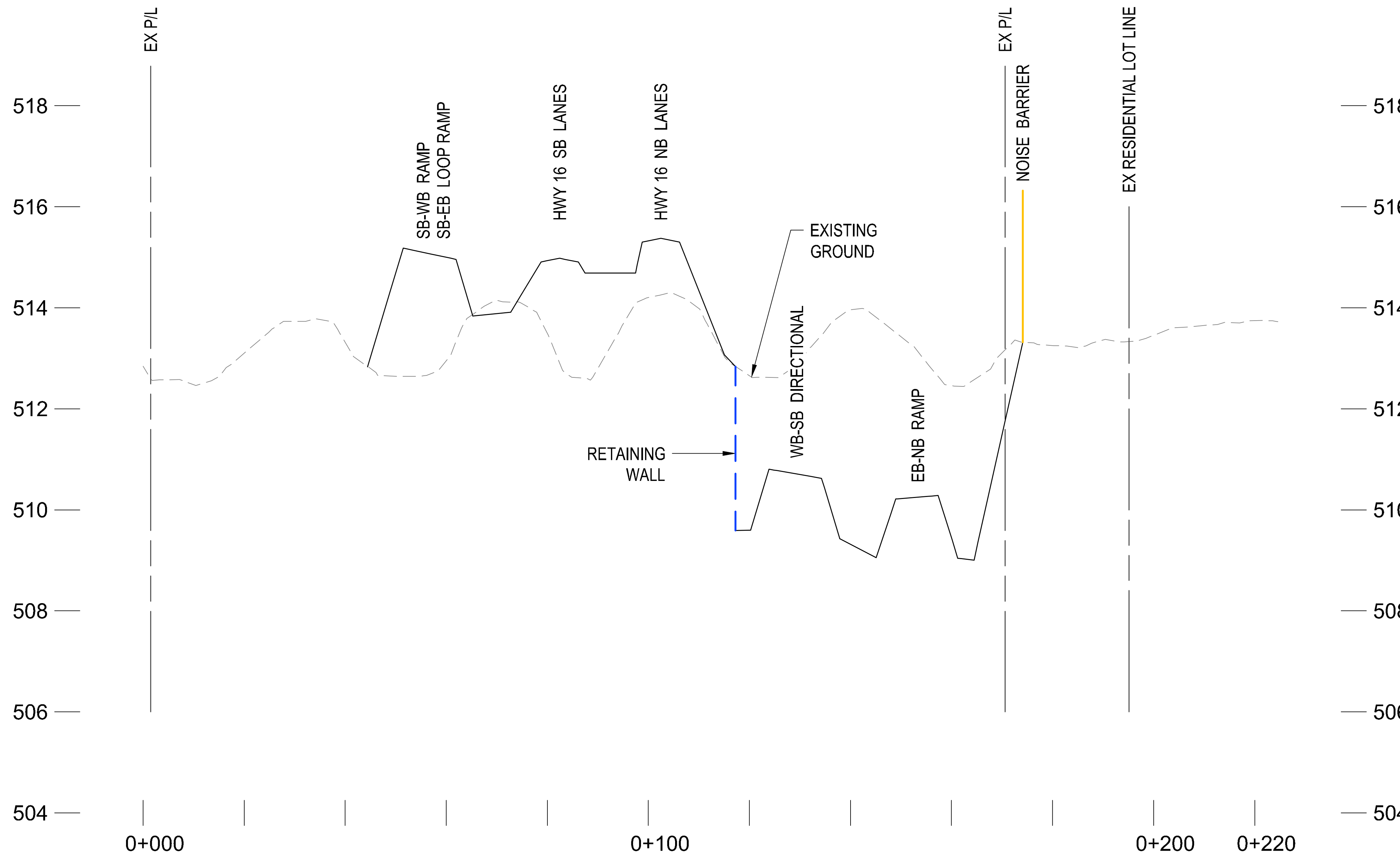
Appendix B06

MAY 2017



LOCATION 53

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 53

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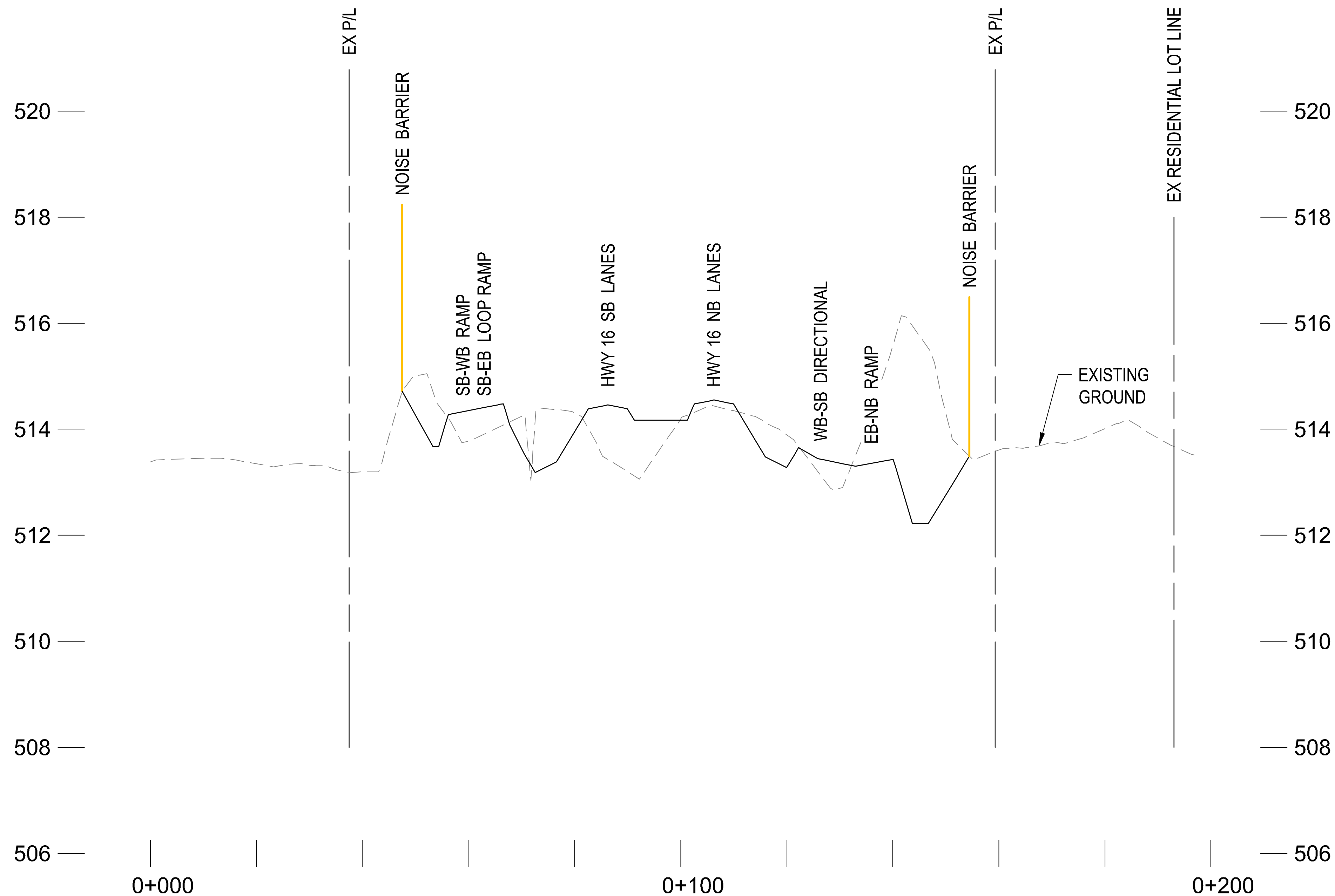
Appendix B07

MAY 2017



LOCATION 54

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 54

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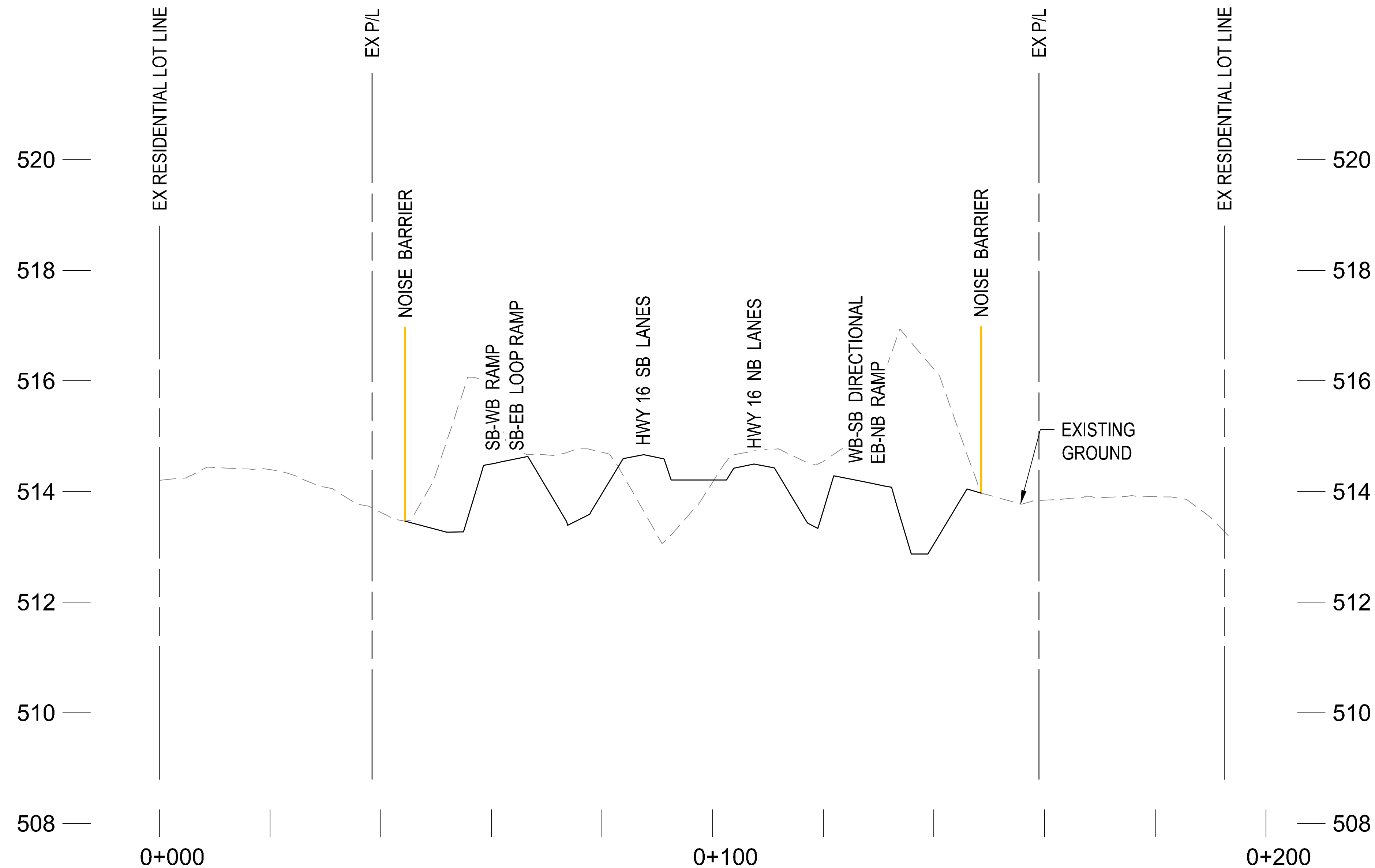
Appendix B08

MAY 2017



LOCATION 55

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 55

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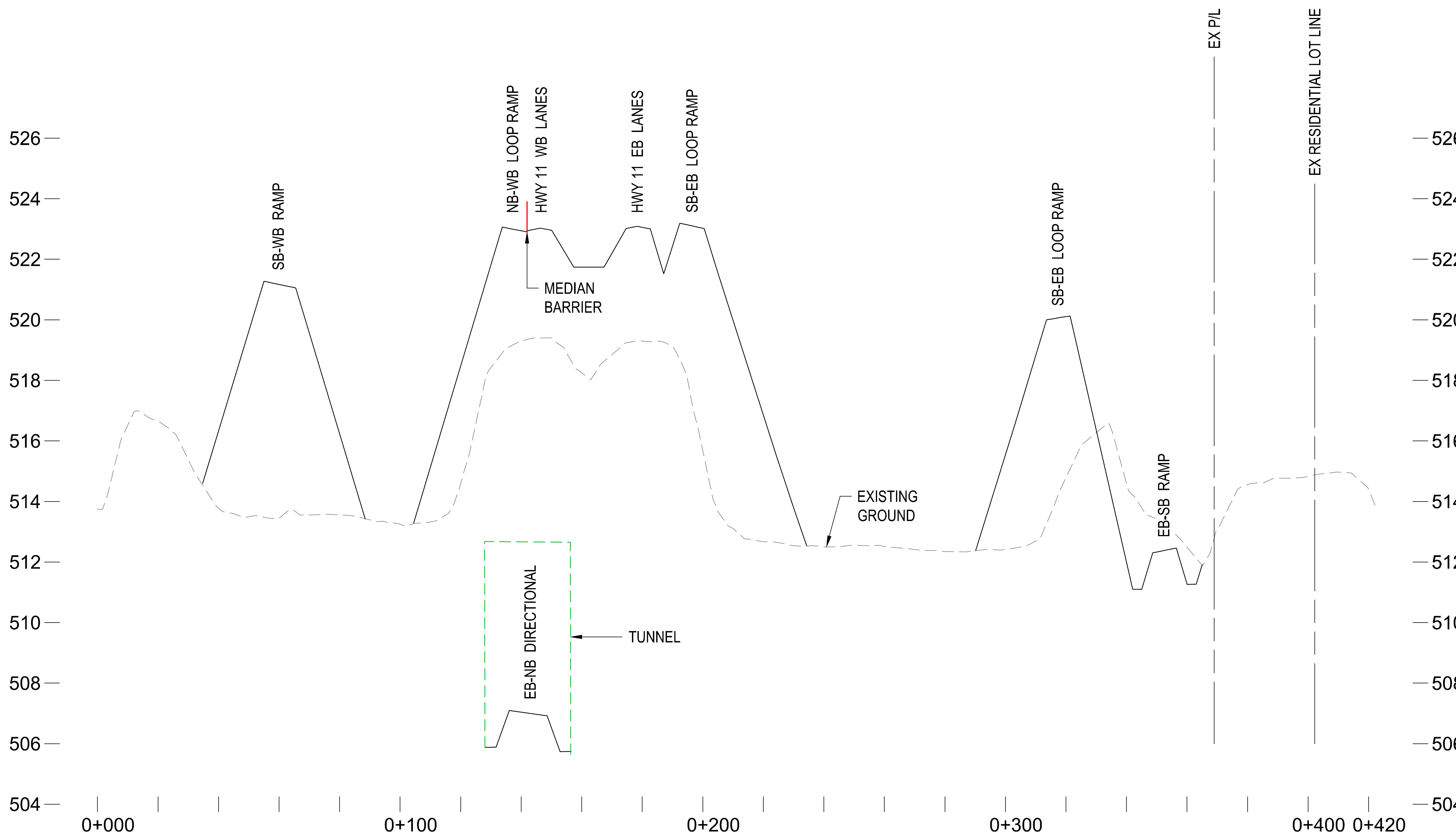
HORZ 1:1000 0 10 20 30 40m

Appendix B09

MAY 2017



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ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 56

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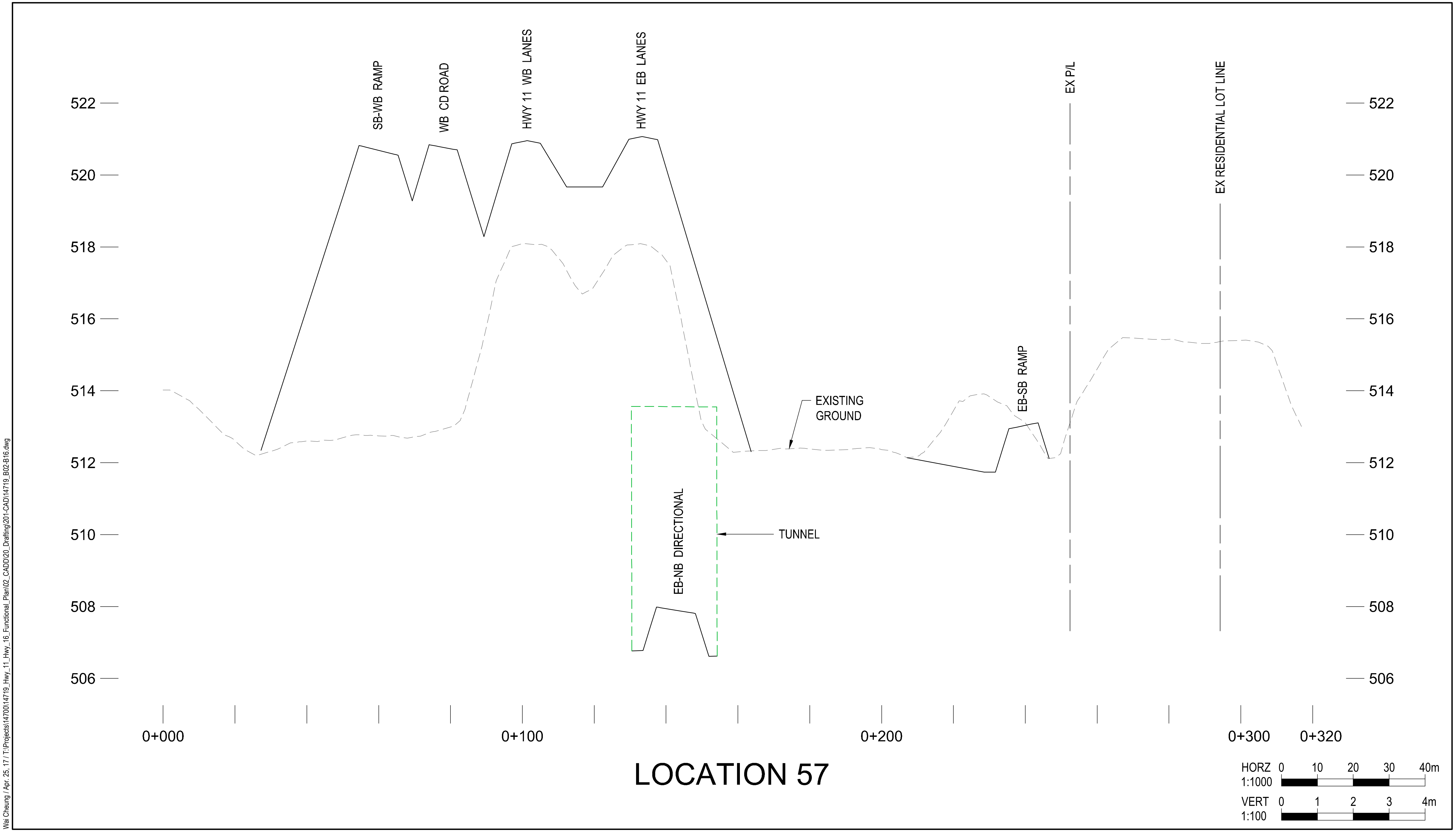
Appendix B10

MAY 2017



LOCATION 57

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 57

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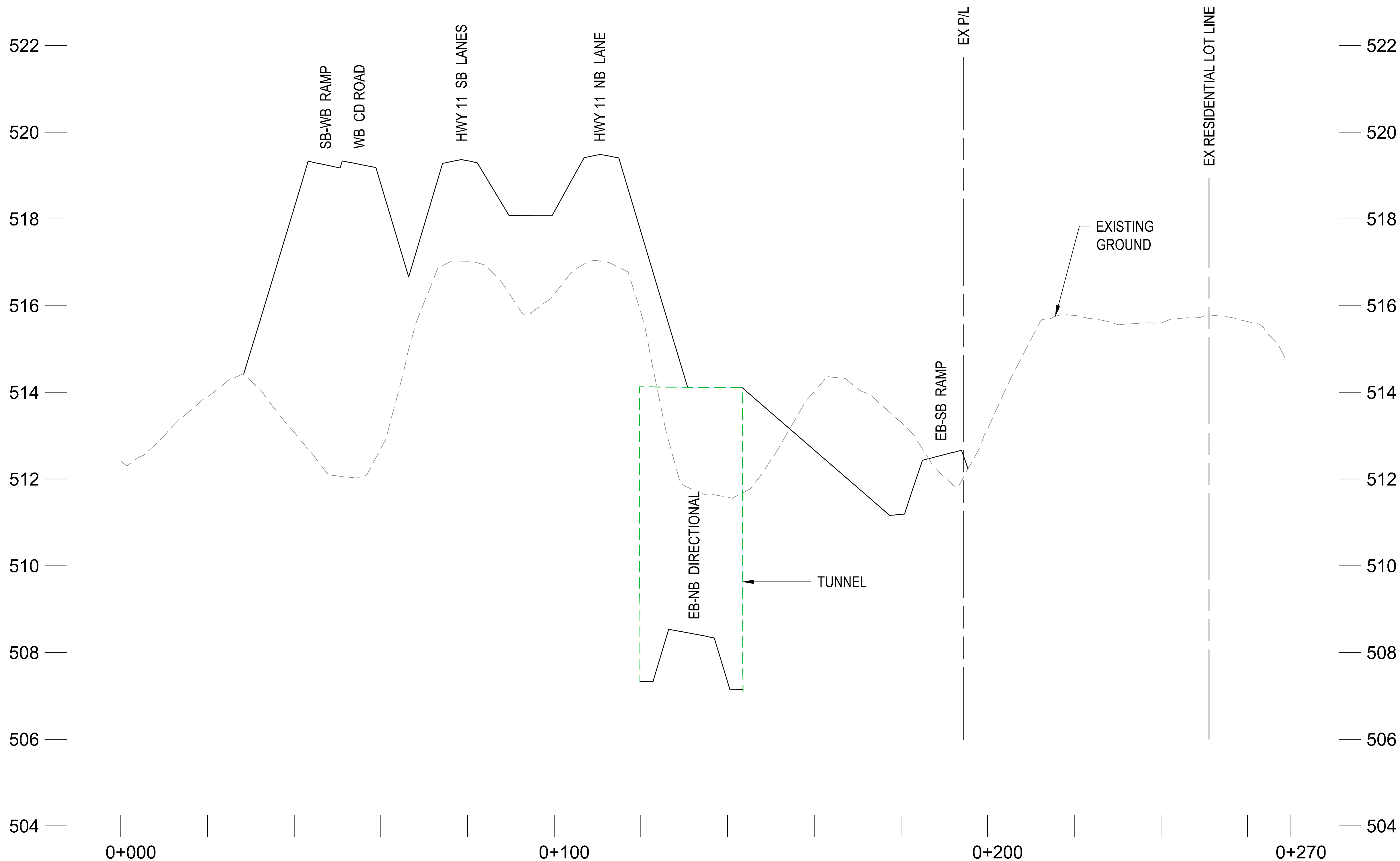
Appendix B11

MAY 2017



LOCATION 58

ISL Engineering and Land Services

City of Saskatoon

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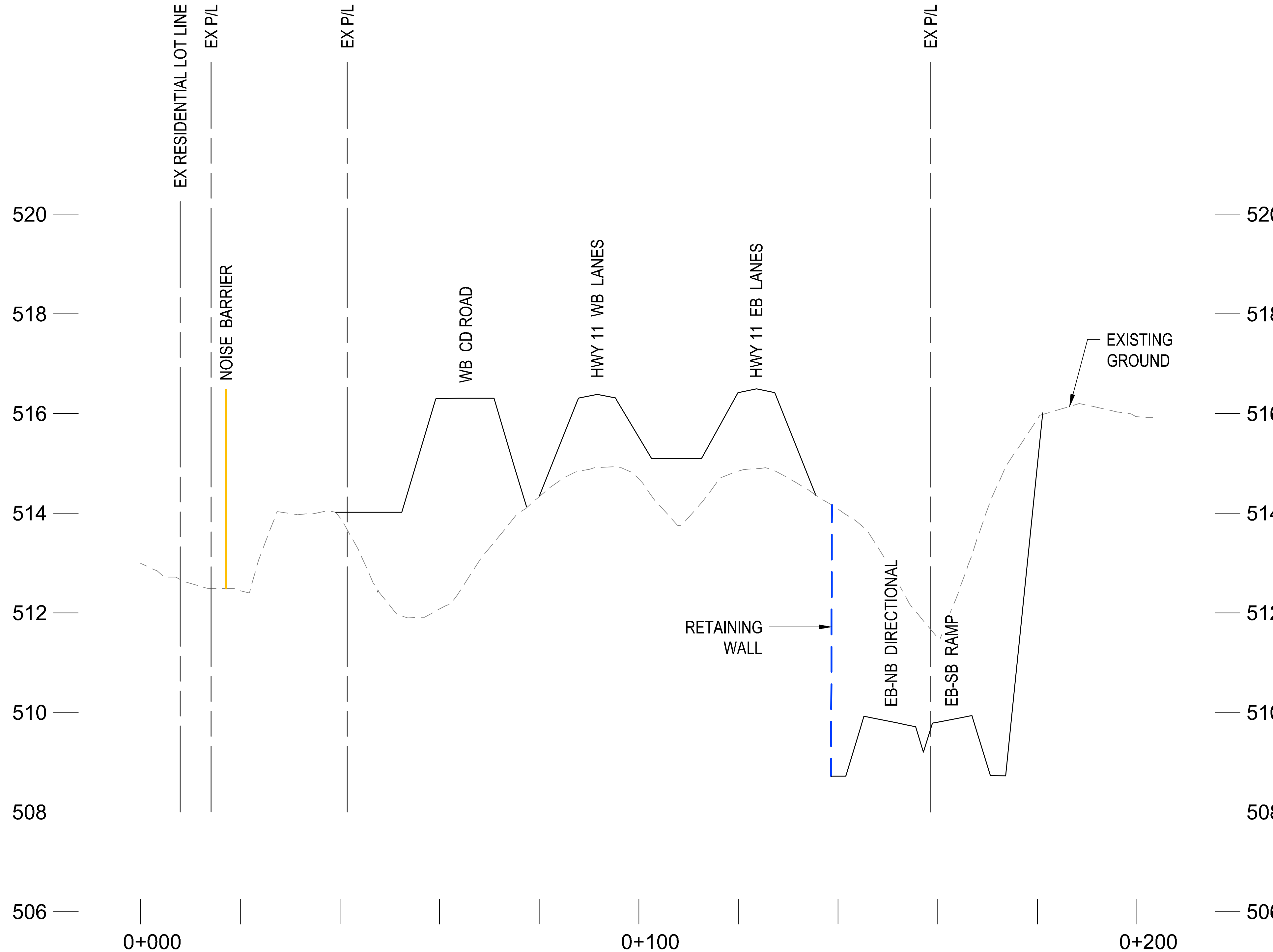
HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 58

Appendix B12

MAY 2017



LOCATION 59

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 59

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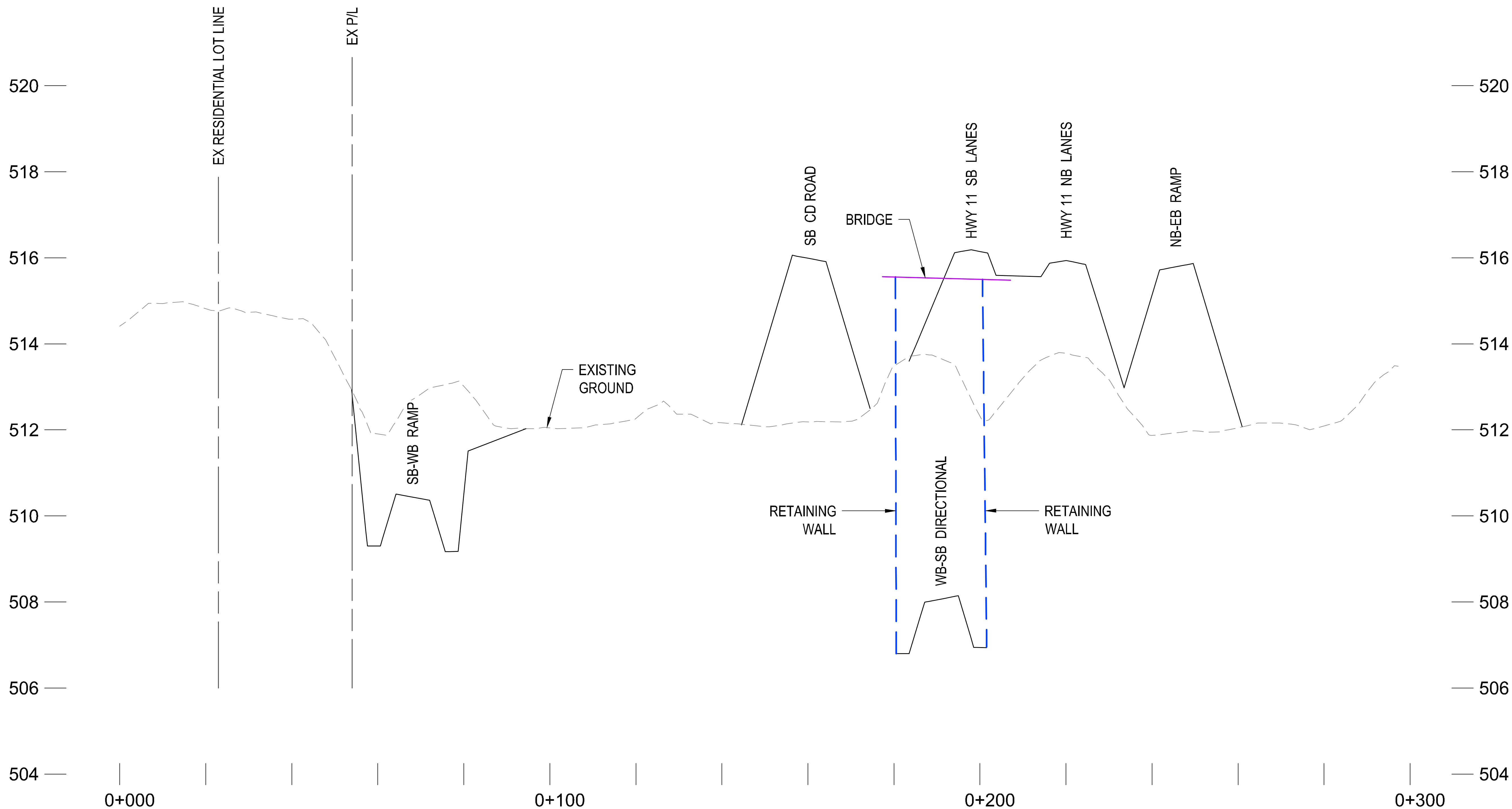
HORZ 1:1000 0 10 20 30 40m

Appendix B13

MAY 2017



LOCATION 60

Wai Cheung / Apr. 25, 17 / T:\Projects\14700\14719_Hwy_11_Hwy_16_Functional_Plan\02_CADD\20_Drafting\201-CAD\14719_B02-B16.dwg

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 60

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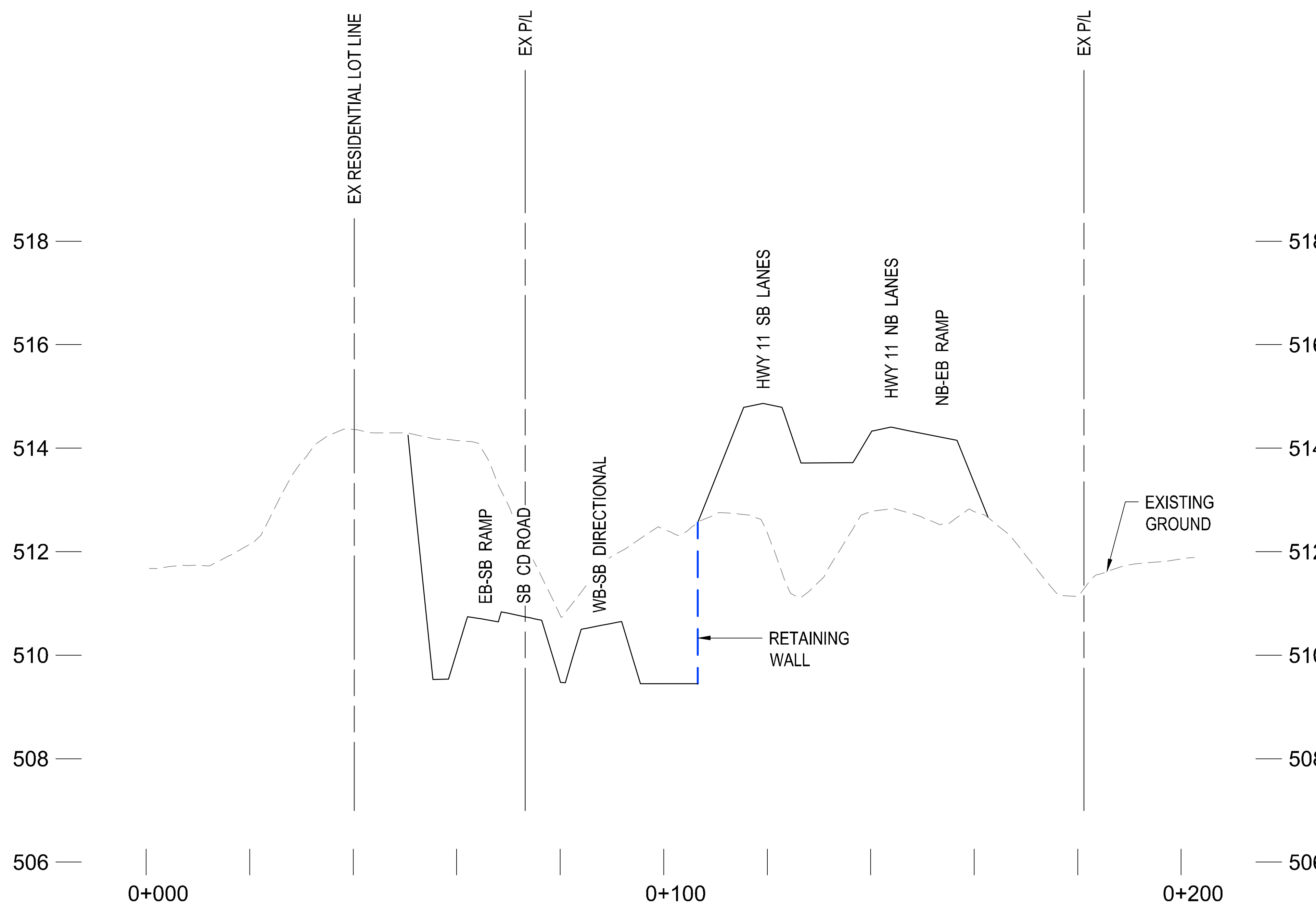
Appendix B14

MAY 2017



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Wai Cheung / Apr. 25, 17 / T:\Projects\14700\14719_Hwy_11_Hwy_16_Functional_Plan\02_CADD\20_Drafting\201-CAD\14719_B02-B16.dwg

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 61

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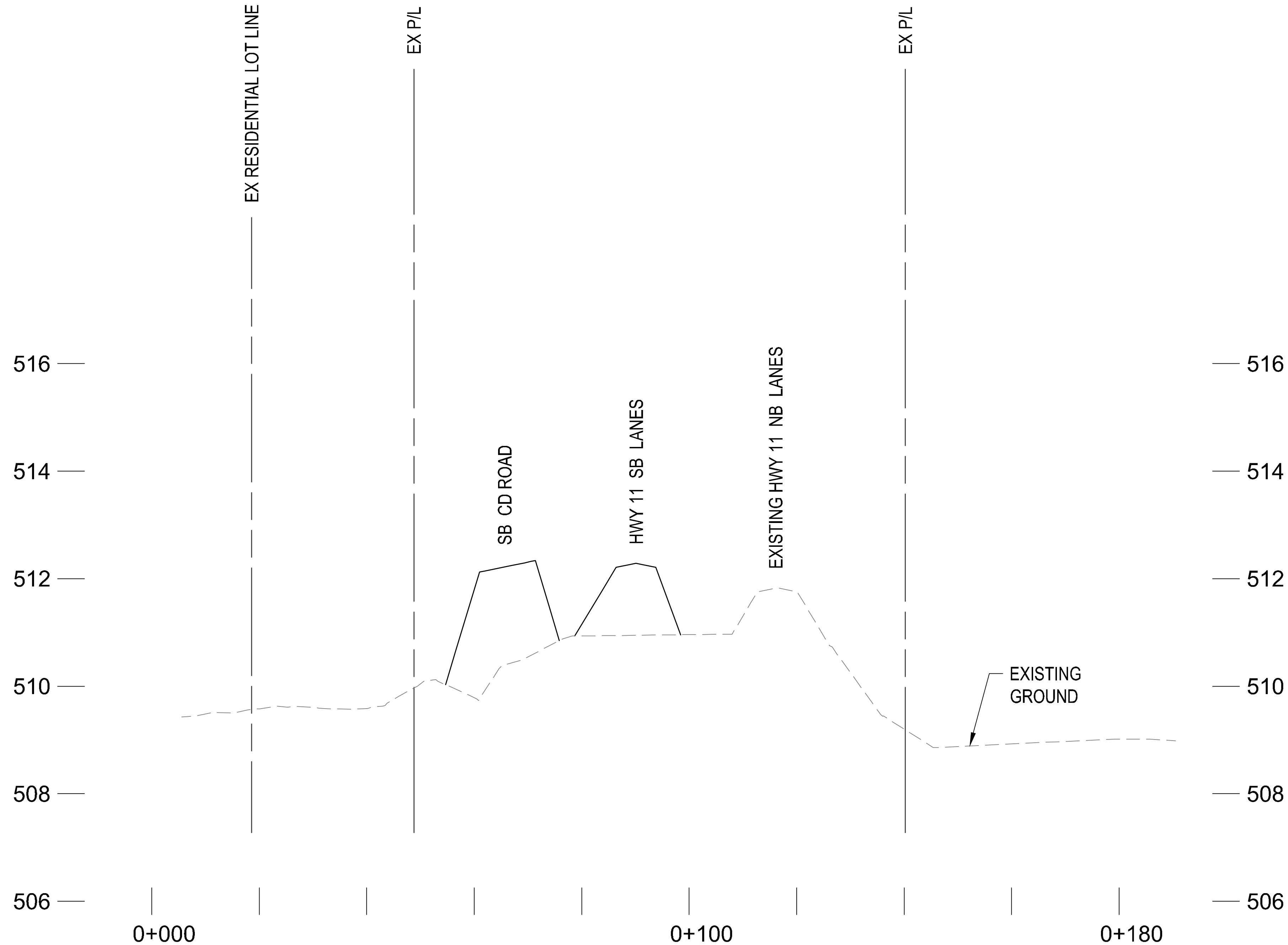
HORZ 1:1000 0 10 20 30 40m

Appendix B15

MAY 2017



LOCATION 62

ISL Engineering and Land Services

City of Saskatoon

HIGHWAY 11 and HIGHWAY 16 INTERCHAGE FUCTIONAL PLANNING STUDY

LONG TERM RECOMMENDED CROSS LOCATION

LOCATION 62

VERT 1:100 0 1 2 3 4m

HORZ 1:1000 0 10 20 30 40m

Appendix B16

MAY 2017

Appendix C
Value Engineering Session Report

ISL Engineering and Land Services

Inspiring sustainable thinking

City of Saskatoon

Workshop Summary

Highway 11 and Highway 16 Functional Planning Study

November 2016

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APPENDICES

TABLES

FIGURES

1.0 Introduction

On October 24, 2016 a workshop was held at the Marriott Hotel in Saskatoon (between 12:30pm and 4:30pm) to evaluate potential options for improving the existing interchange. Attendees are listed below:

- David LeBoutillier (City of Saskatoon, Transportation)
- Justine Marcoux (City of Saskatoon, Transportation)
- M.Nisar Khan (City of Saskatoon, Municipal)
- Hossein Azinfar (City of Saskatoon, Municipal)
- Craig Habermehl (RM of Corman Park)
- Nicole Sinclair (Saskatchewan Trucking Association)
- Steve Melton, M.Eng., P.Eng., PMP (ISL Engineering, Transportation)
- Troy Letwin, P.Eng. (ISL Engineering, Bridges)
- Rob Cholodnuik, AScT (ISL Engineering, Bridges)
- Shelly Moulds, P.Eng. (ISL Engineering, Transportation)
- Hassan Shaheen, P.Eng. (ISL Engineering, Transportation)
- Roy Symons, P.Eng. (ISL Engineering, Transportation)
- Russell Barth. P.Eng. (ISL Engineering, Municipal)
- Devon Chaykowski, P.Eng. (ISL Engineering, Transportation)
- Jimmy Rathod, E.I.T., P.E., M.S. (ISL Engineering, Transportation)
- Chris Delanoy, P.Eng. (ISL Engineering, Transportation)

The afternoon's agenda was as follows:

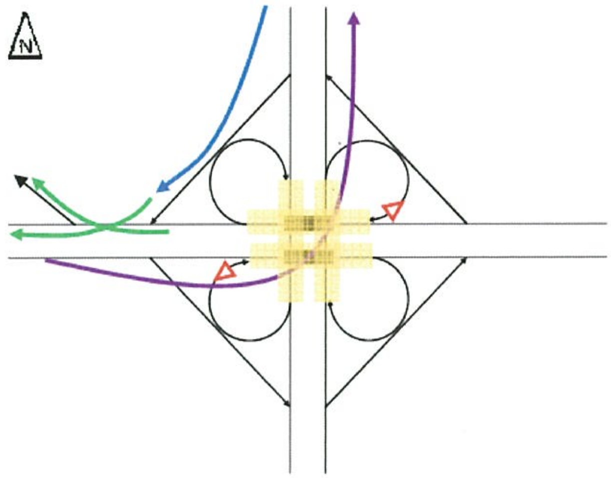
- Background Presentations
- Criteria Development and Ranking
- Brainstorming of Alternatives
- Ranking of Alternatives

1.1 Interchange Background

The existing interchange at the junction of Highway 11 and Highway 16 is a simple cloverleaf configuration that was built in 1966. The interchange is showing signs of age and there are issues with weaving, and with the vertical clearance to the bridge structure. Recent develop restricts expansion of the footprint in three of the four quadrants.

Traffic

In 2016, the major turning movements are southbound right and eastbound left. Overall the interchange has 6.7% trucks, with most trucks entering/exiting the system from the south leg. The largest distribution of trucks is found on the northbound to eastbound ramp (26% during the AM peak), and the westbound to southbound ramp (25% during the AM peak). Figure 1.1 illustrates all of the traffic issues that need to be addressed.



- What volumes are we designing for?
- Can we remove yields?
- Can we remove or reduce weaving inside the Interchange?
- How do we manage weaving and high volumes in limited space between the Interchange and Preston Ave Interchange?
- How do we Improve the Eastbound Left Turn?
- How do we improve the Southbound Right Turn?

Figure 1.1: Traffic Issues to be Addressed

Future volumes for 2041 were extracted from the regional model; however, several volumes were lower than the existing volumes for no apparent reason. As a comparison the existing volumes were forecasted forward linearly at 2% per annum. While these volumes area high, the project team feels that any interchange proposed should be able to accommodate this demand in the future. Traffic volumes and a comparison between scenarios is included in Appendix A.

Bridge Structure

The interchange has twin overpass bridges on Highway 16 over Highway 11, constructed in 1966. Based on recent inspections, it is estimated that the bridges have between 10 and 15 years of service life remaining. The bridges have 5 spans (10m, 18.3m, 16.5m, 18.3m, 10m) totaling approximately 73m in length. Figure 1.2 below shows the interchange as it is built today.

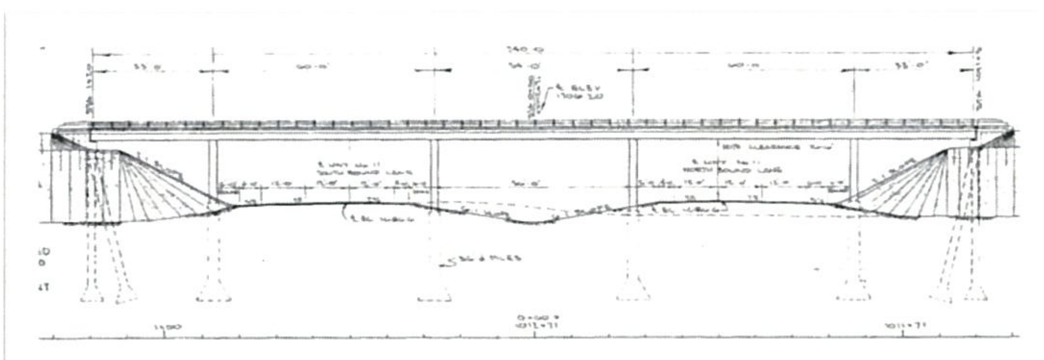


Figure 1.2: Existing Bridge Spans

Currently the bridge has a vertical clearance of 4.7m, and the current standard is 5.6m. Each year the bridge is struck several times by vehicles which is reducing the remaining service life for the structures. Options for increasing the vertical clearance on the existing bridges include:

- Lowering the roadway under the bridges;
- Raising the bridges and adjusting the profile; and
- Replacing the bridges.

All options are feasible, but range in complexity and cost. For details refer to Appendix A.

Drainage

Currently the drainage along the corridor is uncontrolled, with most of the runoff heading south on Highway 11 into the Stonebridge Neighbourhood, and a small portion draining to the east to the Boychuk interchange. Water headed into the Stonebridge Neighbourhood passes through a culvert system within a berm heading to the storm pond on the other side. During heavy rain events the culvert is supercharged, resulting in ponding upstream that can cover the travel lanes.

It is proposed that stormwater management techniques such as dry ponds be located within the interchange footprint to control the release of this stormwater to the neighbourhood. Based on the 7m elevation difference between the interchange and the downstream storm pond, gravity drainage should not be an issue. It is anticipated that the roadway can be lowered several meters without negatively impacting drainage.

Collision Analysis

SGI provided collision data for 2010 to 2015. Analysis shows that the number of collisions has increased each year, with no fatalities. Summaries of the findings are shown below.

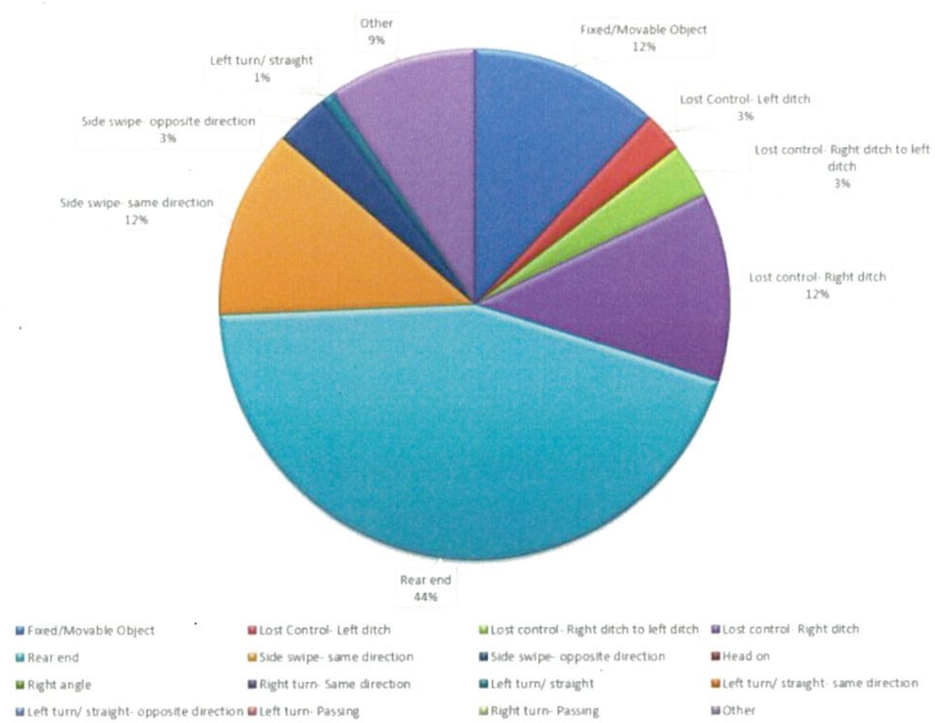


Figure 1.3: Collision Type

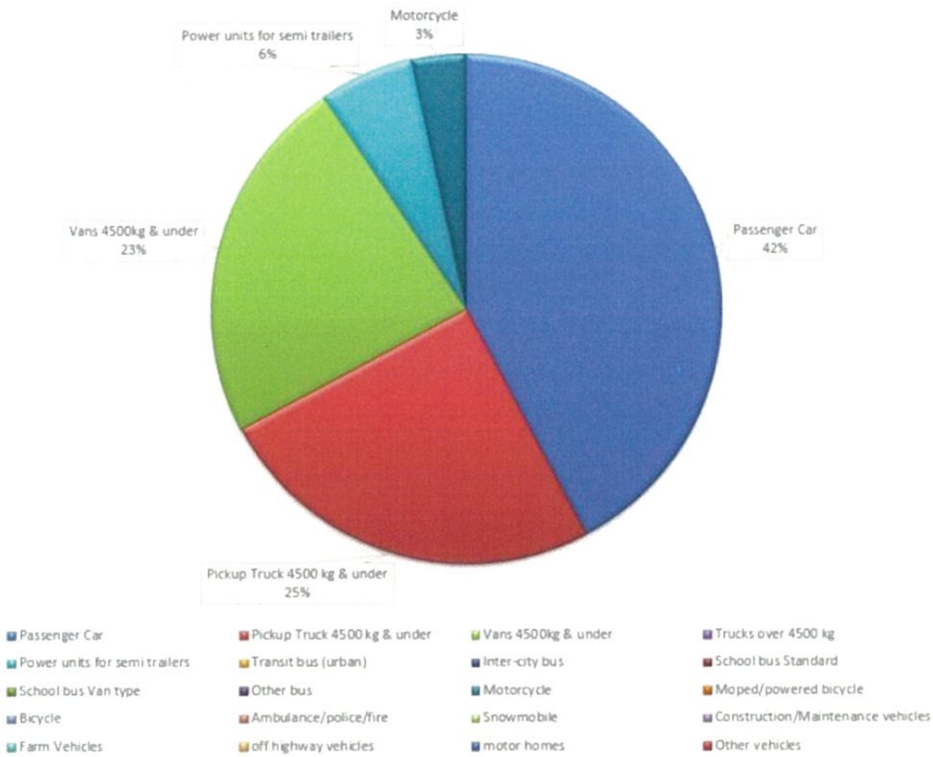


Figure 1.4: Type of Vehicle involved in Collision

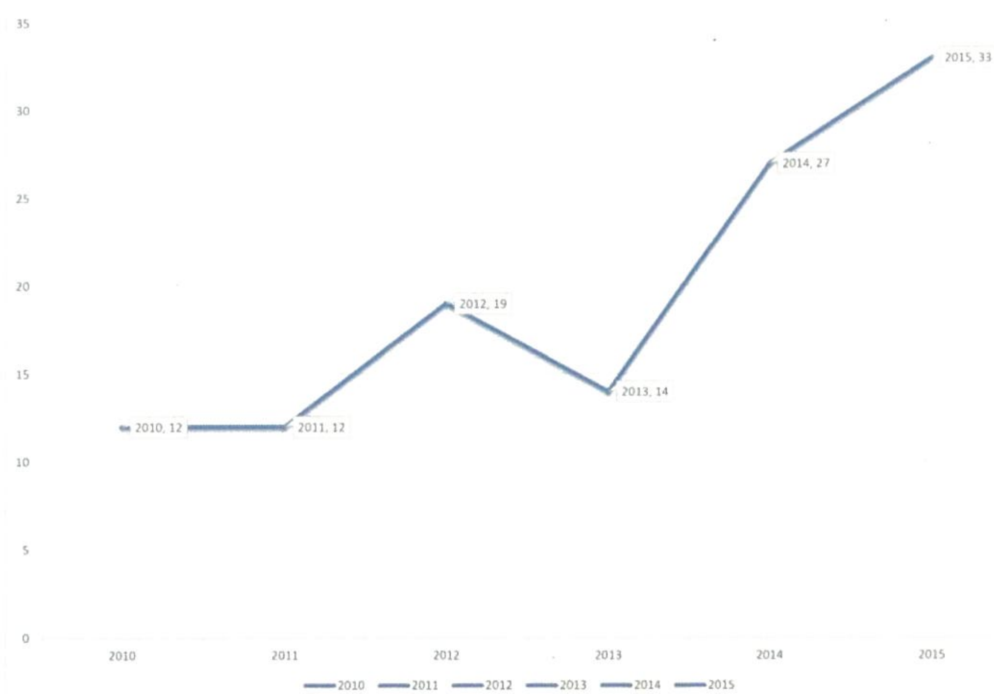


Figure 1.5: Number of Collisions by Year

Utilities

Local utility companies, including SaskPower, SaskEnergy, SaskTel, Shaw Communications, Saskatoon Light and Power, and City of Saskatoon Deep Utilities, were contacted regarding existing utilities in the area. A summary is shown below.

Figure 1.6: Existing Utilities

The major concern SaskEnergy's 323.9mm high pressure gas line that runs east/west through the center of the north loop ramps.

Summary

A long-term solution is needed to resolve the traffic issues in the longer-term. Once the long-term solution has been confirmed, staging will be considered to determine if there is a short-term solution available that can resolve the immediate issues (weaving, and bridge clearances).

2.0 Development of Evaluation Criteria and Ranking System

After some discussion the following criteria was compiled for evaluating each of the potential interchange improvements:

- **Accommodating Oversize Goods Movement** – Corridor must be able to handle oversize (and in fact regular sized loads)
- **Improving Weaving** – Weaving lengths for some movements are too short and must be improved
- **Minimizing Resident Impacts** – There should be minimal impacts to existing residents in Stonebridge, Eastview and Lakeview, including visual impacts and noise etc.
- **Flexibility for Change in the Future –** Because of uncertainty with the traffic numbers, plans should allow some flexibility for the addition of lanes in future should the traffic numbers warrant it.
- **Meeting Driver Expectations –** Traffic movements should be easy for drivers to understand so that sudden movements and quick decisions are not required
- **Constructability / Traffic Accommodation during Construction –** This interchange cannot be closed during construction and therefore the area must be able to accommodate traffic during this time.

Based on the criteria above, the workshop attendees completed a Paired Comparison Analysis to determine the relative importance of each of the criteria identified above. A summary of the findings is shown below in Figure 2.1.

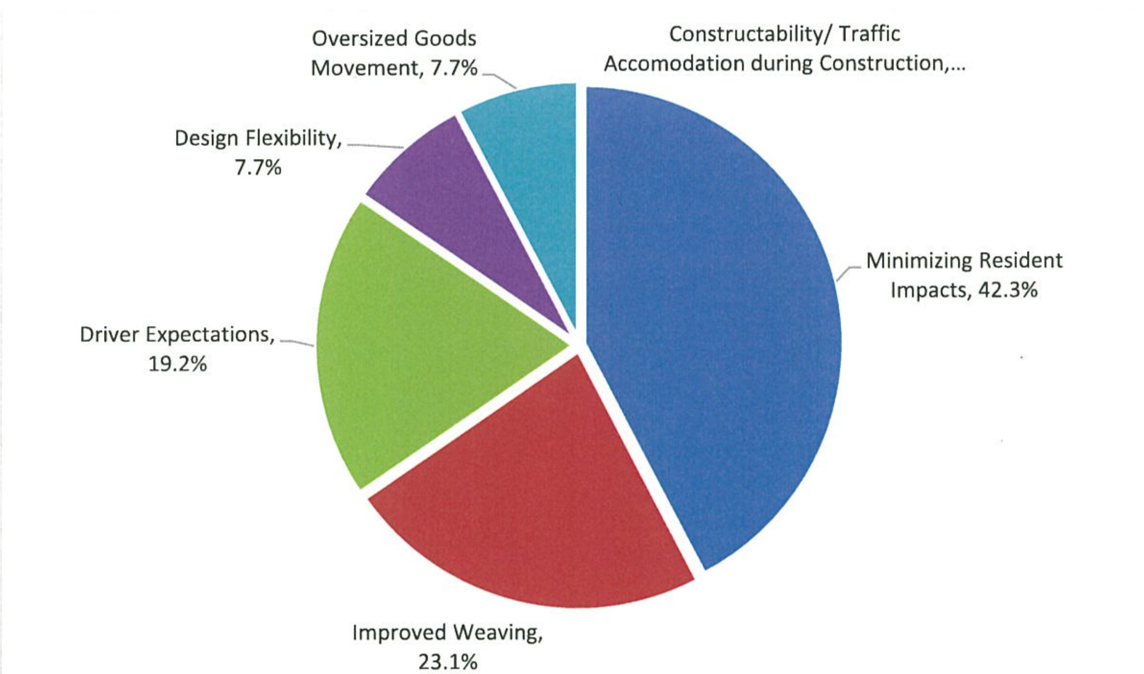


Figure 2.1: Importance of Each Evaluation Criteria

It should be noted that Safety was not included in the evaluation criteria because it is always the top priority, and an unsafe interchange would never be considered.

3.0 Development of Alternatives

The members of the workshop were then given the opportunity to create interchange options that would address the issues.

Option 1: Russell's Option Drop Grade

Option 1 is similar to Option 9, except the southbound to westbound ramp becomes a directional ramp that completes a 420° turn, joining with the northbound to westbound directional ramp before merging onto the mainline. This option requires two additional structures over Option 9, and forces one of the highest volume movements to travel an extra 360 ° unnecessarily. For this reason, this option is not practical and was not explored further.

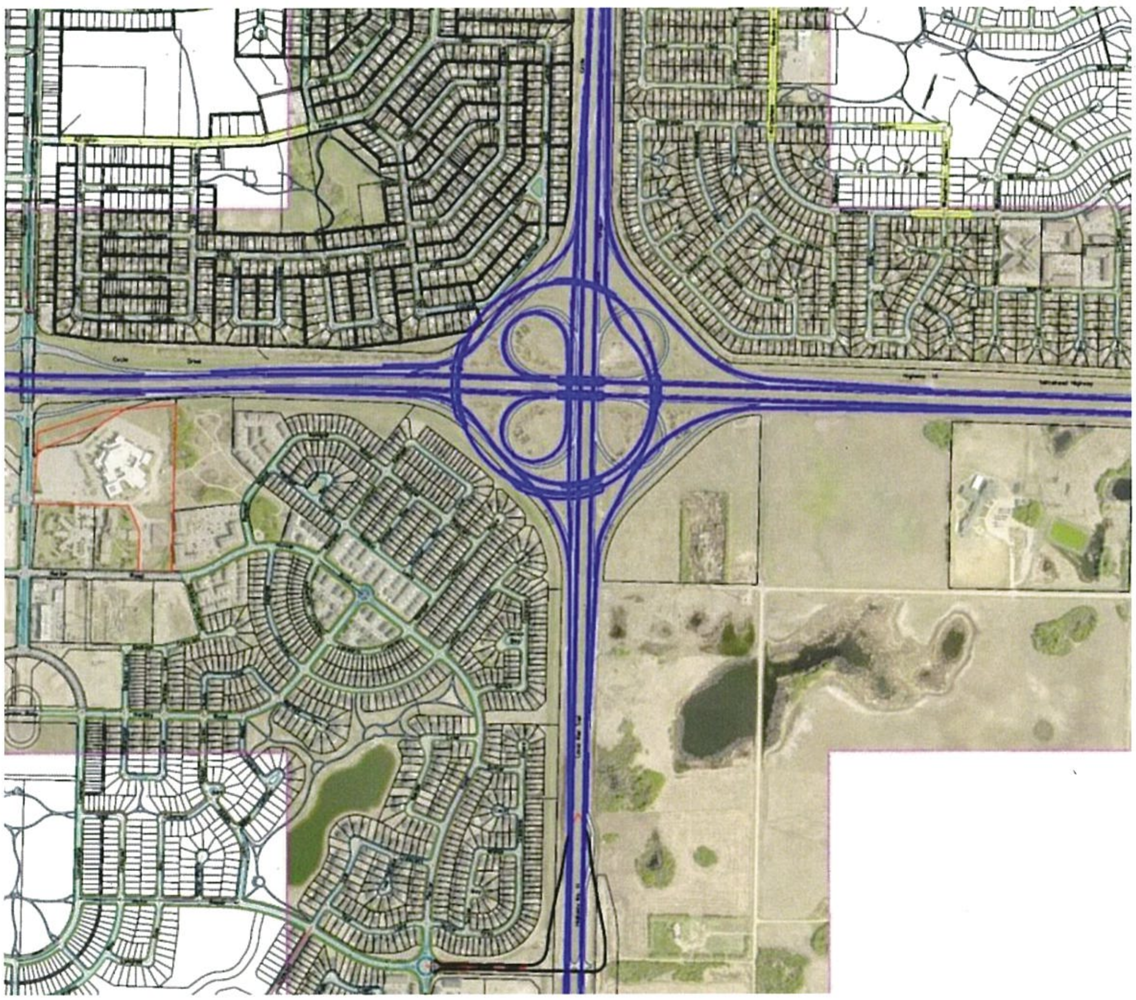


Figure 3.1: Interchange Option 1

Option 2: Offset Circle Drive with Cloverleaf

This option creates a high speed continuous movement for Circle Drive (west and north legs of the interchange), since it has the highest volumes. The remaining movements are accommodated at an interchange shifted slightly to the southeast of the existing location. The option requires significantly more right-of-way than most of the other options, and will be difficult to construct. In total 5 new structures are needed, and weaving between interchanges would need to be checked to confirm that it would work acceptably.

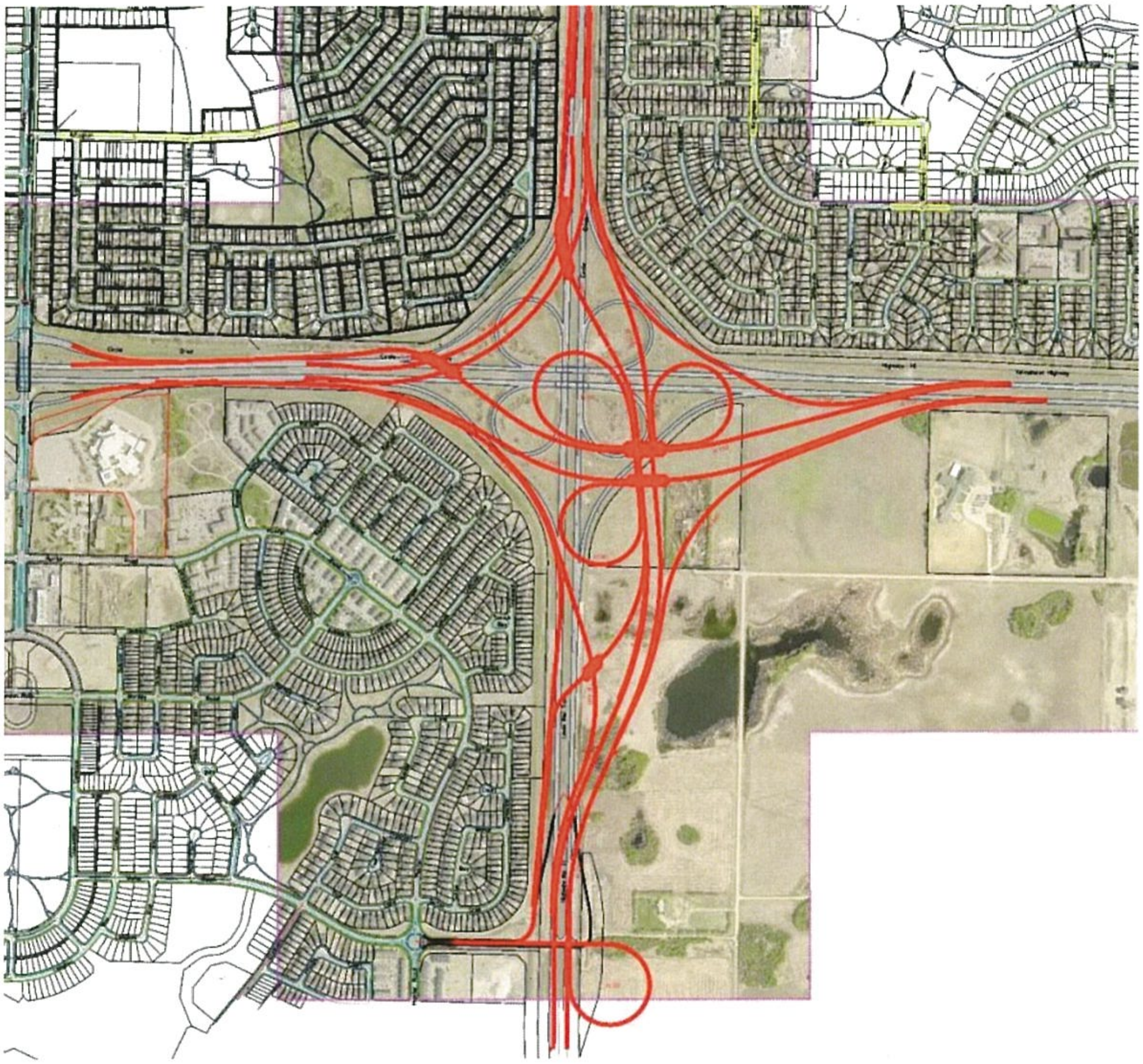


Figure 3.2: Interchange Option 2

It should be noted that the partial interchange at Victor Road to the south has been revised with a EB-NB loop ramp to increase the weaving distances between gore points. The span of the bridge would need to be double checked to confirm that this is feasible.

Option 3: Turbine Option

Option 3 has high speed directional ramps for all left turns, and requires a minimum of 10 structures. Each of the directional ramps are woven together, creating complex profiles that have some steep grades that allow the entire interchange to be no more than 2 storeys high. As with the other options, weaving to adjacent interchanges may be a concern.

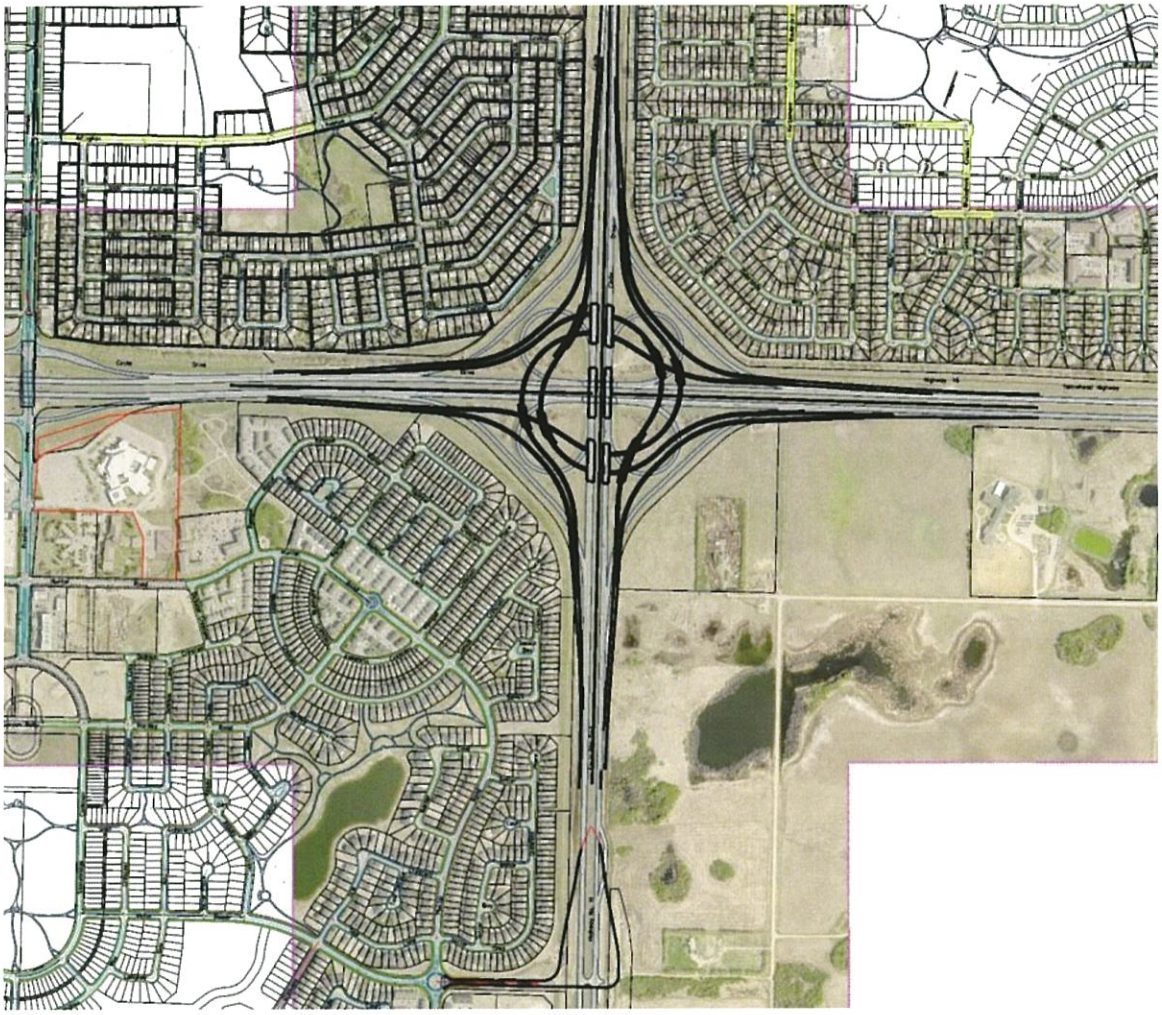


Figure 3.3: Interchange Option 3

Due to the complex nature of the interchange, constructability would be a concern for this option and traffic accommodation would need to be considered carefully.

Option 4: Roundabout Interchange

Option 4 introduces a grade separated roundabout to accommodate all turning movements, resulting three levels of structures. To limit visual and noise impacts to adjacent residents it is recommended that one of through movements be depressed to limit the overall height of the interchange.

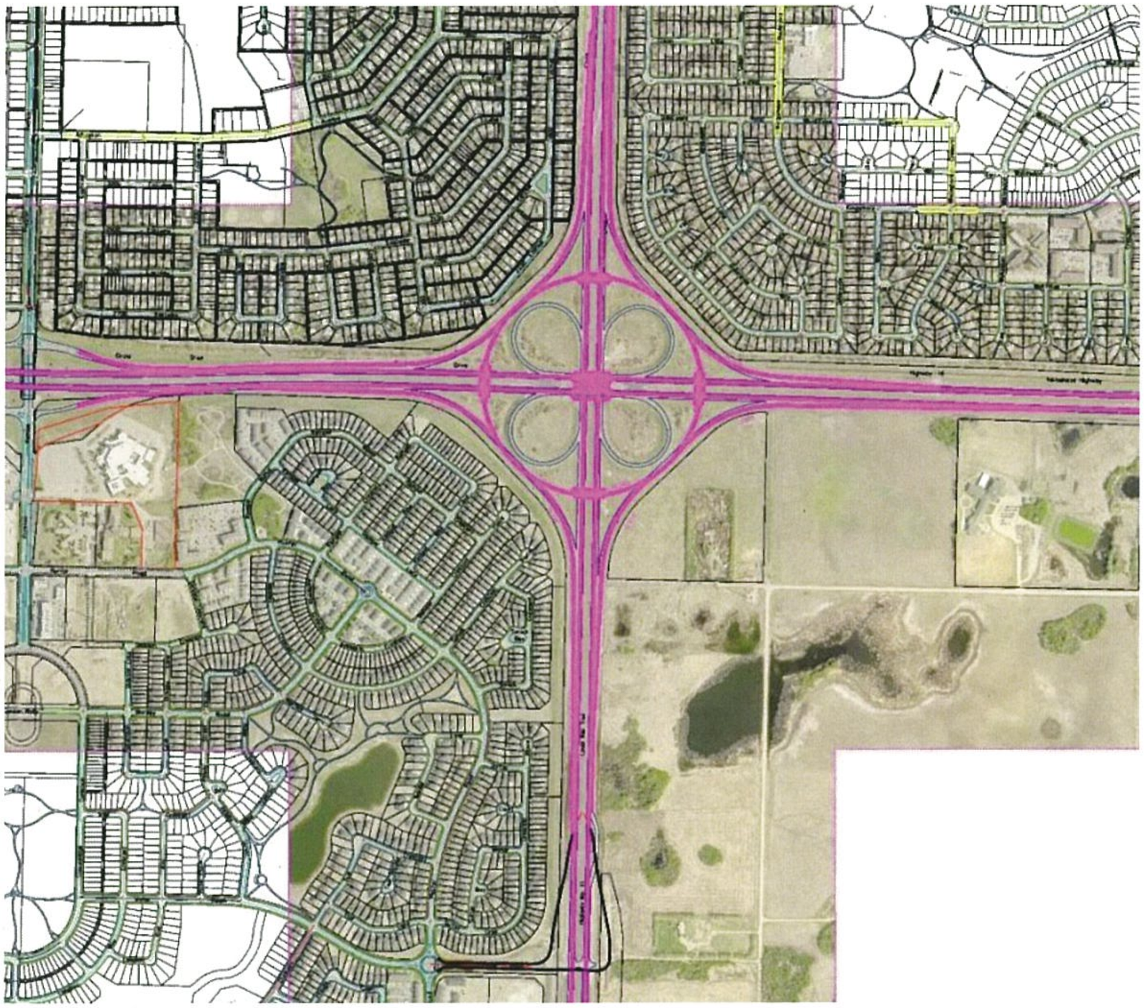


Figure 3.4: Interchange Option 4

Option 4 has similar weave issues as the other interchange options and will likely need CD roads or parallel lanes between the adjacent interchanges due to proximity.

Option 5: Star Interchange

Similar to Option 3, Option 5 uses directional ramps for all left turns within the interchange; however, the ramps are condensed to the center of the interchange in this option. As a result, the interchange is 3 storeys high instead of two.

Constructability and traffic accommodation will be an issue with this option.

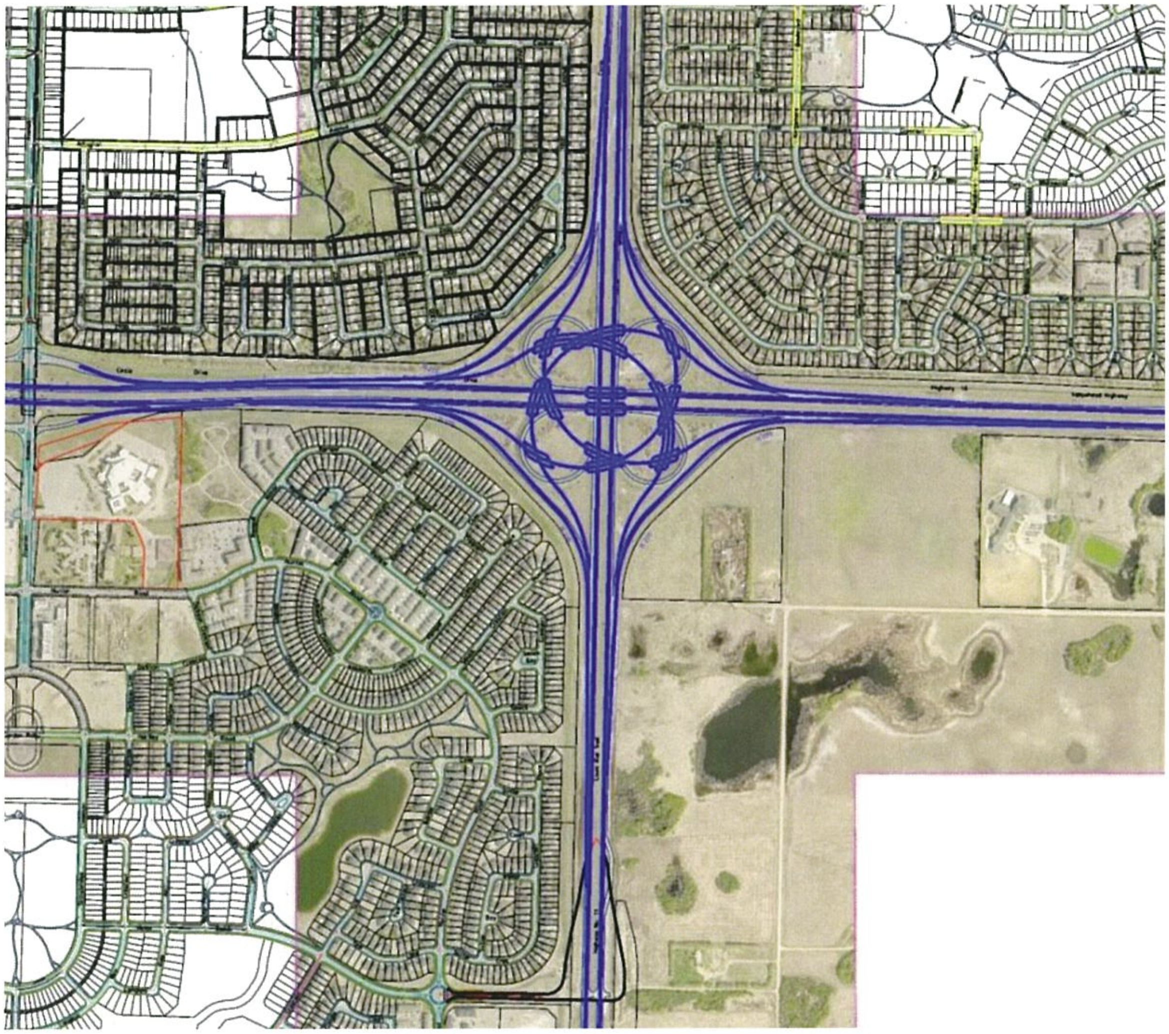


Figure 3.5: Interchange Option 5

Option 6: Offset Circle Drive with a Roundabout

This option creates a high speed continuous movement for Circle Drive (west and north legs of the interchange), since it has the highest volumes. The remaining movements are accommodated at an interchange within the existing footprint. The option will be difficult to construct. In total 4 new structures are needed, and weaving between interchanges would need to be checked to confirm that it would work acceptably.

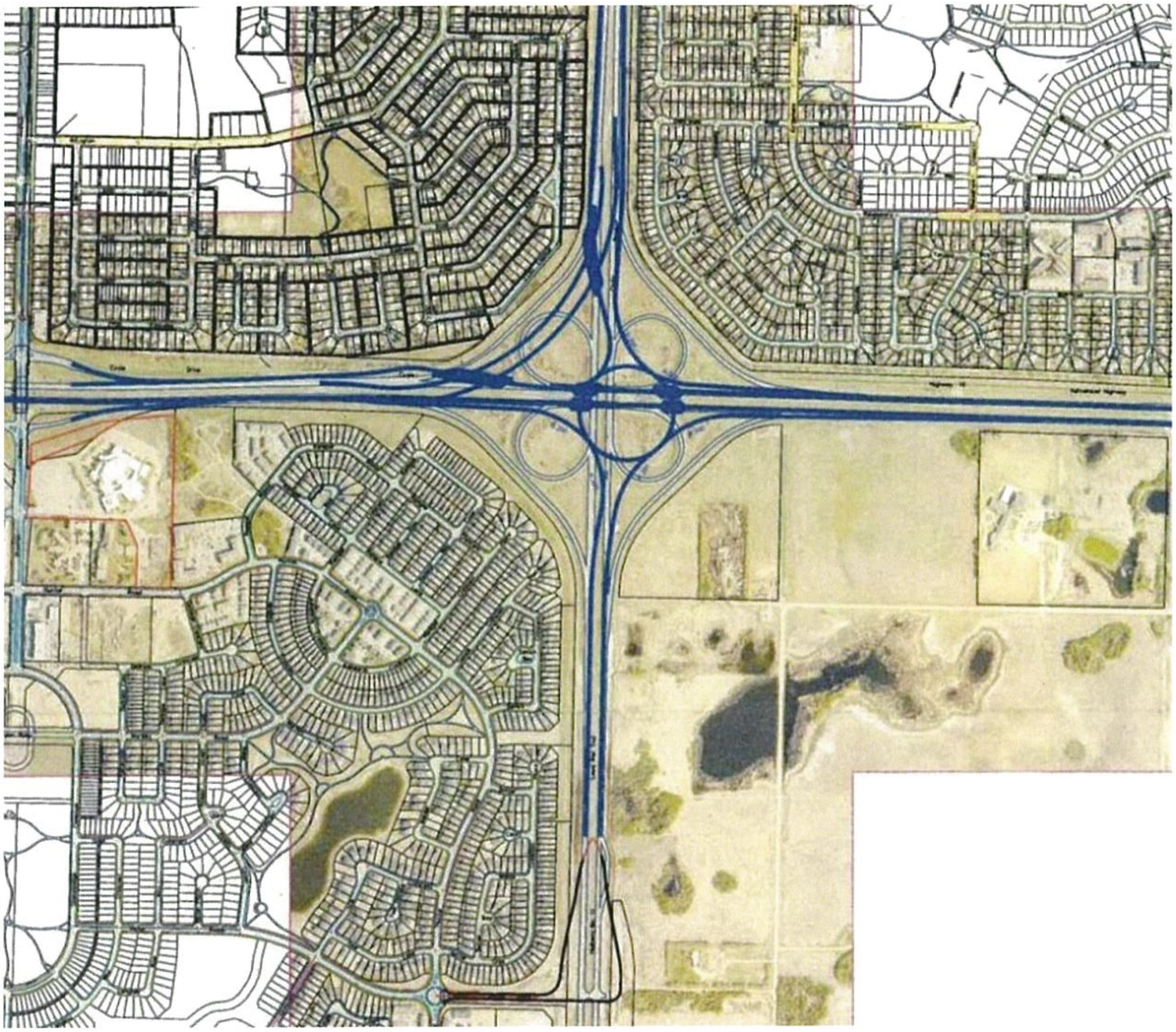


Figure 3.6: Interchange Option 6

Option 6B: Offset Circle Drive with a Split Diamond

Similar to Option 2 and 6, this option provides the highest volume of movements with a continuous high speed connection along Circle Drive. This option requires significant quantities of land, would be difficult to construct, and has two signals (down grade from a systems interchange to a service interchange). The long-term plan uses 4 bridge structures and will likely require some retaining walls in constrained areas. Due to the short weave distances, the westbound to Preston may not work.

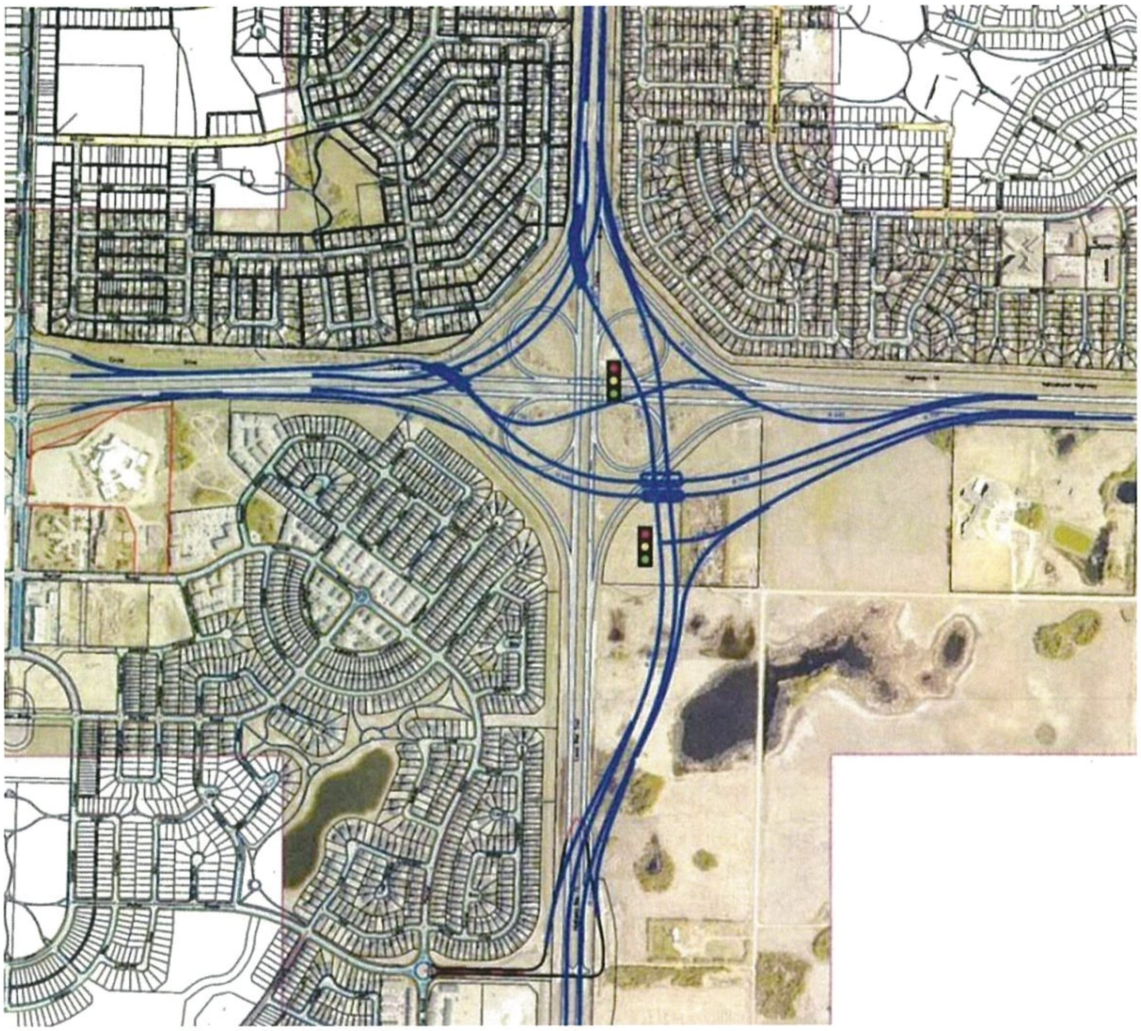


Figure 3.7: Interchange Option 6B

Option 7: Cloverleaf with Half-Diamond at Preston

This Option has all of the same features at Option 10, however, the westbound off-ramp and the eastbound on-ramp from Preston Avenue has been removed to resolve the weaving issues at this location. While this resolves some of the technical constraints, it is unlikely that residents would support this option, particularly without the south half of the Vector interchange constructed since there would be no access into the neighbourhood from the south.

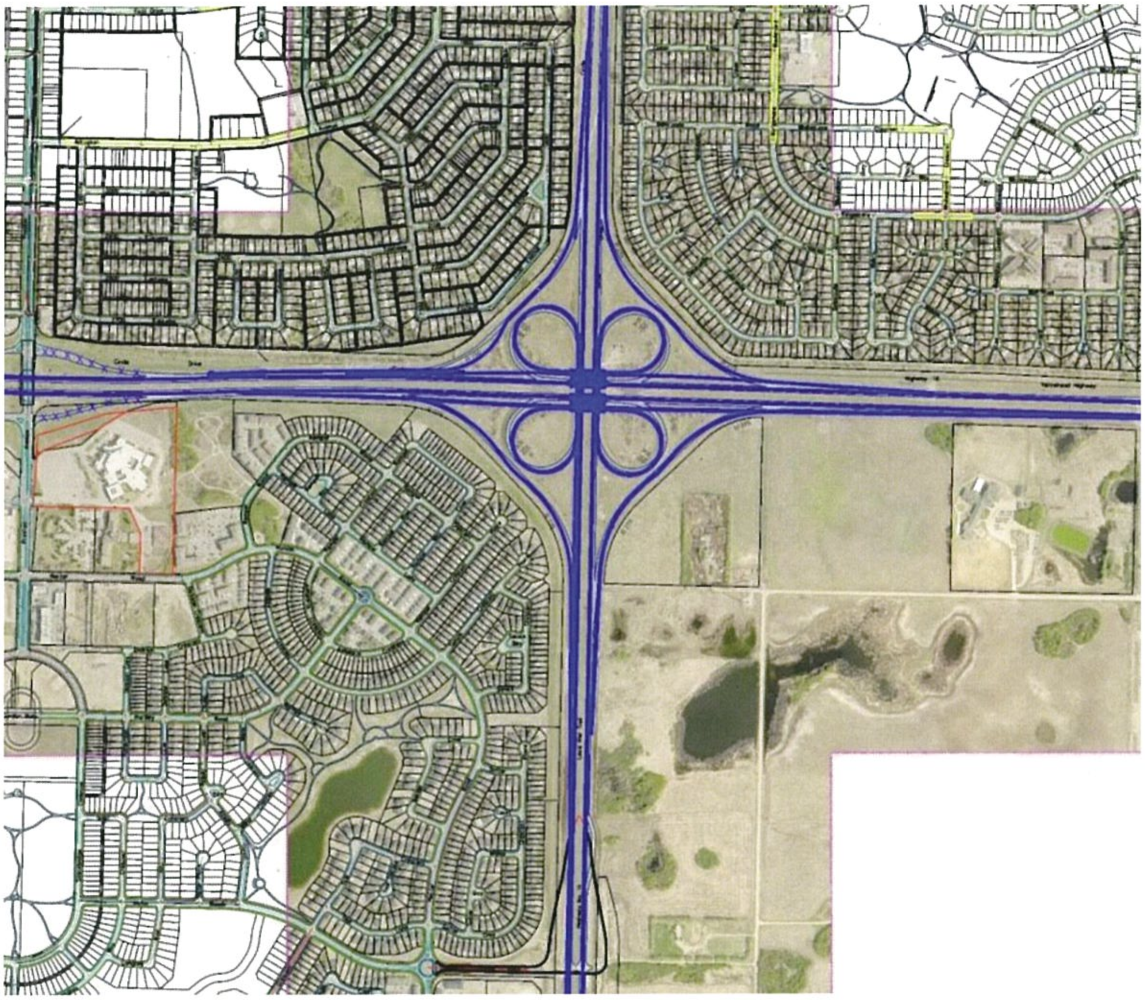


Figure 3.8: Interchange Option 7

Option 8: EB-NB Directional Ramp

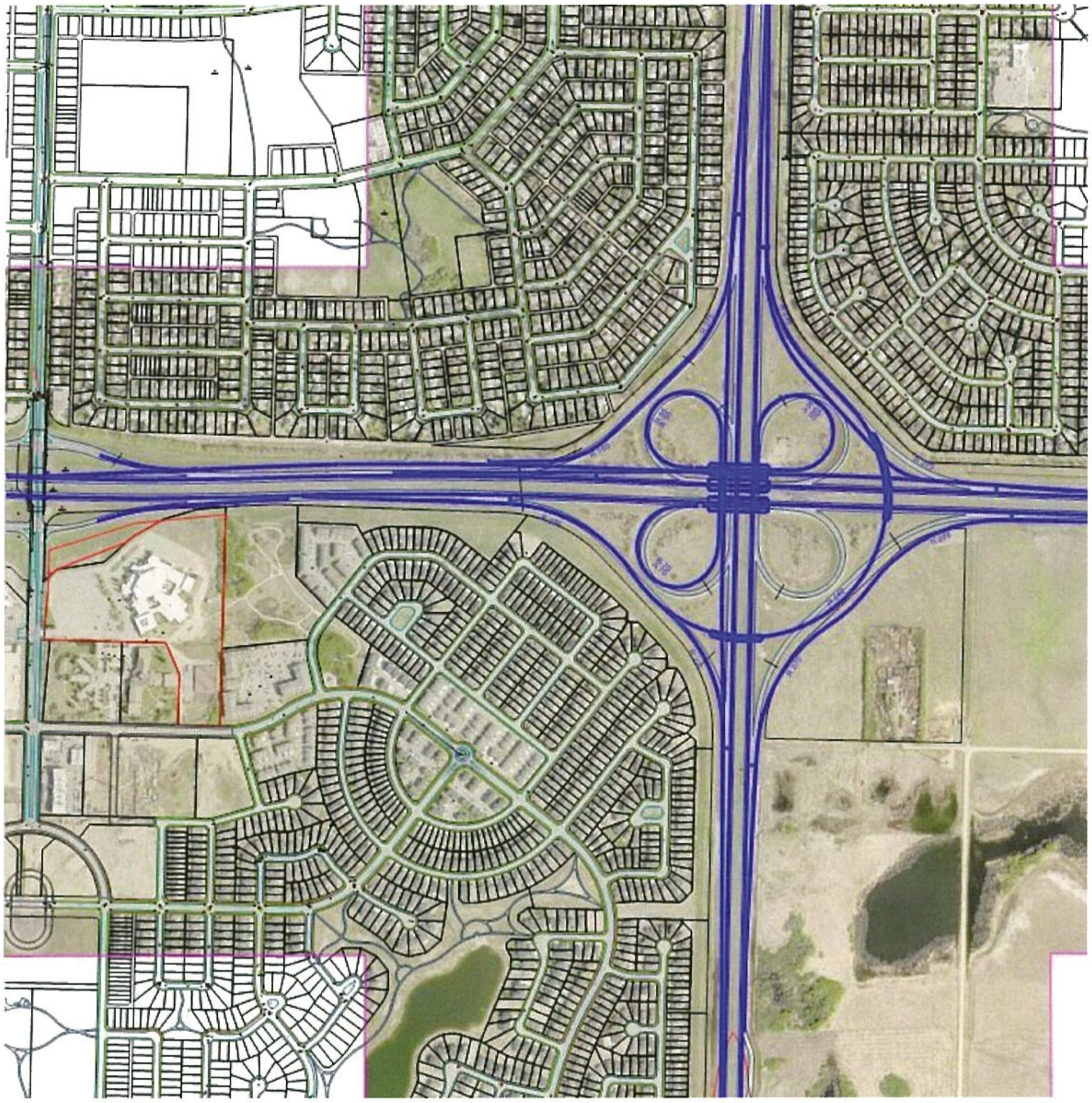


Figure 3.9: Interchange Option 8

Option 8 introduces collector-distributor roads (CD roads) in between the loop ramps to simplify the weaving issues, and includes a directional ramp for the eastbound to northbound high volume movement. This option would also likely need the westbound CD road to extend towards Pearson to assist with the high volume weave. It is anticipated that parallel lanes needed on the mainline between ramp gores due to the proximity of the adjacent interchanges in all directions.

In the short-term the existing bridge structures could remain in place and lowering of the mainline could be considered. In the long-term there would be five new structures within the interchange footprint; however, the structures would not be more than one storey above grade.

Option 9: EB-NB and NB-WB Directional Ramps

Option 9 is similar to Option 8, except the northbound to westbound loop ramp is removed and replaced with a directional ramp, which removes the weaving between the NB-WB loop ramp and the WB-SB loop ramp. Similar to Option 8, this option would also likely need the westbound CD road to extend towards Pearson to assist with the high volume weave and additional parallel lanes would be needed on the other legs of the mainline. This option would also have five bridge structures in the long-term, all no more than one storey above grade. With the introduction of the southbound CD road it is not clear at this point if the existing bridges could be used in the short-term.

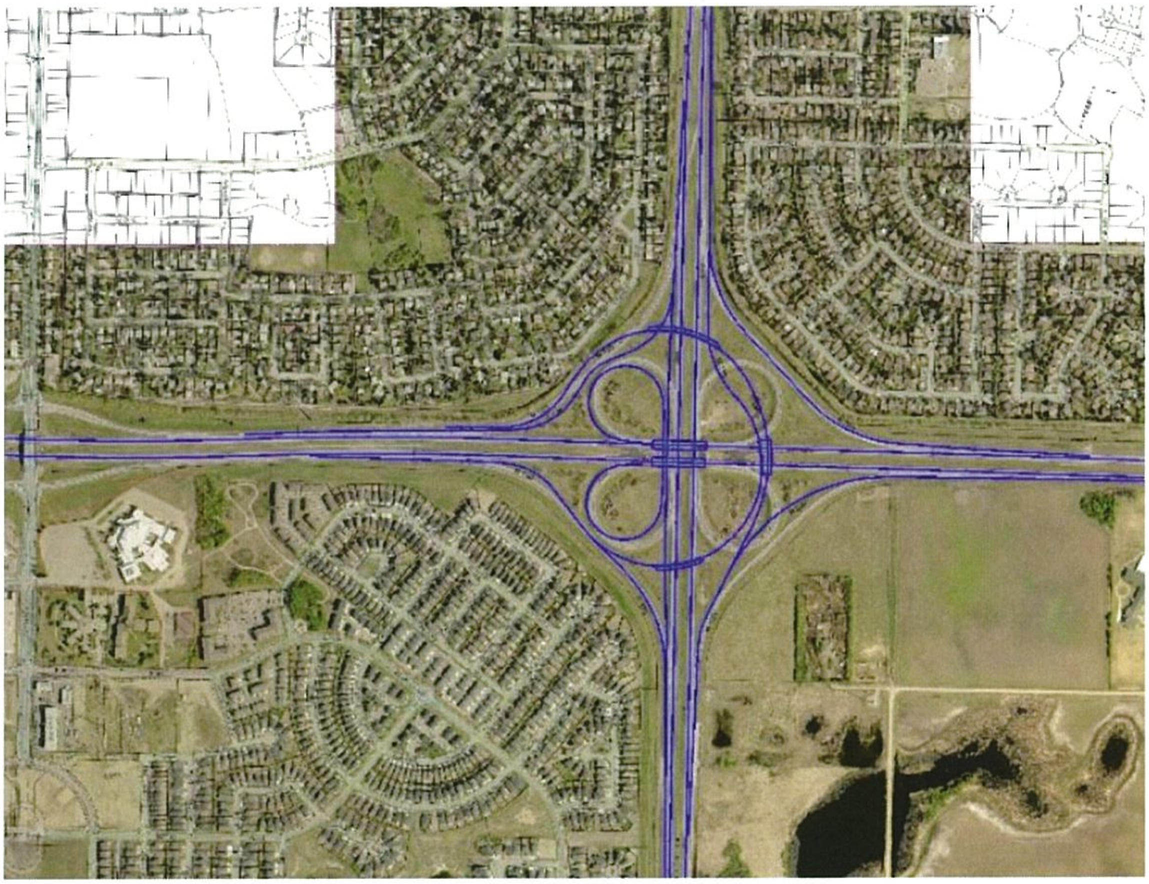


Figure 3.10: Interchange Option 9

Option 10: Cloverleaf with CD Roads

Option 10 retains the existing interchanges configuration, with the addition of east-west CD roads that remove the weaves from the mainline. The greatest concern with this option is that the EB-NB loop ramp will be at capacity as a double lane by 2041. If volumes are higher than anticipated on this movement, there could be operational issues. Similar to Options 8 and 9, the westbound CD road to would need to be extended towards Pearson to assist with the high volume weave and parallel lanes would be needed on the other legs of the mainline.

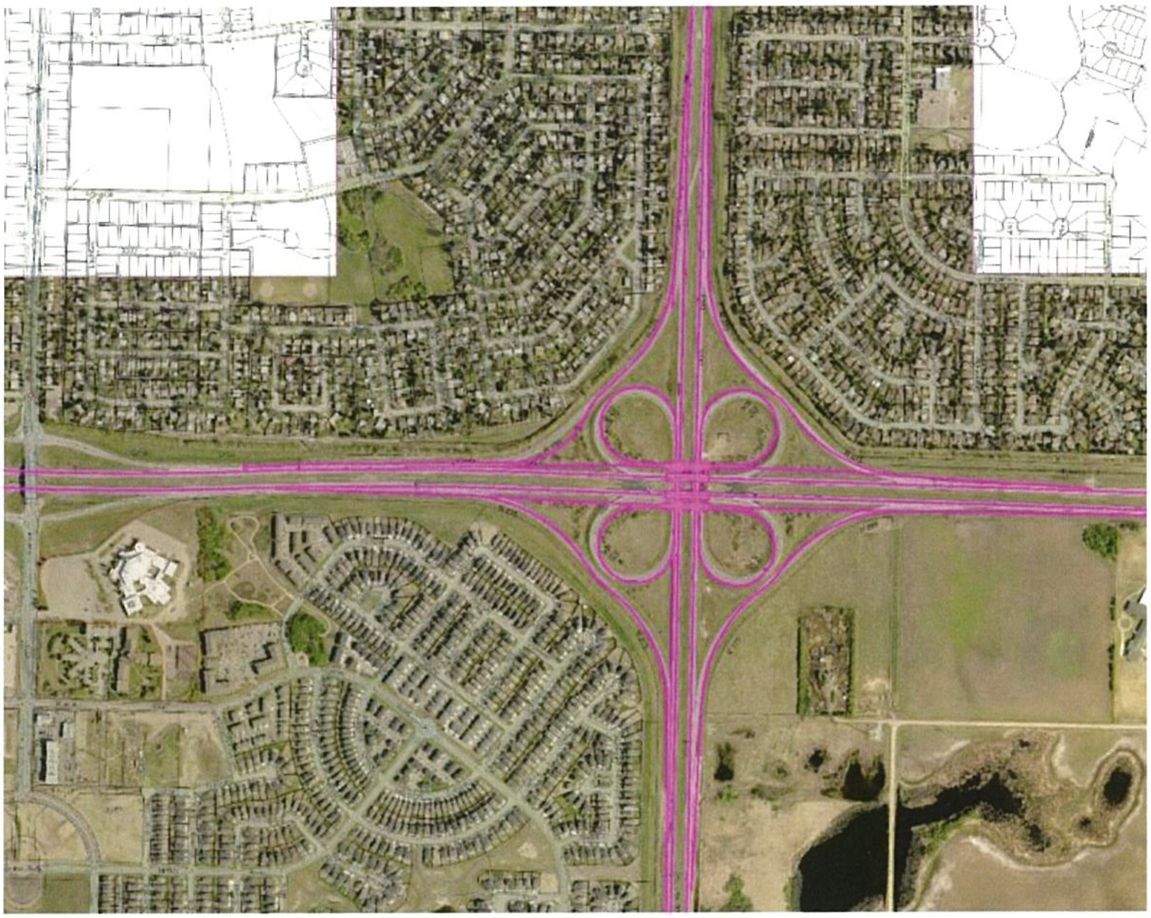


Figure 3.11: Interchange Option 10

This option would have four bridge structures in the long-term, all no more than one storey above grade. With the introduction of the southbound CD road it is not clear at this point if the existing bridges could be used in the short-term.

Option 11: Justine's Option

This option was identified after the workshop, but is being considered here because it addresses many of the technical issues that the other options struggle with. Specifically, it increases the weave distance for the southbound to westbound movement by pulling the ramp closer to the centroid of the interchange.

Unfortunately, this option also includes lower speed directional ramps that would not meet the project design criteria (Design Criteria = 80km/h versus Design= 60 km/h). The project team will need to discuss if this a significant concern.

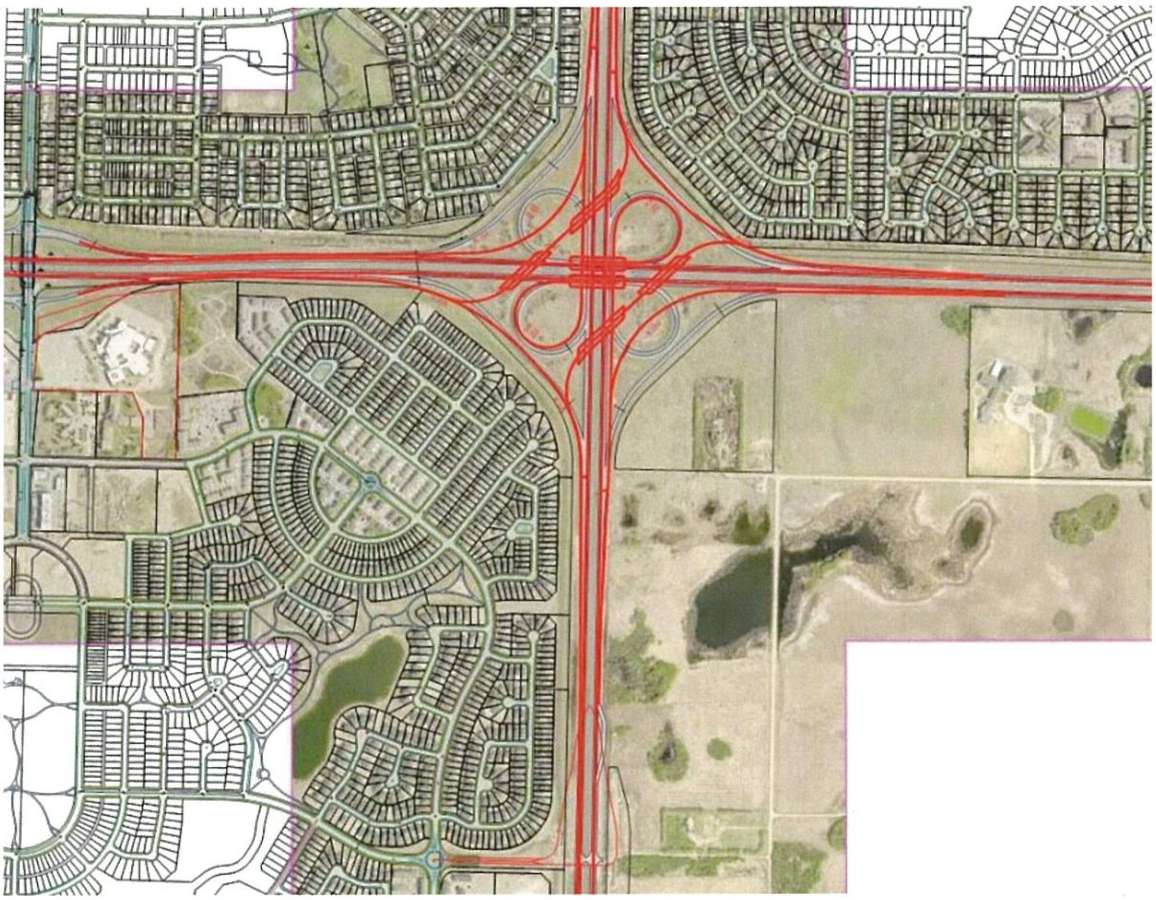


Figure 3.12: Interchange Option 11

This option would have six bridge structures in the long-term. It is proposed that the north-south highway be significantly depressed, with the east-west highway slightly above existing ground, and the directional ramps at the highest elevation. There will be significant earthworks involved for this operation and constructability and traffic accommodation will need to be considered carefully.

4.0 Evaluation of Interchange Options

Each of the 11 interchanges (Option 6B was not evaluated because it was very similar to Option 6) were evaluated using the criteria previously discussed on a scale of 1 to 5, with 1 being poor and 5 being excellent. Refer to Appendix B for the evaluation matrix. The table below shows the preferred interchange ranking and their relative score.

Table 4.1: Ranking of Interchanged Options based on Weighted Evaluation

Ranking	Interchange Option	Weighted Score
1	Option 8: EB-NB Directional Ramp	3.8462
2	Option 6: Offset Circle Drive with a Roundabout	3.7308
3	Option 2: Offset Circle Drive with Cloverleaf	3.5000
4	Option 11: Justine's Option	3.1538
5	Option 4: Roundabout Interchange	3.0769
6	Option 9: EB-NB and NB-WB Directional Ramps	2.8462
7	Option 10: Cloverleaf with CD Roads	2.8077
8	Option 5: Star Interchange	2.6923
8	Option 3: Turbine Option	2.2692
9	Option 7: Cloverleaf with Half-Diamond at Preston	2.2692
10	Option 1: Russell's Option Drop Grade	1.9615

Once the interchange options were drawn up with proper geometry, it became clear that the right-of-way impacts to Options 2 and 6B were too significant and would not be viable, and were therefore removed from consideration.

Profiles

Profiles were prepared for the remaining top three options (8, 6, and 11) to confirm that they are feasible. Refer to Appendix C for profiles for these options.

Option 8 – this option maintains a similar profile to the existing interchange, with the north-south at grade, and the east-west over top. The EB-NB directional ramp is the highest level, approximately 18m above grade. To reduce impacts to local residents, consideration should be given to partially depressing this interchange to limit the overall height.

Option 6 – preliminary profiles developed confirmed that the grades from the roundabout to the east-west highway connects would be in the order of 12.5%. To achieve the maximum grade of 4%, the roundabout would need to be shifted an additional 600m away from the Circle Drive connection. This is considered to be too significant an impact on right-of-way and has been rejected. No further profile work was completed for this option.

Option 11 – To limit impacts to adjacent residents, this option depresses the north-south highway down 6m, resulting at the east-west highway near ground, and the directional ramps approximately 10 m in the air. Both directional ramps rise at a 4% grade to the first bridge, then decline at a 2.6% grade. The 4% grade could be reduced by shifting the gore away from the centroid of the interchange; however, this negatively impacts the weaving distance.

5.0 Next Steps

It is recommended that Option 8 and Option 11 be presented at the November 28 Public Open House to determine if stakeholders have a preferred alternative.

Appendix A

Background Information

Highway 11/Highway 16 Interchange Replacement Functional Planning Study

Agenda

- Lunch and Introductions
- Background Presentation
- Criteria Development and Ranking
- Brainstorming of Alternatives
- Ranking of Alternatives
- Wrap-Up

Background Presentation

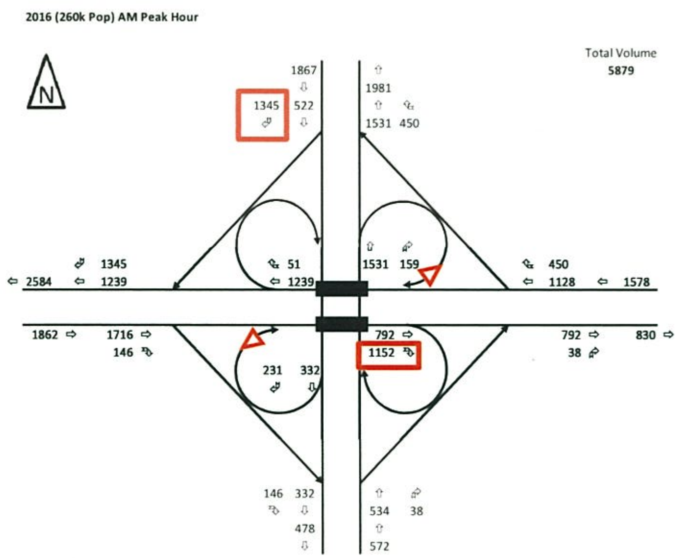
- Interchange History
- Traffic Analysis
- Structural Analysis
- Drainage Analysis
- Collision History
- Design Criteria
- Utilities

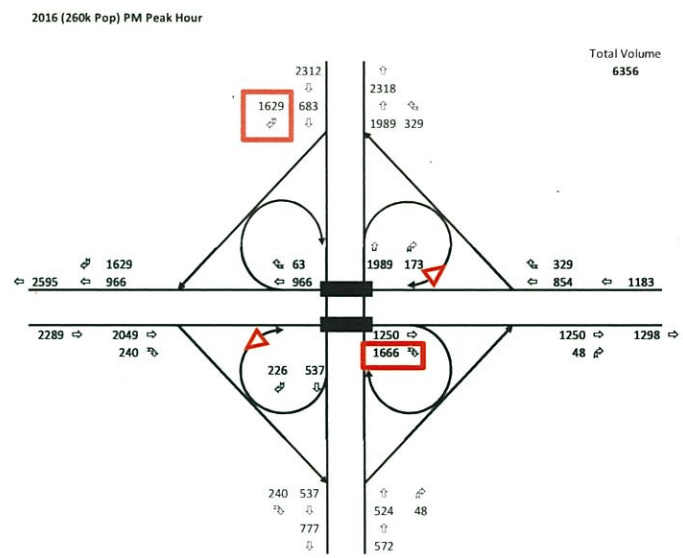
Interchange History

- Constructed in 1960's
- Simple cloverleaf
- Showing its age
- Issues with clearance under the bridges
- Issues with weaving
- Constraints with land

Traffic Volumes and Challenges

2016 Existing Peak Hour Volumes

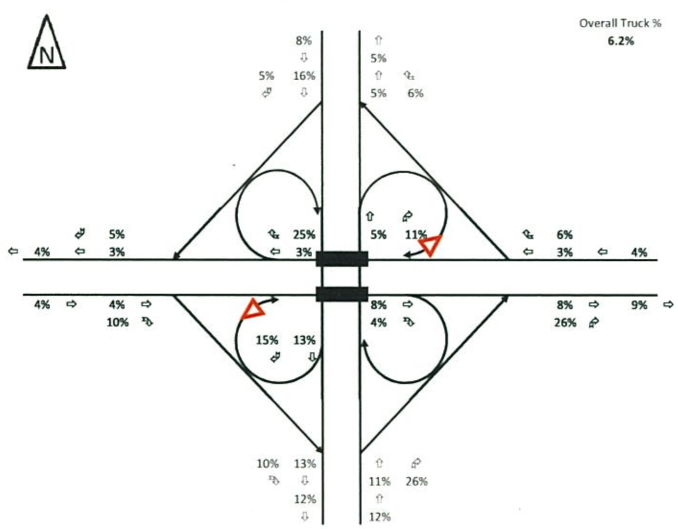




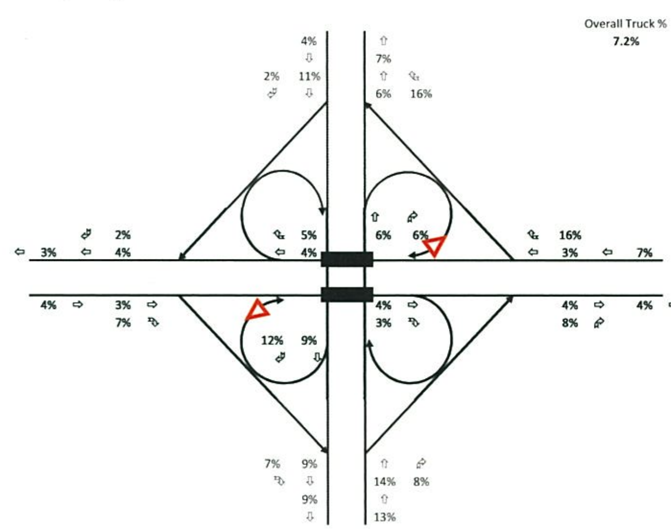
Existing high volume turning movements – SBR and EBL

2016 Existing Peak Hour Truck %

2016 (260k Pop) AM Peak Hour Truck Percentage



2016 (260k Pop) PM Peak Hour Trucks



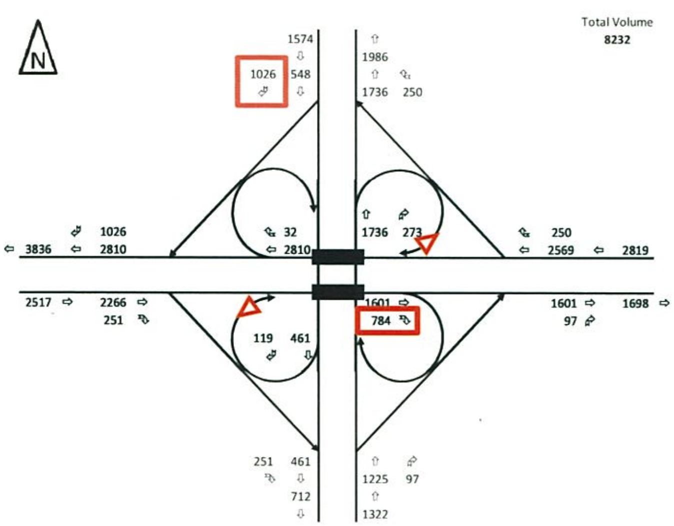
Truck % higher north-south
Some %'s high due to low volumes

Future Traffic Volumes

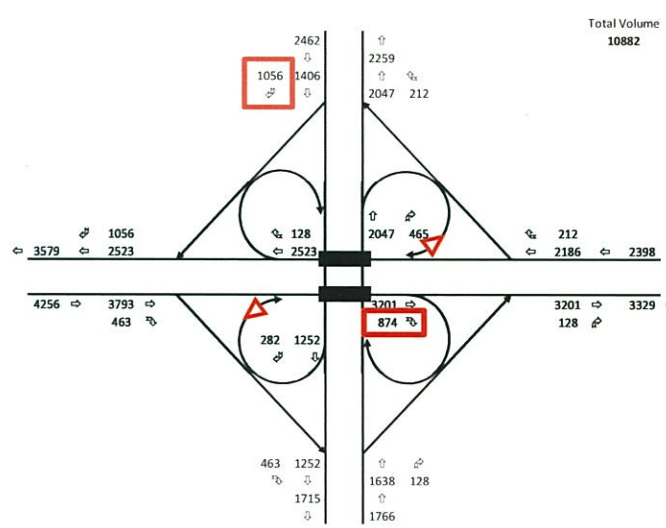
- Two ways forward:
  - 2041 500k Population TDM Model
    - Significantly lower volumes on problem turning movements (SBR and EBL) compared with existing.
    - No obvious reason for the reduction.
    - Existing configuration will perform better for those movements.
  - 2041 at 2% Growth per Annum (1.64 x Existing)
    - Existing high volume turning movements (SBR and EBL) are now much higher, resulting in requirement for two lanes. This creates issues of continuity with other nearby interchanges. i.e. 4 high volume lanes now feeding into 2.

TDM 2041 Model Peak Hour Volumes

2041 (500k Pop) AM Peak Hour (VISUM Model Forecasts)



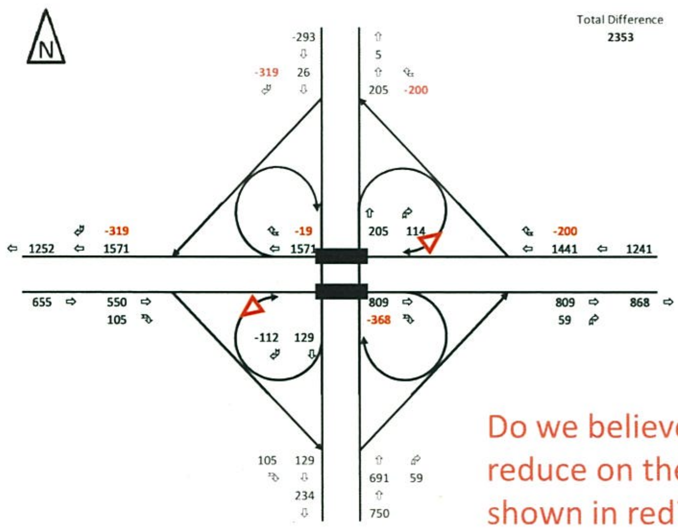
2041 (500k Pop) PM Peak Hour (VISUM Model Forecasts)



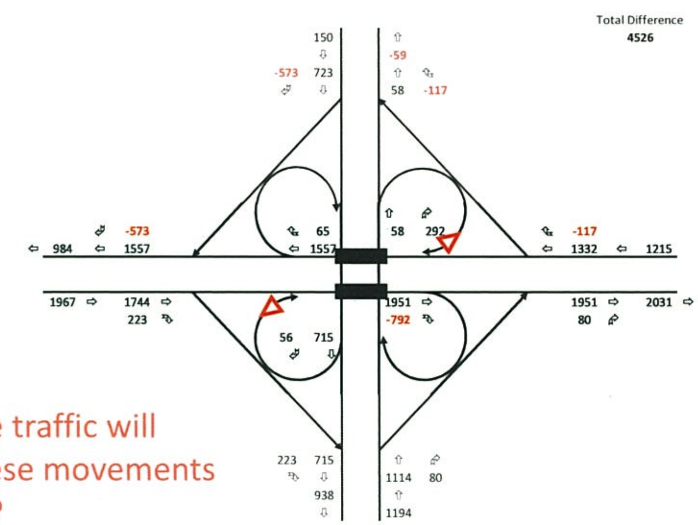
Existing high volume turning movements (SBR and EBL) now much lower

2016 Existing v 2041 Model Comparison

2041 TDM Model - 2016 Existing AM Peak Hour



2041 TDM Model - 2016 Existing PM Peak Hour

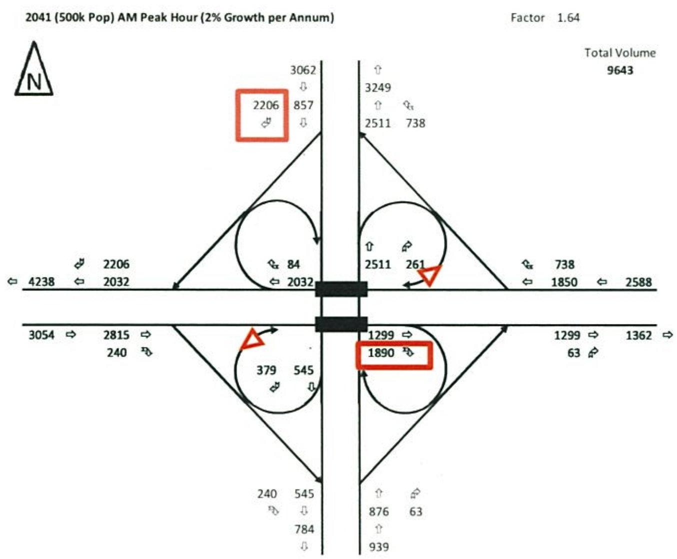


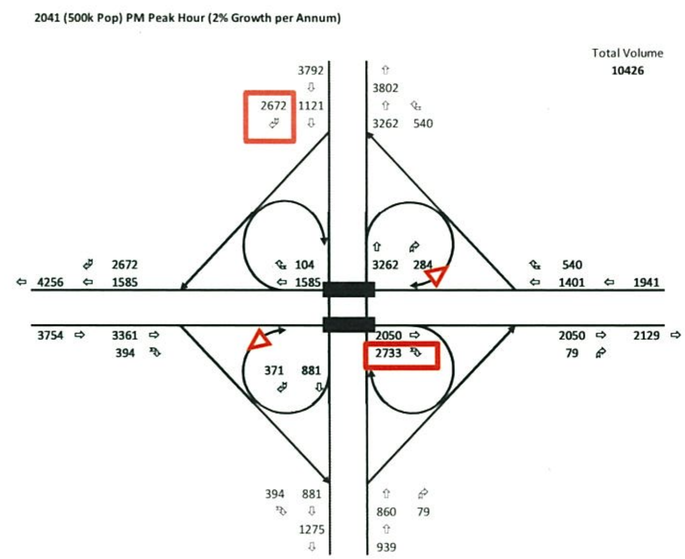
Do we believe traffic will reduce on these movements shown in red?

Negative number means the 2041 TDM Model volume is lower than the 2016 Existing volume

Alternative 2041 Volumes

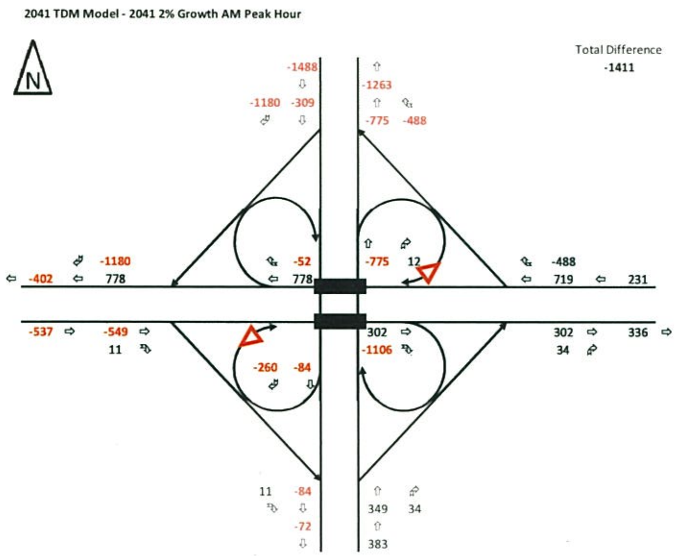
(2016 Existing plus 2% Growth Per Annum)

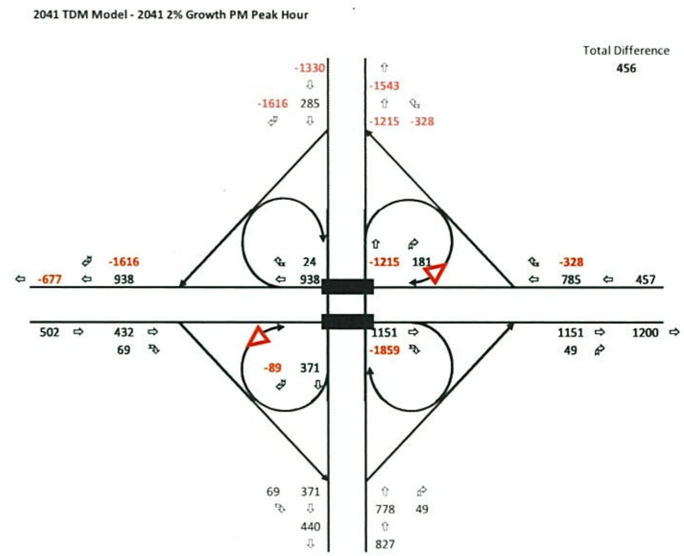




High volume turning movements will require 2 Lanes

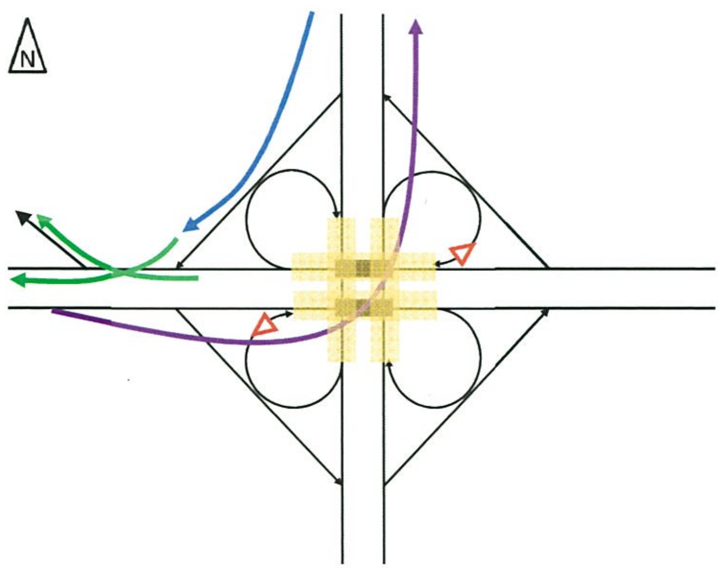
2041 TDM v 2041 2% Growth Comparison





Negative number means the TDM Model volume is lower than the 2% Growth volume

Traffic Problems to Solve

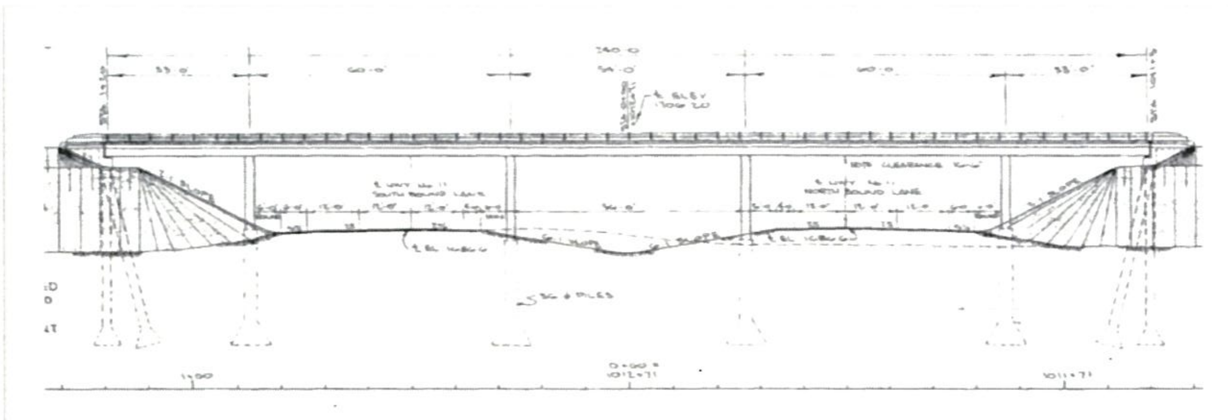


- What volumes are we designing for?
- Can we remove yields?
- Can we remove or reduce weaving inside the Interchange?
- How do we manage weaving and high volumes in limited space between the Interchange and Preston Ave Interchange?
- How do we Improve the Eastbound Left Turn?
- How do we improve the Southbound Right Turn?

Vertical Clearance Issue Under the Bridges at Highway 16 over Highway 11

Existing Bridges

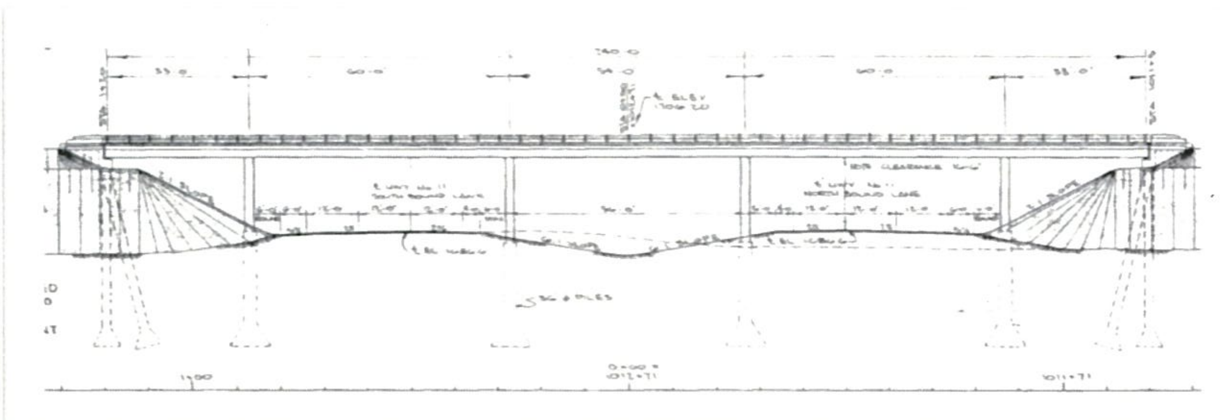
- Twin Overpass bridges on Highway 16 over Highway 11
- 50 years old (1966) (10 to 15 years service life)
- 5 span bridge (10, 18.3, 16.5, 18.3, 10) Total Length is ~ 73 m
- Width of bridges = 14.427 m
- Measured vertical clearance is 4.7 m, desired is 5.6 m
- High load impacts is an issue



Increase Bridge Vertical Clearance

OPTIONS:

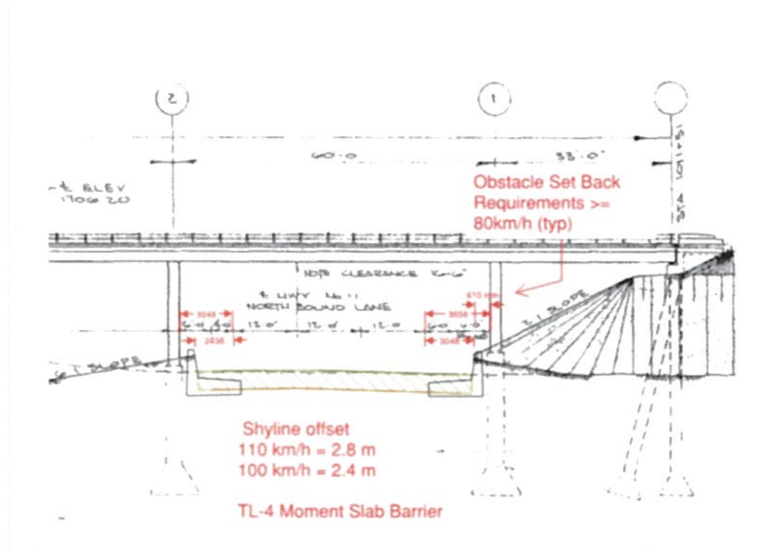
1. Lower Roadway Under Bridges
2. Raise Bridges
3. Replace Bridges



Lower Roadway Under Bridge

Work Involves:

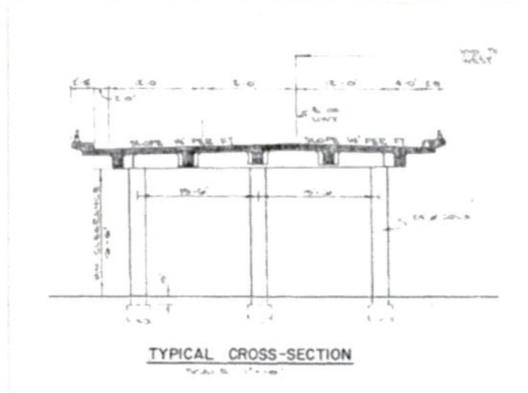
- Lower road by 1 m. Create the low spot in the road south of bridge.
- Total of 500 m of road reconstruction in each travel direction
- Construct moment slab barriers to retain soil and provide pier protection
- Drainage using ditches, install culvert under bridges, longitudinal road drains, drain to the south
- Viable short-term solution

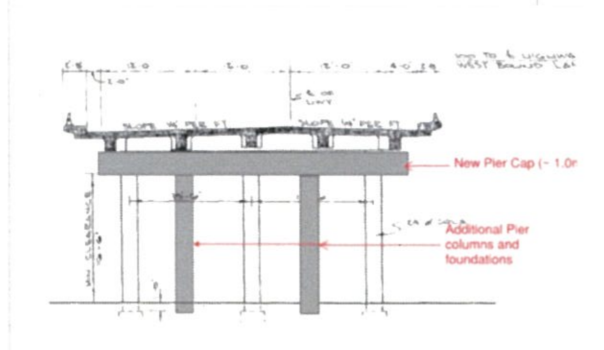


Raise the Bridges

Work Involves:

- Shore the bridge
- Saw cut the piers from the superstructure
- Jack the bridge up 1.0 m simultaneously
- Install additional piers columns and foundations maybe required
- Cast pier caps and install bearings
- Modify the abutment seat and add bearings
- Lower bridge
- Increase road height at approaches by ~1.0 m
- Complex project, not commonly done, is not with out risk, is a viable option

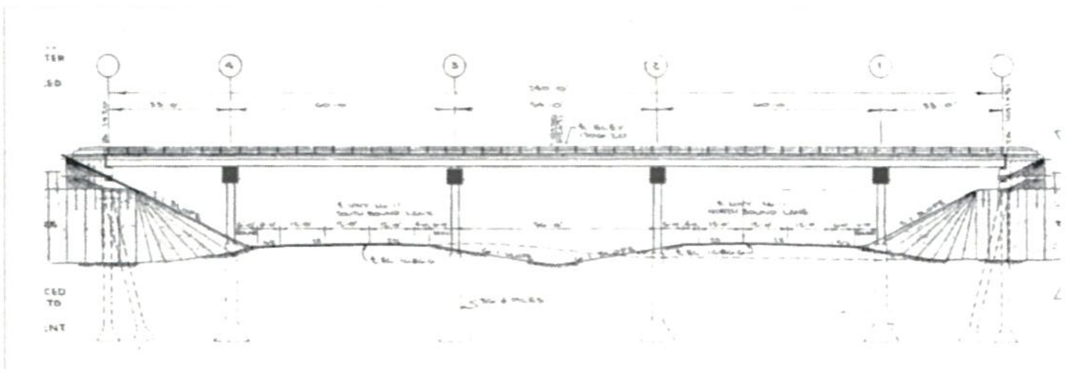




Replace Bridge - Option 1

Work Involves:

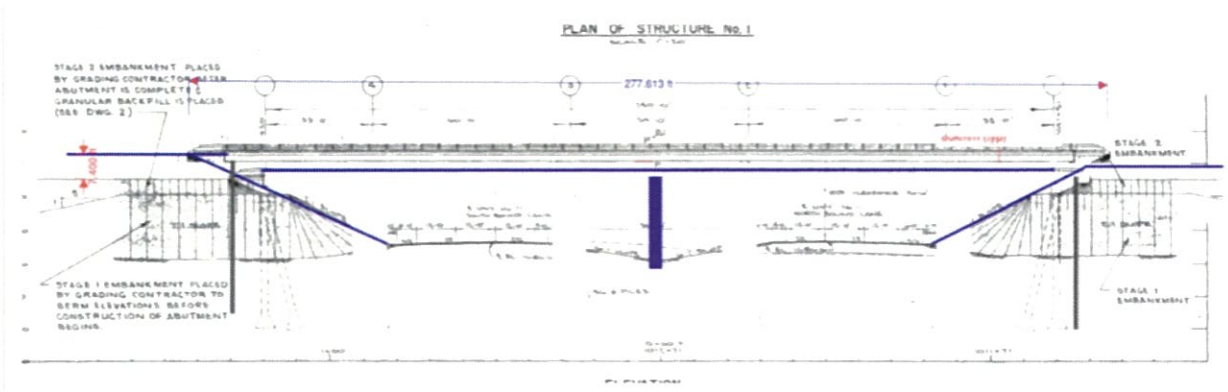
- Replace superstructure only
- New SLC700 Girders (115 Deck and 90 mm ACP) (minimize fills)
- Raise bridge/road approaches 1.2 m
- Cast new pier caps
- Install additional pier columns and foundations
- Reconstruct abutment seats
- Piers currently do not meet impact load requirements, pier protection required.
- Long-term solution



Replace Bridge – Option 2

Work Involves:

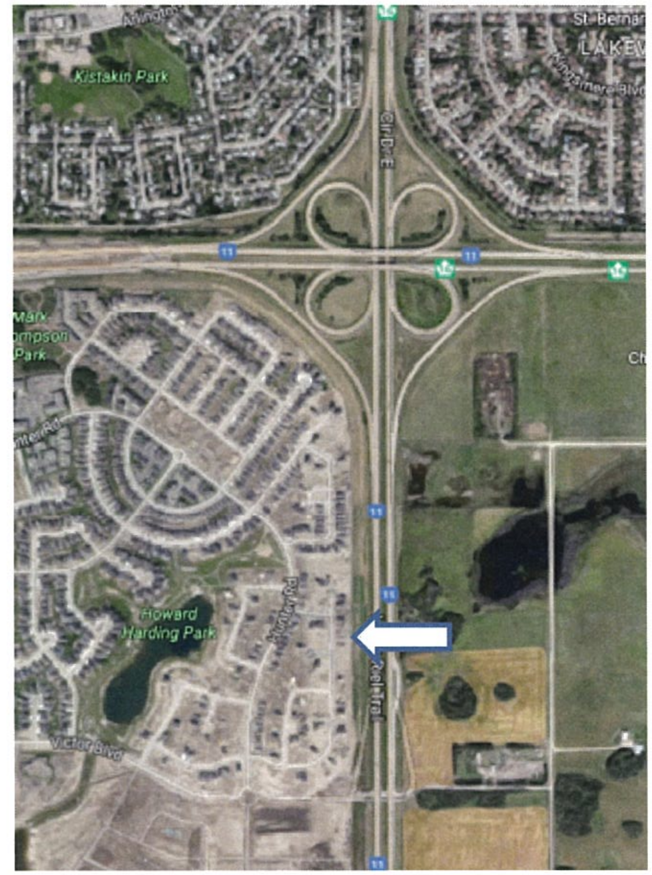
- Replace bridge with two span integral bridge (~40 m, ~40 m)
- New superstructure depth ~ 2.2 m, Road profile to be raised by ~ 2.4 m
- New foundations at abutments,
- Supplement existing pier foundations
- Long-term solution



Drainage Constraints

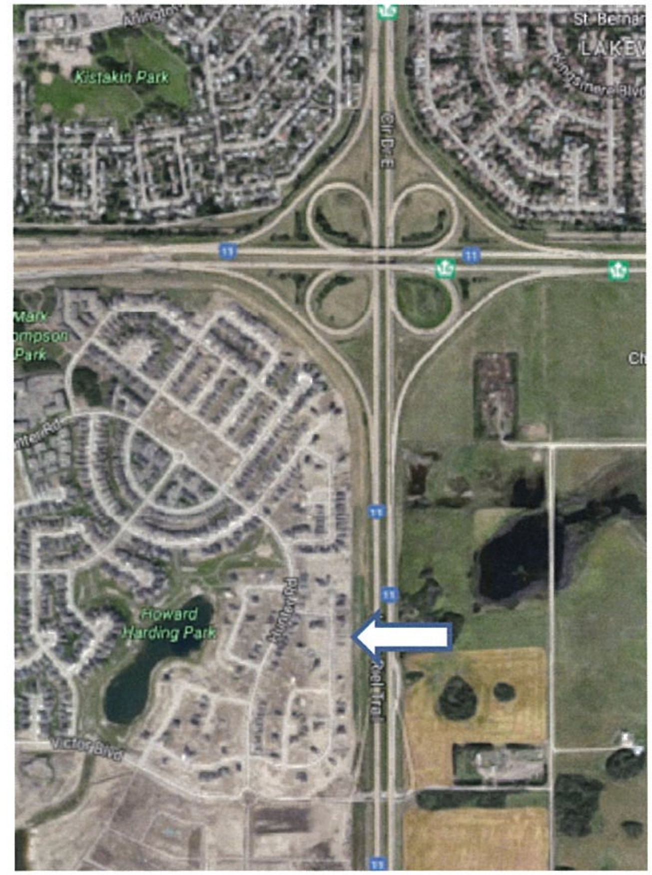
Existing Drainage

- Runoff is currently uncontrolled
- Majority of Intchg drains south on Hwy 11
  - a portion drains east to Boychuk Intchg
- HWY 11 drains west to Stonebridge Nhd
- HWY 11 would flood during 1:100 yr



Proposed Stormwater Management

- SWMFs (dry ponds) within Interchange
  - Locate within ramp areas
  - Controlled release south to HWY 11
- Ditch storage along HWY 11
  - Controlled release to Nhd
- Combined release rate to protect Nhd
- Storage = Runoff - Discharge



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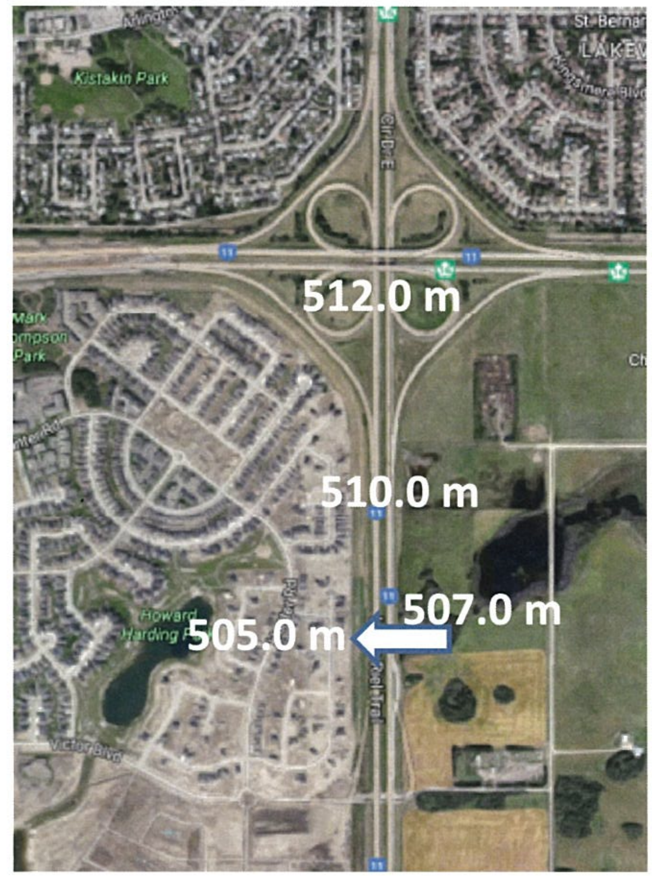
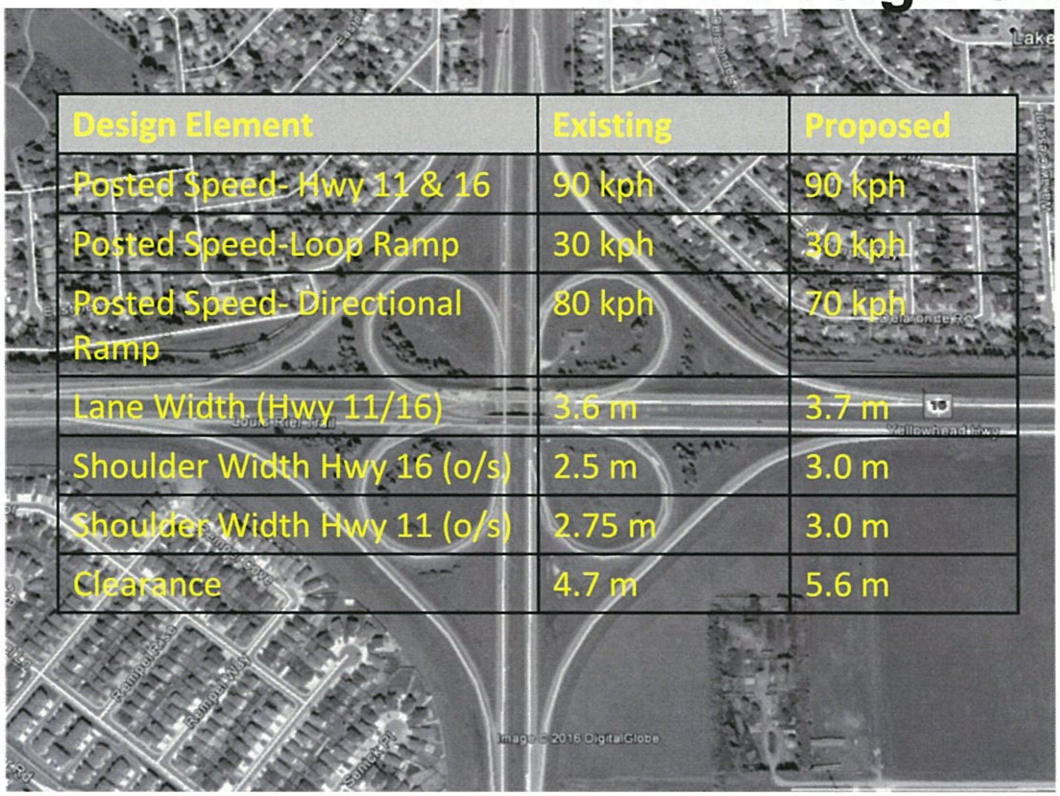
Gravity Drainage

- Good vertical drop avail. to south (5m)
- Dry ponds within Intchg may be able to discharge into d/s ditch on HWY 11
  - Alternative: pipe to Nhd inlet (507 m)
  - If needed: can replace short length of Nhd inlet pipe to get more depth (505 m)
- Can service below-grade interchange design options



Geometric Design Criteria

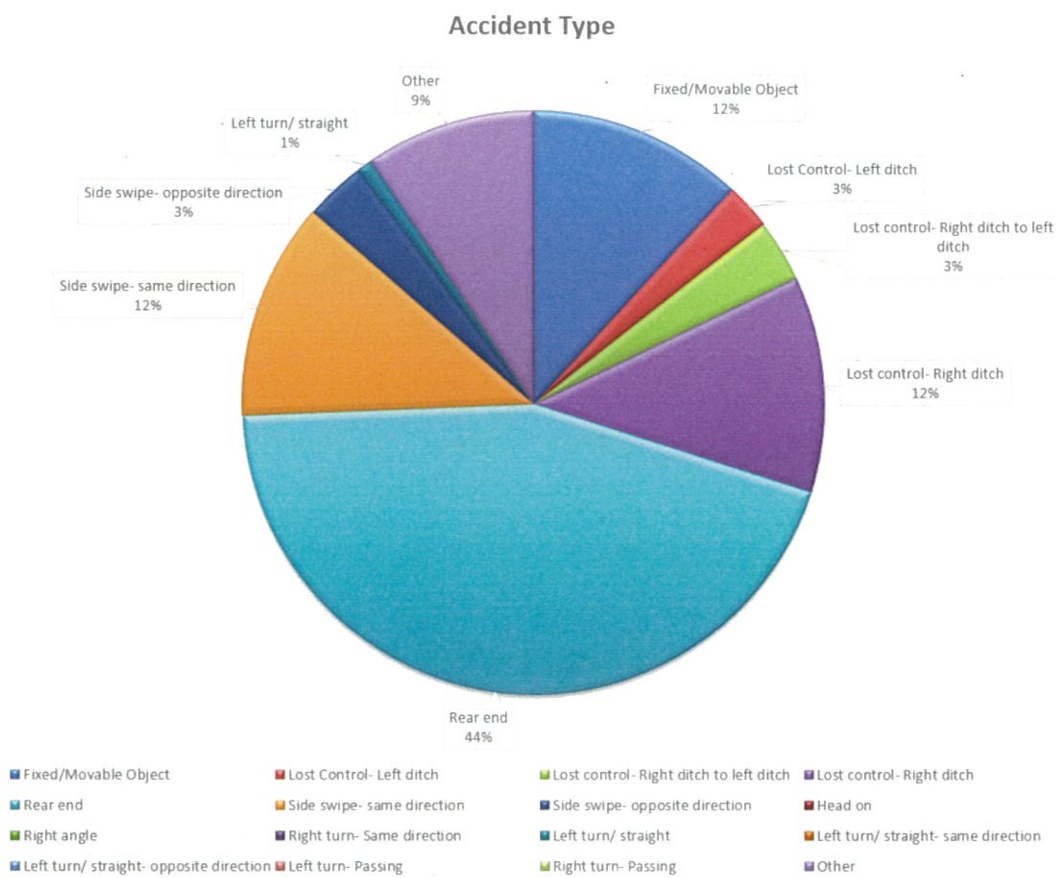


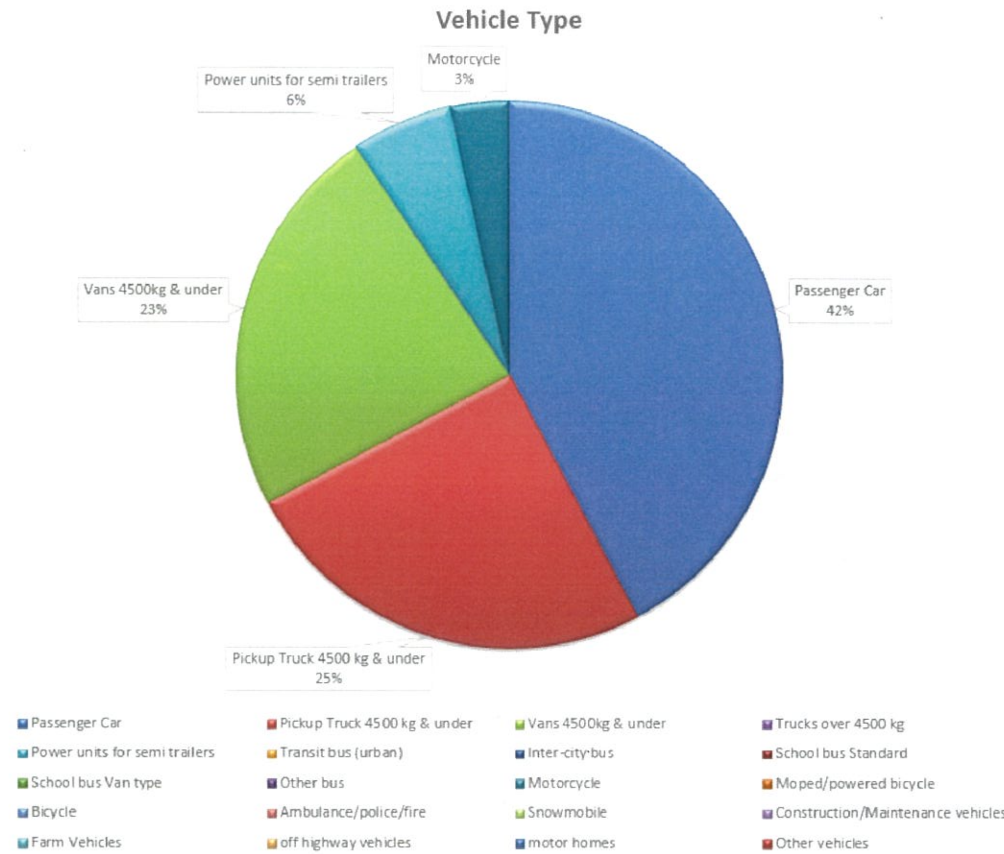
Design Element	Existing	Proposed
Posted Speed- Hwy 11 & 16	90 kph	90 kph
Posted Speed-Loop Ramp	30 kph	30 kph
Posted Speed- Directional Ramp	80 kph	70 kph
Lane Width (Hwy 11/16)	3.6 m	3.7 m
Shoulder Width Hwy 16 (o/s)	2.5 m	3.0 m
Shoulder Width Hwy 11 (o/s)	2.75 m	3.0 m
Clearance	4.7 m	5.6 m

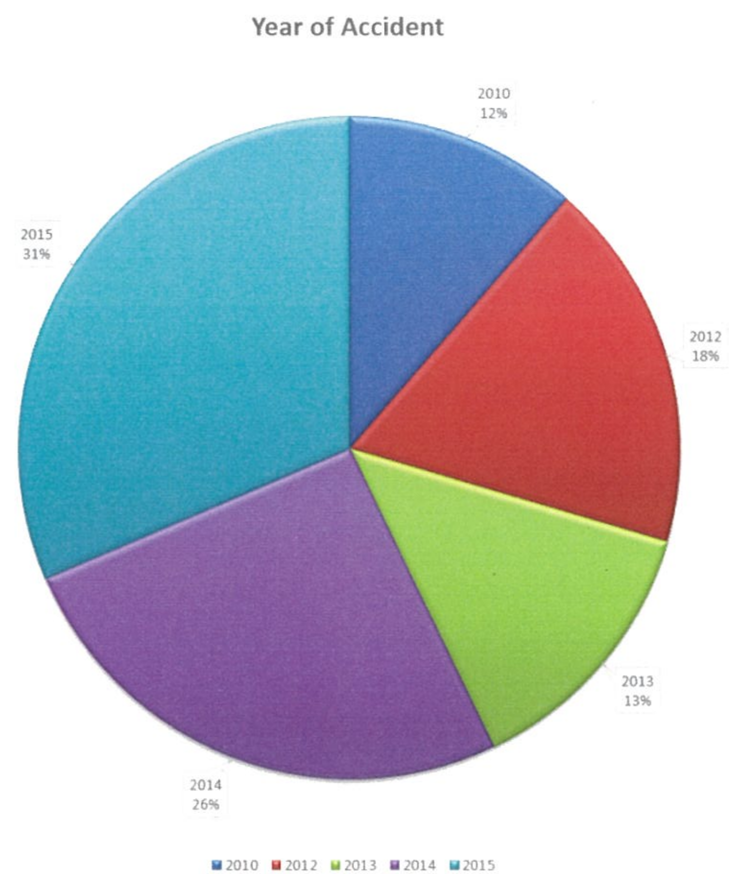
Collision Analysis

Collision Analysis

- Contacted SGI for collision data
- Received data from 2010-2015
- Accident analysis concluded the most common cause of collisions is rear end collision
- No Fatal Collisions reported during this period
- Accidents increasing with highest numbers in 2015


Accident Type
Other
9%
Left turn/ straight
1%
Side swipe- opposite direction
3%
Side swipe- same direction
12%
Fixed/Movable Object
12%
Lost Control- Left ditch
3%
Lost control- Right ditch to left ditch
3%
Lost control- Right ditch
12%
Rear end
44%
Fixed/Movable Object
Lost Control- Left ditch
Lost control- Right ditch to left ditch
Lost control- Right ditch
Rear end
Side swipe- same direction
Side swipe- opposite direction
Head on
Right angle
Right turn- Same direction
Left turn/ straight
Left turn/ straight- same direction
Left turn/ straight- opposite direction
Left turn- Passing
Right turn- Passing
Other

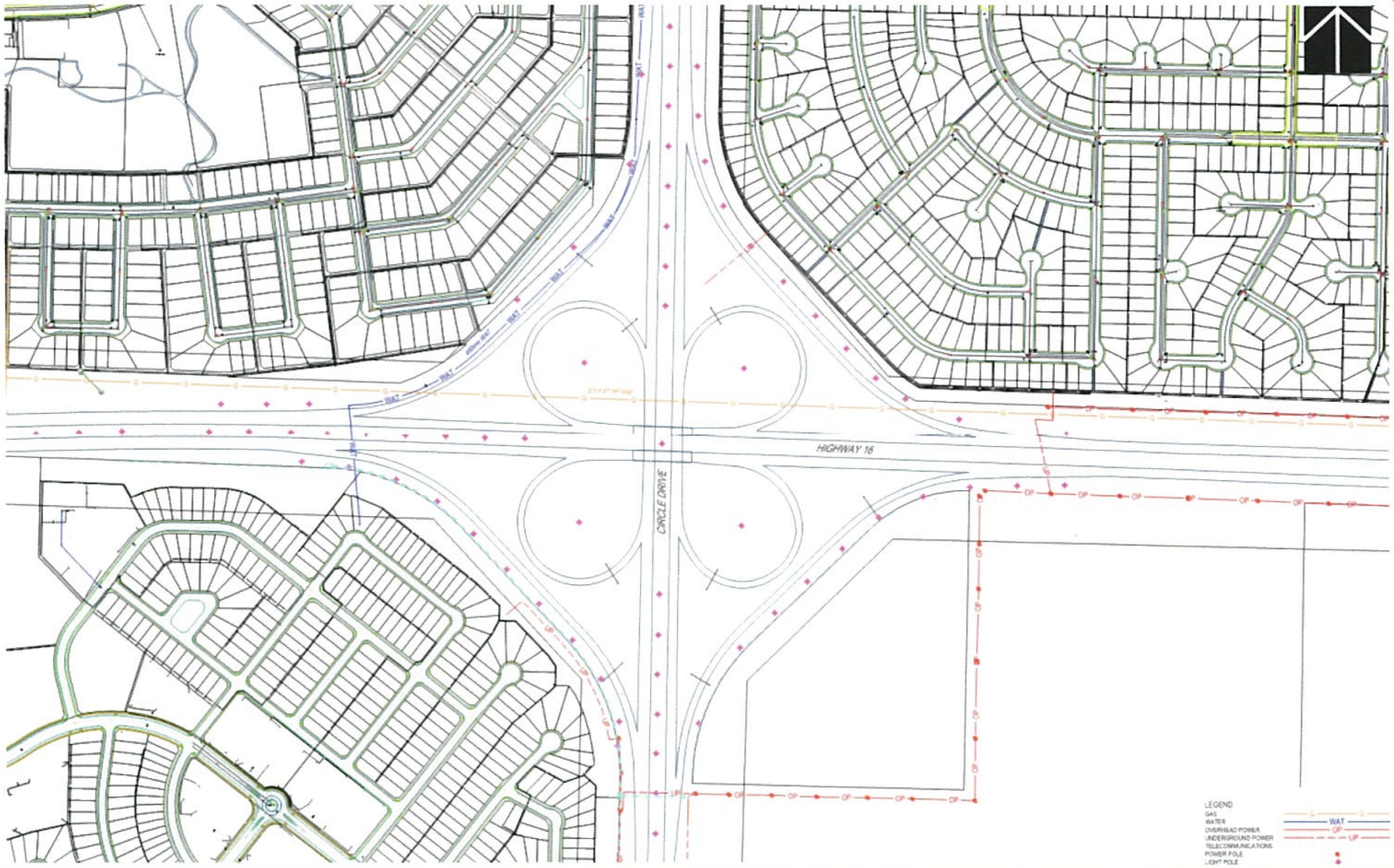

Vehicle Type
Motorcycle 3%
Power units for semi trailers 6%
Vans 4500kg & under 23%
Passenger Car 42%
Pickup Truck 4500 kg & under 25%
Passenger Car
Pickup Truck 4500 kg & under
Vans 4500kg & under
Trucks over 4500 kg
Power units for semi trailers
Transit bus (urban)
Inter-city-bus
School bus Standard
School bus Van type
Other bus
Motorcycle
Moped/powered bicycle
Bicycle
Ambulance/police/fire
Snowmobile
Construction/Maintenance vehicles
Farm Vehicles
off highway vehicles
motor homes
Other vehicles


Year of Accident
2010
12%
2012
18%
2013
13%
2014
26%
2015
31%
2010 2012 2013 2014 2015

Utilities

Existing Utilities

- SaskPower
- SaskEnergy – 323.9mm HP
- SaskTel
- Shaw Communications
- Saskatoon Light and Power
- City of Saskatoon Deep Utilities


HIGHWAY 16
CIRCLE DRIVE
WAT
OP
UP
LEGEND
GAS
WATER
OVERHEAD POWER
UNDERGROUND POWER
TELECOMMUNICATIONS
POWER POLE
LIGHT POLE

Summary of Issues

- Critical traffic movements to be resolved
- Bridge has not reached the end of its life yet:
  - Need to review short term solutions to help solve immediate issues (weaving, bridge clearance)
  - Need to review long term solutions to resolve longer term issues

- Traffic growth is unclear – plan needs to be flexible
- Drainage requires that interchange be constructed above a certain elevation
- Land constraints in NW, NE and SW quadrants of interchange – existing residences, noise aesthetics, etc.
- Collision analysis indicates rear end collisions to be resolved
- High pressure 323.9mm Sask Energy line

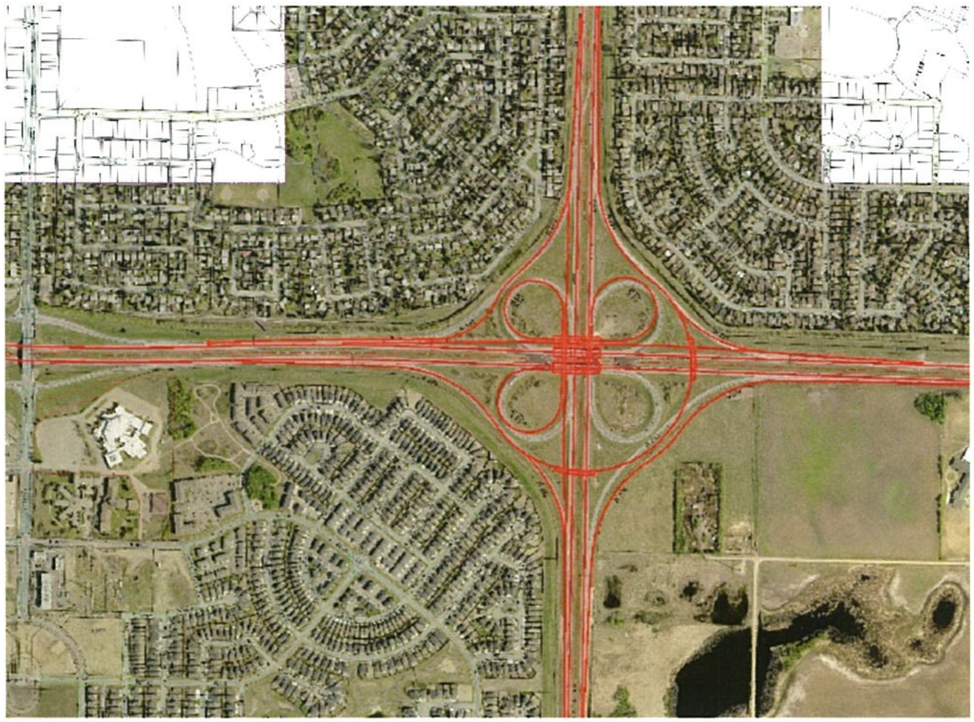
Objectives of today's workshop

- Review evaluation criteria and assign weightings
- Brainstorm options to:
  - Resolve long term issues;
  - Develop short term staging to resolve immediate issues
- Evaluate options against criteria

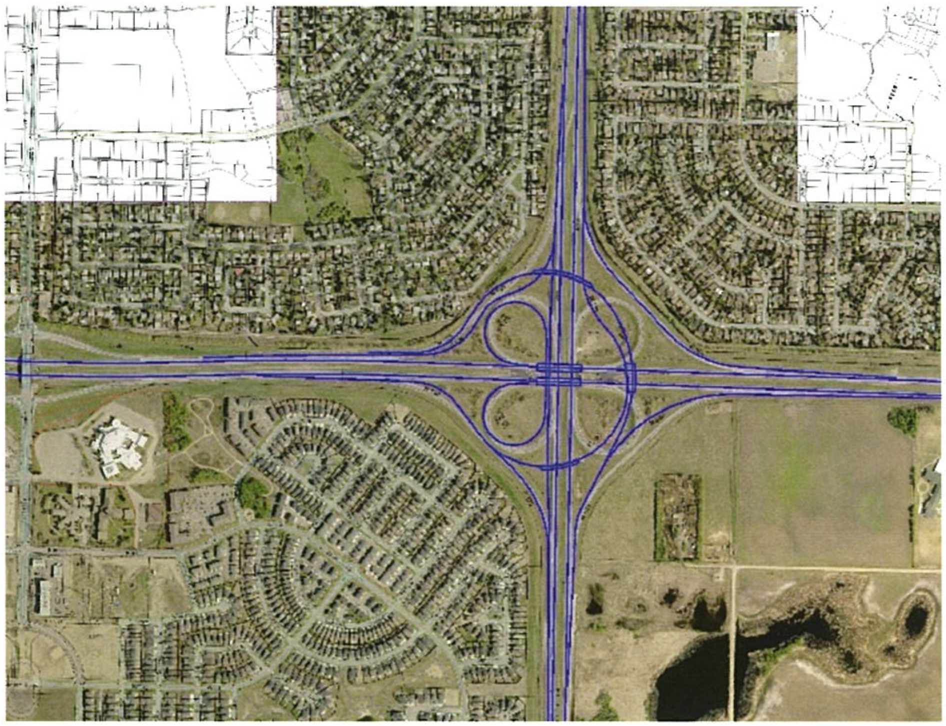
Just to get your juices flowing …

- Alternate 1: EB-NB free flow lane
- Alternate 2: EB – NB and NB – WB Free Flow Ramps
- Alternate 3: Cloverleaf with CD Roads
- Alternate 4: …..
- Alternate 5: …..

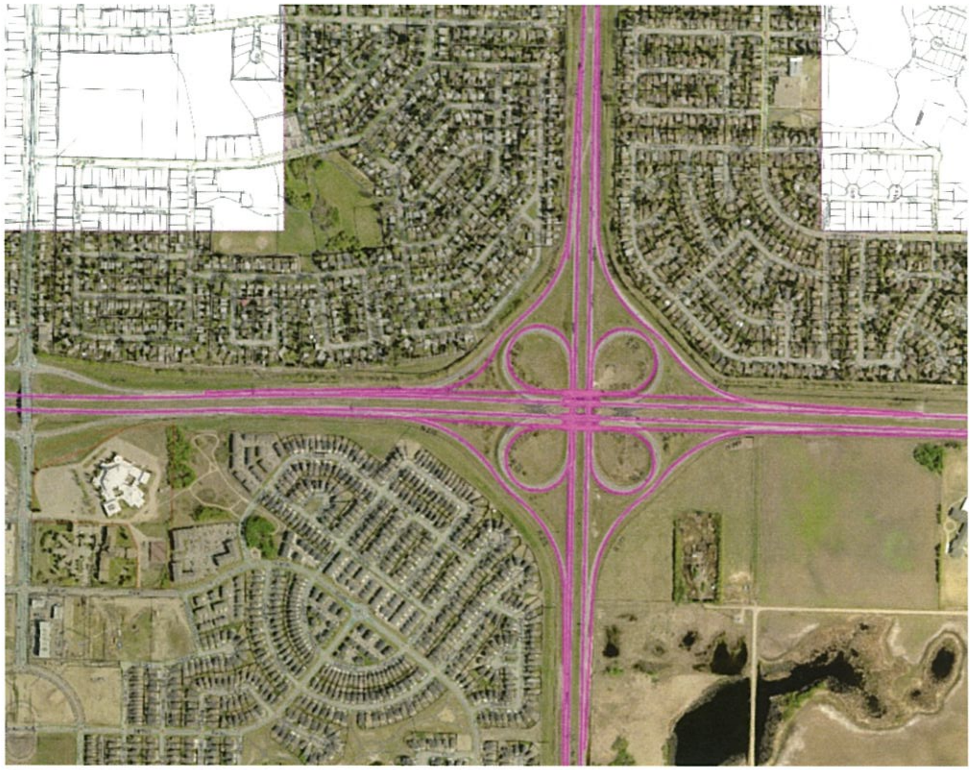
Alternate 1: EB-NB free flow lane



Alternate 2: EB – NB and NB – WB Free Flow Ramps



Alternate 3: Cloverleaf with CD Roads



Appendix B

Evaluation Matrix

CRITERIA ANALYSIS MATRIX

PROJECT: *Highway 11/Circle Drive Interchange* **CLIENT:** *City of Saskatoon*

FACILITATOR: *Steven J. Melton* **DATE:** *October 25, 2016*

	B	C	D	E	F	G	H	I	J	Evaluation Criteria	Score	Weighting factor	Position
A	a 1	c 3	d 1	e 1	a 1					Oversize Goods Movement	2	7.7%	4
	B	c 2	b 1	b 3	b 2					Weaving Improved	6	23.1%	2
		C	c 2	c 2	c 2					Resident Impact	11	42.3%	1
			D	e 2	d 1					Flexibility for Change in Future	2	7.7%	4
				E	e 2					Driver Expectations	5	19.2%	3
					F					Constructability/Traffic Accomodation during construction	0	0.0%	6
						G					0	0.0%	6
							H				0	0.0%	6
								I			0	0.0%	6
									J		0	0.0%	6
										Totals	**26**	**100.0%**	

KEY

Evaluation Criteria are the project elements or alternatives that need to be compared

Score is the total number of points for each element

Weighting Factor is the relative numerical value of each attribute

Position is the order of importance of the elements or alternatives

Ranking

1 Low

2 Medium

3 High

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CRITERIA LISTING

PROJECT: Highway 11/Circle Drive Interchange
FACILITATOR: Steven J. Melton
CLIENT: City of Saskatoon
DATE: October 25, 2016

CRITERIA		CRITERIA DEFINITION
A	Oversize Goods Movement	Corridor must be able to handle oversize (and in fact regular sized loads)
B	Weaving Improved	Weaving lengths for some movements are too short and must be improved
C	Resident Impact	There should be minimal impacts to existing residents in Stonebridge, Eastview and Lakeview, including visual impacts and noise etc.
D	Flexibility for Change in Future	Because of uncertainty with the traffic numbers, plans should allow some flexibility for the addition of lanes in future should the traffic numbers warrant it.
E	Driver Expectations	Driver expectations should be met
F	Constructability/Traffic Accomodation during construction	This interchange cannot be closed during construction and therefore the area must be able to accommodate traffic during this time.
G	0	
H	0	
I	0	
J	0	

ALTERNATE EVALUATION MATRIX

PROJECT: *Highway 11/Circle Drive Interchange*
FACILITATOR: *Steven J. Melton*
CLIENT: *City of Saskatoon*
DATE: *October 25, 2016*

EVALUATION CRITERIA		a Oversize Goods Movement	b Weaving Improved	c Resident Impact	d Flexibility for Change in Future	e Driver Expectations	f Constructability/Traffic Accomodation during construction	g 0	h 0	i 0	j 0	Weighted Score	Ranking
	WEIGHT	8%	23%	42%	8%	19%	0%	0%	0%	0%	0%		
Alternative 1: Russel #1 - Drop grade	Rank	1	3	2	2	1						1.9615	11
	Score	0.0769	0.6923	0.8462	0.1538	0.1923	-	-	-	-	-		
Alterative 2: Chris #1 - Offset Circle Drive with cloverleaf	Rank	4	5	2	3	5						3.5000	3
	Score	0.3077	1.1538	0.8462	0.2308	0.9615	-	-	-	-	-		
Alternative 3: Chris #2 - Turbine Interchange	Rank	1	4	1	1	4						2.2692	8
	Score	0.0769	0.9231	0.4231	0.0769	0.7692	-	-	-	-	-		
Alternative 4: Jimmy/Hassan #1 - Roundabout interchange	Rank	4	2	4	3	2						3.0769	5
	Score	0.3077	0.4615	1.6923	0.2308	0.3846	-	-	-	-	-		
Alternative 5: Hassan #2 - Star Interchange	Rank	1	4	2	1	4						2.6923	10
	Score	0.0769	0.9231	0.8462	0.0769	0.7692	-	-	-	-	-		
Alternative 6: Roy #1 - Offset Circle Drive with Roundabout	Rank	4	5	3	3	4						3.7308	2
	Score	0.3077	1.1538	1.2692	0.2308	0.7692	-	-	-	-	-		
Alterative 7: Hassan #3 - Cloverleaf with half-diamond at Preston	Rank	3	4	1	4	2						2.2692	8
	Score	0.2308	0.9231	0.4231	0.3077	0.3846	-	-	-	-	-		
Alternative 8:Shelly #1 - Single Directional with weaving	Rank	3	4	4	3	4						3.8462	1
	Score	0.2308	0.9231	1.6923	0.2308	0.7692	-	-	-	-	-		
Alternative 9: Shelly #2 - Double Directional with Weaving	Rank	2	4	2	2	4						2.8462	6
	Score	0.1538	0.9231	0.8462	0.1538	0.7692	-	-	-	-	-		
Alternative 10: Cloverleaf with weaving	Rank	3	4	2	3	3						2.8077	7
	Score	0.2308	0.9231	0.8462	0.2308	0.5769	-	-	-	-	-		
Alternative 11: Justine's Option	Rank	4	4	3	1	3						3.1538	4
	Score	0.3077	0.9231	1.2692	0.0769	0.5769	-	-	-	-	-		

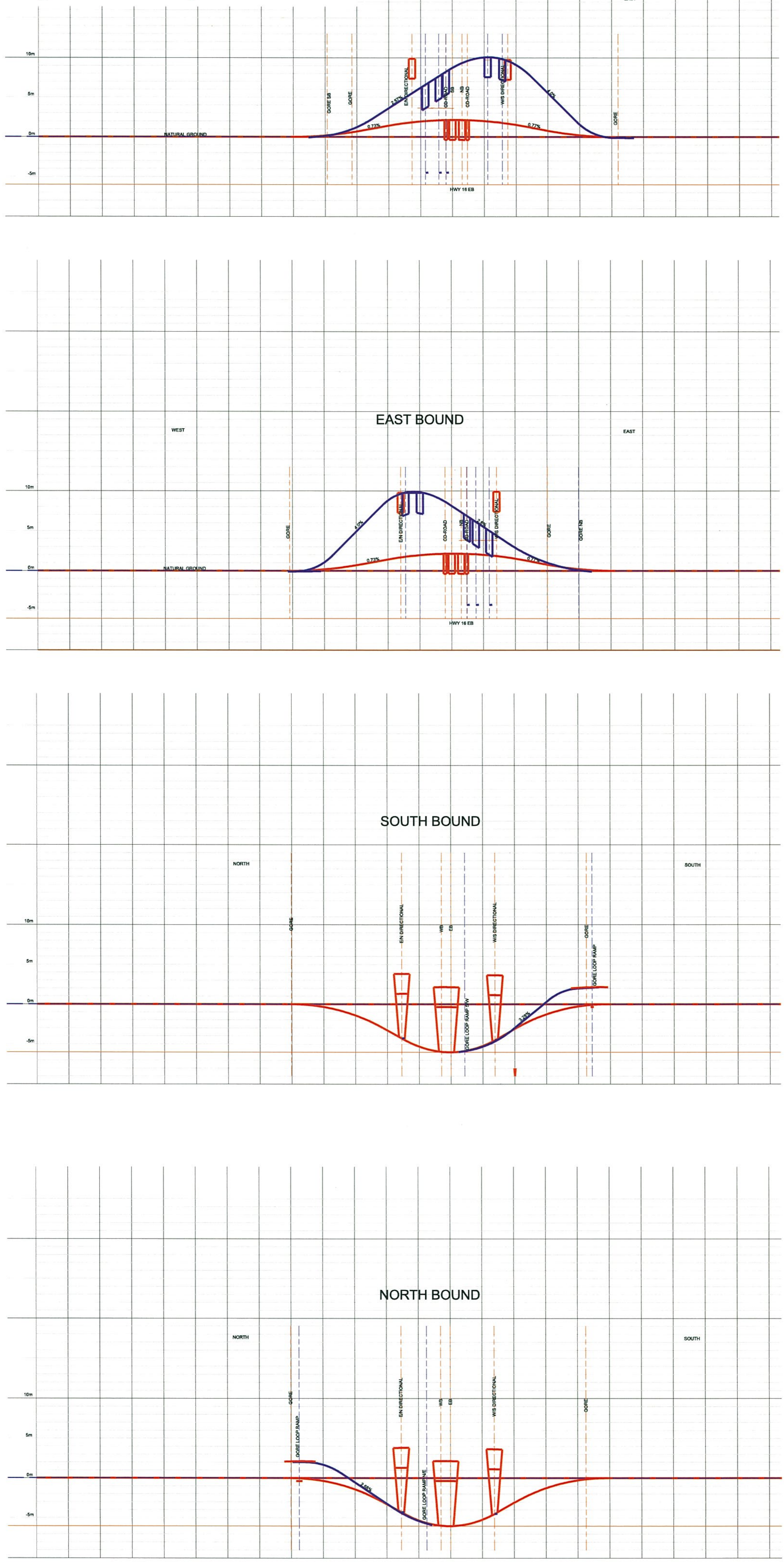
Rank:
1- poor 1 - poor
10 - excellent 7 - Excellent

ISL Engineering and Land Services

Appendix C

Preliminary Profiles

Preliminary Profile Option 11



Appendix D

Public Consultation Reports

A Public Open House was held on November 28, 2016, to provide area residents and businesses with the opportunity to view project information and discuss their interests and concerns with the project team. The event was held at the Circle Drive Church (3035 Preston Ave South), from 4:00pm to 8:00 pm.

In preparation for the event, invitations were circulated to City Council and the local community leagues. Invitations posted on the City website, in the local newspaper, and on roadside signs throughout the immediate study area. The City also used social media to promote the event.

Guests were asked to sign in, and then were given the opportunity to review display boards that showcased the projects progress to date, including: background information and existing constraints, traffic data and projections, interchange configurations that have been rejected (and why), and interchange configurations still being considered. A copy of the display boards are attached to this document.

In total, 127 people attended, representing the following communities:

- 17 people from the Lakeridge community;
- 15 people from the Stonebridge community;
- 11 people from Corman Park;
- 10 people from “Saskatoon”;
- 9 people from the Briarwood community;
- 8 people from RR5;
- 7 people from the Rosewood community;
- 6 people from the Lakeview community;
- 3 people from the Lakewood community;
- 3 people from the Wildwood community;
- 2 people from East College Park;
- 2 people from the Allan community;
- 2 people from the Eastview community; and
- 1 person each from Forest Grove, Highway 219, Nutana Park, Avalon, Churchill, the RR3050 region, Willowgrove, Sutherland, Easthill, Vonda, Floral Road, and Highway 11.

During the event, 32 comments were returned, and 1 comment was posted on the Shaping Saskatoon website. There were several reoccurring themes that received in the comment forms:

- Interchange Option B is preferred to Option A (18 to 3) because it removes the weave between the existing loop ramps; seems more intuitive to drivers, it depresses some of the highest volume ramps (helps with noise); and it moves roadways away from the residential areas.
- Traffic safety and operations are an ongoing concerns.
- Local residents are concerned about noise and proximity to their properties.
- Local residents would like the south ramps at Victor Road to be constructed to help address traffic congestion and backtracking, as well as emergency egress.
- Local residents are excited about the recent announcement of the Boychuk interchange.
- Local residents wonder what the impact of the Perimeter Road will have on traffic at this location.
- Local residents are interested in the short-term solutions that will be presented in the spring of 2017.

All of the comments received are included at the end of this document.

Welcome
Highway 11 & 16 Interchange Functional Planning Study Open House

November 28, 2016

4:00pm to 8:00pm

City of Saskatoon

ISL Engineering and Land Services

Open House Format and Purpose

This Open House is an informal venue where area residents and businesses are provided with the opportunity to view the project information and discuss their interests and concerns with project staff.

The purpose of the event is to make the community aware of the study and invite the public to comment on the proposed interchange options being considered. Feedback from this event will be incorporated as much as possible into the final recommendations.

City of Saskatoon

ISL Engineering and Land Services

Study Purpose

- Improve overall traffic operations at this junction;
  - Short Term: What can we do to keep the interchange operational? How long will it last?
  - Long Term: What is needed in the future?
- Reduce collisions and improve safety;
- Add capacity for critical movements;
- Facilitate good interconnections between the two provincial highways;
- Minimize environmental impacts;
- Minimize right-of-way acquisition and impacts to adjacent lands;
- Optimize costs and benefits.

City of Saskatoon

ISL Engineering and Land Services

Existing Interchange

- Built in the 1960's as a cloverleaf interchange
- Structurally it is near the end of it's life cycle
- The vertical clearance is below today's standards – large vehicles have hit the bridge
- Drivers fail to obey the yield signs

City of Saskatoon

ISL Engineering and Land Services

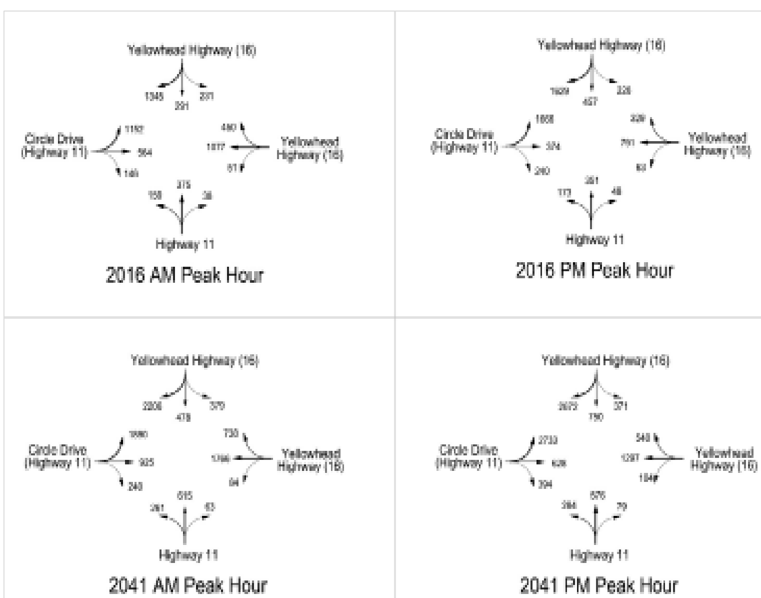
Known Constraints

- Adjacent interchanges (existing or planned) are in close proximity to this interchange – creates highly congested weaving conditions
- Lack of available land surrounding the interchange
- Major SaskEnergy gas line within the interchange right-of-way
- Large storm events can result in localized ponding in the ditches

City of Saskatoon

ISL Engineering and Land Services

Traffic Volumes



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Criteria for Evaluating Interchange Options

- Safety
- Limiting residential impacts (land acquisition, visual, & noise)
- Accommodating trucks (proper bridge clearances)
- Efficient traffic maneuvers
- Meeting drivers expectations (entering and exiting to the right)
- Flexibility in the design to adjust to future traffic demands
- Ease of construction / Traffic accommodation during construction
- Construction and maintenance costs

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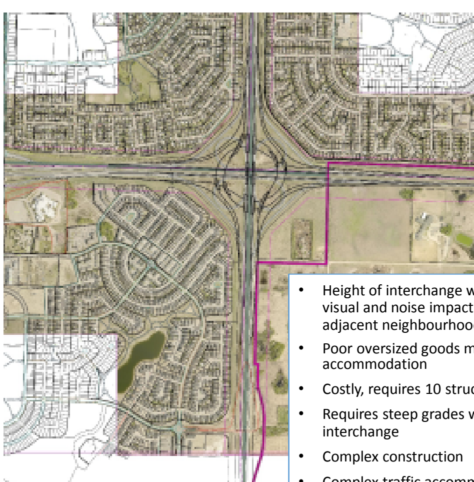
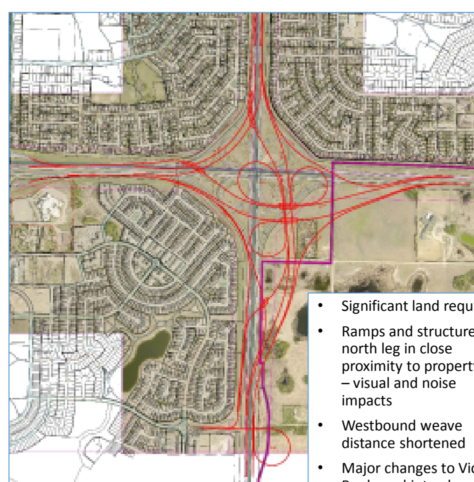
Interchange Configurations that were Rejected



- Height of interchange would have visual and noise impacts on adjacent neighbourhoods
- Poor oversized goods movement accommodation
- Costly, requires 10 structures
- Requires steep grades within the interchange
- Complex construction
- Complex traffic accommodation requirements during construction



- Significant land required
- Ramps and structures on north leg in close proximity to property line – visual and noise impacts
- Westbound weave distance shortened
- Major changes to Victor Boulevard interchange required

City of Saskatoon

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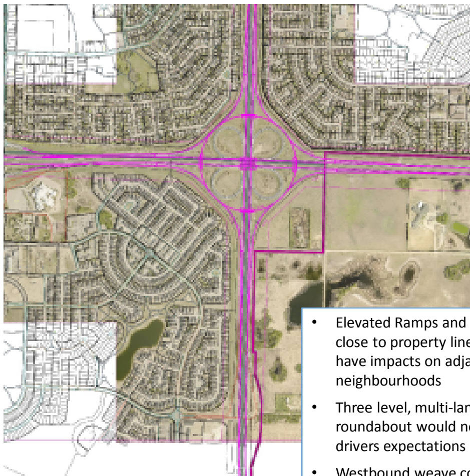
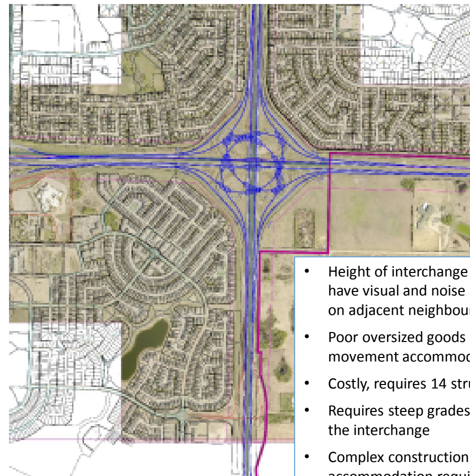
Interchange Configurations that were Rejected



- Elevated Ramps and bridges close to property lines would have impacts on adjacent neighbourhoods
- Three level, multi-lane roundabout would not meet drivers expectations
- Westbound weave condition not improved



- Height of interchange would have visual and noise impacts on adjacent neighbourhoods
- Poor oversized goods movement accommodation
- Costly, requires 14 structures
- Requires steep grades within the interchange
- Complex construction and traffic accommodation requirements during construction

City of Saskatoon

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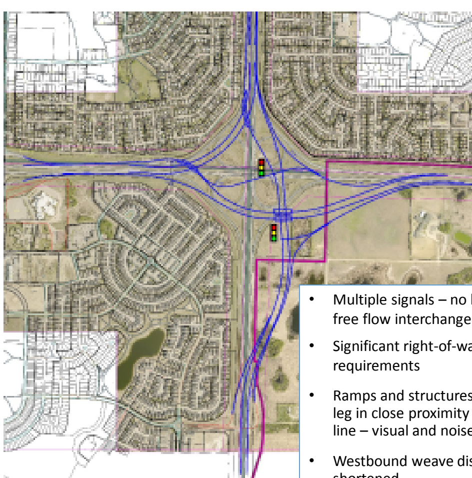
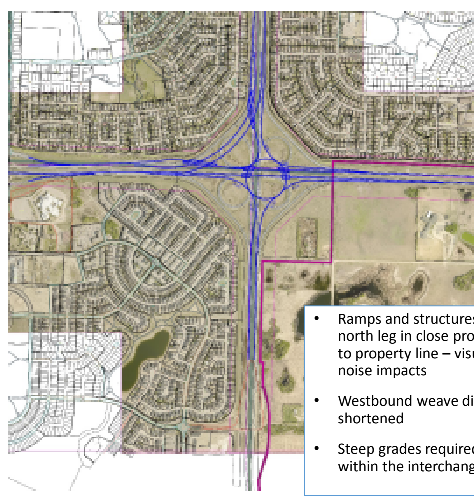
Interchange Configurations that were Rejected



- Multiple signals – no longer a free flow interchange
- Significant right-of-way requirements
- Ramps and structures on north leg in close proximity to property line – visual and noise impacts
- Westbound weave distance shortened

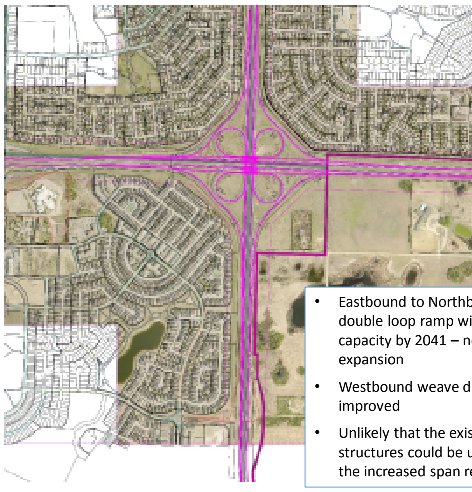


- Ramps and structures on north leg in close proximity to property line – visual and noise impacts
- Westbound weave distance shortened
- Steep grades required within the interchange

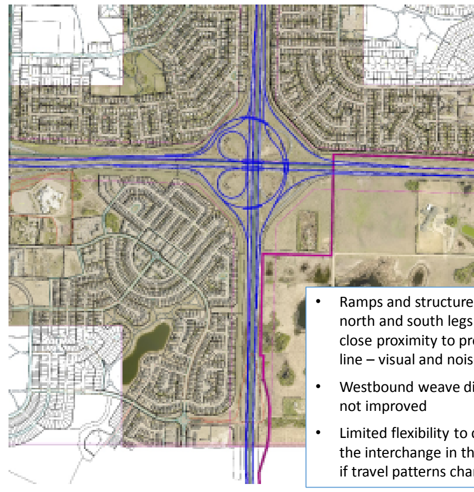
City of Saskatoon

ISL Engineering and Land Services

Interchange Configurations that were Rejected



- Eastbound to Northbound double loop ramp will be at capacity by 2041 – no room for expansion
- Westbound weave distance not improved
- Unlikely that the existing structures could be used due to the increased span requirements



- Ramps and structures on north and south legs are in close proximity to property line – visual and noise impacts
- Westbound weave distance not improved
- Limited flexibility to change the interchange in the future if travel patterns change

City of Saskatoon

ISL Engineering and Land Services

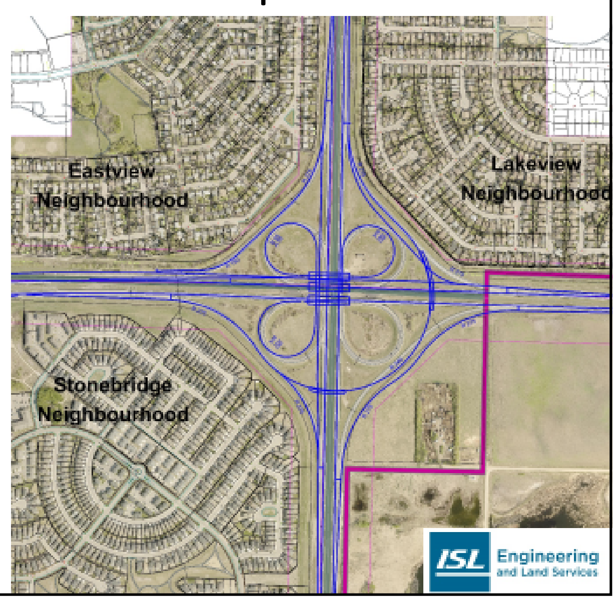
Interchanges being Considered, Option A: Adding an EB to NB Directional Ramp

Pros

- Highest volume movements provided with high speed free-flow movement
- Simplifies weaves between southbound loop ramps

Cons

- Westbound weave near Preston Avenue remains
- Bridge in NE quadrant high and close to existing residents – visual and noise impacts



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ISL Engineering and Land Services

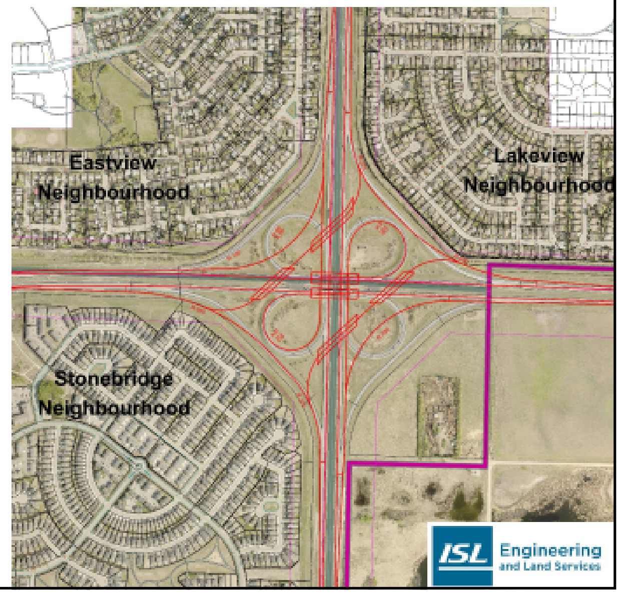
Interchanges being Considered, Option B: Adding 2 Directional Ramps

Pros

- Highest volume movement provided with moderate speed free-flow movement
- Improves westbound weave distance
- Removes weave condition between loop ramps
- Moves bridges away from property lines, lessens visual and noise impacts

Cons

- Complex construction and traffic accommodation requirements



City of Saskatoon

ISL Engineering and Land Services

Next Steps

- A long-term preferred interchange configuration will be selected from the two options under consideration based on the results of the project team evaluation, and will incorporate as much feedback as possible from this event.
- The long-term preferred interchange, and short-term improvements, will be developed in detail and will be presented at Public Open House #2 in the spring of 2017.

City of Saskatoon

ISL Engineering and Land Services

Thank-you for your participation.

Please complete the Comment Form and leave it at the Welcome Desk tonight.

The form can also be returned by mail, email, or completed online at:
http://shapingsaskatoon.ca/discussions

City of Saskatoon

ISL Engineering and Land Services

Below is a summary of all feedback received.

Part 1

1. Where do you live?

- Saskatoon
- Corman Park
- Stonebridge
- Briarwood
- Rosewood
- Eastview
- RR #5 Saskatoon

Part 2

2. Which option was preferred as per the comments

Potential Option A x 3

Potential Option B x 18

Do you have comments or suggestions regarding potential Options A

- Option A would be the most acceptable to provide a safe movement of traffic.
- Option A looks like a better probley cheaper diversion.
- Change from 3 bridge to 2 four lanes.
- Option A you have to know too far in advance of you are using the interchange on which bridge to be on.
- Option A looks like it would leave three of four existing clover loops and peoples driving habits here are generally to timid to facilitate smooth merges in these locations usual result: stalled traffic in peak times; dangerous backups ect,
- If the bridge in the NE quadrant (option A) would be replaced by a tunnel most of the noise complaints could be avoided.

Do you have comments or suggestions regarding potential Options B

- It might be interesting to see what changes might be considered at this interchange if the Saskatoon East bypass were complete first.
- Heavy truck traffic could have maximum height restrictions and possibly eliminate height changes to existing structures.
- Most heavy trucks were excluded from this interchange our main goal would be to move commuter traffic as quickly as possible.
- Option B does a better job of separating the traffic and also enables the movement of the off-ramp to Preston Avenue (when heading west) to be moved away from the Eastview neighborhood, thereby reducing noise to the residential neighborhood.
- Option B seems to take larger traffic patterns into consideration better.
- It seems more like an interchange I would expect in a larger city like Edmonton.
- I like the idea of less loops and better flow
- Option B appears best for smooth traffic flow
- Option B appears to be the best option to accommodate future growth.
- A preference to option B for smoothest traffic flow.
- Option B appears to best address the noise level for my neighborhood. Easthill the recent addition of a sound wall has helped considerably. However based on traffic projections noise level will no doubt increase.
- Although option B is said to be more complex and thus likely more expensive it appears that the bridges would be place as far as possible from residents.
- Perhaps it would be possible to (place sound suppression materials along the edge of the entire interchange, multiple trees especially caragana as a green belt, urban forest with bushes and trees in all

open areas could suppress a lot of sound as well as help with vehicle exhaust concerns as well it would add to the beauty of the area).
- Option B, I understand the need to fix the interchange but I support the option that also reduces noise. I live in Lakeview (Delaronde) and the noise is enough to wake us at night (2 story house). It is particularly bad at night due to engine retarder use. Any consideration to noise must assume that trucks ignore bylaws at night. The noise level is so bad sometimes that we must keep windows shut at night.
- Option B seems better due to eliminating all weave movements on the interchange
- I'm glad an underpass crossroad will work with drainage. Keeping the profiles at lower elevations is great for the surrounding neighborhoods
- Option B should be built in conjunction with a south access to #11 highway at Victor Road.
- Option B looks like the best option for me less curves to worry about during slippery winter months and takes less space, asphalt and money to build.
- I prefer option B as it will handle long term growth. Construction should be given to bikes and pedestrians trying to cross from Stoneridge to Eastview to Lakeridge. Not easy.
- Option B more efficient and safer.
- Option B is indeed too complex and would be too confusing for drivers.
- Option B being considered seems sensible and practical.

Part 3 Additional Comments

- South ramps at Victor Road should be included with this construction.
- Victor Road connecting at #11 south bound and north bound.
- Stonebridge residents are totally hammered in from the north side by Circle Drive, and from the south side by the railroad. Our way out is Preston Avenue Clarence so looking for an exit to south off Victor Road. This is a very dangerous situation in case of an emergency.
- Victor Road definitely needs an exit southbound.
- Some kind of 3D visual and animations would be good to understand the plans better.
- I think it is important to consider the cost of each option before making a decision when speaking with City Reps tonight said costs have not been estimated.
- I don't mind consideration for noise level but people choose where they live. If you are not happy with the visual or noise levels of an interchange – don't buy a house there!
- There is noise everywhere – train, planes highway traffic even semi's you get used to it. You only hear it when you are listening for it. Some people will complain no matter what.
- 1st concern is about costs, safety, case of use (especially if you don't live here – don't make it confusing).
- More concerning to us and many people I suspect is the perimeter highway planning which would alleviate much of the traffic of the 11/16 interchange. We look forward to hearing more about the planning process and stages surrounding that initiative.
- Interchange at Boychuk looks good. Lights at Kingsmere and Boychuk many need to change to accommodate more traffic since there will not be any lights controlling traffic on to Boychuk.
- The peak volumes that I have seen on-site are confirmed by the data you have shown. Hopefully the new design addresses the intense merging situations that exist. I'm sure many city residents would like to see the City invest in a larger more costly alternative in the hopes that long-term growth and development patterns do not jeopardize the new plan.
- I'm glad that the City is addressing this interchange as it is an integral cog to City's freeway traffic.
- I live on an acreage east of the City on Floral Road and travel this (Highway 11) south and north every day of the week and I have never seen any problems with the height of the overpass. My suggestion is to raise it and leave the overpass as it is.
- There are definitely other issues to be dealt with. The south perimeter freeway (Saskatoon Freeway) still has not been finalized and the City is considering overpass when they do not even know where the highway overpass will be e.g.) Boychuk overpass and McOrmond ??) Let's get plans coordinated with the Highway plan.
- I think this area should be left as it is.
- A Boychuk and Highway 16 intersection should be addressed
- A pass route east of the city connecting to the New North River Bridge would alleviate this need.
- Clearance and appropriate height, with some extra for truckers, farm machinery etc.

- Interchange design must support Perimeter Highway in order to assist highway traffic with a route to bypass the city.
- The Northbound weave is presently very dangerous. It is too short and 3 traffic situation require lane changes, it makes for an almost impossible situation. This is much worse at night in low light conditions.
- Raise overpass at good heights restriction.
- The overall future plans for the interchange are acceptable.
- Flooding concerns could be alleviated by providing a storm pond with in the complex.
- Noise reduction for the 3 neighborhoods surrounding the interchange should be #1. This interchange should be moved 2.5 kms south of Stonebridge, away from all residential neighborhoods. Future speeds limits should be covered to 60 km/hr. or less.
- One aspect which is still missing from all options is some pedestrian and cycle access. As is 11 & 16 and this interchange are complete barriers to cycling and walking. Stonebridge and Lakeview are pretty close to each other but totally impractical to get from one to the other (for example). The cycling and walking in each quadrant is ok, but no connections between them.
- It is a shame through that we are so far behind getting other infrastructure in place to accommodate residential development. Boychuk and 16 is a disaster today and the new Costco interchange will soon outgrow its ability to move traffic safety.
- Traffic moving east on #16 highway and entering Boychuk now backed up for extended periods of time. When the new interchange is built at #16 highway and Boychuk the traffic lights at Kingsmere and Boychuk will have to be tied to the flow of traffic moving north from #16 highway.

A Public Open House was held on April 12, 2017 to provide area residents and businesses with the opportunity to view project information and discuss their interests and concerns with the project team. The event was held at the Circle Drive Church (3035 Preston Ave South), from 4pm to 8pm.

In preparation for the event, invitations were circulated to City Council and the local community leagues. Invitations were also posted on the City website, in the local newspaper, and on roadside signs throughout the immediate study area; and the City used social media to promote the event.

Guests were asked to sign in, and then were given the opportunity to review display boards that showcased the projects progress to date, including: background information and existing constraints, a summary from Open House #1, the short- and long-term recommendations (including impacts on the environment, noise attenuation, utilities and stormwater management), and the opinion of probable costs. A copy of the exhibits are attached.

In total, 98 people attended, representing the following communities:

- 4 people from the Lakeridge community;
- 17 people from the Stonebridge community;
- 2 people from Corman Park;
- 5 people from "Saskatoon";
- 6 people from the Briarwood community;
- 1 people from RR5;
- 3 people from the Rosewood community;
- 5 people from the Lakeview community;
- 1 people from the Lakewood community;
- 5 people from the Wildwood community;
- 1 people from East College Park;
- 2 people from the Allan community;
- 2 Brevort Park community;
- 2 people from the Furdale community;
- 3 people from the Clavet community;
- 2 people from the Avalon community;
- 6 people from the Eastview community; and
- 1 person each from Hautain, Dundurn, College Park, Forest Grove, Silverspring, Erindale, Caswell, Floral, Greenbryre, Nutana, Hanely, Grasswood Estates and Hanley. 1 person from CKOM News.

During the event, 6 comments were returned with the following comments:

- Seems like a total overkill just raise the existing overpasses or lower the road. Since they didn't include off ramps out of Stonebridge to Regina and back into Stonebridge from Regina all that traffic ends up in the cloverleaf now. Those ramps should have been built.
- Before you do anything get some left turn arrows on Preston and Taylor so a person can turn off to the left without a 20 minutes wait.
- Consideration given too: snow removal?, flooding?
- Way too many roads, way too many bridges, the merging speeds increased. Accidents will be more serious. These limited resources could be used much more effectively. Boychuk approach is excellent!
- Curious how the aquifer 35m deep is impacted or impacts on this construction. I imagine the two tunnels are very expensive – what part of the total $258M are they? $258M seems a lot when there are some aspects of the interchange that are not likely to be exchanged appreciably.
- The west bound ramp to the C.D. road on the west bound lanes looks very tight and uncomfortable to drive while approaching a merge. This is a very expensive option. Is there nothing less expensive?

Welcome
Highway 11 & 16 Interchange Functional Planning Study Open House #2

April 12, 2017

4:00pm to 8:00pm

City of Saskatoon

ISL Engineering and Land Services

Open House Format and Purpose

This Open House is an informal venue where area residents and businesses are provided with the opportunity to view the project information and discuss their interests and concerns with project staff.

The purpose of the event is to make the community aware of the study and invite the public to comment on the preferred interchange configuration. Feedback from this event will be incorporated as much as possible into the final recommendations.

City of Saskatoon

ISL Engineering and Land Services

Study Purpose

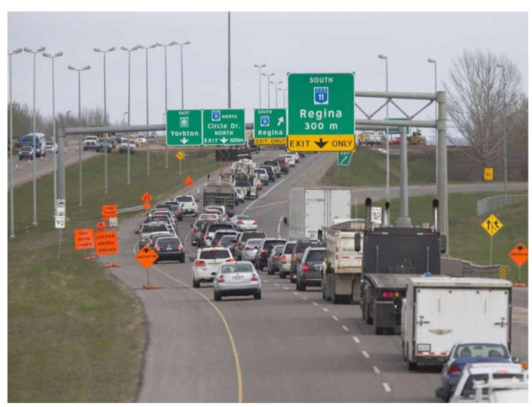
- Improve overall traffic operations at this junction;
  - Short Term: What can we do to keep the interchange operational? How long will it last?
  - Long Term: What is needed in the future?
- Reduce collisions and improve safety;
- Add capacity for critical movements;
- Facilitate good interconnections between the two provincial highways;
- Minimize environmental impacts;
- Minimize right-of-way acquisition and impacts to adjacent lands;
- Optimize costs and benefits.

City of Saskatoon

ISL Engineering and Land Services

Existing Interchange

- Built in the 1960's as a cloverleaf interchange
- Structurally it is near the end of it's life cycle
- The vertical clearance is below today's standards – large vehicles have hit the bridge
- Operational issues cause delays



Source: Saskatoon StarPhoenix

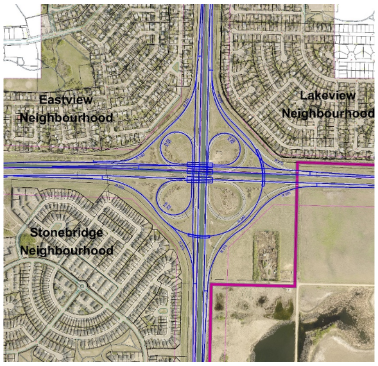
City of Saskatoon

ISL Engineering and Land Services

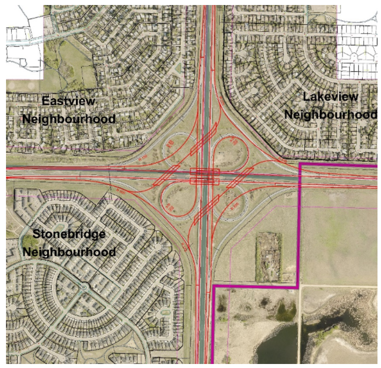
Comments from Open House #1 (Nov. 28, 2016)

- 127 people attended and 33 comments were received.
- Two interchange configurations were presented as viable options:

Option A



Option B



City of Saskatoon

ISL Engineering and Land Services

Comments from Open House #1 (Nov. 28, 2016)

Reoccurring themes on the comment forms included:

- Interchange Option B was preferred to Option A (18 to 3).
- Option B was preferred because it:
  - removes the weave between the existing loop ramps,
  - seems more intuitive to drivers,
  - it depresses some of the highest volume ramps (helps with noise), and
  - it moves roadways away from some of the residential areas.
- Traffic safety and operations are an ongoing concerns.
- Local residents are concerned about noise and proximity to their properties.

City of Saskatoon

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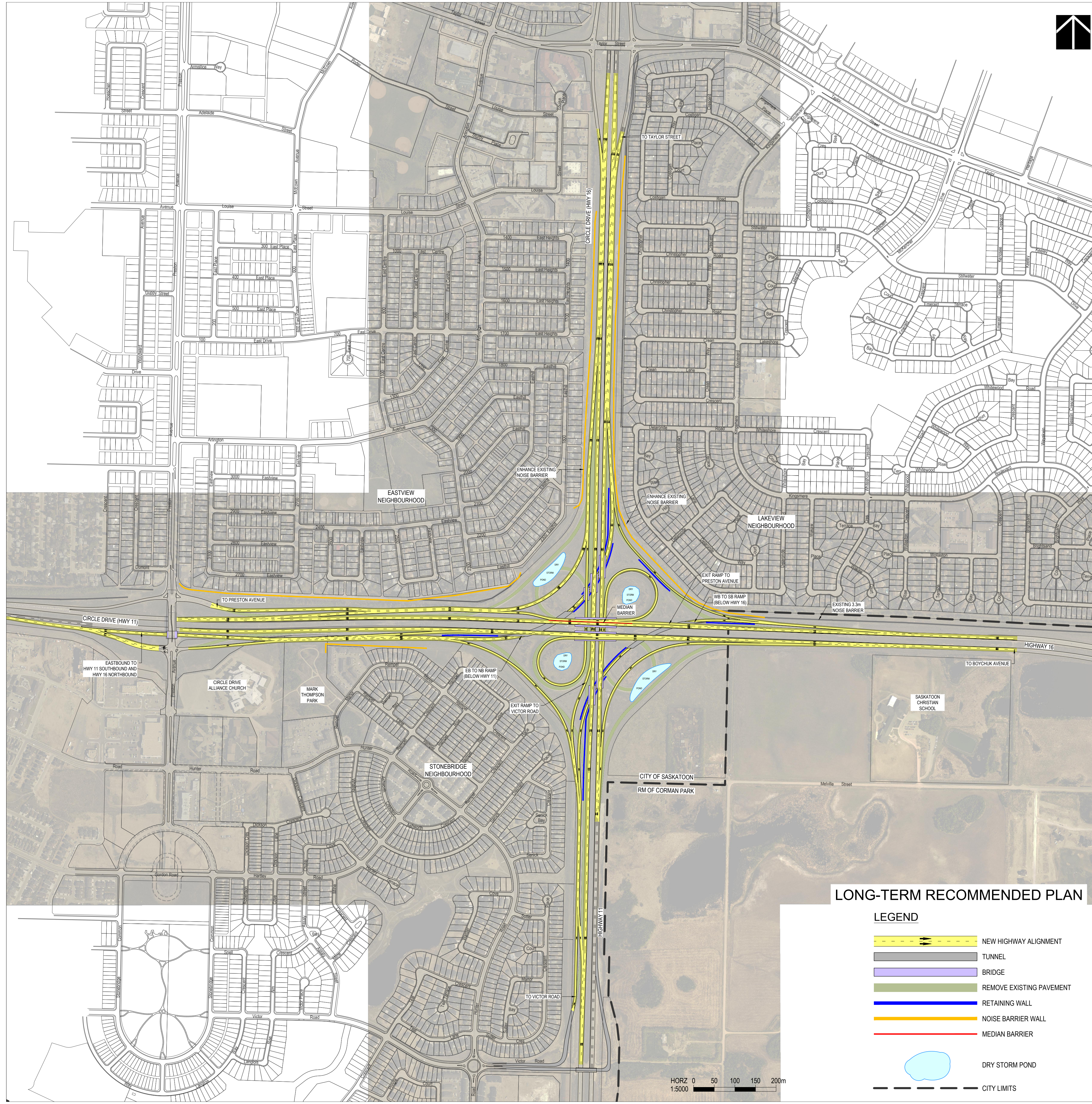
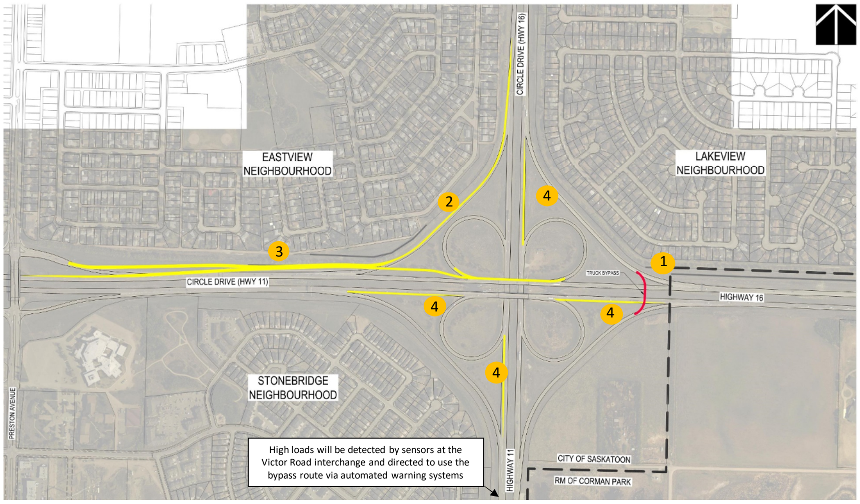


LONG-TERM RECOMMENDED PLAN
LEGEND
NEW HIGHWAY ALIGNMENT
TUNNEL
BRIDGE
REMOVE EXISTING PAVEMENT
RETAINING WALL
NOISE BARRIER WALL
MEDIAN BARRIER
DRY STORM POND
CITY LIMITS
HORZ 0 50 100 150 200m
1:5000
CIRCLE DRIVE (HWY 16)
CIRCLE DRIVE (HWY 11)
HIGHWAY 16
HIGHWAY 11
TO TAYLOR STREET
TO PRESTON AVENUE
TO BOYCHUK AVENUE
TO VICTOR ROAD
EASTVIEW NEIGHBOURHOOD
LAKEVIEW NEIGHBOURHOOD
STONEBRIDGE NEIGHBOURHOOD
ENHANCE EXISTING NOISE BARRIER
ENHANCE EXISTING NOISE BARRIER
EXIT RAMP TO PRESTON AVENUE
WB TO SB RAMP (BELOW HWY 16)
EXISTING 3.3m NOISE BARRIER
MEDIAN BARRIER
EASTBOUND TO HWY 11 SOUTHBOUND AND HWY 16 NORTHBOUND
CIRCLE DRIVE ALLIANCE CHURCH
MARK THOMPSON PARK
EB TO NB RAMP (BELOW HWY 11)
EXIT RAMP TO VICTOR ROAD
SASKATOON CHRISTIAN SCHOOL
CITY OF SASKATOON
RM OF CORMAN PARK

Stage 1 Improvement Recommendations



Construct:

1. Northbound high-load bypass lane across Hwy 16
2. 2nd lane for the SB-WB off- ramp
3. WB Collector/Distributor Road to improve the weave condition with Preston Ave
4. Extend on-ramp lanes to increase merging time for drivers

City of Saskatoon

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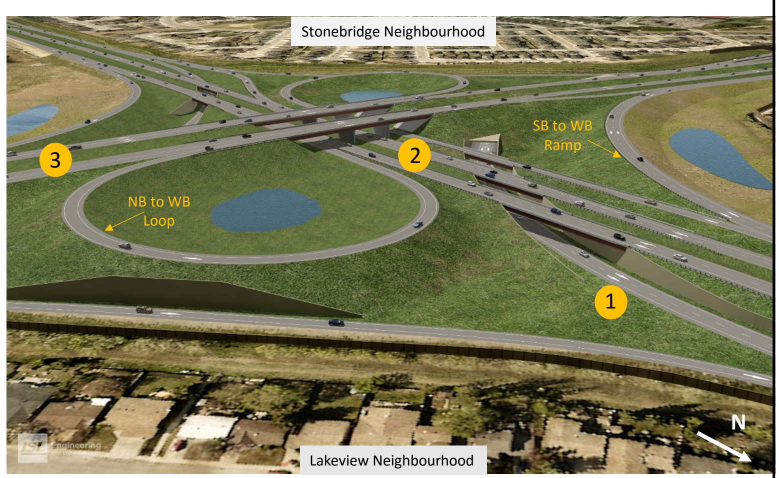
Ultimate Improvements

- A new interchange will be constructed that maintains free flow movements in all directions.
- The interchange will be 3-levels:
  1. Directional ramps (6m below existing ground)
  2. North/South highway (2m higher than existing)
  3. East/West highway (4m higher than existing)
- Collector/Distributor Roads improve the weave conditions between adjacent interchanges.



Rendering of proposed interchange, looking southwest.

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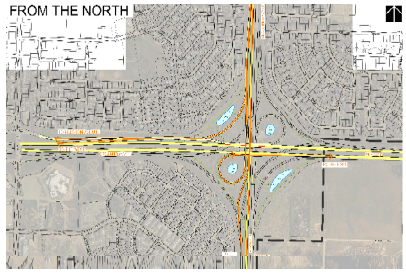
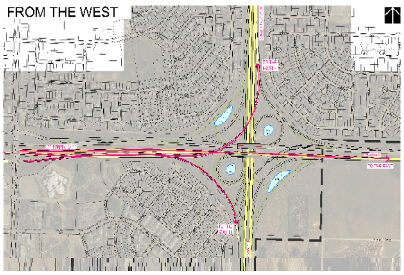
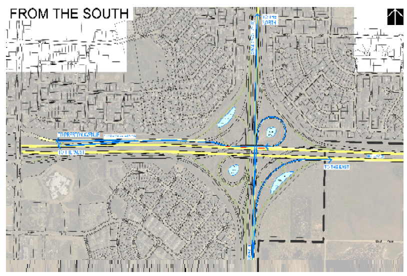
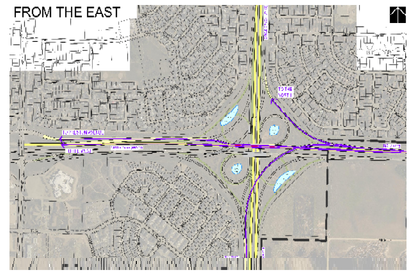
How do I get where I am going?









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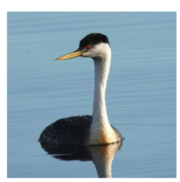
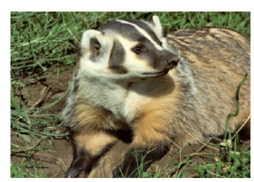
Environmental Assessment







- Aquatic Habitat Protection Permits may be required from the Ministry of Environment for the crossing or alteration of wetlands.
- There are no known federally listed and 11 provincially listed plant species in the study area.
- There are no known federally or provincially listed species in the study area; however, existing habitat would be appealing to 28 listed species.
- There is no suitable fish habitat within the project area.

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Geotechnical Assessment

- Geotechnical investigation will be conducted at the detailed design stage.
- Frost susceptible soils in the area will influence the design for the bridge foundations, retaining walls, and pavement designs.
- The Forestry Farm Aquifer is approximately 35m below the surface and will need to be considered at the design stage.

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Storm Water Management & Other Utilities

- New storm water management ponds will be constructed within the interchange footprint to manage major storm events. Refer to the recommended plan for locations.
- Storm water will ultimately be directed to the Stonebridge storm water lake via ditches and underground pipes.

- Utility companies impacted by the project have been contacted.
- Mitigation / relocation costs have been included within the project budget, and will be confirmed at the design stage.

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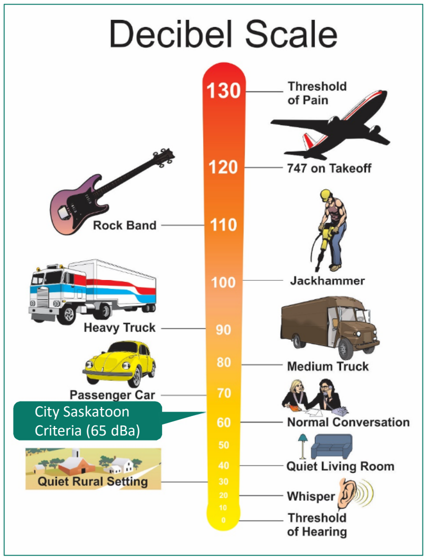
Understanding Noise: Decibel Scale



- Noise is measured using the Decibel (dB) Scale
- The Decibel Scale is a base-10 logarithm scale (similar to Richter Scale)
  - Change of 1-2 dB: threshold for subjective change
  - Change of 3 dB: barely perceptible
  - Change of 5 dB: strongly perceptible
  - Change of 10 dB: considered twice as loud

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Forecasted Noise Levels

- Today's noise levels range from 61dBa to 69 dBA.
- Forecasts are for the long-term horizon.
- Noise levels shown are **with** the proposed noise attenuation recommendations in place.
- Noise mitigation is shown on the long-term plan.

City of Saskatoon

aci acoustical consultants inc

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Opinion of Probable Costs

Rendering of proposed interchange, looking west.

- Stage 1 costs are in the order of $5M dollars.
- Long term improvement costs are in the order of $258M dollars.
- Estimates are based on current unit rates of construction.

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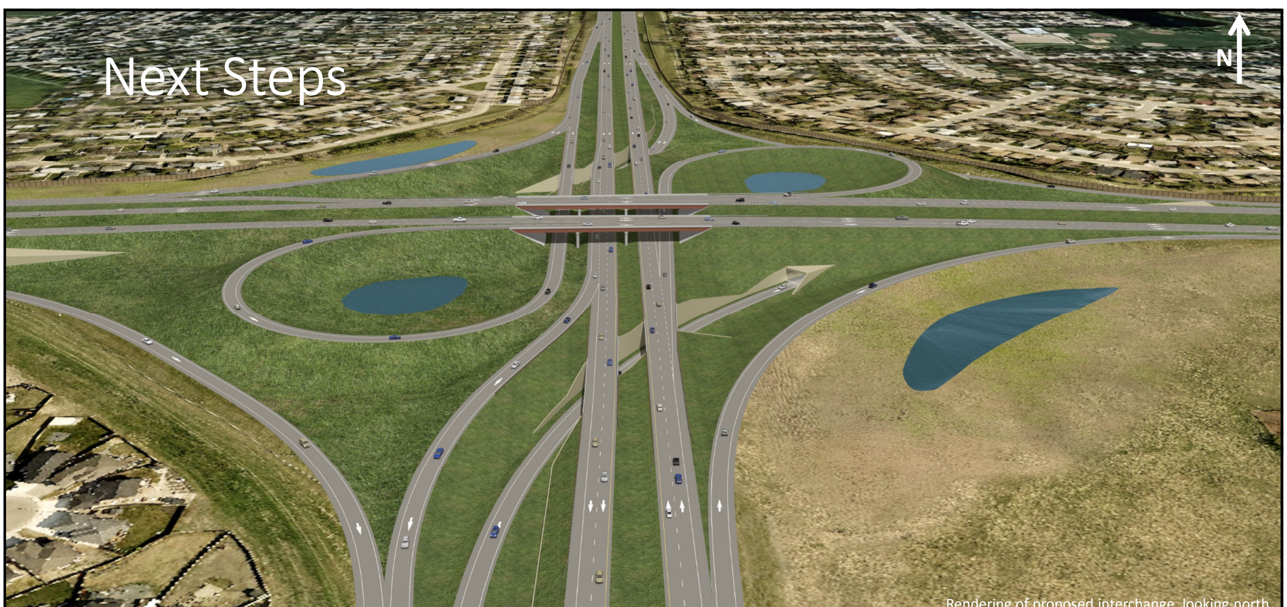
Next Steps



Rendering of proposed interchange, looking north.

Recommendations will be documented in a final report and submitted to the City in late spring. The final report will be used to develop future capital budgets and construction priorities.

City of Saskatoon

ISL Engineering and Land Services

Thank-you for your participation.

Please complete the Comment Form and leave it at the Welcome Desk tonight.

The form can also be returned by mail, email, or join the online discussion at:
http://shapingsaskatoon.ca/discussions

City of Saskatoon

ISL Engineering and Land Services

Appendix E

Traffic Report

Table of Contents

TABLES

FIGURES

1.0
Traffic Volumes and Analysis

1.1 Traffic Volumes

1.1.1 Existing Traffic Volumes

Existing traffic volumes were collected by the City of Saskatoon in September 2016. For later comparison with forecast model volumes the existing condition reflects a 260k population. The AM and PM peak hour survey volumes are shown in Figure 6-1. They show the southbound right turn and eastbound left turn to be the predominant turning movements and are likely to require the most consideration in the development of alternative options.

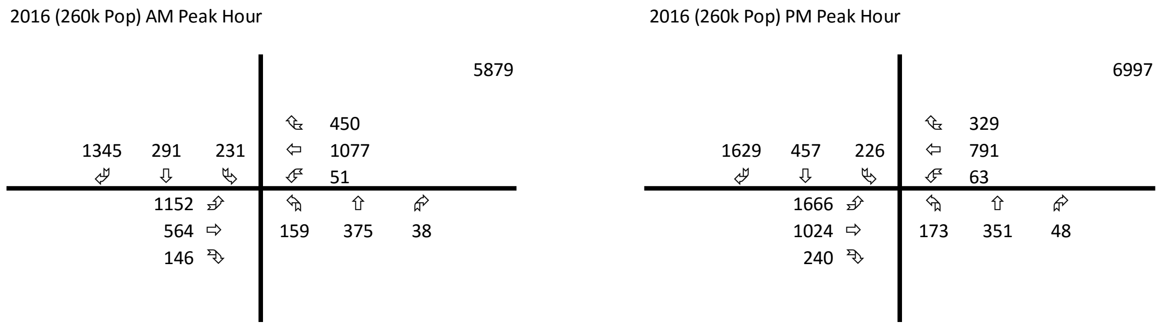


Figure 1.1: AM and PM Peak Hour Existing Traffic Volumes

1.1.2 Future Traffic Volumes

The City of Saskatoon provided traffic volumes for the 500k population scenario from the City's VISUM based Travel Demand Model (TDM). This 500k population is expected to be reached by 2041. Figure 6-2 provides a summary of the TDM volumes.

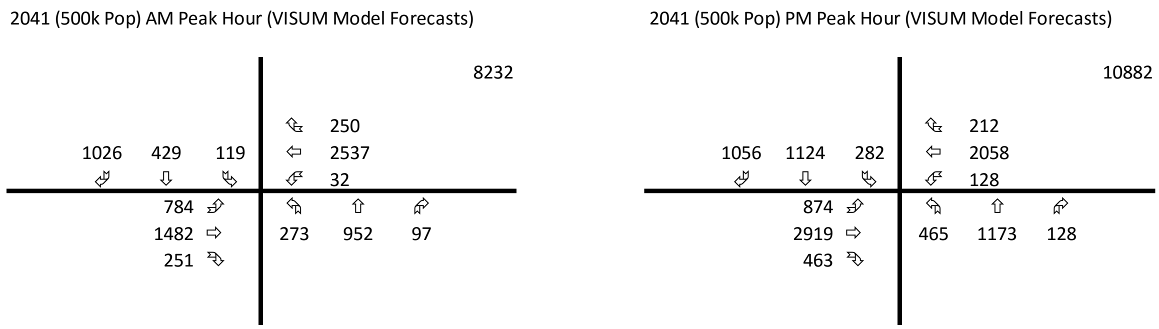


Figure 1.2: AM and PM Peak Hour 2041 TDM Volumes

The TDM volumes show overall growth in traffic through the interchange, however, the volumes for the southbound right turn and eastbound left turn are considerably less than they are at present. This was a concern going forward and the City undertook a review of their model to try and determine the reason for such a reduction in volumes. They were unable to find any conclusive reasons for this reduction on the two predominant movements.

As a test, a second design year scenario will be analyzed to reflect a more traditional growth expectation. The existing condition volumes will be increased based upon a universal 2% growth rate per annum up to 2041. Figure 6-3 shows these volumes.

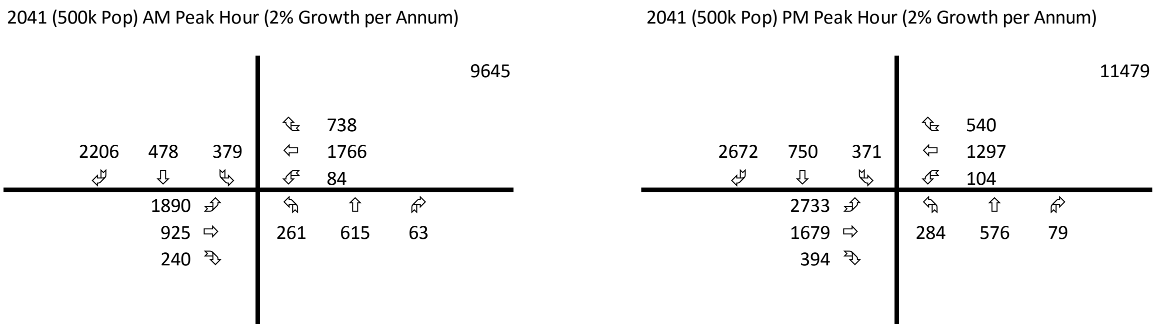


Figure 1.3: AM and PM Peak Hour 2041 2% Growth Rate Volumes

The two sets of future traffic volumes both present difficulties in planning for the future. The TDM model predicts the existing high volume turning movements will be much less than at present, thus the existing interchange may operate more effectively as travel patterns change over time. The 2% growth rate volumes present a very different problem, with those predominant turning movements now much higher and likely requiring two free flow lanes. Subject to upstream lane configurations, it may not even be possible to feed such high volumes onto a double lane ramp.

1.2 Traffic Model and Performance Metrics

The interchange and proposed improvements will be assessed using a VISSIM micro-simulation model. VISSIM is a microscopic multi-modal traffic flow simulation software package where each entity (car or truck in this case) is simulated individually. Each vehicle is represented by a corresponding entity in the simulation that interacts with the physical limitations (i.e. curbs and lanes, curves and merges/diverges) and other entities (i.e. maintaining headways, merging into gaps) to accurately represent observed conditions. It provides the flexibility to test many unique configurations and is ideally suited to a study such as this.

The VISSIM model can provide a number of performance metrics which allow us to compare the impacts of different volume scenarios or different interchange types. The following metrics will be reviewed:

Volume – The volume data helps us identify where there are capacity issues in the network. If the model does not record all vehicles anticipated to make that movement, it tells us the interchange does not have sufficient capacity. Small variables between the input volume and model output volume are not significant as the model has slight variability programmed into it and is averaged over multiple runs. However large differences are a sign that capacity is insufficient.

Delay – The delay for each movement is measured in seconds from the upstream merge to the downstream diverge and will include any time where a vehicle is travelling below its ideal speed through the network.

Travel Time – The travel time for each movement is measured for the upstream merge to the downstream diverge, thus it includes delays that may occur at the merge areas also, but provides a good overall indication of how this part of the network is operating.

As the Highway 11 and 16 Interchange is a systems interchange, the performance target should essentially be free-flow conditions with minimal delay at merge and diverge locations.

1.3 Existing Configuration Traffic Model

This analysis reflects the conditions observed today (September 2016) at the intersection. It is important that this accurately reflects existing conditions and provides a valid base to test future traffic volumes. If it accurately reflects existing conditions we can have some confidence that when future volumes are tested they provide a reasonable assessment of future operation. The existing condition model was visually compared with on-site observations to confirm it provided a reasonable representation of existing conditions.

To determine the need for future improvements we also test the existing interchange with forecast future traffic volumes, this is the 'Do-Nothing' scenario, and provides an estimate of traffic operation in 2041 should we leave the interchange with its current configuration. This 'Do-Nothing' scenario was tested with the 2041 TDM model volumes and 2041 2% Growth volumes.

1.3.1 Existing Configuration – Volumes

In the 2016 and 2041 TDM models, the VISSIM input and output volumes are very similar suggesting little congestion within the model and all intended traffic is making it through the network. In the 2041 2% Growth model, many of the output volumes are much lower than the input volumes. This is to be expected given a single lane can only accommodate in the region of 2000 vehicles. The backups from the EBL and SBR likely also reduce throughput of adjacent vehicles creating a knock-on effect through the network.

Table 1.1: Existing Configuration VISSIM Input and Output Traffic Volumes

Movement	2016 PM		2041 TDM PM		2041 2% PM	
	Input	Output	Input	Output	Input	Output
Eastbound Left	1537	1564	814	761	2521	1750
Eastbound Through	1153	1142	2979	2781	1891	1304
Eastbound Right	240	249	463	434	394	278
Westbound Left	52	56	106	107	86	90
Westbound Through	802	809	2080	2089	1315	1337
Westbound Right	329	329	212	210	540	536
Northbound Left	42	39	303	317	69	66
Northbound Through	482	479	1335	1335	791	797
Northbound Right	48	43	128	124	79	80
Southbound Left	202	207	258	257	332	249
Southbound Through	481	474	1148	1146	789	589
Southbound Right	1629	1607	1056	1029	2672	2048

Based on the above analysis, the 2041 TDM volumes could be accommodated reasonably well by the existing cloverleaf layout due to the change in travel patterns, but the 2% growth scenario will require significant changes to provide the appropriate levels of throughput.

1.3.2 Existing Configuration – Delays

There are minimal delays in the 2016 existing condition model, simply small slowdowns for some movements.

In the TDM scenario where the volumes for those high volume turning movements reduce significantly from the existing condition, the delay for the EBL is still much greater due to the volume and additional weaving taking place. The queue back from the EBL loop ramp also impacts the other eastbound movements and effectively creating congested conditions on the eastbound mainline.

In the 2% growth scenario, where those high volume turning movements become even higher, so high in fact that one lane is not sufficient to accommodate the demand, the delays are considerably higher than existing.

Both future year scenarios suggest the interchange is not capable of accommodating future demand without experiencing congested conditions.

Table 1.2: Existing Configuration VISSIM Traffic Delays (Seconds)

Movement	2016 PM	2041 TDM PM	2041 2% PM
Eastbound Left	18	62	115
Eastbound Through	5	32	52
Eastbound Right	6	42	58
Westbound Left	2	4	3
Westbound Through	1	3	2
Westbound Right	9	9	30
Northbound Left	3	6	4
Northbound Through	2	4	6
Northbound Right	7	29	10
Southbound Left	14	13	64
Southbound Through	2	2	35
Southbound Right	7	5	58

1.3.3 Existing Configuration – Travel Times

The Table below provides the travel time for each movement and then the percentage increase in travel time between the existing condition and the future condition. We can see the TDM model only sees increases on the eastbound movements and the northbound right. The 2% model sees large increases on many of the movements.

Table 1.3: Existing Configuration VISSIM Travel Times (Seconds)

Movement	2016 PM	2041 TDM PM		2041 2% PM	
	TT	TT	% Inc	TT	% Inc
Eastbound Left	145	189	30%	242	67%
Eastbound Through	102	130	27%	149	46%
Eastbound Right	69	104	51%	121	75%
Westbound Left	149	151	1%	150	1%
Westbound Through	91	93	2%	92	1%
Westbound Right	108	108	0%	129	19%
Northbound Left	121	125	3%	122	1%
Northbound Through	84	85	1%	87	4%
Northbound Right	104	126	21%	108	4%
Southbound Left	179	179	0%	229	28%
Southbound Through	88	88	0%	121	38%
Southbound Right	79	77	-3%	131	66%

1.4 Ultimate Configuration Traffic Model

Based on earlier higher level analysis and discussion only one solution was deemed to have enough merit to be taken forward for further analysis. The selected interchange has directional ramps for the eastbound and westbound left turn movements, primarily for the purposes of facilitating the high volume eastbound left turn and removing the weaving conditions currently experienced between the loop ramps.

As the analysis of this option proceeded, an iterative process of model development took place to improve the operation of the highway between adjacent interchanges and the study interchange. Given the high volumes and complexity of movements between interchanges, it was necessary to add additional lanes and in some places collector-distributor roads to accommodate all traffic (in the 2% Growth scenario) with minimal delay.

1.4.1 Ultimate Configuration – Volumes

The input traffic volumes remain the same as those used during the initial existing condition model runs. The output volumes have been updated to reflect the throughput achieved with the ultimate interchange configuration. We can see that the output volumes more closely reflect the volumes input to the model, thus confirming that the proposed design is capable of accommodating such high volumes.

Table 1.4: Ultimate Configuration VISSIM Input and Output Traffic Volumes

Movement	2016 PM		2041 TDM PM		2041 2% PM	
	Input	Output	Input	Output	Input	Output
Eastbound Left	1537	1571	814	831	2521	2489
Eastbound Through	1153	1144	2979	2986	1891	1882
Eastbound Right	240	250	463	467	394	385
Westbound Left	52	56	106	107	86	90
Westbound Through	802	809	2080	2090	1315	1336
Westbound Right	329	329	212	210	540	540
Northbound Left	42	40	303	317	69	66
Northbound Through	482	480	1335	1335	791	798
Northbound Right	48	43	128	126	79	80
Southbound Left	202	209	258	258	332	328
Southbound Through	481	475	1148	1146	789	772
Southbound Right	1629	1607	1056	1030	2672	2614

1.4.2 Ultimate Configuration – Delays

The delay calculations for the existing condition model indicated minimal delays with existing volumes but predicted significant increases in delay under both growth scenarios tested. The updated delay calculations for the ultimate configuration show that delays are greatly reduced in the ultimate configuration for both growth scenarios. What small delays are shown are primarily related to “modelling” issues with merge movements and would not be observed in reality in any meaningful way.

Table 1.5: Existing and Ultimate Configuration VISSIM Traffic Delays (seconds)

Movement	2016 PM		2041 TDM PM		2041 2% PM	
	Existing	Ultimate	Existing	Ultimate	Existing	Ultimate
Eastbound Left	18	2	62	1	115	5
Eastbound Through	5	2	32	7	52	3
Eastbound Right	6	1	42	2	58	1
Westbound Left	2	1	4	2	3	2
Westbound Through	1	1	3	2	2	2
Westbound Right	9	2	9	3	30	4
Northbound Left	3	2	6	4	4	3
Northbound Through	2	1	4	2	6	1
Northbound Right	7	2	29	7	10	3
Southbound Left	14	4	13	8	64	7
Southbound Through	2	1	2	1	35	1
Southbound Right	7	2	5	2	58	6

1.4.3 Ultimate Configuration – Travel Times

Travel time determined in the existing condition model was a factor of the delay caused by congestions as well as the clover leaf loop ramp configuration that required vehicles to slow down and weave. For some movements in the ultimate configuration, the proposed directional ramps allow speed to be maintained and provide a shorter trip length through the interchange.

Table 1.6: Existing and Ultimate Configuration VISSIM Travel Times (seconds)

Movement	2016 PM		2041 TDM PM		2041 2% PM	
	Existing	Ultimate	Existing	Ultimate	Existing	Ultimate
Eastbound Left	145	74	189	74	242	77
Eastbound Through	102	99	130	104	149	101
Eastbound Right	69	65	104	66	121	66
Westbound Left	149	101	151	103	150	102
Westbound Through	91	91	93	92	92	92
Westbound Right	108	103	108	104	129	105
Northbound Left	121	107	125	110	122	108
Northbound Through	84	83	85	84	87	83
Northbound Right	104	100	126	106	108	103
Southbound Left	179	162	179	167	229	165
Southbound Through	88	86	88	88	121	88
Southbound Right	79	75	77	74	131	78

The above results show that the significant improvements are those using the left turn directional ramps, where travel time halves in the existing condition/existing volumes scenario and is approximately one third of the existing condition/future volume scenario. Furthermore, travel times are consistent across all traffic volume scenarios tested, indicating the ultimate configuration will provide greater reliability in travel times.

These reductions in travel time provide additional benefits to Saskatoon by reducing fuel use, emissions and reducing delays to the travelling public, over the life of the interchange, these savings provide significant economic benefits.

1.5 Conclusion of Traffic Analysis

When reviewing the above analysis of the existing, interim and ultimate configurations, it is important to have a clear understanding of the goals of the project and how traffic patterns may or may not change between now and the design year. Some points to consider when reviewing the design options include:

- **Project is about more than traffic capacity** – This project has other priorities over and above providing additional traffic capacity. Two primary goals of this project are to address the road safety concerns over the weaving requirements of the existing configuration and the frequent truck collisions with the low bridges. Furthermore, removing the bridge collisions will resolve the mobility and accessibility issues that arise when repairs are required due to such a collision.

- **How will we move in the future?** - Previous thinking has always placed a focus on designing for traffic growth based on historical trends and travel patterns. However travel patterns and technologies are changing and how we travel in 20 years may be very different than how we travel now. With transit becoming a higher priority in densifying cities, the bicycle gaining in popularity and the advent of the autonomous car fast approaching, designing for traffic capacity based on historic growth alone may result in unwarranted spending.

- **What is realistic?** – The Travel Demand Model predicts lower volumes for some movements than we see today, and there may be valid reasons for such a reduction, such as improved transit, alternative mode-share assumptions, and changes in land use. However, with that being said, with a population set to double between 2016 and 2041 it seems unlikely that car trips will reduce. For this reason, there is a question mark over the TDM volumes and this is the reason two design year scenarios have been included in the analysis.

- **Do we build for growth or build to control growth?** – If we build to accommodate the TDM volumes or 2% growth volumes, we are essentially permitting that level of traffic to occur. If there is appetite within the City to restrict automobile use in favour of other modes, lower capacity roadways can help in achieving this mode shift, providing the other modes are available to pick up the slack. The City should be comfortable that the final solution achieves their objectives.

- **Capacity must be consistent with adjacent interchanges** – If we propose a two lane directional ramp, but it is fed by just one lane upstream, or feeds into one lane downstream, there is little benefit and we are essentially designing to numbers without the context of adjacent capacity. If there are complimentary upgrades planned for adjacent interchanges there may be benefit in increased number of lanes, but ultimately a balanced road system should be the goal.

1.5.1 Next Steps

The above recommendations are provided with the disclaimer that there is a high level of uncertainty in the forecast volumes which have led to the determination of two very different future traffic volume scenarios. Going forward, we would advise additional investigation is undertaken:

- Further examination of the regional travel demand model is undertaken to better understand how the forecast volumes were produced and if the TDM growth scenario is valid.
- The study VISSIM model is expanded to include adjacent interchanges. Their close proximity to each other and the operation of each is critical to the operation of the others.
- The proposed configuration was determined as a solution that would work for the 2% scenario. A phased approach as discussed could allow it to be built out on an as needed basis, potentially reducing investment until it is required.
- Lastly, we recommend monitoring traffic patterns over the coming years to better understand the manner in which traffic volumes are changing.

Appendix F

Geotechnical Overview

May 19, 2017

GEOTECHNICAL DESKTOP SCREENING REPORT FOR

Functional Planning Study Interchange at Intersection of Highways 11 and 16

Submitted to:
ISL Engineering and Land Services Ltd.
259 Robin Crescent
Saskatoon, SK
S7L 6M8

REPORT

Report Number: 1655310

Distribution:

1 Copy ISL Engineering and Land Services Ltd. (electronic format)
1 Copy Golder Associates Ltd.

Golder Associates

Table of Contents

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was commissioned by ISL Engineering and Land Services Ltd. (ISL), on behalf of the Ministry of Highways and Infrastructure, to complete a "desktop" geotechnical screening as part of the planning process for the proposed for the interchange at the junction of Highways 11 and 16, located in southeast Saskatoon, Saskatchewan. The location of the study area is shown on Figure 1. The study area at this location, includes a cross shaped area that encompasses the existing interchange at the junction of Highways 11 and 16.

Golder's scope of work was to assess geotechnical conditions for the general study area on the basis of published geotechnical information. The study was completed as a desktop review, addressing local landforms and materials that may affect the proposed alignments and potential structures with respect to foundation requirements and embankment/excavation considerations. No intrusive investigation or soil testing was conducted for this study.

This report should be read in conjunction with "Information and Limitations of This Report" included in Appendix A. The reader's attention is specifically drawn to this information, as it is essential for proper use and interpretation of this report.

2.0 GEOLOGY

2.1 General Description of Regional Geology

As glaciers retreated downslope to the north in the Saskatoon area, a lake basin formed. The basin became occupied by Lake Saskatchewan into which the South Saskatchewan River emptied, forming a delta south of the city. The history of deglaciation of the Saskatoon area is dominated by glacial Lake Saskatchewan, the delta formed south of the city and the evolving South Saskatchewan River (Christiansen & Sauer, 1994).

In general, the geology in this region comprises of surficial stratified deposits overlying a thick stratum of clayey glacial tills, overlying clay shale deposits (bedrock). The glacial deposits are divided into two groups based on the carbonate content and stratigraphic position (Sauer, 1991). The two groups are referred to as the Saskatoon Group and the Sutherland Group. The Saskatoon Group is younger and overlies the Sutherland Group.

The Saskatoon Group is subdivided into the Battleford and Floral Formations on the basis of pre-consolidation pressures, structure, staining and carbonate content. The Battleford Formation is typically softer than the Floral Formation, massive and unstained and can be over 100 m thick in this area. The Floral Formation contains over-consolidated, jointed and stained tills that range in thickness from less than 1 to 70 m. In some regions, the Upper and Lower Floral Formation tills are separated by the Riddell Member, which consists of sand and gravel.

The Sutherland Group is subdivided into the Warman, Dundurn and Mennon Formations (in descending order). The Sutherland Group formations are generally comprised of glacial till. The Warman Formation ranges in thickness from less than 1 m to about 20 m in this area. The tills of the Warman formation are generally comprised of grey, medium to highly plastic silty clay till. The Dundurn Formation is generally comprised of grey, unoxidized silt and clay till and generally has more inter-bedded sand and gravel than the other formations in the Sutherland Group. The Mennon Formation ranges in thickness from less than 1 m to about 30 m. The Mennon Formation is generally comprised of grey, unoxidized, low to medium plastic, clayey silt tills. Tills of the Sutherland Group have lower carbonate content, are more clayey and have a higher liquid limit than tills of the Saskatoon Group (Christiansen, 1991).

The Bearpaw Formation forms the bedrock surface over much of this region and is the youngest bedrock formation, overlying the Judith River and Lea Park Formations. The Bearpaw Formation is predominately marine silty clays and sands and thins as it progresses westward. The silts and clays of the formation have a low hydraulic conductivity; therefore, the top of the formation is considered an impermeable lower boundary for the groundwater system above.

2.2 Geology within the Study Area

The western side of the study area is generally located within an Eolian Plain or Eolian Hummocky land form. The eastern side of the study area is located within a Glacio-lacustrine Plain (Saskatchewan Research Council, 2008). In general, the surficial soils within an Eolian Plain will include sands and silts and the terrain can be flat or undulating. The surficial soils within a Glacio-lacustrine Plain will generally consist of clays and silts and the terrain will generally be flat (Figure 2).

The surficial stratified deposits present within the study area is the Haultain Formation. The Haultain Formation is considered to be part of the Saskatoon Group and comprises of up to 30 m of soft grey silt and clay inter-bedded with sand. Its contact with the underlying Battleford Formation is commonly gradational. The silts, clays and sands of the Haultain Formation were deposited in deeper parts of the pro-glacial Lake Saskatchewan as it shifted north with the retreating ice front. In general silt and sand are found at surface within the western half of the study area and are underlain with clay and silt. The surficial stratified deposits in the western half of the study area extends to about 20 m below surface. Within the footprint of the eastern half of the study area, clay and silt is generally found at surface. The surficial stratified deposits within the east half of the study area are much thinner and extend to between 2 m and 10 m below surface (MDH, 2011). Battleford till may be found at surface in some areas of the eastern half of the study area.

The Saskatoon Group includes the Floral and Battleford Formations and the Riddell Member (MDH, 2011). Within the study area, both the Battleford and Floral Formations can be encountered below the surficial stratified deposits and the Battleford Formation itself, is fairly thin. The Riddell Member is generally present within the Floral Formation and ranges in thickness from less than 5 m to about 20 m. The Forestry Farm Aquifer (part of the Riddell Member) is a major aquifer in the area. The Forestry Farm Aquifer is approximately 35 m below surface (MDH, 2011) and is discussed further in Section 3.1.

The tills and sand and gravel units of the Saskatoon Group extend to between 40 m and 50 m below surface.

The Sutherland Group includes only the Dundurn Formation within the study area footprint (MDH, 2011).

The Empress formation may be present but generally it appears to pinch out north of the study area. The Empress formation consists of stratified preglacial sediments deposited between the bedrock surface and the glacial sediments (Whitaker, 1972).

The Bearpaw Formation is approximately 50 to 150 m below surface within the footprint of the study area. The Judith River Formation and Lea Park Formation range from about 100 m to 150 m below surface and are not discussed further in this report (MDH, 2011).

3.0 HYDROGEOLOGY

3.1 Aquifers

Stratified deposits between the Sutherland and Saskatoon Groups and between the individual till formations within the groups, in general, represent the major aquifers within the Saskatoon region. The inter-bedded stratified deposit that occurs between the contact of the Sutherland Group and the Saskatoon Group has been informally called the Lower Floral Aquifer, an aquifer interpreted to be discontinuous in the region. The Lower Floral Aquifer has been encountered in thicknesses up to 53 m and at depths below ground surface between 3 and 100 m. The Lower Floral Aquifer may at times be hydraulically connected to the Upper Floral Aquifer in the Saskatoon area. These hydro-stratigraphic units form important aquifers in the Saskatoon area, of which one is formally named the Forestry Farm Aquifer and is present approximately 35 m below the surface of the study area. The continuity and hydraulic head data of the aquifer reveals a fairly flat surface and several discontinuities have been inferred within the Forestry Farm Aquifer. A number of groundwater investigations carried out in the area estimate that the hydraulic conductivity of this aquifer can be expected to be within the range of $1x10^{-6}$ to $1x10^{-3}$ m/s. The groundwater flow in the Forestry Farm Aquifer is toward the South Saskatchewan River. Figure 3 shows the extents of the drift aquifers in the area, including the Floral and Battleford aquifers (MDH, 2011). The drift aquifers are generally discontinuous and geotechnical investigations are required to determine their depth and extent within proposed alignment right-of-ways.

3.2 Groundwater

A query of the SaskWater water well database (SaskWater, 2000) indicated 7 wells for research, 1 for industrial withdrawal and 8 for domestic withdrawal. The search was conducted within the study area and extended to a one km radius outside of the study area. The well lithology was not recorded on a number of the logs; where the lithology was recorded, clay or sand to a depth of up to 15 m was recorded. Groundwater levels that were recorded ranged from about 1.5 to 6 m below ground surface. A summary of the records search, as well as individual water well records are included in Appendix B.

4.0 GEOTECHNICAL CONSIDERATIONS

Surficial soils within the study area are expected to consist of silts, sands and/or clays and silts.

4.1 Embankments and Roadways

Embankments constructed with sand will provide good subgrade support and stable embankments and can reduce the thickness of pavement structure required. However, consideration should be given to the potential for encountering poorly graded silty sand which is highly frost susceptible or clean poorly graded sands which may require stabilization. Silts are highly frost susceptible and can cause significant movements in roadway and interchange embankments in Saskatchewan's climate. Frost action in silt subgrades can be mitigated by subgrade excavation and replacement with free draining granular material and by providing subgrade drainage. However, silts are not recommended for subgrade or embankment construction.

Clays used to construct the embankments require special consideration. Clays are expansive and compressive in nature, and generally have a lower load-bearing capacity than the sands or tills. The thickness of pavement structure required increases for embankment materials with a lower load-bearing capacity. Clays can also be difficult to work when wet and can require extended schedules for drying and conditioning. When using clay fill for the embankments, it is important to monitor pore water pressures which can increase and then dissipate slowly over an extended time period due to the low hydraulic conductivity of the soil. Consolidation of the clay soil material only occurs after the excess pore water pressure dissipates and stress is transferred to the soil structure. If pavement structures are constructed on clay embankments before most of the consolidation has occurred, the structures may crack and shift as the embankment settles. Dewatering measures to lower possible high groundwater tables may be required and placement of fill embankments well in advance of construction should be considered to expedite consolidation of the subgrade materials and reduce settlement damage. Instrumentation to monitor pore water pressures, settlement, and lateral deformation may be required in any approach embankments.

According to the published literature, glacial till may be found at surface near the east, northeast edge of the study area. However, according to the SaskWater well database, glacial till can be up to 40 m or greater below surface. It would be uneconomical to excavate to these depths for borrow material. Utilizing low to medium plastic cohesive glacial tills to construct the roadway and interchange embankments will provide good consistent subgrade support and will reduce the thickness of pavement structure required to support the anticipated traffic loading. Glacial tills are also superior to clay for the construction of interchange embankments.

Groundwater levels in general averaged about 6 m below surface, but were as shallow as 1.5 m.

Geotechnical investigations should be conducted to determine groundwater levels and to verify soil conditions.

Construction through any wetlands created by the water channels and sloughs would likely require dewatering, excavation of organic materials, and backfilling with more stable materials. Road grade construction through these types of areas may require use of geotextile materials to reduce the extent of subgrade excavation and backfill.

4.2 Foundations for Structures

Driven or cast-in-place pile foundations would be expected to be suitable for the soil conditions found at the site. Cast-in-place piles within the silt, sand and gravel surficial deposits may require sleeving. Boulders are commonly found at random or in layers within the Saskatchewan glacial tills. The Forestry Farm Aquifer is about 35 m below surface and should be considered when determining pile lengths, excavations and cuts.

Concrete in contact with the soil should be produced with sulphate resistant Portland cement.

4.3 Slope Stability

The current study area would not be expected to have any existing slopes that may cause issues; however, slopes within trenches, excavations and cuts may become unstable over time depending on ground moisture conditions, fluctuations in the groundwater table and changes to surface drainage patterns.

5.0 CLOSURE

This report presents a summary of existing information obtained from Geology and Surficial Geology Maps and the records of water wells from the SaskWater database. Comments on suitability of native materials for subgrade, groundwater levels, and slope stability are general in nature and should be confirmed with a field investigation and engineering analysis to provide more detailed recommendations on a site specific basis.

The information presented in this report was gathered from existing information and provides general commentary on geotechnical conditions that may be encountered along the proposed road alignments. The contents of this report do not constitute a design in whole or in part, of any of the elements of any future work. Detailed geotechnical investigations will be required when a final alignment is determined.

We trust that this report addresses your current needs for this project. Please call if you wish to discuss this report or require any clarification.

Report Signature Page

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER
T.L. FRANK
MEMBER 9199
2017 05 19
YR. MN. DAY
SASKATCHEWAN

PROFESSIONAL ENGINEER
P.G. BRUCH
MEMBER 6039
2017 05 19
YR. MN. DAY
SASKATCHEWAN

Terry Frank, P.Eng., PMP
Associate, Senior Geotechnical Engineer

Phil Bruch, M.Sc., P.Eng.
Principal, Senior Geotechnical Engineer

TLF/PGB/pls/jlb

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Association of Professional Engineers & Geoscientists of Saskatchewan

CERTIFICATE OF AUTHORIZATION

Golder Associates Ltd.

Number C0230

Permission to Consult held by:

Discipline	Sk. Reg. No.	Signature
Geotech	09199	

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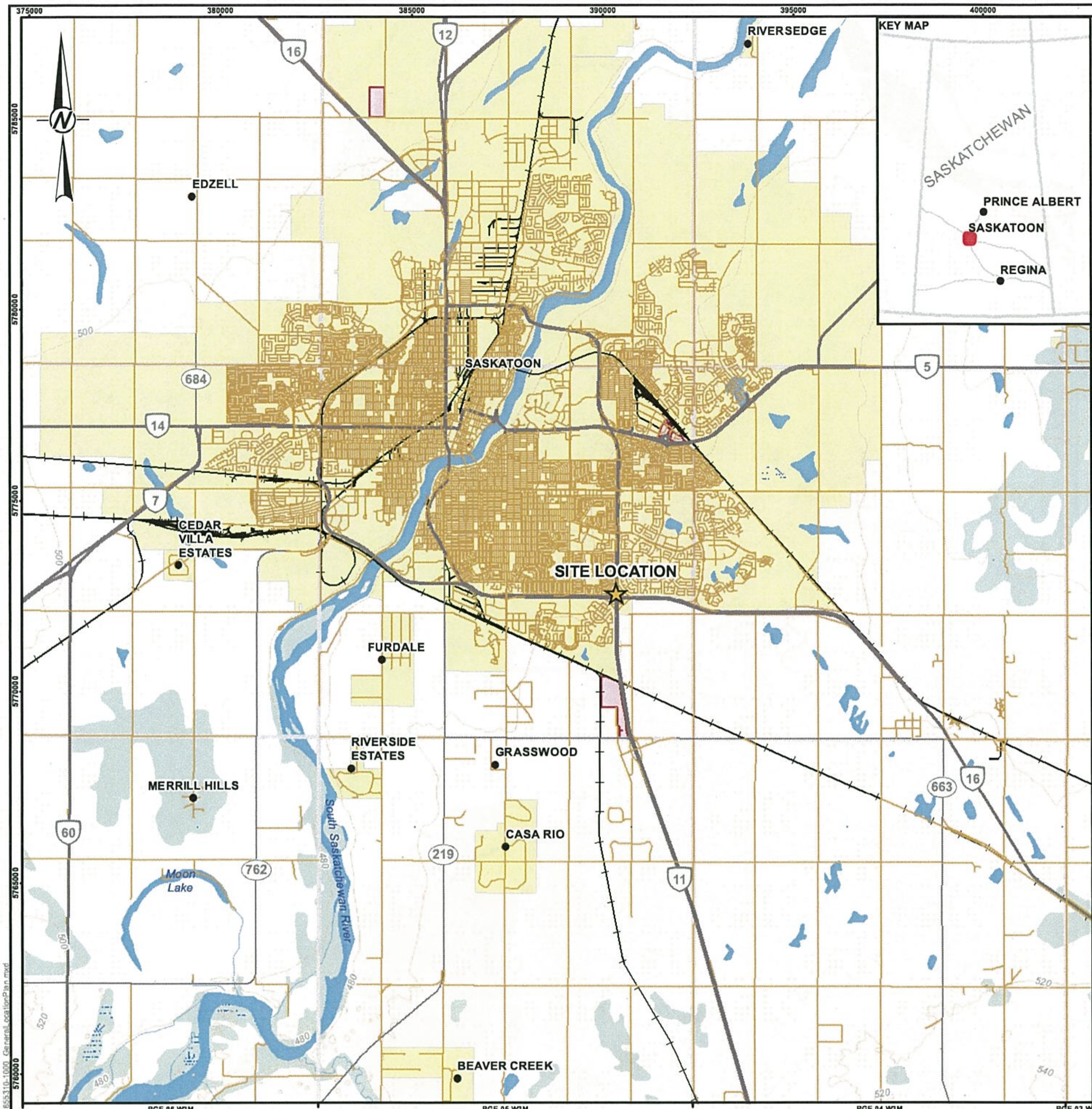
FIGURES



LEGEND

- ★ SITE LOCATION
- ● POPULATED PLACE
- ELEVATION CONTOUR (20m INTERVAL)
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- WATERBODY
- WETLAND
- WOODED AREA
- URBAN MUNICIPALITY

0 3 6

1:150,000 KILOMETRES

REFERENCE(S)

1. NATIONAL TOPOGRAPHIC DATA BASE (NTDB) DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. ROADS OBTAINED FROM NATIONAL ROAD NETWORK. RAILWAY OBTAINED FROM IHS ENERGY INC.

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

ISL ENGINEERING AND LAND SERVICES LTD.

PROJECT

GEOTECHNICAL DESKTOP SCREENING
SASKATOON, SASKATCHEWAN

TITLE

GENERAL LOCATION PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-05-19
DESIGNED	TF
PREPARED	ANK
REVIEWED	TF
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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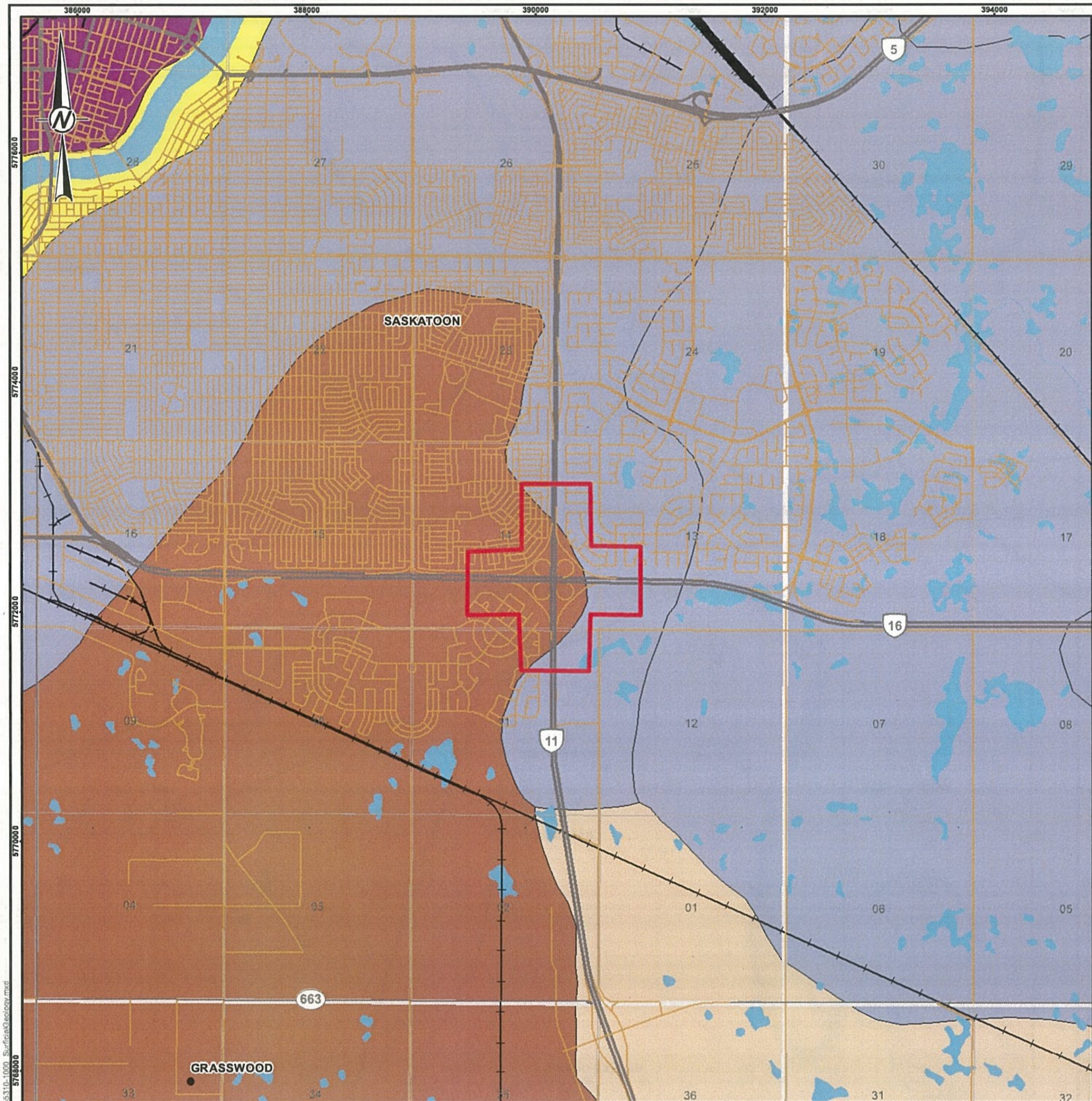

LEGEND

- ● POPULATED PLACE
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- RAILWAY
- WATERCOURSE
- WATERBODY
- STUDY AREA

SURFICIAL GEOLOGY

- ALLUVIAL PLAIN
- EOLIAN
- EOLIAN PLAIN
- GLACIOLACUSTRINE DELTA
- GLACIOLACUSTRINE PLAIN

0 1 2

1:50,000 KILOMETRES

REFERENCE(S)

1. 250K SURFICIAL GEOLOGY OBTAINED FROM GEOLOGICAL ATLAS OF SASKATCHEWAN VIEWER © 2016, GOVERNMENT OF SASKATCHEWAN
2. ROADS OBTAINED FROM NATIONAL ROAD NETWORK. RAILWAY OBTAINED FROM IHS ENERGY INC.

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

ISL ENGINEERING AND LAND SERVICES LTD.

PROJECT

GEOTECHNICAL DESKTOP SCREENING
SASKATOON, SASKATCHEWAN

TITLE

SURFICIAL GEOLOGY

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-05-19
DESIGNED	TF
PREPARED	ANK
REVIEWED	TF
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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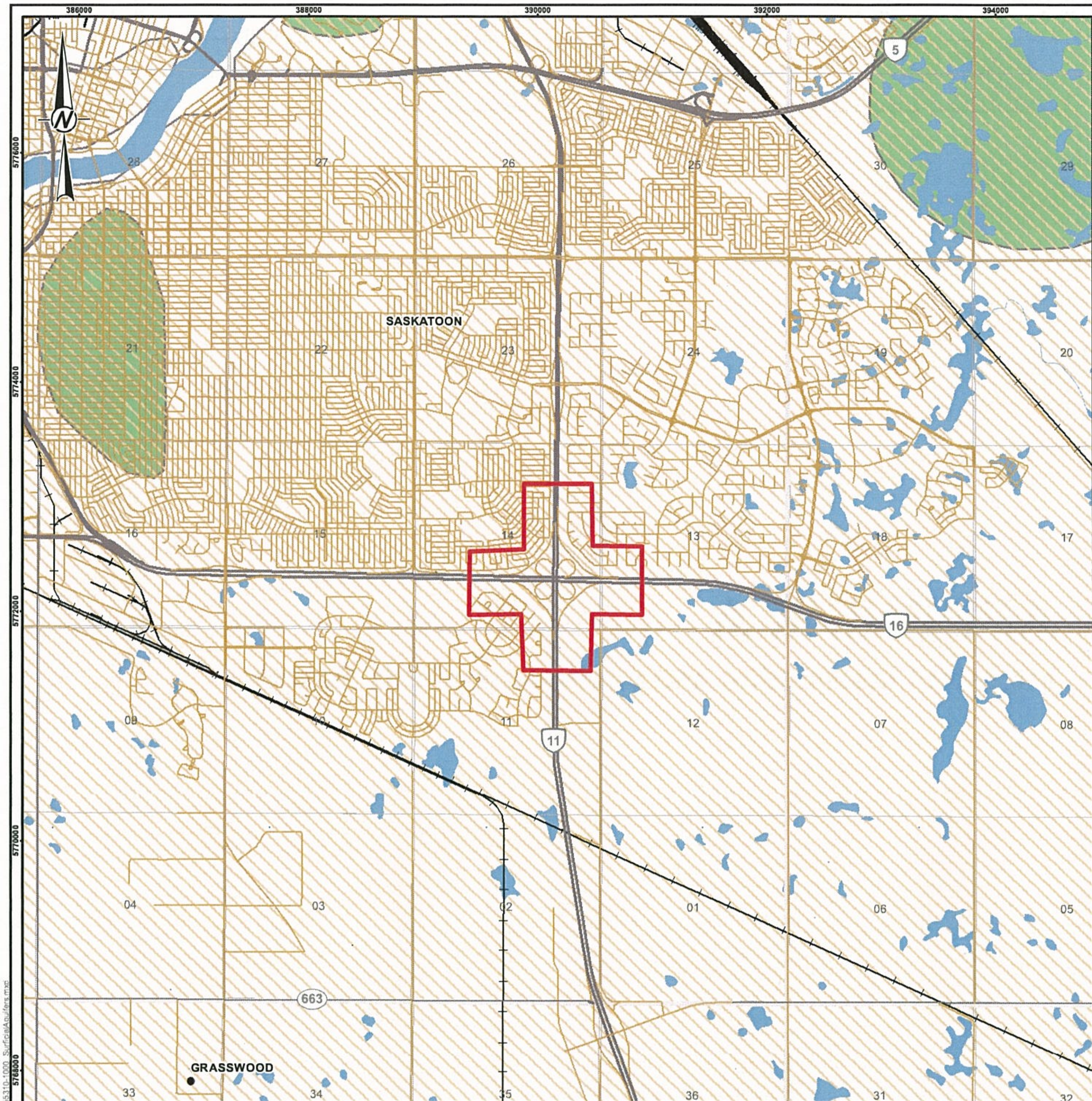

LEGEND

- ● POPULATED PLACE
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- RAILWAY
- WATERCOURSE
- WATERBODY
- STUDY AREA

DRIFT AQUIFERS

- SURFICIAL
- SASKATOON FLORAL

0 1 2

1:50,000 KILOMETRES

REFERENCE(S)
1. PROVINCIAL AQUIFER BOUNDARIES: SRC
2. ROADS OBTAINED FROM NATIONAL ROAD NETWORK. RAILWAY OBTAINED FROM IHS ENERGY INC.
PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT
ISL ENGINEERING AND LAND SERVICES LTD.

PROJECT
GEOTECHNICAL DESKTOP SCREENING
SASKATOON, SASKATCHEWAN

TITLE
SURFICIAL AQUIFERS

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-05-19
DESIGNED	TF
PREPARED	ANK
REVIEWED	TF
APPROVED	PB

PROJECT NO.	PHASE	REV.	FIGURE
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APPENDIX A

Important Information and Limitations of this Report

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

Basis and Use of the Report: This report has been prepared for the specific site, design objective, development and purpose described to Golder by the Client. The factual data, interpretations and recommendations pertain to a specific project as described in this report and are not applicable to any other project or site location. Any change of site conditions, purpose, development plans or if the project is not initiated within eighteen months of the date of the report may alter the validity of the report. Golder can not be responsible for use of this report, or portions thereof, unless Golder is requested to review and, if necessary, revise the report.

The information, recommendations and opinions expressed in this report are for the sole benefit of the Client. No other party may use or rely on this report or any portion thereof without Golder's express written consent. If the report was prepared to be included for a specific permit application process, then upon the reasonable request of the client, Golder may authorize in writing the use of this report by the regulatory agency as an Approved User for the specific and identified purpose of the applicable permit review process. Any other use of this report by others is prohibited and is without responsibility to Golder. The report, all plans, data, drawings and other documents as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder, who authorizes only the Client and Approved Users to make copies of the report, but only in such quantities as are reasonably necessary for the use of the report by those parties. The Client and Approved Users may not give, lend, sell, or otherwise make available the report or any portion thereof to any other party without the express written permission of Golder. The Client acknowledges that electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore the Client can not rely upon the electronic media versions of Golder's report or other work products.

The report is of a summary nature and is not intended to stand alone without reference to the instructions given to Golder by the Client, communications between Golder and the Client, and to any other reports prepared by Golder for the Client relative to the specific site described in the report. In order to properly understand the suggestions, recommendations and opinions expressed in this report, reference must be made to the whole of the report. Golder can not be responsible for use of portions of the report without reference to the entire report.

Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Groundwater Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. **The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report.** The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client's expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder's report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder's report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder's report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder's report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder's responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

APPENDIX B

SaskWater Database Information

WWDR	cUtm Zone	nUtm Northing	nUtm Easting	cWells Quarter	cWells Section	cWells Township	cWells Range	cWells Meridian	Well Name	Driller	cntsmap	Elevation (ft)	crm	LSD	Completion Date	Install Method	Borehole Depth (ft)	Bit Dia (in)	nWaterLevel	Water Use	Well Use
219604	13	5772200	389242	SW	14	36	5	3	UNKNOWN	UNKNOWN	73B02	1663	344	0			39	0	0		
220034	13	5773042	387626	NW	15	36	5	3	SRC	UNKNOWN	73B02	1653	344	0	1967.10.12	Augered	85	0	0	Research	Soil Test Hole
220043	13	5774596	390098	NE	23	36	5	3	SRC	UNKNOWN	73B02	1702	344	0	1967.12.31	Augered	35	0	0	Research	Soil Test Hole
220044	13	5774596	390098	NE	23	36	5	3	SRC	UNKNOWN	73B02	1702	344	0	1968.06.16	Augered	95	0	0	Research	Soil Test Hole
31967	13	5774596	390098	NE	23	36	5	3	SASK RESEARCH COUNCIL	HAYTER DRILLING LTD	73B02	1715	344	0	1972.05.20	Drilled	661	0	0	Research	Water Test Hole
220031	13	5771394	388397	NE	10	36	5	3	SRC	UNKNOWN	73B02	1660	344	0	1967.11.23	Augered	17	0	0	Research	Soil Test Hole
31960	13	5771375	389224	NW	11	36	5	3	KLASSEN	UNKNOWN	73B02	1650	344	0	1953.06.01	Unknown	20	42	5	Domestic	Withdrawal
31961	13	5772161	390870	SW	13	36	5	3	MITCHELL	UNKNOWN	73B02	1675	344	0	1958.09.01	Unknown	18	0	12	Domestic	Water Test Hole
13104	13	5770570	389206	SW	11	36	5	3	GOOSER	PRAIRIE WATER LTD	73B02	1650	344	0	1974.10.01	Bored	25	36	0	Domestic	Withdrawal
57597	13	5771412	387588	NW	10	36	5	3	WINSKY	PRAIRIE WATER LTD	73B02	1650	344	0	1979.05.22	Bored	21	36	0	Domestic	Withdrawal
220032	13	5771356	390028	NE	11	36	5	3	SRC	UNKNOWN	73B02	1660	344	0	1967.10.12	Augered	55	0	0	Research	Soil Test Hole
60569	13	5770607	387571	SW	10	36	5	3	REMAI CONSTRUCTION	TWEIDT WELLBORING SERVICING LTD	73B02	1650	344	0	1979.05.09	Bored	50	42	14	Domestic	Withdrawal
60570	13	5770607	387571	SW	10	36	5	3	REMAI CONSTRUCTION	TWEIDT WELLBORING SERVICING LTD	73B02	1650	344	0	1979.05.10	Bored	50	42	11	Domestic	Withdrawal
220033	13	5773005	389261	NW	14	36	5	3	SRC	UNKNOWN	73B02	16666	344	0	1967.12.05	Augered	27	0	0	Research	Soil Test Hole
114381	13	5772144	391677	SE	13	36	5	3	ADVANTAGE TENNIS CENTRE	WELLEN BORING LTD	73B02	1673	344	0	2001.08.09	Drilled	67	5	12	Industrial	Withdrawal
31959	13	5771001	387984		10	36	5	3	SOMMERFIELD	UNKNOWN	73B02	1650	344	0		Unknown	25	0	21	Domestic	Withdrawal

3-Mar-2017

WSaskWWDR01

Water Security Agency

Water Well Driller's Report

Well Name: **UNKNOWN** WWDR #: **219604**

Well Location

Land Location **SW-14-036 -05 -W3**

LSD **00**

Reserve

RM: **344**

NTS Map: **73B02**

Elevation (ft) **1663**

Aquifer

Location of Well (in Quarter)

0 ft from N/S Boundary

0 ft from E/W Boundary

Major Basin: **06**

SubBasin: **30**

Well Information

Driller **UNKNOWN**

Completion Date

Hole #

Install Method

Borehole Depth (ft) **39**

Bit Dia (in) **0**

Water Level **0**

Flowing Head **0**

Water Use

Well Use

Completion Method

E-Log

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

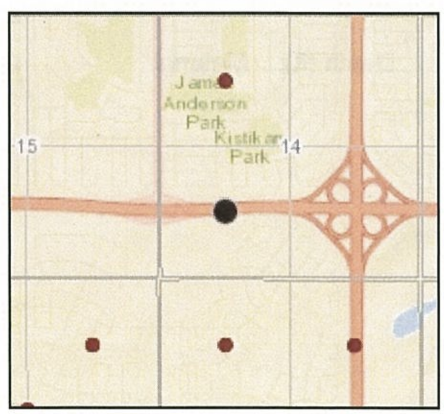
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description



Water Well Driller's Report

3-Mar-2017
WSaskWWDR01

Well Name: **SRC**	WWDR #: **220034**

Well Location

Land Location	**NW-15-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0**	ft from N/S Boundary
Reserve		**0**	ft from E/W Boundary
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1653**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**UNKNOWN**
Completion Date	**1967.10.12**
Hole #	
Install Method	**Augered**
Borehole Depth (ft)	**85**
Bit Dia (in)	**0**
Water Level	**0**
Flowing Head	**0**
Water Use	**Research**
Well Use	**Soil Test Hole**
Completion Method	
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	
0	**0**	**0**	
0	**0**	**0**	

Well Screens

Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description

Water Security Agency — Water Well Driller's Report

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WSaskWWDR01

Well Name: **SRC** WWDR #: **220043**

Well Location

Land Location	**NE-23-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1702**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**UNKNOWN**
Completion Date	**1967.12.31**
Hole #	
Install Method	**Augered**
Borehole Depth (ft)	**35**
Bit Dia (in)	**0**
Water Level	**0**
Flowing Head	**0**
Water Use	**Research**
Well Use	**Soil Test Hole**
Completion Method	
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	**0** ft
Duration	**0** hrs
Pumping Rate	**0** igpm
Temperature	**0** deg. F
Rec. Pumping Rate	**0** igpm

Lithology List

Depth (ft):	Material	Colour	Description

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WSaskWWDR01

Water Security Agency

Water Well Driller's Report

Well Name: **SRC** | WWDR #: **220044**

Well Location

Land Location	**NE-23-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0**	ft from N/S Boundary
Reserve		**0**	ft from E/W Boundary
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1702**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**UNKNOWN**
Completion Date	**1968.06.16**
Hole #	
Install Method	**Augered**
Borehole Depth (ft)	**95**
Bit Dia (in)	**0**
Water Level	**0**
Flowing Head	**0**
Water Use	**Research**
Well Use	**Soil Test Hole**
Completion Method	
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	
0	**0**	**0**	
0	**0**	**0**	

Well Screens

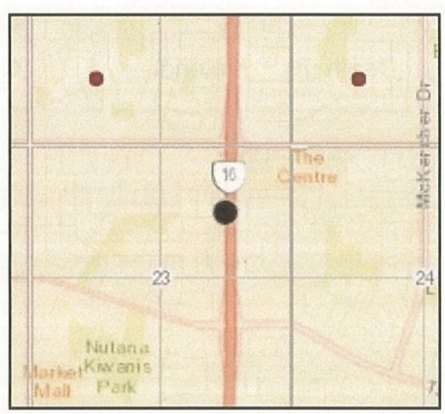
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description



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WSaskWWDR01

Water Security Agency

Water Well Driller's Report

Well Name: **SASK RESEARCH COUNCIL** WWDR #: **031967**

Well Location

Land Location	**NE-23-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1715**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**HAYTER DRILLING LTD**
Completion Date	**1972.05.20**
Hole #	
Install Method	**Drilled**
Borehole Depth (ft)	**661**
Bit Dia (in)	**0**
Water Level	**0**
Flowing Head	**0**
Water Use	**Research**
Well Use	**Water Test Hole**
Completion Method	
E-Log	**SCANNED**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	
0	**0**	**0**	
0	**0**	**0**	

Well Screens

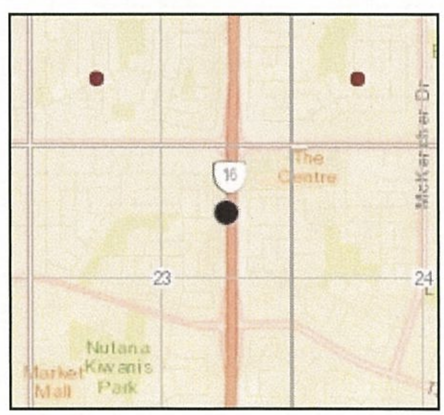
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0** ft
Duration	**0** hrs
Pumping Rate	**0** igpm
Temperature	**0** deg. F
Rec. Pumping Rate	**0** igpm

Lithology List

Depth (ft):	Material	Colour	Description
8	Silt	Unknown	Calcareous
49	Till	Unknown	Oxidized
76	Till	Unknown	Unoxidized
86	Sand	Unknown	Unknown
105	Till	Unknown	Unoxidized
162	Till	Unknown	Oxidized
228	Till	Unknown	Unoxidized
236	Sand	Unknown	Unknown
252	Sand	Unknown	Noncalcareous
509	Silt	Grey	Noncalcareous
511	Sand	Unknown	Noncalcareous
537	Silt	Grey	Noncalcareous
561	Sand	Grey	Noncalcareous
569	Silt	Grey	Noncalcareous



579	Sand	Grey	Noncalcareous
585	Silt	Grey	Noncalcareous
615	Sand	Grey	Noncalcareous
661	Silt	Grey	Noncalcareous

Water Security Agency

Water Well Driller's Report

3-Mar-2017

WSaskWWDR01

Well Name: **SRC** WWDR #: **220031**

Well Location

Land Location	**NE-10-036 -05 -W3**
LSD	**00**
Reserve	
RM:	**344**
NTS Map:	**73B02**
Elevation (ft)	**1660**
Aquifer	

Location of Well (in Quarter)

0 ft from N/S Boundary

0 ft from E/W Boundary

Major Basin: **06**

SubBasin: **30**

Well Information

Driller	**UNKNOWN**
Completion Date	**1967.11.23**
Hole #	
Install Method	**Augered**
Borehole Depth (ft)	**17**
Bit Dia (in)	**0**
Water Level	**0**
Flowing Head	**0**
Water Use	**Research**
Well Use	**Soil Test Hole**
Completion Method	
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	
0	**0**	**0**	
0	**0**	**0**	

Well Screens

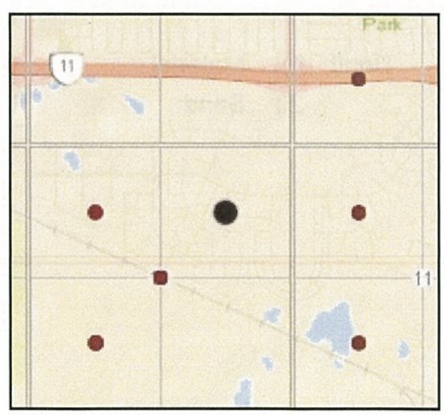
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description



Water Well Driller's Report

3-Mar-2017
WSaskWWDR01

Well Name: **KLASSEN** WWDR #: **031960**

Well Location

Land Location	**NW-11-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0**	ft from N/S Boundary
Reserve		**0**	ft from E/W Boundary
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1650**	SubBasin:	**30**
Aquifer	**Glac**		

Well Information

Driller	**UNKNOWN**
Completion Date	**1953.06.01**
Hole #	
Install Method	**Unknown**
Borehole Depth (ft)	**20**
Bit Dia (in)	**42**
Water Level	**5**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Curbed**
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	**Wood**
0	**0**	**0**	
0	**0**	**0**	

Well Screens

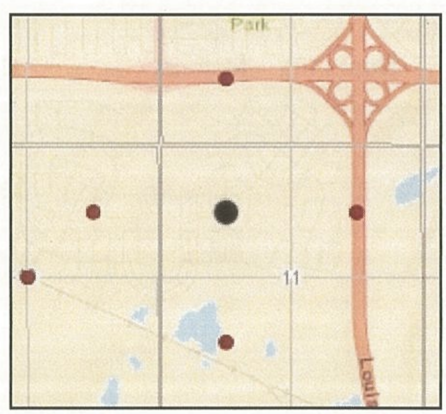
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description
20	Sand	Unknown	Unknown



Water Well Driller's Report

3-Mar-2017
WSaskWWDR01

Well Name: **MITCHELL** WWDR #: **031961**

Well Location

Land Location	**SW-13-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1675**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**UNKNOWN**
Completion Date	**1958.09.01**
Hole #	
Install Method	**Unknown**
Borehole Depth (ft)	**18**
Bit Dia (in)	**0**
Water Level	**12**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Water Test Hole**
Completion Method	
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	
0	**0**	**0**	
0	**0**	**0**	

Well Screens

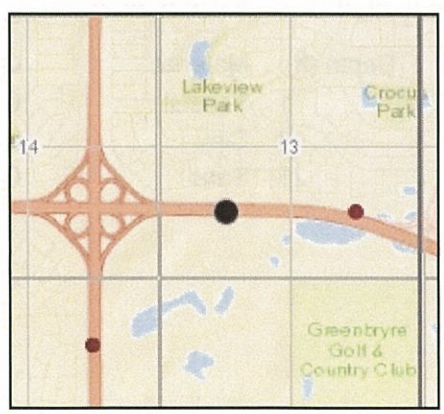
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description
10	Clay	Yellow	Unknown
18	Sand	Unknown	Unknown



Water Well Driller's Report

3-Mar-2017

WSaskWWDR01

Well Name: **GOOSER** WWDR #: **013104**

Well Location

Land Location	**SW-11-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1650**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**PRAIRIE WATER LTD**
Completion Date	**1974.10.01**
Hole #	
Install Method	**Bored**
Borehole Depth (ft)	**25**
Bit Dia (in)	**36**
Water Level	**0**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Curbed**
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	36	Porous Concrete
0	0	0	
0	0	0	

Well Screens

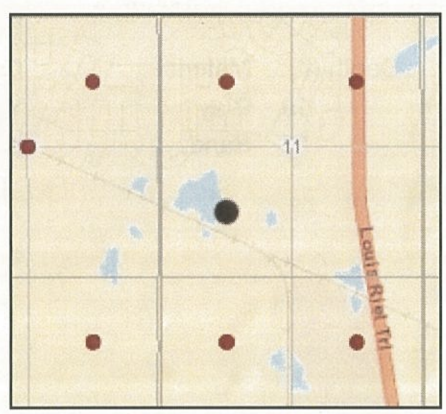
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description
1	Topsoil	Unknown	Unknown
10	Clay	Brown	Unknown
25	Sand	Grey	Silty



Water Well Driller's Report

3-Mar-2017
WSaskWWDR01

Well Name: **WINSKY** WWDR #: **057597**

Well Location

Land Location	**NW-10-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1650**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**PRAIRIE WATER LTD**
Completion Date	**1979.05.22**
Hole #	
Install Method	**Bored**
Borehole Depth (ft)	**21**
Bit Dia (in)	**36**
Water Level	**0**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Curbed**
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
22	**21**	**36**	**Porous Concrete**
0	**0**	**0**	
0	**0**	**0**	

Well Screens

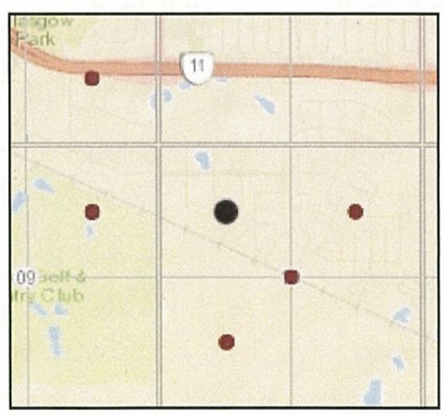
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description
1	Topsoil	Unknown	Unknown
17	Clay	Brown	Unknown
21	Silty Clay	Blue	Unknown



Water Security Agency

Water Well Driller's Report

3-Mar-2017

WSaskWWDR01

Well Name: **SRC** WWDR #: **220032**

Well Location

Land Location	**NE-11-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1660**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**UNKNOWN**
Completion Date	**1967.10.12**
Hole #	
Install Method	**Augered**
Borehole Depth (ft)	**55**
Bit Dia (in)	**0**
Water Level	**0**
Flowing Head	**0**
Water Use	**Research**
Well Use	**Soil Test Hole**
Completion Method	
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

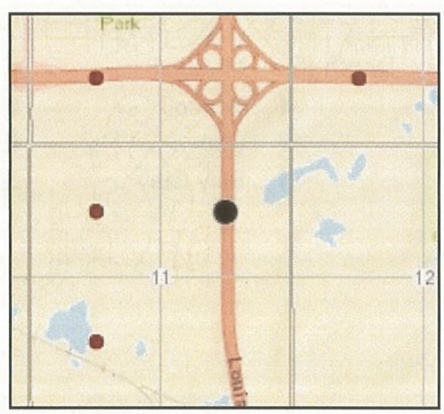
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description



Water Security Agency

Water Well Driller's Report

3-Mar-2017
WSaskWWDR01

Well Name: **REMAI CONSTRUCTION** WWDR #: **060569**

Well Location

Land Location	**SW-10-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1650**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**TWEIDT WELLBORING SERVICING LTD**
Completion Date	**1979.05.09**
Hole #	
Install Method	**Bored**
Borehole Depth (ft)	**50**
Bit Dia (in)	**42**
Water Level	**14**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Curbed**
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
52	**50**	**30**	**Galvanized Iron**
0	**0**	**0**	
0	**0**	**0**	

Well Screens

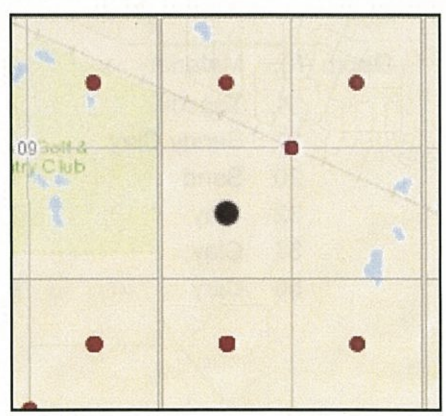
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**7**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description
1	Topsoil	Unknown	Unknown
17	Clay	Yellow	Unknown
31	Clay	Blue	Unknown
36	Sand	Unknown	Water
50	Clay	Blue	Unknown



Water Security Agency

Water Well Driller's Report

3-Mar-2017

WSaskWWDR01

Well Name: **REMAI CONSTRUCTION** WWDR #: **060570**

Well Location

Land Location	**SW-10-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1650**	SubBasin:	**30**
Aquifer			

Well Information

Driller	**TWEIDT WELLBORING SERVICING LTD**
Completion Date	**1979.05.10**
Hole #	
Install Method	**Bored**
Borehole Depth (ft)	**50**
Bit Dia (in)	**42**
Water Level	**11**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Curbed**
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
52	50	30	Galvanized Iron
0	0	0	
0	0	0	

Well Screens

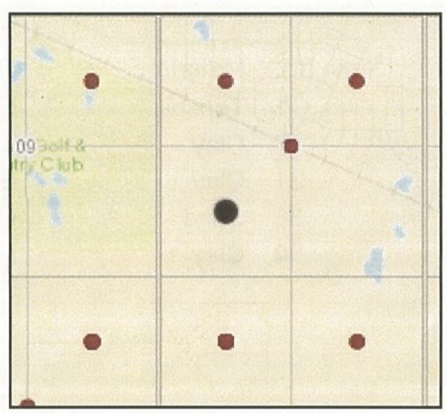
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	9	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description
1	Topsoil	Unknown	Unknown
11	Sandy Clay	Unknown	Dry
20	Sand	Unknown	Water
32	Clay	Blue	Unknown
37	Clay	Blue	Sandy
50	Clay	Blue	Unknown



Water Security Agency

Water Well Driller's Report

3-Mar-2017

WSaskWWDR01

Well Name: **SRC** WWDR #: **220033**

Well Location

Land Location	NW-14-036 -05 -W3	Location of Well (in Quarter)	
LSD	00	0	ft from N/S Boundary
Reserve		0	ft from E/W Boundary
RM:	344		
NTS Map:	73B02	Major Basin:	06
Elevation (ft)	16666	SubBasin:	30
Aquifer			

Well Information

Driller	UNKNOWN
Completion Date	1967.12.05
Hole #	
Install Method	Augered
Borehole Depth (ft)	27
Bit Dia (in)	0
Water Level	0
Flowing Head	0
Water Use	Research
Well Use	Soil Test Hole
Completion Method	
E-Log	No

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	0	0	
0	0	0	
0	0	0	

Well Screens

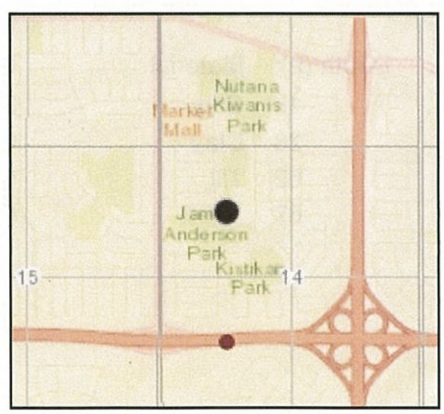
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	0	0	0	
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	0	ft
Duration	0	hrs
Pumping Rate	0	igpm
Temperature	0	deg. F
Rec. Pumping Rate	0	igpm

Lithology List

Depth (ft):	Material	Colour	Description



Water Security Agency

Water Well Driller's Report

3-Mar-2017

WSaskWWDR01

Well Name: **ADVANTAGE TENNIS CENTRE** WWDR #: **114381**

Well Location

Land Location	SE-13-036 -05 -W3	Location of Well (in Quarter)	
LSD	00	0	ft from N/S Boundary
Reserve		0	ft from E/W Boundary
RM:	344		
NTS Map:	73B02	Major Basin:	06
Elevation (ft)	1673	SubBasin:	30
Aquifer			

Well Information

Driller	WELLEN BORING LTD
Completion Date	2001.08.09
Hole #	001
Install Method	Drilled
Borehole Depth (ft)	67
Bit Dia (in)	5
Water Level	12
Flowing Head	0
Water Use	Industrial
Well Use	Withdrawal
Completion Method	Well Screen And Gravel Pack
E-Log	Yes

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
64	62	5	P.V.C.
0	0	0	
0	0	0	

Well Screens

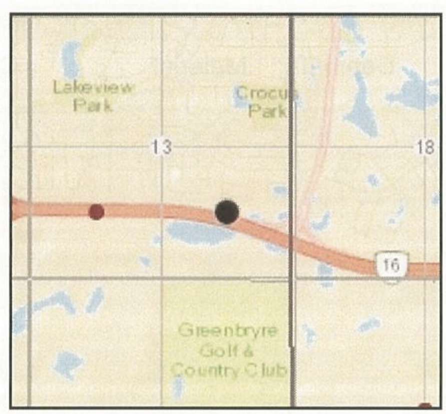
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
5	67	3.5	18	Stainless Steel
0	0	0	0	
0	0	0	0	

Pump Test

Draw Down	22	ft
Duration	6	hrs
Pumping Rate	12	igpm
Temperature	0	deg. F
Rec. Pumping Rate	10	igpm

Lithology List

Depth (ft):	Material	Colour	Description
18	Clay	Brown	Soft
28	Clay	Grey	Unknown
62	Till	Grey	Unknown
67	Sand	Grey	Medium



Water Security Agency

Water Well Driller's Report

3-Mar-2017
WSaskWWDR01

Well Name: **SOMMERFIELD** WWDR #: **031959**

Well Location

Land Location	**-10-036 -05 -W3**	Location of Well (in Quarter)	
LSD	**00**	**0** ft from N/S Boundary	
Reserve		**0** ft from E/W Boundary	
RM:	**344**		
NTS Map:	**73B02**	Major Basin:	**06**
Elevation (ft)	**1650**	SubBasin:	**30**
Aquifer	**Glac**		

Well Information

Driller	**UNKNOWN**
Completion Date	
Hole #	
Install Method	**Unknown**
Borehole Depth (ft)	**25**
Bit Dia (in)	**0**
Water Level	**21**
Flowing Head	**0**
Water Use	**Domestic**
Well Use	**Withdrawal**
Completion Method	**Unknown**
E-Log	**No**

Well Casings

Length (ft)	Btm (ft)	Dia (in)	Material
0	**0**	**0**	**Steel**
0	**0**	**0**	
0	**0**	**0**	

Well Screens

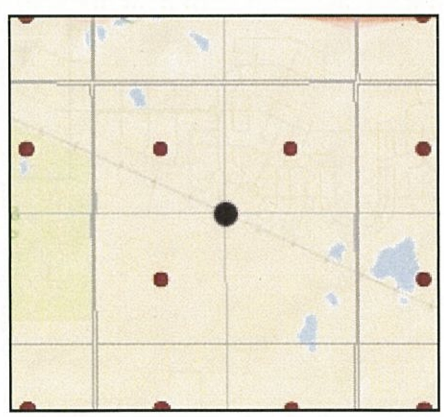
Length (ft)	Bottom (ft)	Dia (in)	Slot (in)	Material
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	
0	**0**	**0**	**0**	

Pump Test

Draw Down	**0**	ft
Duration	**0**	hrs
Pumping Rate	**0**	igpm
Temperature	**0**	deg. F
Rec. Pumping Rate	**0**	igpm

Lithology List

Depth (ft):	Material	Colour	Description
25	Sand	Unknown	Boulders



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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1721 8th Street East
Saskatoon, Saskatchewan, Canada S7H 0T4
Canada
T: +1 (306) 665 7989

Golder Associates

Appendix G

Environmental and Heritage Overview

May 2017

Environmental Screening for the Interchange at the Intersection of Highways 11 and 16

Submitted to:
ISL Engineering and Lands Services Ltd.
259 Robin Crescent
Saskatoon, Saskatchewan
S7L 6M8

REPORT

Report Number: 1655310/2000

Distribution:

1 Copy - Associated Engineering (Sask) Ltd., Saskatoon, Saskatchewan (PDF)
2 Copies - Golder Associates Ltd., Saskatoon, Saskatchewan

Golder Associates

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Saskatchewan Activity Restrictions Guidelines for Sensitive Species

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) prepared a desktop environmental screening for the proposed interchange at the intersection of Highways 11 and 16, located in southeast Saskatoon, Saskatchewan (the Project).

The objective of this desktop screening report is to document the current environmental conditions based on available current resources and maps (including topographic and aerial imagery), and to summarize the regulatory contacts that will likely be required should the Project proceed. Unless otherwise stated in each section of the report, for the purpose of this report, the Project area is defined as a 2 kilometre-buffer centred on the interchange at the intersection of Highways 11 and 16 (the Interchange)(Figure 1).

2.0 EXISTING ENVIRONMENT

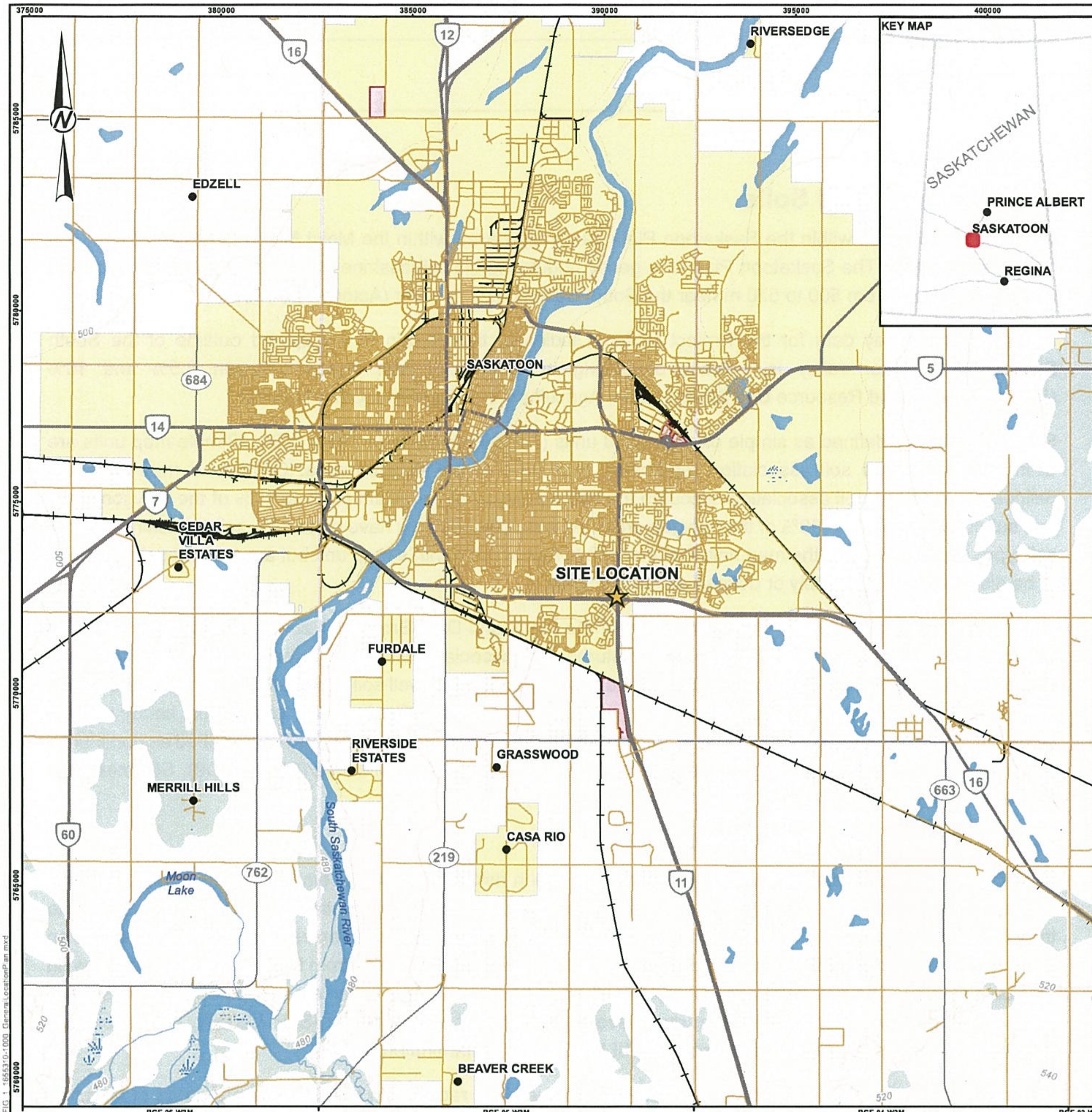
2.1 Land and Resource Use

The Project will occur within the boundaries of the City of Saskatoon (the City) and the R.M. of Corman Park No. 344. Outside of the City boundaries there is a mixture of agricultural land (e.g., cropland and tame pasture), developed areas for residential acreages and industrial purposes, and remnant wetland basins and tree and shrub patches. No Agricultural Crown land, Indian Reserve land, or private conservation easements are located within 2 km of the Interchange (MOE 2017). The closest Indian Reserve is the English River I.R. 192J, located south of the Project bordering a rail line and extending south to Grasswoods Road on the west side of Highway 11 in the E ½ of Section 2-36-05 W3M. A Canadian National rail line is located approximately 2 km south of the interchange. There are numerous local utilities present throughout the City and R.M. of Corman Park.

2.2 Heritage Resources

Heritage resources, as defined under *The Heritage Property Act*, include all historic and precontact archaeological sites, architecturally significant structures, and paleontological resources. According to the Developers' Online Screening Tool (Ministry of Parks, Culture and Sport 2017), five quarter sections overlapping the proposed Project are potentially heritage sensitive lands, including the E ½ 11, SE 15, and the S ½ 14-36-05 W3M. The following land locations overlapping the Project were determined not to be heritage sensitive: NE 14, S ½ 13, and SE 23-36-05 W3M.

A review of the Project activities on the potentially heritage sensitive lands should be submitted to the Heritage Conservation Branch to determine if an Heritage Resources Impact Assessment is required to be completed.



LEGEND

- SITE LOCATION
- POPULATED PLACE
- ELEVATION CONTOUR (20m INTERVAL)
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- LOCAL ROAD
- RAILWAY
- WATERCOURSE
- INDIAN RESERVE
- WATERBODY
- WETLAND
- WOODED AREA
- URBAN MUNICIPALITY

0 3 6

1:150,000 KILOMETRES

REFERENCE(S)

1. NATIONAL TOPOGRAPHIC DATA BASE (NTDB) DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
2. ROADS OBTAINED FROM NATIONAL ROAD NETWORK. RAILWAY OBTAINED FROM IHS ENERGY INC.

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

ISL ENGINEERING AND LAND SERVICES LTD.

PROJECT

ENVIRONMENTAL DESKTOP SCREENING
SASKATOON, SASKATCHEWAN

TITLE

GENERAL LOCATION PLAN

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-10
DESIGNED	TF
PREPARED	ANK
REVIEWED	AW
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
1655310	2000	0	1

PATH: G:\2016\1655310_ISL_Hwy11&16_Functional_Study_SK\Figures\2000_Environmental_Screening\FINAL\FIG_1_1655310-1000_GeneralLocationPlan.mxd

25mm

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

2.3 Terrain and Soils

The Project is located within the Saskatoon Plain Landscape Area within the Moist Mixed Grassland Ecoregion (Acton et al. 1998). The Saskatoon Plain is a gently undulating glaciolacustrine and eroded glacial till plain with elevations ranging from 500 to 520 m near the South Saskatchewan River (Acton et al. 1998).

Historical soil survey data for the Project footprint indicates that terrain in the upland outside of the South Saskatchewan River valley is typically undulating to hummocky with slopes between 0.5% and 10% (Saskatchewan Land Resource Unit [SLRU] 2004; Agriculture and Agri-Food Canada 2005).

Soil map units are defined as simple or compound units (Agriculture Canada 1982; 1991). Simple map units are delineated when one soil association represents over 85% of the polygon area. Compound map units are delineated when two soil associations occur in the same polygon as dominant (60% to 70% of the polygon area) and subdominant (25% to 30% of the polygon area). All soil polygons may have up to 15% soil inclusions of other soil types not described in the map unit; these are soils that occur within a map unit but are not extensive enough to be distinguished separately or defined as subdominant.

The Project footprint is located on the boundary of the Black and Dark Brown soil zones of Saskatchewan. The majority of the Project is located on previously disturbed soil associated with the City and existing developments. However, southeast of the Interchange the soil is classified as the Bradwell soil association which consists mainly of Chernozemic Dark Brown soils developed on medium to moderately fine textured, calcareous, sandy alluvial-lacustrine deposits (Saskatchewan Land Resource Unit [SLRU] 2004; SLRU 2009). Br3 is described as dominantly Orthic Dark Brown series with significant amounts of Eluviated Dark Brown series (SLRU 2009). Stoniness has not been classified for this area.

2.3.1 Water and Wind Erosion

The water and wind erosion potential represents the erosion risk for a given soil type when it is left unvegetated or without other protection following construction. Water and wind erosion potential for soil map unit adjacent to the Project was obtained from digital information (SLRU 2004). These ratings are an estimation of potential erosion for an entire map unit and individual soils may occur within the area that varies from the assigned water and wind erosion potential. The soil southeast of the Interchange has a very low water erosion potential with isolated dissections between shallow gullies that may have higher rates of water erosion (SLRU 2004). These soils are classified as having low wind erosion potential (SLRU 2004). Contaminated Sites

According to the SaskSpills Database over 600 spills have been reported in the Saskatoon area as of March 6, 2017 (Government of Saskatchewan 2017). The majority of these records do not provide an exact spill location; however, many spills are of chlorine, chlorinated water, diesel fuel, gasoline, oil, ammonia, acids and sewage. The closest spills are located at Grasswood Road and Clarence Avenue South.

2.4 Surface Water

Based on aerial imagery and Google Earth Street View photographs (2016), wetlands were classified according to Stewart and Kantrud (1971). In the existing highway right-of-way (ROW) north of the Interchange, there is a Class IV semi-permanent wetland located at 13U 390025 5772401; however, based on the vegetation management practices along roadways in the City, the majority of the wetland is regularly mowed during the growing season (Photo 1).

Photo 1: Class IV semi-permanent wetland in west ditch of Highway 11, north of the Interchange.

The Class IV semi-permanent wetlands in the project area are characterized by common cattail (*Typha latifolia*) in the deepest portion of the wetland basin with sedge (*Carex* spp.) and rush (*Juncus* and *Eleocharis* spp.) species around the perimeter of common cattail growth. A large Class IV semi-permanent wetland is located in the southeast loop of the Interchange and is not typically mowed (Photo 2 and 3).

A Class IV semi-permanent wetland with cattail and willow species (*Salix* spp.) is located at 13U 391085 5772124, south of Highway 16 in SW 13-36-05 W3M (Photo 4). A Class III seasonal wetland is located between the southeast loop of the Interchange and the Highway 11 off ramp to the east at 13U 390096 5771924. Three Class IV semi-permanent wetlands with trees and shrubs occur east of Highway 11 in the NE 11-36-05 W3M at 13U 390119 5771658, 13U 390080 5771334, and 13U 390170 5771147. Another large Class IV wetland occurs in this quarter section, but further east from the Project.

Additionally, there are several runoff storage ponds that have been constructed throughout the City. These storage ponds often act as semi-permanent or permanent wetlands. The closest of these ponds to the Project is a Class V wetland located at 13U 391512 5772100, immediately south of Highway 16 in SE 13-36-05 W3M (Photo 5). Additional ponds occur further from the Project. One pond is located 380 m west of Highway 11 in the N ½ 11-36-05 W3M, while another is located 550 m east of Highway 11 in the NW 13-36-05 W3M.

Photo 2 and 3: Looking east (top photo) and south (bottom photo) at a large Class IV semi-permanent wetland located in the southeast loop of the Interchange. This wetland has not been mowed during previous growing seasons.

Photo 4: Looking southeast at a Class IV wetland south of Highway 16 at 13U 391085 5772124.

Photo 5: Looking southeast at a Class V wetland south of Highway 16 at 13U 391512 5772100.

2.5 Vegetation

Historically, open grassland with shrubland and woodland restricted to wetland edges characterized the Moist Mixed Grassland Ecoregion (Acton et al. 1998). Open grassland was historically dominant on loamy soils, while a mixture of grassland, shrubland, and trees typically characterize areas with sandy soils. Currently, the area surrounding the City has been extensively cultivated and modified for agricultural crop production and acreage development. Native grassland in this region is typically comprised of wheatgrasses (*Elymus* and *Pascopyrum* spp.) and speargrasses (*Hesperostipa* spp.) with blue grama grass (*Bouteloua gracilis*) on upper slopes and plains rough fescue (*Festuca hallii*) and Hooker's oat grass (*Avenula hookeri*) in lower slope positions (Acton et al. 1998).

The encroachment of trembling aspen (*Populous tremuloides*) was historically prevented by fire; however, since settlement, aspen stands have advanced outward from the periphery of wetland areas into previously open grassland (Acton et al. 1998). Uncultivated depressional areas are often saline and support foxtail barley (*Hordeum jubatum ssp. jubatum*), Nuttall's salt-meadow grass (*Puccinellia nuttalliana*), and red samphire (*Salicornia rubra*). Trembling aspen and willow species can be found in remnant non-saline depressions.

Introduced plant species such as smooth brome grass (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), red fescue (*Festuca rubra ssp. rubra*), clover (*Trifolium* spp.), yellow sweet clover (*Melilotus officinalis*) and turf-grass species are commonly found in highway ditches or other perennial vegetation communities established on previously disturbed areas. Smooth brome grass often establishes a monoculture in highway ditches. In saline areas of roadside ditches, foxtail barley is common.

Based on Google Earth Street View photographs (2016) and Golder's knowledge of the Project area, planted trees and shrubs including willow species, Manitoba maple (*Acer negundo var. interius*), American elm (*Ulmus americana*), poplar (*Populus* spp.) and ornamental species are found surrounding the Interchange (Photo 6) and in the nearby residential areas of the City.

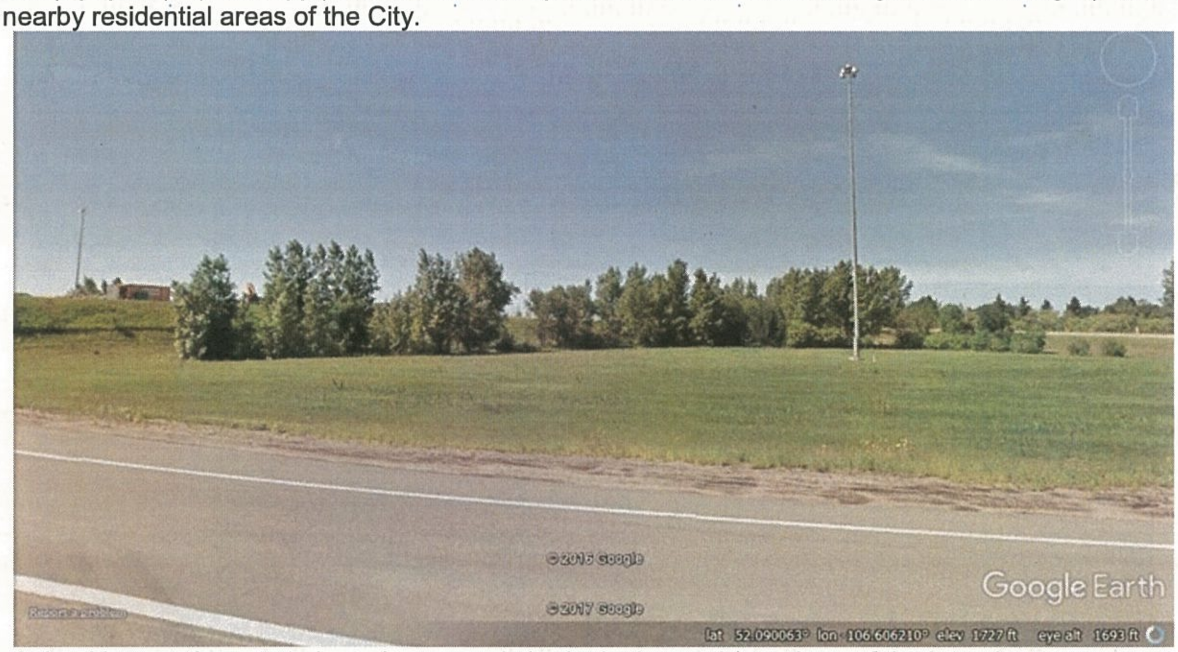


Photo 6: Looking southwest at planted trees and shrubs in the northwest loop of the Interchange.

2.5.1 Listed Plant Species

For the purpose of this report, all species identified by the Hunting, Angling and Biodiversity Information of Saskatchewan (HABISask) database, or those listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and/or Schedule 1 of the *Species at Risk Act* (*SARA*) will be referred to as "listed species".

A review of the HABISask application database (MOE 2017) was completed to identify known occurrences of listed plant species within the Project footprint. No federally listed plant species under COSEWIC and/or *SARA* have been previously recorded within the 3 km of the Interchange (MOE 2017). There are 11 provincially listed plant species with known occurrences within 3 km of the Interchange (Figure 2). An overview of the habitat requirements for these species, their specific rankings, and their likelihood to occur in the Project area is provided in Table 1.

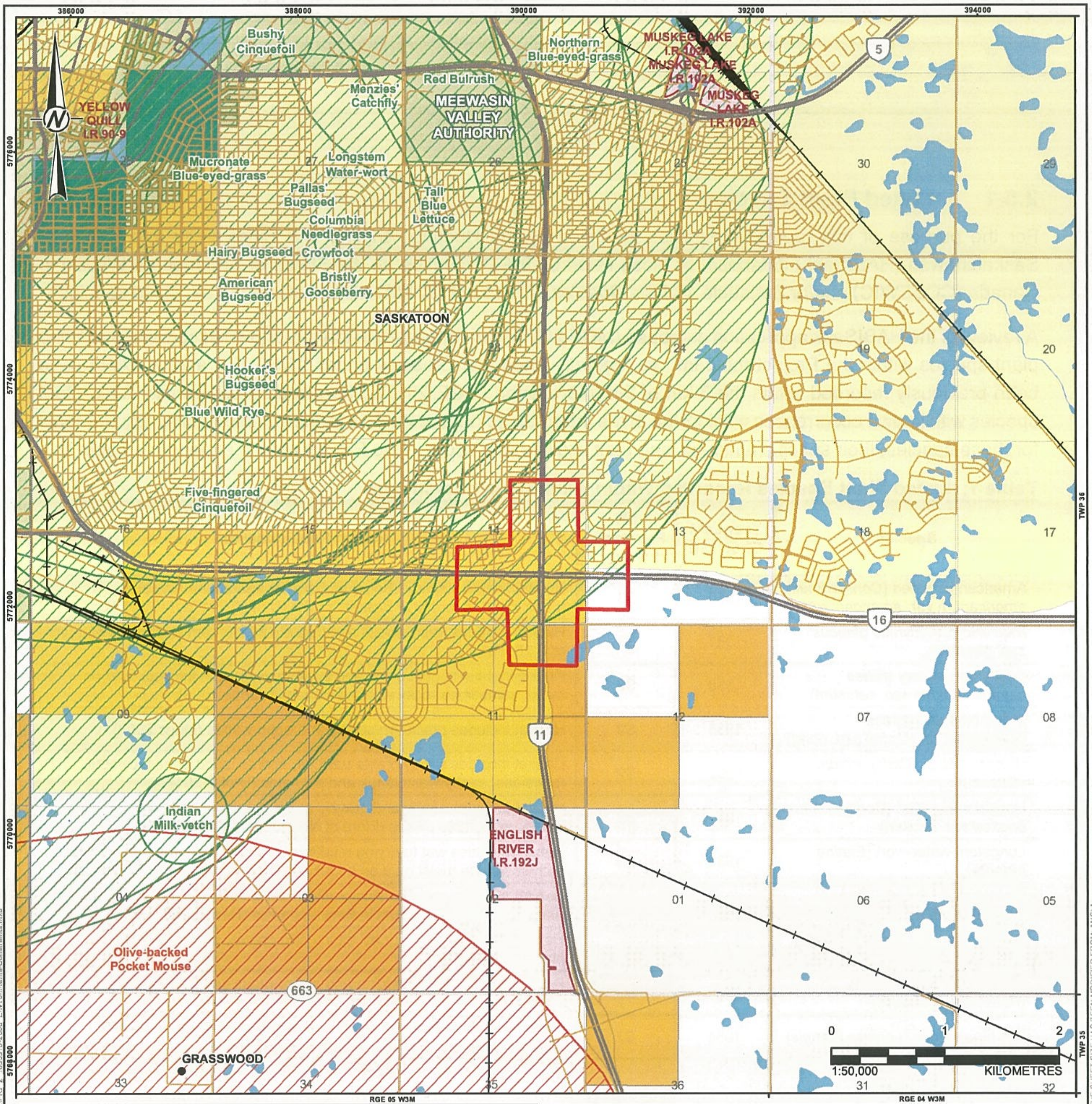
Table 1: Listed Plant Species Recorded within 3 km of the Interchange

Species	Year Last Observed	SK Provincial Listing[(a)]	Habitat Requirements
American bugseed (*Corispermum americanum var. americanum*)	1970	S3	Habitat includes sandy shores and prairie, sand dune blowouts, roadsides (University of Saskatchewan [U of S] 2017a, NS 2014).
Blue wild rye (*Elymus glaucus ssp. glaucus*)	1931	S3	Habitat includes open woods and thickets in southern Saskatchewan (U of S 2017b).
Bristly gooseberry (*Ribes oxyacanthoides ssp. setosum*)	1938	S2	Prefers habitat in moist, rich and swampy woods, in thickets, and on moist, sometimes rocky wooded slopes (Tannas 2003).
Columbia needlegrass (*Achnatherum nelsonii ssp. dorei*)	1938	S3	Habitat includes prairie grassland and open woods (Moss 2008).
Hairy bugseed (*Corispermum villosum*)	1992	S2	Habitat includes sandy prairie barrens, shores, sand dune blowouts, roadsides, sandy wastelands and old fields (U of S 2017c).
Hooker's bugseed (*Corispermum hookeri var. hookeri*)	1921	S2	Habitat includes sandy and gravely shores of rivers and streams, sand dunes, and waste places (Flora of North America [FNA] 2017a).
Longstem water-wort (*Elatine triandra*)	1939	S2	Habitat includes wet to drying mudflats, in slough bottoms and tilled field potholes in the moist mud on edges of drying wetlands (U of S 2017d).
Mucronate blue-eyed grass *(Sisyrinchium mucronatum)*	1915	S3	Habitat includes moist or seasonally moist grassland, primarily in the Aspen Parkland and south in Saskatchewan (Harms and Leighton 2011).
Pallas' bugseed (*Corispermum pallasii*)	1939	S2	Habitat includes sand dunes, sandy and gravely shores, and waste places (FNA 2017b).
Red-stemmed cinquefoil (*Potentilla rubricaulis)*	1939	S3	Preferred habitat is subalpine and alpine grasslands on dry exposed slopes (Tannas 2004).
Tall blue lettuce (*Lactuca biennis*)	1954	S3	Preferred habitat includes moist woods and shrub thickets (U of S 2017e).

[(a)]SKCDC (2017a). SK = Saskatchewan

Provincial Rank Definitions

S2 – Rare; S3 - Rare/Uncommon



LEGEND

●	POPULATED PLACE		WATERBODY
	PRIMARY HIGHWAY		URBAN MUNICIPALITY
	SECONDARY HIGHWAY		HERITAGE SENSITIVE LOCATION
	LOCAL ROAD		LISTED ANIMAL OCCURRENCE
	RAILWAY		LISTED PLANT OCCURRENCE
	WATERCOURSE		MIGRATORY BIRD CONCENTRATION SITE
	INDIAN RESERVE		AGRICULTURAL CROWN LAND
	PARK		STUDY AREA

NOTE(S)

1. THE INFORMATION DISPLAYED ON THIS MAP IS MADE AVAILABLE BY THE SASKATCHEWAN GOVERNMENT. THE GOVERNMENT OF SASKATCHEWAN MAKES NO GUARANTEE REGARDING THE ACCURACY OF THE INFORMATION. THIS INFORMATION IS UPDATED CONSISTENTLY AND THIS FIGURE IS A REPRESENTATION OF THE DATA ONLY FOR THE DATE INDICATED HERE: FEBRUARY 2016

REFERENCE(S)

1. CONSTRAINTS DATA OBTAINED FROM GEOSASK © 2016, GOVERNMENT OF SASKATCHEWAN
2. RARE SPECIES OBTAINED FROM SASKATCHEWAN CONSERVATION DATA CENTRE © 2016, GOVERNMENT OF SASKATCHEWAN
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4. ROADS OBTAINED FROM NATIONAL ROAD NETWORK. RAILWAY OBTAINED FROM IHS ENERGY INC.

PROJECTION: UTM ZONE 13 DATUM: NAD 83

CLIENT

ISL ENGINEERING AND LAND SERVICES LTD.

PROJECT

ENVIRONMENTAL DESKTOP SCREENING
SASKATOON, SASKATCHEWAN

TITLE

ENVIRONMENTAL CONSTRAINTS

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-10
DESIGNED	AW
PREPARED	ANK
REVIEWED	AW
APPROVED	BN

PROJECT NO.	PHASE	REV.	FIGURE
1655310	2000	0	2

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25mm

2.5.2 Weed Species

Noxious and nuisance plant species designated under *The Weed Control Act* (2010) are common in disturbed areas, such as highways, railways, and residential developments. Common nuisance weeds often seen in the City include common dandelion (*Taraxicum officianale*), kochia (*Kochia scoparia*), foxtail barley, goat's-beard (*Tragopogon pratensis*), and quackgrass (*Elymus repens*).

Based on Golder's experience in the Project area, common noxious species often seen in the City and surrounding area include absinthe (*Artemisia absinthium*), perennial sow-thistle (*Sonchus arvensis ssp. uliginosus*), spiny-leaved sow thistle (*Sonchus asper ssp. asper*), narrow-leaved hawk's-beard (*Crepis tectorum*), and Canada thistle (*Cirsium arvense*).

While these plants are recognized as noxious or a nuisance under the *Weed Control Act*; their distribution in the province is typically widespread and their occurrence in vegetation communities is common, especially in disturbed areas.

2.6 Wildlife

The Moist Mixed Grassland Ecoregion supports a variety of avian species and mammal species (Acton et al. 1998). Common bird species potentially found in the Project area include savannah sparrow (*Passerculus sandwichensis*), western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), Swainson's hawk (*Buteo swainsoni*), mallard (*Anas platyrhynchos*) and blue-winged teal (*Anas discors*). Common mammal species encountered in the Project area include white-tailed deer (*Odocoileus virginianus*), stripped skunk (*Mephitis mephitis*), Richardson's ground squirrel (*Urocitellus richardsonii*), and coyote (*Canis latrans*) (Acton et al. 1998).

A diversity of amphibians and reptiles are present in the Ecoregion including barred tiger salamander (*Ambystoma mavortium*), boreal chorus frog (*Pseudacris maculata*) and northern leopard frog (*Lithobates pipiens*). One of the most common reptile species found in the Ecoregion is the red-sided garter snake (*Thamnophis sirtallis parietalis*).

Although most of the Project area has been extensively modified for residential and transportation corridor development, suitable wildlife habitat remains, including nesting habitat. Wildlife habitat is present in modified grassland along roadsides, woody patches, and wetlands. Based on the results of this desktop screening, no suitable fish habitat is located with the Project area.

The South Saskatchewan River, approximately 5 km from the Interchange, is a Migratory Bird Concentration Site (MBCS). This MBCS is considered locally significant for staging geese including 1,000 to 5,000 snow geese (*Chen caerulescens*) and Ross' geese (*Chen rossii*) and 1,000 to 3,000 Canada Geese (*Branta canadensis*) and greater white-fronted geese (*Anser albifrons*) (MOE 2017).

2.6.1 Listed Wildlife Species

A review of the HABISask database (MOE 2017) was completed to identify known occurrences of listed wildlife species within the Project area. There are no recorded occurrences of federally or provincially listed wildlife species within 3 km of the Interchange (MOE 2017). However, within 5 km of the Interchange there is one record of a provincially listed species (MOE 2017). The Olive-backed pocket mouse (*Perognathus fasciatus*), an S3 or vulnerable species in Saskatchewan, was observed in 1955. An exact location of the animal was not provided, but described as being a few miles south of Saskatoon (MOE 2017). The Olive-backed pocket mouse prefers habitat in various arid and semiarid upland habitats, typically with sparse vegetation and loose sandy to clayey soil. Habitat such as dry grasslands or floodplains with scattered cottonwoods are also used (Cassola 2016). Currently, this species is not federally listed by the COSEWIC or under the *SARA*.

Additionally, all migratory bird species and their nests, eggs, and young are protected by the *Migratory Birds Convention Act* (1994) and pre-construction nest surveys are required in available habitat during the nesting period of April 15 to August 15 each year (Environment and Climate Change Canada 2016).

Several habitat types (e.g., wetlands, tree and shrub habitat, native grassland, and modified grassland) occur in and adjacent to the Project area that are generally associated with listed wildlife species such as northern leopard frog, yellow rail (*Coturnicops noveboracensis*), horned grebe (*Podiceps auritus*), loggerhead shrike (*Lanius ludovicianus excubitordes*), or Sprague's pipit (*Anthus spragueii*). For example, the riparian areas associated with the South Saskatchewan River and wetlands, and native grasslands may support northern leopard frogs during breeding and foraging. Local wetlands may support breeding yellow rails and horned grebes. The tall shrubs in the CN ROW may provide loggerhead shrike nesting habitat, and the fences along the ROW may provide perching and feeding sites where shrike can impale their prey. The grasslands bisected by the eastern access route and those north of the west access road and existing CN ROW, may have some potential to support Sprague's pipit nesting. Relatively large areas of intact grassland with varying degrees of litter may make this area attractive as nesting habitat for Sprague's pipit.

Twenty-eight federally and/or provincially listed species have potential to occur within the Project area based on available habitat types. These species, their federal and provincial designations, preferred habitats and the potential for their occurrence are described in Table 2. Based on available habitats associated with the Interchange and highway right-of-ways, the barn swallow (*Hirundo rustica*) has high potential to occur in the Project area (Table 2).

Table 2: Listed Wildlife Species with Some Potential to Occur Within the Project Area

Species	Scientific Name	*Species at Risk Act* [(a)]	COSEWIC [(b)]	SK Provincial Listing[(c)]	Habitat	Potential for Occurrence in the Project Area
AMPHIBIANS AND REPTILES						
Great plains toad	*Bufo cognatus*	Special Concern - Schedule 1	Special Concern	S3	Found in river flood plains, irrigation canals, and ephemeral to permanent wetlands (Canadian Herpetological Society 2012). Inhabits native short-grass prairie, particularly sandy areas near water (Fisher et al. 2007).	Moderate – potentially suitable breeding and foraging habitat associated with wetlands.
Northern leopard frog	*Lithobates pipiens*	Schedule 1	Special Concern	S3	The northern leopard frog requires a mosaic of habitat types to meet the life stages and inhabits scattered, permanent, small waterbodies with emergent vegetation in the spring for breeding, and over-wintering, and moves out to the permanent wet areas, which may be adjacent to the breeding sites in summer (Alberta Fish and Wildlife 1991; Alberta Sustainable Resource Development 2003).	Moderate – potentially suitable breeding and foraging habitat associated with wetlands.
BIRDS						
Western grebe	*Aechmophorus occidentalis*	No Status or Schedule	Special Concern	S3B S3M	Western grebes breed in freshwater lakes and marshes that have large areas of open water bordered by emergent vegetation (Storer and Nuechterlein 1992).	Low – limited suitable habitat exists in the Project area; species is a summer visitor in the Saskatoon area (Smith 1996).
Baird's sparrow	*Ammodramus bairdii*	No Status or Schedule	Special Concern	S4B	Baird's sparrows prefer ungrazed to lightly grazed native grasslands and haylands (Smith 1996).	Low – limited suitable breeding habitat exists in the Project area.
Sprague's pipit	*Anthus spragueii*	Threatened - Schedule 1	Threatened	S3B S3M	Sprague's pipits are typically found in prairie grasslands that have been unburned and uncultivated (Godfrey 1986). They can also be found in areas of native grassland with intermediate vegetation height and litter depth, or in moderately grazed areas (Smith 1996).	Low – limited suitable breeding habitat exists in the Project area.
Short-eared owl	*Asio flammeus*	Special Concern - Schedule 1	Special Concern	S3B S2N S3M	Short-eared owls typically prefer open grassland and hayland. Potential nesting and foraging habitat for short-eared owls is in low areas containing native vegetation or grassy wetland margins (Godfrey 1986; Smith 1996).	Low to Moderate - suitable breeding habitat in Project area and species has been reported as a confirmed breeder in the Saskatoon area (Smith 1996).
Burrowing owl	*Athene cunicularia*	Endangered - Schedule 1	Endangered	S2B S2M	Burrowing owls prefer pasture land that has been grazed, but they can be found nesting in ditches and along road allowances (Godfrey 1986).	Low - suitable breeding habitat is limited in Project area, although species has been reported as a confirmed breeder in the Saskatoon area (Smith 1996).

Table 2: Listed Wildlife Species with Some Potential to Occur Within the Project Area

Species	Scientific Name	*Species at Risk Act* [(a)]	COSEWIC [(b)]	SK Provincial Listing[(c)]	Habitat	Potential for Occurrence in the Project Area
Ferruginous hawk	*Buteo regalis*	Threatened - Schedule 1	Threatened	S3	The ferruginous hawk prefers open grassland plains, and prairie with little tree cover (Godfrey 1986). Nests are generally constructed in lone trees or small bluffs, but can also be constructed on the ground (Smith 1996).	Low– limited habitat exists in the area, although the species is a confirmed breeder in the in the Saskatoon area (Smith 1996).
McCown's longspur	*Calcarius mccownii*	Special Concern - Schedule 1	Threatened	S3B	Semi-arid shortgrass prairie and overgrazed pastures (With 2010).	Low – limited suitable habitat in the Project area; however, no recorded occurrences of species in the Saskatoon area (Smith 1996).
Chestnut-collared longspur	*Calcarius ornatus*	Threatened - Schedule 1	Threatened	S3B	Typical breeding habitat includes mowed or heavily grazed short and mixed grass prairie (Hill and Gould 1997).	Low – limited suitable habitat exists in the Project area; confirmed breeder in the Saskatoon area (Smith 1996).
Red knot	*Calidris canutus rufa*	Endangered, Schedule 1	Endangered	S2M	This species is uncommon, but a regular visitor where spring flocks are observed on large saline lakes.	Low - species may migrate through the area in the spring or fall (Smith 1996). This species may use wetland habitat during their migrations, even though these wetlands are not their optimal habitats.
Piping plover	*Charadrius melodus*	Endangered - Schedule 1	Endangered	S3B	Prefers to nest on sand or gravel beaches of saline or freshwater lakes, reservoirs, river shorelines, and wetlands (Boyne 2001).	Low - species is a confirmed breeder within the Saskatoon area (Smith 1996). Limited habitat in the Project area.
Common nighthawk	*Chordeiles minor*	Threatened - Schedule 1	Threatened	S4B S4M	Forages in the air. Roosts in trees in open woodlands, fence posts in open areas, or on the ground. Nests on the ground in woodland openings, natural open areas, burnt lands, and flat tops of buildings (Godfrey 1986).	Moderate - suitable habitat exists in the Project area. Species is a confirmed breeder in the Saskatoon area (Smith 1996).
Olive-sided flycatcher	*Contopus cooperi*	Threatened - Schedule 1	Threatened	S4B S4M	Breeds in subarctic and boreal forests in Saskatchewan (Smith 1996).	Low – species is a spring and fall transient in the Saskatoon area (Smith 1996).
Yellow rail	*Coturnicops noveboracensis*	Special Concern - Schedule 1	Special Concern	S3B S3M	Typically found nesting in marshes dominated by sedges, grasses, and rushes where there is little or no standing water, and the substrate remains saturated throughout the summer (COSEWIC 2009).	Low to Moderate – limited suitable habitat in the Project area; however, species is a probable breeder in the Saskatoon area (Smith 1996).
Bobolink	*Dolichonyx oryzivorus*	No Status	Threatened	S4B S4M	Bobolink prefers fields and meadows of tall grass, clover, alfalfa, or grain (Godfrey 1986).	Low to moderate – vegetation is mowed within the Highway right-of-way. However, suitable habitat exists in the Project area.
Rusty blackbird	*Euphagus carolinus*	Special Concern - Schedule 1	Special Concern	S3B SUN S3M	Breeds in boreal forest in northern Saskatchewan (COSEWIC 2006). Wintering birds observed at farm feedlots (Smith 1996).	Low - limited suitable habitat exists in the Project area. Species is a winter resident in Saskatoon area (Smith 1996).

Table 2: Listed Wildlife Species with Some Potential to Occur Within the Project Area

Species	Scientific Name	*Species at Risk Act* [(a)]	COSEWIC [(b)]	SK Provincial Listing[(c)]	Habitat	Potential for Occurrence in the Project Area
Peregrine falcon	*Falco peregrinus anatum*	Special Concern - Schedule 1	Special Concern	S1B SNRM	Nests primarily on cliff ledges or crevices, although some pairs nest on tall buildings or bridges (COSEWIC 2007).	Moderate - suitable breeding and foraging habitat exists in the Project area. Species is a confirmed breeder in the Saskatoon area (Smith 1996).
Whooping Crane	*Grus americana*	Endangered – Schedule 1	Endangered	SXB S1M	During migration, whooping cranes stop and use a variety of habitats along the way. Whooping crane use wetland and cropland habitats to roost and forage. They feed on waste grains, aquatic organisms, insects and small rodents (Johns et al. 1997).	Low - species may migrate through the area in the spring or fall, or be a summer visitor (Smith 1996).
Barn swallow	*Hirundo rustica*	No Status	Threatened	S5B S5M	Barn swallow breeding habitat includes modified grassland for foraging, and enclosed vertical or horizontal structures for nesting (e.g., buildings), and waterbodies to obtain mud for nest building (Brown and Brown 1999).	High – breeding and foraging habitat exists in the Project area; species is a confirmed breeder in the Saskatoon area (Smith 1996).
Loggerhead shrike	*Lanius ludovicianus excubitorides*	Threatened - Schedule 1	Threatened	S2B S2M	Loggerhead shrikes prefer open areas with scattered shrubby growth. They can be found in open country, savannah, and desert scrub (Godfrey 1986). They typically breed in shelterbelts and willow-ringed ponds on the prairies (Smith 1996).	Moderate - habitat exists in the Project area; species is a confirmed breeder in the Saskatoon area (Smith 1996).
Long-billed curlew	*Numenius americanus*	Special Concern - Schedule 1	Special Concern	S3B S4M	Nesting habitat for long-billed curlews includes native grasslands and open grassy meadows, usually near water; however, birds have also been found nesting in cereal crops.	Low to moderate - suitable nesting habitat is limited in the Project area.
Horned grebe	*Podiceps auritus*	No Status	Special Concern	S5B S5M	This species prefers small waterbodies (sloughs, ponds, and dugouts) with extensive marshy areas.	Moderate – suitable breeding habitat in the Project area and species is a confirmed breeder throughout the Saskatoon area (Smith 1996).
Bank swallow	*Riparia riparia*	No Status	Threatened	S4B S5M	Nests in cutbanks along watercourses and artificial habitats associated with gravel extraction, roads, and railways (Smith 1996).	Low - habitat is limitedin the Project area, but species is a confirmed breeder in the Saskatoon area (Smith 1996).
MAMMALS						
Little brown bat	*Myotis lucifugus*	Endangered - Schedule 1	Endangered	S4	The species overwinters in cold and humid hibernacula (caves/mines) with summer maternity colonies established by females in buildings or large-diameter trees. Foraging occurs over water, along waterways, forest edges, and in gaps in the forest (COSEWIC 2013).	Moderate - suitable foraging habitat exists in the Project area, as foraging occurs over water.

Table 2: Listed Wildlife Species with Some Potential to Occur Within the Project Area

Species	Scientific Name	*Species at Risk Act* [a]	COSEWIC [b]	SK Provincial Listing[c]	Habitat	Potential for Occurrence in the Project Area
Northern myotis	*Myotis septentrionalis*	Endangered - Schedule 1	Endangered	S3	Hibernacula (e.g., caves or abandoned mines) for overwintering, and summer foraging areas with structures for roosting and maternal colonies (e.g., trees, rock crevices, buildings, bat houses) (Caceres and Barclay 2000).	Moderate - suitable foraging habitat exists in the Project area, as foraging occurs over water.
American badger	*Taxidea taxus taxus*	No Status or Schedule	Special Concern	S3	American badgers prefer sandy to loamy soils for burrowing and are often found in close proximity to roads, fence lines, and field edges, while generally avoiding cultivated land (COSEWIC 2012).	Low – suitable habitat is limited in the Project area, but species may hunt suitable prey in roadside ditches.
ARTHROPODS						
Monarch Butterfly	*Danaus plexippus*	Special Concern - Schedule 1	Endangered	S2B	This butterfly is primarily wherever milkweed species (*Asclepius*) and wildflowers grow. This includes abandoned farmland, along roadsides, and other open spaces where these plants grow. Monarchs are migratory, leaving the prairies in August (Layberry et al. 1998).	Moderate – milkweed is often intentionally grown in residential gardens and can be found established along roadsides and railways.

[a]SARA (2017). [b]COSEWIC (2017). [c]SKCDC (2017b). SK = Saskatchewan.

Provincial Rank Definitions

S1 Critically Imperiled – Very high risk of extinction or extirpation; S2 Imperiled – A high risk of extinction or extirpation;
S3 Vulnerable – Moderate risk of extinction or extirpation; S4 Apparently Secure – Uncommon, but not rare;
S5 Secure – Demonstrably secure under present conditions.
B – for a migratory species, rank applies to the breeding population in the province.
M – for a migratory species, rank applies to the transient population in the province.
N – for a migratory species, rank applies to the non-breeding population in the province.

3.0 POTENTIAL ENVIRONMENTAL CONSIDERATIONS

The following provides potential Project-related considerations and mitigation measures.

3.1 Heritage Resources

- A portion of the Project is located on heritage sensitive land, therefore the Project should be submitted to the Heritage Conservation Branch to determine if an Heritage Resources Impact Assessment is required.

3.2 Soil

- Topsoil should be stripped and stored separately from subsoils to prevent admixing.
- Saturated, potentially saline, soils are associated with wetlands. Topsoil in these areas should be stripped and stored separately to prevent admixing with subsoils.
- Salvaged topsoil should be replaced on graded back slopes or recontoured slopes once construction is complete.
- Seeding should occur on disturbed areas where topsoil is replaced.
- Equipment should arrive on-site clean and free of soil and plant material (i.e. weed seeds).

3.3 Surface Water

- An Aquatic Habitat Protection Permit (AHPP) may be required from MOE for the crossing or alteration of wetlands.
- Erosion and sediment control practices should be implemented where appropriate and excavated topsoil and subsoil has been stored in such a manner as to avoid sediment transfer into the wetlands crossed by or adjacent to the Project.
- Equipment should be inspected for leaks prior to entry into the Project area, and throughout the duration of construction.
- Equipment will be limited to working within the Highway and Interchange right-of-way and staging areas.
- Spill response equipment should be on-site during construction, and any spills will be isolated and cleaned up immediately, to minimize the potential of a release into the wetland crossed by or adjacent to the Project.
- Stationary equipment such as water pumps should have secondary containment to prevent fluids from entering water bodies in the event of a spill or leak.
- Fuel for equipment and water pumps should be stored 100 m from wetlands.
- Hydraulic hose changes, oil changes, or maintenance activities on equipment should be kept to a minimum area and oils, greases, and fuels should be contained so as not to contaminate soil or wetlands in the area.

- Spill response equipment should be stored on-site during construction and also carried on heavy equipment in the event a hose ruptures or a leak/spill.
- If a spill or leak occurs, contaminated soil should be excavated, stored in a container and taken to an approved waste facility for disposal.
- Fueling should occur either by fuel trucks or from a temporary double-walled fuel tank located at a designated location on the Project site, a minimum of 100 m from a wetland location.

3.4 Vegetation

- The Project is located within an existing disturbance corridor; as such, the habitat crossed by the Project has a low to moderate potential to support listed plant species.
- Localized clearing of trees and tall shrubs may be required, but should be kept to the minimum amount necessary.
- Weed species likely occur within the existing roadside ditches, so appropriate vegetation management should be considered to prevent seed production and to mitigate the transfer and spread of these species.
- Pre-construction listed plant surveys should occur in and adjacent to the Project footprint.
- If any listed plants are found in the Project footprint, MOE should be contacted to discuss mitigation measures. Activity restriction guidelines for sensitive plant and wildlife species (MOE 2015b) are provided in Appendix A.
- No federal listed plants have been documented on or adjacent to the Project, but that does not preclude their occurrence.

3.5 Wildlife

- Disturbance to wildlife habitat may occur, specifically the clearing of woodlands, removal of low vegetation cover, and alteration or removal of wetlands.
- No federally listed species have been documented on or adjacent to the Project, but that does not preclude their occurrence.
- Disturbance to nesting migratory bird species is possible, depending on timing of construction. Pre-construction nest surveys may be required considering construction will occur within the nesting periods (between April 15 and August 15) for most avian species (Environment and Climate Change Canada 2016). Active nests should be avoided by buffer distances determined by either MOE or Environment and Climate Change Canada.

4.0 CLOSURE

We trust that this report presents the information that you require. Should any portion of the report require clarification, please do not hesitate to contact Brad Novecosky.

GOLDER ASSOCIATES LTD.

Amy Wheeler, B.Sc., P.Ag.
Terrestrial Biologist

Brad Novecosky, M.A.
Principal

ALW/BN/kpl

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APPENDIX A

Saskatchewan Activity Restrictions Guidelines for Sensitive Species

Government of Saskatchewan

Saskatchewan Activity Restriction Guidelines for Sensitive Species

These guidelines aim to assist proponents during the planning of proposed projects. Pre-planning and avoidance of key habitats of sensitive species during sensitive periods is preferred. If your project activities fall within the listed set-back distances, please contact the Ministry of Environment at centre.inquiry@gov.sk.ca early in the planning stage to minimize impacts to sensitive species.

Taxon, Taxa	Key Wildlife Features	Restricted Activity Periods	Setback Distances by Disturbance Category with Examples Provided		
			Low E.g., foot traffic, vehicles <1 ton including ATVs, operating oil or gas wells, pipelines) *FOOT TRAFFIC ONLY (FTO) is indicated for select taxa)	**Medium** E.g., vehicles >1 ton, plough-in pipeline, operating compressor station or battery. *In the case of FTO, small vehicles and ATVs are a medium disturbance.	**High** E.g., Road, battery or compressor station construction, seismic, drilling rigs, trench-in pipeline, blasting, mines, gravel pit, quarries, rock crushing, asphalt batching.
AMPHIBIANS					
Great Plains Toad (*Anaxyrus cognatus*)	Breeding and overwintering habitat	Year Round	10 m	400 m	500 m
Canadian Toad (*Anaxyrus hemiophrys*)	Breeding and overwintering habitat	Year Round	0 m FTO	90 m	90 m
Plains Spadefoot (*Spea bombifrons*)	Breeding and overwintering habitat	Year Round	0 m FTO	90 m	90 m
Northern Leopard Frog (*Lithobates pipiens*)	Breeding and overwintering habitat	Year Round	10 m	200 m	500 m
REPTILES					
Snapping Turtle (*Chelydra serpentina*)	Nesting Site	Mar. 15-June 30	0 m FTO	400 m	400 m
Eastern Yellow -bellied Racer (*Coluber constrictor flaviventris*)	Hibernacula	Apr. 1-Sept. 30	100 m	200 m	1000 m
		Oct. 1-Mar. 31	0 m FTO	200 m	200 m
Smooth Greensnake (*Opheodrys vernalis*)	Hibernacula	Apr. 1-Sept. 30	50 m	200 m	200 m
		Oct. 1-Mar. 31	0 m FTO	200 m	200 m
Plains Hog-nosed Snake (*Heterodon nasicus*)	Hibernacula	Apr. 1-Sept. 30	50 m	200 m	200 m
		Oct. 1-Mar. 31	0 m FTO	200 m	200 m
Prairie Rattlesnake (*Crotalus viridis viridis*)	Hibernacula	Apr. 1-Sept. 30	100 m	200 m	200 m
		Oct. 1-Mar. 31	0 m FTO	200 m	200 m
Greater Short-horned Lizard (*Phrynosoma hernandesi*)	Eroded Slopes (blue-shale outcrops)	Mar.15-Nov. 15	50 m	200 m	200 m

This report is cited as: Ministry of Environment, Fish and Wildlife Branch. June 2015. Activity Restriction Guidelines for Sensitive Species. Regina, Saskatchewan.

BIRDS *Breeding Bird is characterized by: territorial behaviour; calling to competing male, mate or young; singing; courtship displays; carrying food or nest materials etc., and; presence of nest or young found incidentally.					
Trumpeter Swan (*Cygnus buccinator*)	Breeding Bird*	Apr. 1-July 31	500 m	1000 m	1000 m
Greater Sage-Grouse (*Centrocercus urophasianus*)	SARA Emergency Protection Order (EPO)	Year Round	Refer to the Emergency Protection Order (EPO)		
	Non-EPO Lek	Year Round	500 m	3200 m	6400 m
	Habitat	Year Round	1000 m	1000 m	1000 m
Sharp-tailed Grouse (*Tympanuchus phasianellus*)	Lek	Mar. 15-May 15	200 m FTO	400 m	400 m
Loons (*Gavia sp.*) and Colonial Nesting Grebes (Eared, Western, and Clark's Grebes)[1]	Breeding Bird* or Breeding Grebe Colony	May 15-July 15	100 m	200 m	200 m
American Bittern (*Botaurus lentiginosus*)	Breeding Bird*	May 1-July 15	100 m	150 m	350 m
Colonial Nesting Birds (American White Pelican, Double-crested Cormorant, Great Blue Heron, Great Egret, Snowy Egret, Little Blue Heron, Cattle Egret, Black-crowned Night-Heron, White-faced Ibis and Glossy Ibis[2]	Nesting Colony	Apr. 1-July 31	500 m	1000 m	1000 m
Osprey (*Pandion haliaetus*)	Nest Site	May 1-Aug. 15	500 m	1000 m	1000 m
Cooper's Hawk (*Accipiter cooperii*)	Nest Site	Apr. 1-July 31	200 m	400 m	400 m
Ferruginous Hawk (*Buteo regalis*)	Nest Site	Mar. 15-July 15	500 m	750 m	1000 m
Golden Eagle (*Aquila chrysaetos*)	Nest Site	Feb. 15-July 15	500 m	1000 m	1000 m
Bald Eagle (*Haliaeetus leucocephalus*)	Nest Site	Mar. 15-July 15	500 m	750 m	1000 m
Whooping Crane (*Grus americana*)	Staging Area	May 1-Nov. 1	500 m	1000 m	1000 m
Yellow Rail (*Coturnicops noveboracensis*)	Breeding Bird*	May 1-July 15	100 m	150 m	350 m
Snowy Plover (*Charadrius nivosus*)	High-water Mark	May 1-July 31	200 m	400 m	600 m
		Aug. 1-Sept. 30	100 m	400 m	600 m
Piping Plover (*Charadrius melodus circumcinctus*)	High-water Mark	May 1-July 31	200 m	400 m	600 m
		Aug. 1-Sept. 30	100 m	400 m	600 m
Mountain Plover (*Charadrius montanus*)	Breeding Bird*	May 1-July 31	200 m	400 m	500 m

Long-billed Curlew (*Numenius americanus*)	Breeding Bird*	Apr. 15-July 15	100 m	200 m	200 m
Red Knot (*Calidris canutus rufa*)	Staging Area	May 15-Jun. 30 Aug. 1-Aug. 31	500 m	500 m	1000 m
Gulls and Terns (*Laridae*), except Ring-billed and California Gulls[3]	Nesting Colony	May 1-July 15	200 m	400 m	400 m
Short-eared Owl (*Asio flammeus*)	Breeding Bird*	Mar. 25-Aug. 1	100 m	300 m	500 m
Great Gray Owl (*Strix nebulosa*)	Nest Site	Mar. 1-July 15	100 m	400 m	400 m
Barred Owl (*Strix varia*)	Nest Site	Mar. 1-July 15	100 m	400 m	400 m
Burrowing Owl (*Athene cunicularia*)	Breeding Bird*	Apr.1-July 15	200 m	300 m	500 m
		July 16-Oct. 15	100 m	200 m	500 m
		Oct. 16-Mar. 31	10 m	200 m	500 m
Western Screech Owl (*Megascops kennicottii*)	Nest Site	Mar. 1-July 15	100 m	400 m	400 m
Eastern Screech-Owl (*Megascops asio*)	Nest Site	Mar. 1-July 15	100 m	400 m	400 m
Northern Hawk Owl (*Surnia ulula*)	Nest Site	Mar. 1-July 15	100 m	400 m	400 m
Common Poorwill (*Phalaenoptilus nuttallii*)	Breeding Bird*	May 1-Aug. 31	0 - 50 m	100 m	200 m
Eastern Whip-poor-will (*Antrostomus vociferus*)	Breeding Bird*	May 1-Aug. 31	0 - 50 m	100 m	200 m
Common Nighthawk (*Chordeiles minor*)	Breeding Bird*	May 1-Aug. 31	0 - 50 m	100 m	200 m
Chimney Swift (*Chaetura pelagica*)	Breeding Bird*	May 1-July 31	0 - 50 m	150 m	300m
Red-headed Woodpecker (*Melanerpes erythrocephalus*)	Breeding Bird*	Apr. 15-June 30	0 m FTO	100 m	100 m
Peregrine Falcon (*Falco peregrinus anatum*)	Nest Site	Apr. 1-Aug. 15	300 m	500 m	1000 m
Prairie Falcon (*Falco mexicanus*)	Nest Site	Mar. 15-July 15	500 m	750 m	1000 m
Olive-sided Flycatcher (*Contopus cooperi*)	Breeding Bird*	May 1-Aug. 31	0 - 50 m	150 m	300m
Loggerhead Shrike (*Lanius ludovicianus excubitorides*)	Breeding Bird*	May 1-Aug. 15	50 m	250 m	400 m
Sage Thrasher (*Oreoscoptes montanus*)	Breeding Bird*	May 15 – July 31	100m	200 m	200 m
Sprague's Pipit (*Anthus spragueii*)	Breeding Bird*	Apr. 21-Aug. 31	50 m	200 m	250 m
Chestnut-collared Longspur (*Calcarius ornatus*)	Breeding Bird*	May 1-July 31	25 m	100 m	200 m

McCown's Longspur (*Rhynchophanes mccownii*)	Breeding Bird*	May 1-July 31	25 m	100 m	200 m
Canada Warbler (*Cardellina canadensis*)	Breeding Bird*	May 1-July 31	0 - 50 m	150 m	300 m
Rusty Blackbird (*Euphagus carolinus*)	Breeding Bird*	May 1-July 31	0 - 50 m	150 m	300 m
MAMMALS					
Black-footed Ferret (*Mustela nigripes*)	Residence or Prairie Dog Colony	Year Round	0 m FTO	250 m	500 m
Black-tailed Prairie Dog (*Cynomys ludovicianus*)	Colony	Year Round	0m FTO	250 m	500 m
Ord's Kangaroo rat (*Dipodomys ordii*)	Den	Year Round	50 m	250 m	500 m
Swift Fox (*Vulpes velox*)	Den	Feb. 15-Aug. 31	500 m	500 m	2000 m
	Den	Sept. 1-Feb. 14	100 m	500 m	2000 m
Bats (*Vespertilionidae*)	Roost/Foraging Site	Year Round	100 m	500 m	500 m
PLANTS Federal and provincial plants of concern					
1. Those plants listed under SARA. 2. Those plants listed in the *Wildlife Act, 1998*. 3. Those plants ranked as S1, S2, SH or SX on the SKCDC tracking list.	Occurrence	Year Round	0 m FTO	30 m All examples of Low and Medium except FTO	300 m
1. Those plant species not previously identified in these guidelines that are on the SKCDC tracking list (e.g., S3).	Occurrence	Year Round	0 m FTO	30 m	

FISH Proponents should be aware of the following listed fish species and the waters in which they live. Contact the Department of Fisheries and Oceans (contacts below) if your project is in, or near, these waters.	
Bigmouth Buffalo (*Ictiobus cyprinellus*)	The Qu'Appelle basin, including the waters of Buffalo Pound, Last Mountain, Pasqua, Echo, Mission, Katepwa (The Fishing Lakes), Crooked and Round lakes.
Chestnut Lamprey (*Ichthyomyzon castaneus*)	The waters of the Qu'Appelle River below the outlet of Round Lake and the upper Assiniboine basin including the Whitesand River and Shell River.
Lake Sturgeon (*Acipenser fulvescens*)	The waters of the North Saskatchewan, South Saskatchewan and Saskatchewan Rivers (including large connected waters such as the Torch River) and the waters of the Churchill River below the confluence of the Reindeer River.
Shortjaw Cisco (*Coregonus zenithicus*)	The waters of Reindeer Lake, Lake Athabasca, Black, Giles Lake and Wapata lake.

[1] Western Grebe (*Aechmophorus occidentalis*), Clark's Grebe (*Aechmophorus clarkii*) and Eared Grebe (*Podiceps auritus*)

[2] American White Pelican (*Pelicanus erythrorhynchos*), Double-crested Cormorant (*Phalacrocorax auritus*), Great Blue Heron (*Ardea herodias*), Great Egret (*Ardea alba*), Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*), Cattle Egret (*Bubulcus ibis*), Black-crowned Night-Heron (*Nycticorax nycticorax*), White-faced Ibis (*Plegadis chihi*), and Glossy Ibis (*Plegadis falcinellus*)

[3] Gulls (*Larus sp., Leucophaeus sp., Chroicocephalus sp.* and Ross's Gull, (*Rhodostethia rosea*), except California Gull (*Larus californicus*) and Ring-billed Gull (*Larus delawarensis*)

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
1721 8th Street East
Saskatoon, Saskatchewan, Canada S7H 0T4
Canada
T: +1 (306) 665 7989

Golder Associates

Appendix H

Noise Modelling

aci Acoustical Consultants Inc.
5031 – 210 Street
Edmonton, Alberta, Canada T6M 0A8
Phone: (780) 414-6373
www.aciacoustical.com

Environmental Traffic Noise Modelling
And
Traffic Noise Barrier Recommendations

For

Circle Drive & Highway 11 & Highway 16 Interchange

Prepared for:
ISL Engineering and Land Services

Prepared by:
S. Bilawchuk, M.Sc., P.Eng.
aci Acoustical Consultants Inc.
Edmonton, Alberta
APEGA Permit to Practice #P7735

PROFESSIONAL ENGINEER ALBERTA
S. BILAWCHUK

aci Project #: 17-021
April 20, 2017

4/20/2017

<u>**Executive Summary**</u>

aci Acoustical Consultants Inc., of Edmonton AB, was retained by ISL Engineering and Land Services to conduct environmental traffic noise modeling and provide traffic noise barrier recommendations for the proposed Interchange between Circle Drive and Highway 11 and Highway 16 (the Interchange). The purpose of the work was to generate a computer noise model for the study area under *future* (400k population) traffic conditions and to compare the results to the City of Saskatoon assessment criteria of 65 dBA L_{dn}. Further, for all areas with *future* noise levels exceeding 65 dBA L_{dn}, the noise model was used to determine the minimum required noise barrier height to reduce the noise levels to below 65 dBA L_{dn}.

The results of the noise modeling under *future* conditions *without* mitigation indicate noise levels that are modeled to be above 65 dBA L_{dn} for most of the receptors to the northeast and northwest of the Interchange and for a small portion of receptors to the southwest of the Interchange. The maximum modeled noise level was 69.6 dBA L_{dn}. As such, noise mitigation will be required to achieve noise levels below 65 dBA L_{dn}.

The results of the noise modeling under *future* conditions *with* mitigation indicate noise levels that are modeled to be below 65 dBA L_{dn} for all of the residential receptors within the study area. The maximum modeled noise level was 64.9 dBA L_{dn} and the noise level reduction, relative to the *future* noise levels *without* mitigation, ranges from -0.0 to -6.2 dBA.

In order to achieve *future* noise levels below 65 dBA L_{dn} throughout the entire study area, noise barriers are required for almost all of the northeast and northwest areas (with the exception of the existing earth berm located directly northwest of the Interchange) as well as for a small portion of the southwest area. The new noise barrier heights range from 1.83 m (6 ft) to 4.0 m. The total running length of the new noise barriers is approximately 3,760 m.

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1.0 Introduction

aci Acoustical Consultants Inc., of Edmonton AB, was retained by ISL Engineering and Land Services to conduct environmental traffic noise modeling and provide traffic noise barrier recommendations for the proposed Interchange between Circle Drive and Highway 11 and Highway 16 (the Interchange). The purpose of the work was to generate a computer noise model for the study area under *future* (400k population) traffic conditions and to compare the results to the City of Saskatoon assessment criteria of 65 dBA L_{dn}. Further, for all areas with *future* noise levels exceeding 65 dBA L_{dn}, the noise model was used to determine the minimum required noise barrier height to reduce the noise levels to below 65 dBA L_{dn}.

2.0 Location Description

The study area includes the proposed interchange at Circle Drive, Highway 11, and Highway 16, as indicated in Figure 1. The design of the Interchange will modify the roads and elevation contours spanning from approximately 500 m west of Preston Avenue to approximately 950 m east of Highway 11 and from approximately 1,200 m north of Highway 16 to approximately 1,100 m south of Highway 16. The design of the Interchange and associated roadways will involve road realignments, bridges, tunnels, retaining walls, and elevation changes.

The area to the northeast of the Interchange is comprised of residential development. The residential receptors backing onto Circle Drive and Highway 16 within the area are single family detached houses with backyard amenity spaces. At the rear property line, most of the houses have either no fence, or chainlink fences, or wooden fences with large gaps that provide minimal noise attenuation. As such, residential fences have not been included in the noise model. There are, however, existing noise barriers at the south end of the study area, as follows:

- On the east side of Circle Drive, there is 3.3 m tall masonry noise barrier that starts at approximately #367 Delaronde Road and continues for approximately 480 m to the southeast where it ends and overlaps with another masonry noise barrier that extends approximately 1,300 m further east along Highway 16. This current 480 m noise barrier will be removed as part of the project due to space requirements. In addition, a portion of the existing 1,300 m barrier will be removed at the west end due to space requirements.

- On the east side of Circle Drive, there is a 1.83 m tall masonry barrier that starts just south of Taylor Street and continues for approximately 300 m to the south approximately midway in between the rear residential property lines and the northbound off-ramp for Circle Drive, ending at approximately 431 Costigan Road. Previous noise studies for Circle Drive have indicated a need to replace this barrier with a taller barrier. However, for the purposes of this study, the existing barrier has been unmodified.

In addition there is a significant existing earth berm located immediately to the east of Circle Drive starting at Taylor Street and spanning south until approximately #367 Delaronde Road. As part of the Project, a large portion of this earth berm will be modified and partially removed to allow for the updated road alignments.

The area to the northwest of the Interchange is comprised of residential development. The residential receptors backing onto Circle Drive within the area consist primarily of single family detached houses with backyard amenity spaces. There are also some multi-family buildings to the north, immediately south of Tayler Street which are outside of the study area for the Interchange. The houses to the west and north of Circle Drive have back-alley access. At the rear property line, most of the houses have either no fence, or chainlink fences, or wooden fences with large gaps that provide minimal noise attenuation. As such, residential fences have not been included in the noise model. There are, however, existing noise barriers near the Interchange as follows:

- On the west side of Circle Drive, there is a 3.3 m tall noise barrier that starts at 2301 Easthill and extends for approximately 285 m to the west until 2546 Eastview. This wall partially overlaps with another 3.3 m tall noise barrier that starts at 2550 Eastview and extends for approximately 193 m to the west until 2658 Eastview. Both of these barriers will be removed as part of the project due to space requirements (193 m barrier) and poor/ineffective placement (285 m barrier).

In addition, there is a significant existing earth berm located immediately to the west of Circle Drive starting at Taylor Street and spanning south until approximately 2205 Easthill. As part of the Project, a large portion of this earth berm will be modified and partially removed to allow for the updated road alignments. There is also another earth berm located immediately to the northwest of the Interchange which will remain as part of the Project.

The area to the southwest of the Interchange is comprised of residential development. The residential receptors backing onto Circle Drive and Highway 11 within the area are largely single family detached houses with backyard amenity spaces. At the western end, there are row-style houses which back onto

Circle Drive. At the rear property line, most of the houses have either no fence, or chainlink fences, or wooden fences with large gaps that provide minimal noise attenuation. As such, residential fences have not been included in the noise model. In addition, there is an earth berm in between the residential properties and Circle Drive and Highway 11. For most of the area, the earth berm is approximately 3 m high, blocking the line-of-sight between the outdoor amenity space and the adjacent roads.

Topographically, at the north end of the study area, Circle Drive is generally at a lower elevation than the adjacent residential properties on the east and west sides by approximately 5 m. Further to the south, the difference in elevation becomes smaller with Circle Drive approximately equal in elevation with the adjacent residential properties as it enters the interchange with Highway 11 and Highway 16. As mentioned previously, there is also an earth berm in between the residential properties and Circle Drive on both the east and west sides, ranging in height from 1 - 5 m, above the elevation of Circle Drive. As a result, most of the residential properties do not have line-of-sight to Circle Drive. The exceptions to this are the houses immediately northwest of the Interchange between Circle Drive and Highway 11 and Highway 16 where the earth berm reduces in height to allow for direct line-of-sight to Circle Drive and the southbound to westbound turning ramp. Detailed elevation contours (in 0.2 m vertical resolution) have been incorporated into the noise model for increased accuracy with the modeling results. In addition, all of the proposed elevation changes associated with the Interchange have been incorporated into the noise model.

The land is covered with field grasses and small patches of bushes. Given the relatively short distances between the residential properties and the adjacent roadways, the quantity of vegetative sound absorption is minimal and has not been included in the noise model.

3.0 Modeling Methods

The computer noise modeling was conducted using the CADNA/A (Version 2017, Build 159.4707) software package. CADNA/A allows for the modeling of various noise sources such as road, rail, and various stationary sources. In addition, topographical features such as land contours, vegetation, and bodies of water can be included. Finally, meteorological conditions such as temperature, relative humidity, wind-speed and wind-direction can be included in the calculations.

The calculation method used for noise propagation follows the standard RLS-90 and the ISO standard 9613-2. All receiver locations were assumed as being downwind from the source(s). In particular, as stated in Section 5 of the ISO document:

> *"Downwind propagation conditions for the method specified in this part of IS0 9613 are as specified in 5.4.3.3 of IS0 1996-2:1987, namely*
>
> - *wind direction within an angle of ± 45⁰ of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region, with the wind blowing from source to receiver, and*
> - *wind speed between approximately 1 m/s and 5 m/s, measured at a height of 3 m to 11 m above the ground.*
>
> *The equations for calculating the average downwind sound pressure level LAT(DW) in this part of IS0 9613, including the equations for attenuation given in clause 7, are the average for meteorological conditions within these limits. The term average here means the average over a short time interval, as defined in 3.1.*
>
> *These equations also hold, equivalently, for average propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights".*

Due to the small amount of vegetation, and thus relative ineffectiveness to mitigate the noise climate, no vegetation was included in the model. Similarly, no snow cover was included since there can be variation in absorption/reflection caused by different snow conditions. As a result, all sound level propagation calculations are considered representative of summertime conditions for all surrounding residents.

Note that not every commercial building and house in the area was modeled. Only the first row of buildings (in relation to the major roadways) were included, since these are the ones which will have the highest sound levels and will result in the greatest shielding for all residential areas further in from the major roadways.

As part of the study, three scenarios were modeled including:

1) *Future* Conditions *Without* Mitigation: This included *future* (400k population) traffic conditions without any additional noise mitigation.
2) *Future* Conditions *With* Mitigation: This included *future* (400k population) traffic conditions as well as noise barriers if required to achieve *future* modeled noise levels below 65 dBA L_{dn}.

The computer noise modeling results were calculated in two ways. First, sound levels were calculated at specific receiver locations (i.e. all residents within the specific study area adjacent to the major roadways). Next, the sound levels were calculated using a 5 m x 5 m grid over the entire study area. This provided color noise contours for easier visualization of the results.

Refer to Appendix I for a list of the computer noise modeling parameters, Appendix II for a description of the acoustical terminology, and Appendix III for a list of common noise sources.

4.0 Permissible Sound Levels

Environmental noise levels from road traffic are commonly described in terms of equivalent sound levels or L_{eq}. This is the level of a steady sound having the same acoustic energy, over a given time period, as the fluctuating sound. In addition, this energy averaged level is A–weighted to account for the reduced sensitivity of average human hearing to low frequency sounds. These L_{eq} in dBA, which are the most common environmental noise measure, are often given for day-time (07:00 to 22:00) L_{eq}Day and night-time (22:00 to 07:00) L_{eq}Night while other criteria use the entire 24-hour period as L_{eq}24 or the day-night average sound level L_{dn}, which is a 24-hour L_{eq} with a 10 dBA penalty added during the night-time hours.

Currently, the City of Saskatoon does not have specific traffic noise assessment criteria. Historically, the criteria were as follows[1]:

> *"Only existing residential sites with a rear or side lot abutting high traffic roadways would be considered for a sound attenuation barrier. In general, the outdoor area must experience a noise level standard of 65 dBA L_{dn} or higher without a sound attenuation wall to be considered for future installation.*
>
> *Sound attenuation walls will be constructed of City-approved composite materials with due consideration to streetscape and future maintenance requirements. A public meeting with property owners may be conducted prior to deciding on the type of wall to be constructed, however, the final decision regarding the type of wall to be constructed will be at the discretion of the City of Saskatoon. Sound attenuation barriers will be constructed on the City right-of-way only. Installation of the private side yard fencing is the sole responsibility of the property owner."*

As part of the current study, the previous criteria will be referenced (i.e. 65 dBA L_{dn}). The noise modeling results were assessed within the backyard or side-yard facing the adjacent major roadway, at a distance of 5 m from the rear or side property line, at a height of 1.5 m.

[1] Obtained from the previous City of Saskatoon Website discussion of noise barriers. Information is no longer available on the City of Saskatoon Website.

5.0 Results and Discussion

5.1. *Future* Conditions *Without* Mitigation

The results of the noise modeling under *future* conditions *without* mitigation are provided within Tables 1a – 1c and within Figures 2a – 2d. Note that the receptors have been grouped into those within the northeast, the northwest, and the southwest of the Interchange. The noise modeling results indicate that the *future* noise levels are modeled to be above 65 dBA L_{dn} for most of the receptors to the northeast and northwest of the Interchange as well as a small portion of receptors to the southwest of the Interchange. The maximum modeled noise level was 69.6 dBA L_{dn}. As such, noise mitigation will be required to achieve noise levels below 65 dBA L_{dn}.

Table 1a. *Future* Conditions *Without* Mitigation Noise Modeling Results, Northeast Receptors

Receptor	L_{dn} (dBA)		Receptor	L_{dn} (dBA)
NE-001	67.6		NE-036	66.9
NE-002	66.7		NE-037	66.3
NE-003	66.4		NE-038	65.8
NE-004	65.7		NE-039	65.3
NE-005	67.1		NE-040	64.8
NE-006	66.8		NE-041	64.4
NE-007	66.6		NE-042	64.1
NE-008	66.4		NE-043	64.0
NE-009	66.4		NE-044	64.0
NE-010	66.1		NE-045	64.0
NE-011	65.9		NE-046	64.3
NE-012	65.3		NE-047	64.4
NE-013	64.2		NE-048	64.4
NE-014	64.4		NE-049	64.5
NE-015	64.6		NE-050	64.4
NE-016	64.6		NE-051	64.6
NE-017	65.1		NE-052	65.0
NE-018	65.6		NE-053	65.7
NE-019	66.4		NE-054	66.6
NE-020	66.5		NE-055	66.9
NE-021	67.3		NE-056	65.7
NE-022	67.8		NE-057	65.1
NE-023	68.8		NE-058	64.9
NE-024	69.3		NE-059	64.7
NE-025	69.5		NE-060	64.5
NE-026	69.5		NE-061	64.3
NE-027	69.5		NE-062	64.0
NE-028	69.3		NE-063	63.7
NE-029	69.2		NE-064	63.1
NE-030	68.8		NE-065	62.4
NE-031	67.8		NE-066	61.8
NE-032	67.3		NE-067	61.2
NE-033	67.0		NE-068	60.8
NE-034	67.2		NE-069	60.8
NE-035	67.2		NE-070	60.7

Table 1b. *Future* Conditions *Without* Mitigation Noise Modeling Results, Northwest Receptors

Receptor	L_{dn} (dBA)		Receptor	L_{dn} (dBA)
NW-001	65.8		NW-039	63.0
NW-002	66.2		NW-040	62.7
NW-003	66.4		NW-041	61.7
NW-004	66.1		NW-042	61.5
NW-005	66.2		NW-043	61.4
NW-006	66.3		NW-044	64.7
NW-007	66.1		NW-045	65.0
NW-008	66.0		NW-046	65.1
NW-009	65.8		NW-047	65.3
NW-010	65.6		NW-048	65.5
NW-011	65.6		NW-049	65.6
NW-012	66.0		NW-050	65.8
NW-013	67.4		NW-051	66.2
NW-014	67.9		NW-052	66.8
NW-015	68.3		NW-053	67.1
NW-016	68.9		NW-054	67.3
NW-017	69.0		NW-055	67.4
NW-018	69.2		NW-056	67.6
NW-019	69.4		NW-057	67.8
NW-020	69.5		NW-058	68.0
NW-021	69.6		NW-059	67.6
NW-022	69.6		NW-060	67.5
NW-023	69.6		NW-061	67.4
NW-024	69.6		NW-062	67.2
NW-025	69.4		NW-063	67.0
NW-026	69.2		NW-064	66.8
NW-027	68.8		NW-065	66.7
NW-028	68.3		NW-066	66.5
NW-029	63.5		NW-067	66.4
NW-030	63.6		NW-068	66.2
NW-031	63.1		NW-069	66.0
NW-032	62.8		NW-070	65.8
NW-033	62.6		NW-071	65.6
NW-034	62.6		NW-072	65.5
NW-035	62.5		NW-073	65.4
NW-036	62.5		NW-074	65.3
NW-037	62.5		NW-075	65.4
NW-038	62.6			

Table 1c. *Future* Conditions *Without* Mitigation Noise Modeling Results, Southwest Receptors

Receptor	L_{dn} (dBA)		Receptor	L_{dn} (dBA)
SW-001	60.7		SW-041	59.3
SW-002	62.0		SW-042	59.5
SW-003	65.5		SW-043	59.9
SW-004	65.0		SW-044	60.1
SW-005	64.7		SW-045	60.1
SW-006	64.4		SW-046	60.2
SW-007	63.0		SW-047	61.0
SW-008	64.1		SW-048	61.6
SW-009	63.9		SW-049	61.7
SW-010	63.6		SW-050	61.7
SW-011	63.5		SW-051	61.2
SW-012	63.6		SW-052	61.1
SW-013	62.8		SW-053	61.4
SW-014	62.2		SW-054	61.2
SW-015	61.4		SW-055	60.8
SW-016	63.3		SW-056	60.3
SW-017	63.9		SW-057	60.9
SW-018	63.6		SW-058	59.6
SW-019	63.1		SW-059	60.2
SW-020	62.6		SW-060	62.0
SW-021	62.3		SW-061	61.6
SW-022	62.1		SW-062	61.3
SW-023	61.9		SW-063	60.0
SW-024	61.7		SW-064	60.2
SW-025	61.6		SW-065	59.7
SW-026	61.5		SW-066	59.9
SW-027	61.3		SW-067	60.7
SW-028	61.2		SW-068	60.5
SW-029	61.1		SW-069	60.2
SW-030	60.9		SW-070	59.9
SW-031	60.8		SW-071	59.5
SW-032	60.7		SW-072	58.6
SW-033	60.6		SW-073	58.3
SW-034	60.4		SW-074	59.7
SW-035	60.3		SW-075	60.6
SW-036	60.0		SW-076	61.2
SW-037	60.1		SW-077	61.0
SW-038	60.3		SW-078	60.2
SW-039	60.0		SW-079	60.1
SW-040	59.9		SW-080	60.9

5.2. *Future* Conditions *With* Mitigation

The results of the noise modeling under *future* conditions *with* mitigation are provided within Tables 3a – 3c and within Figures 3a – 3d. The results indicate that the *future* noise levels *with* mitigation are modeled to be below 65 dBA L_{dn} for all of the residential receptors within the study area. The maximum modeled noise level was 64.9 dBA L_{dn} and the noise level reduction, relative to the *future* noise levels *without* mitigation, ranges from -0.0 to -6.2 dBA. Refer to Section 5.3 for a detailed description of the noise barriers incorporated into the noise model.

Table 2a. *Future* Conditions *With* Mitigation Noise Modeling Results, Northeast Receptors

Receptor	L_{dn} (dBA)	Reduction *With* Mitigation (dBA)		Receptor	L_{dn} (dBA)	Reduction *With* Mitigation (dBA)
NE-001	64.6	-3.0		**NE-036**	64.2	-2.7
NE-002	63.5	-3.2		**NE-037**	63.9	-2.4
NE-003	63.3	-3.1		**NE-038**	63.7	-2.1
NE-004	62.7	-3.0		**NE-039**	63.7	-1.6
NE-005	63.6	-3.5		**NE-040**	63.6	-1.2
NE-006	63.2	-3.6		**NE-041**	63.4	-1.0
NE-007	62.9	-3.7		**NE-042**	63.2	-0.9
NE-008	62.7	-3.7		**NE-043**	63.0	-1.0
NE-009	62.7	-3.7		**NE-044**	62.9	-1.1
NE-010	62.3	-3.8		**NE-045**	62.9	-1.1
NE-011	62.3	-3.6		**NE-046**	63.1	-1.2
NE-012	61.9	-3.4		**NE-047**	63.1	-1.3
NE-013	61.2	-3.0		**NE-048**	63.1	-1.3
NE-014	61.2	-3.2		**NE-049**	63.3	-1.2
NE-015	61.4	-3.2		**NE-050**	63.1	-1.3
NE-016	61.4	-3.2		**NE-051**	63.4	-1.2
NE-017	61.7	-3.4		**NE-052**	63.5	-1.5
NE-018	62.0	-3.6		**NE-053**	63.9	-1.8
NE-019	62.6	-3.8		**NE-054**	64.4	-2.2
NE-020	62.6	-3.9		**NE-055**	64.2	-2.7
NE-021	63.5	-3.8		**NE-056**	64.4	-1.3
NE-022	63.6	-4.2		**NE-057**	64.0	-1.1
NE-023	63.6	-5.2		**NE-058**	63.9	-1.0
NE-024	63.8	-5.5		**NE-059**	63.6	-1.1
NE-025	64.1	-5.4		**NE-060**	63.3	-1.2
NE-026	64.3	-5.2		**NE-061**	62.9	-1.4
NE-027	64.8	-4.7		**NE-062**	62.5	-1.5
NE-028	64.9	-4.4		**NE-063**	62.2	-1.5
NE-029	64.9	-4.3		**NE-064**	61.8	-1.3
NE-030	64.2	-4.6		**NE-065**	61.4	-1.0
NE-031	63.1	-4.7		**NE-066**	61.2	-0.6
NE-032	63.0	-4.3		**NE-067**	60.8	-0.4
NE-033	63.0	-4.0		**NE-068**	60.6	-0.2
NE-034	63.6	-3.6		**NE-069**	60.7	-0.1
NE-035	64.1	-3.1		**NE-070**	60.7	0.0

Table 2b. *Future* Conditions *With* Mitigation Noise Modeling Results, Northwest Receptors

Receptor	L_{dn} (dBA)	Reduction *With* Mitigation (dBA)		Receptor	L_{dn} (dBA)	Reduction *With* Mitigation (dBA)
NW-001	62.7	-3.1		**NW-039**	63.0	0.0
NW-002	62.5	-3.7		**NW-040**	62.7	0.0
NW-003	62.8	-3.6		**NW-041**	61.6	-0.1
NW-004	62.6	-3.5		**NW-042**	61.5	0.0
NW-005	62.7	-3.5		**NW-043**	61.4	0.0
NW-006	62.7	-3.6		**NW-044**	60.9	-3.8
NW-007	62.5	-3.6		**NW-045**	61.6	-3.4
NW-008	62.4	-3.6		**NW-046**	62.4	-2.7
NW-009	62.3	-3.5		**NW-047**	62.4	-2.9
NW-010	62.1	-3.5		**NW-048**	62.7	-2.8
NW-011	62.2	-3.4		**NW-049**	62.8	-2.8
NW-012	62.5	-3.5		**NW-050**	62.8	-3.0
NW-013	63.2	-4.2		**NW-051**	62.7	-3.5
NW-014	63.4	-4.5		**NW-052**	62.9	-3.9
NW-015	63.8	-4.5		**NW-053**	63.0	-4.1
NW-016	63.2	-5.7		**NW-054**	62.9	-4.4
NW-017	63.1	-5.9		**NW-055**	63.0	-4.4
NW-018	63.5	-5.7		**NW-056**	63.0	-4.6
NW-019	63.5	-5.9		**NW-057**	63.2	-4.6
NW-020	63.9	-5.6		**NW-058**	63.3	-4.7
NW-021	64.0	-5.6		**NW-059**	62.8	-4.8
NW-022	63.8	-5.8		**NW-060**	63.1	-4.4
NW-023	63.7	-5.9		**NW-061**	63.5	-3.9
NW-024	63.4	-6.2		**NW-062**	63.0	-4.2
NW-025	63.3	-6.1		**NW-063**	62.6	-4.4
NW-026	63.2	-6.0		**NW-064**	62.1	-4.7
NW-027	63.0	-5.8		**NW-065**	61.9	-4.8
NW-028	62.4	-5.9		**NW-066**	61.7	-4.8
NW-029	63.3	-0.2		**NW-067**	62.1	-4.3
NW-030	63.4	-0.2		**NW-068**	63.9	-2.8
NW-031	63.0	-0.1		**NW-069**	64.8	-1.7
NW-032	62.8	0.0		**NW-070**	64.1	-2.3
NW-033	62.7	0.1		**NW-071**	63.6	-2.0
NW-034	62.6	0.0		**NW-072**	64.1	-1.4
NW-035	62.6	0.1		**NW-073**	63.8	-1.6
NW-036	62.5	0.0		**NW-074**	63.3	-2.0
NW-037	62.5	0.0		**NW-075**	63.8	-1.6
NW-038	62.6	0.0				

Table 2c. *Future* Conditions *With* Mitigation Noise Modeling Results, Southwest Receptors

Receptor	L_{dn} (dBA)	Reduction *With* Mitigation (dBA)		Receptor	L_{dn} (dBA)	Reduction *With* Mitigation (dBA)
SW-001	60.7	0.0		**SW-041**	59.3	0.0
SW-002	61.5	-0.5		**SW-042**	59.5	0.0
SW-003	61.3	-4.2		**SW-043**	60.0	0.1
SW-004	61.3	-3.7		**SW-044**	60.1	0.0
SW-005	61.1	-3.6		**SW-045**	60.1	0.0
SW-006	60.7	-3.7		**SW-046**	60.3	0.1
SW-007	60.0	-3.0		**SW-047**	61.0	0.0
SW-008	60.6	-3.5		**SW-048**	61.7	0.1
SW-009	60.4	-3.5		**SW-049**	61.7	0.0
SW-010	60.3	-3.3		**SW-050**	61.7	0.0
SW-011	60.9	-2.6		**SW-051**	61.2	0.0
SW-012	63.0	-0.6		**SW-052**	61.1	0.0
SW-013	62.9	0.1		**SW-053**	61.5	0.1
SW-014	62.4	0.2		**SW-054**	61.2	0.0
SW-015	61.7	0.3		**SW-055**	60.8	0.0
SW-016	63.6	0.3		**SW-056**	60.3	0.0
SW-017	64.2	0.3		**SW-057**	60.9	0.0
SW-018	63.8	0.2		**SW-058**	59.6	0.0
SW-019	63.4	0.3		**SW-059**	60.3	0.1
SW-020	62.9	0.3		**SW-060**	62.0	0.0
SW-021	62.6	0.3		**SW-061**	61.6	0.0
SW-022	62.3	0.2		**SW-062**	61.3	0.0
SW-023	62.1	-1.5		**SW-063**	60.0	0.4
SW-024	61.9	-1.2		**SW-064**	60.2	0.0
SW-025	61.8	-0.8		**SW-065**	59.7	-2.3
SW-026	61.6	-0.7		**SW-066**	59.9	-1.7
SW-027	61.5	0.2		**SW-067**	60.7	0.0
SW-028	61.4	0.2		**SW-068**	60.5	0.0
SW-029	61.2	0.1		**SW-069**	60.2	0.0
SW-030	61.1	0.2		**SW-070**	59.9	0.0
SW-031	61.0	0.2		**SW-071**	59.5	0.0
SW-032	60.8	0.1		**SW-072**	58.6	0.0
SW-033	60.7	0.1		**SW-073**	58.3	0.0
SW-034	60.5	0.1		**SW-074**	59.7	0.0
SW-035	60.4	0.1		**SW-075**	60.6	0.0
SW-036	60.1	0.1		**SW-076**	61.2	0.0
SW-037	60.1	0.0		**SW-077**	61.0	0.0
SW-038	60.3	0.0		**SW-078**	60.2	0.0
SW-039	60.0	0.0		**SW-079**	60.1	0.0
SW-040	59.9	0.0		**SW-080**	60.9	0.0

5.3. Noise Mitigation Details

The noise model was used to determine the minimum barrier heights required to achieve noise levels below 65 dBA L_{dn}. Taller barriers may be used at the discretion of the City of Saskatoon. Note that taller barriers will provide additional mitigation and allow for a larger margin for error in the noise modeling results.

Note also that the noise barrier heights are based on the projected topographical information associated with the Interchange design. If the final topography, relative to the modeled values, differs for any of the noise barriers, then the noise barrier height requirements may need to be adjusted accordingly. A spreadsheet with the detailed noise barrier geometries is provided along with the report.

Finally, note that the design of the Interchange was modified relative to that which was used in the noise model, after the noise modeling results were calculated. The change involved using bridges in place of the two north/south tunnels. Relative to a tunnel, a bridge will perform similarly due to the reflective nature of the retaining walls, road surface, and underside of the bridge structure as well as the shielding provided by the retaining walls and bridge structure. The fundamental noise difference will be slightly more open area on either side of the bridge, that would otherwise have been closed-in with a tunnel. All other topographical and road configurations remain the same. The modeling results for the original design indicated that the specific roads for which this change applies have a much lower contribution to the overall noise climate than other roads in the area due to their relatively low traffic volumes and the fact that they are lower in elevation. Given the already relatively low noise impact and the relatively short length of the specific portions of road that this change applies to, this change will not have a significant impact on the noise levels within the surrounding area and the noise mitigation information provided below will not be affected.

5.3.1. Northeast Receptors

The minimum required noise barriers for the northeast receptors are indicated in Figure 4 and are as follows:

- Existing 3.3m tall noise barrier to the south of the residential development (north of Highway 16) was cut short by approximately 100 m to accommodate the Interchange
- New noise barrier starting at the shortened west end of the existing 3.3 m tall barrier. 2.44 m noise barrier height. Approximately 232 m noise barrier length.

- New noise barrier starting at end of 2.44 m noise barrier. 1.83 m noise barrier height. Approximately 230 m noise barrier length.
- New noise barrier starting at end of 1.83 m noise barrier. 3.0 m noise barrier height. Approximately 275 m noise barrier length.
- New noise barrier starting at end of 3.0 m noise barrier. 1.83 m noise barrier height. Approximately 845 m noise barrier length. Ending at location of existing barrier at the north end of the study area.

In general, the new noise barrier should be located on top of (i.e. at the centerline of) the existing/modified earth berm to allow for the greatest amount of noise barrier effect. At a minimum, the new noise barrier must be at least 12 m from the road curb. Note that within the northeast area, some sections do not require a noise barrier at all, however, a continuous noise barrier with no breaks is required in order to achieve noise levels below 65 dBA L_{dn} for all receptors. As such, a minimum 1.83 m noise barrier height was used throughout with taller sections where required. Sections with noise barrier heights beyond 1.83 m were extended for at least 1-full residential lot beyond the residential lot requiring the taller noise barrier to minimize flanking around the taller noise barrier. As mentioned in Section 2.0, previous noise studies in this area indicate that the existing noise barrier to the north (south of Taylor Street) is insufficient to achieve 65 dBA L_{dn}. However, that was not part of this study area and additional heights for that specific noise barrier were not included in this noise assessment.

5.3.2. Northwest Receptors

The minimum required noise barriers for the northwest receptors are indicated in Figure 5 and are as follows:

- New noise barrier starting at the north, approximately 35 m north of the north-most residential lot. 1.83 m noise barrier height. Approximately 575 m noise barrier length.
- New noise barrier starting at end of 1.83 m noise barrier. 3.0 m noise barrier height. Approximately 90 m noise barrier length.
- New noise barrier starting at end of 3.0 m noise barrier. 3.5 m noise barrier height. Approximately 215 m noise barrier length, ending at northwest end of the existing earth berm that is located directly to the northwest of the Interchange. Noise barrier height can be tapered as it climbs the earth berm such that the overall top height is maintained.

- New noise barrier starting at the southwest end of the existing earth berm that is located directly to the northwest of the Interchange. Noise barrier height can be tapered as it climbs the earth berm such that the overall top height is maintained. 4.0 m noise barrier height. Approximately 715 m noise barrier length. Locate noise barrier as close to the rear alleyway as practical.
- New noise barrier starting at the end of 4.0 m noise barrier. 2.44 m noise barrier height. Approximately 305 m noise barrier length. Locate noise barrier as close to the rear alleyway as practical. Wrap west end around to the north along Preston Avenue as far as practical.

In general, the new noise barrier should be located on top of (i.e. at the centerline of) the existing/modified earth berms to allow for the greatest amount of noise barrier effect. At a minimum, the new noise barrier must be at least 12 m from the road curb. Note that within the northeast area, some sections do not require a noise barrier at all, however, a continuous noise barrier with no breaks is required on the east side and on the south side in order to achieve noise levels below 65 dBA L_{dn} for all receptors. As such, a minimum 1.83 m barrier height was used throughout (with the exception of the earth berm directly to the northwest of the Interchange which functions as a noise barrier, assuming that it remains as part of the Project). Sections requiring noise arrier heights beyond 1.83 m were extended at for least 1-full residential lot beyond the residential lot requiring the taller noise barrier to minimize flanking around the taller noise barrier.

5.3.3. Southwest Receptors

The minimum required noise barrier for the southwest receptors is indicated in Figure 6 and includes a 1.83 m noise barrier, starting to the west of the row-style housing (wrapping around to the south for approximately 15 m) and extending to the east for approximately 275 m. The new noise barrier should be located on top of (i.e. centerline of) the existing earth berm.

5.3.4. General Barrier Information

In terms of meeting the minimum noise reduction requirements, noise barrier construction can be either solid screen wood fences or masonry noise walls or earth berms or combinations of the various materials. If using wood materials, the fences should be, at a minimum, double boarded with no visible gaps through the fence or at the bottom and have a surface density of at least 20 kg/m^2. A sample schematic of fence construction is provided in Figure 7. For masonry noise walls, there should also be no visible gaps and the surface density must also be at least 20 kg/m^2. Note that the materials used are subject to local building codes and practices. For example, most municipalities will not allow wood to be used for noise barrier heights taller than 2.44 m (8 ft).

For areas where noise barrier heights change from one height to another, the change can either be abrupt or gradual, as long as the minimum height is achieved throughout.

6.0 Conclusion

The results of the noise modeling under *future* conditions *without* mitigation indicate noise levels that are modeled to be above 65 dBA L_{dn} for most of the receptors to the northeast and northwest of the Interchange and for a small portion of receptors to the southwest of the Interchange. The maximum modeled noise level was 69.6 dBA L_{dn}. As such, noise mitigation will be required to achieve noise levels below 65 dBA L_{dn}.

The results of the noise modeling under *future* conditions *with* mitigation indicate noise levels that are modeled to be below 65 dBA L_{dn} for all of the residential receptors within the study area. The maximum modeled noise level was 64.9 dBA L_{dn} and the noise level reduction, relative to the *future* noise levels *without* mitigation, ranges from -0.0 to -6.2 dBA.

In order to achieve *future* noise levels below 65 dBA L_{dn} throughout the entire study area, noise barriers are required for almost all of the northeast and northwest areas (with the exception of the existing earth berm located directly northwest of the Interchange) as well as for a small portion of the southwest area. The new noise barrier heights range from 1.83 m (6 ft) to 4.0 m. The total running length of the new noise barriers is approximately 3,760 m.

7.0 References

- International Organization for Standardization (ISO), *Standard 1996-1, Acoustics – Description, measurement and assessment of environmental noise – Part 1: Basic quantities and assessment procedures, 2003*, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-1, Acoustics – Attenuation of sound during propagation outdoors – Part 1: Calculation of absorption of sound by the atmosphere, 1993*, Geneva Switzerland.
- International Organization for Standardization (ISO), *Standard 9613-2, Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation, 1996*, Geneva Switzerland.

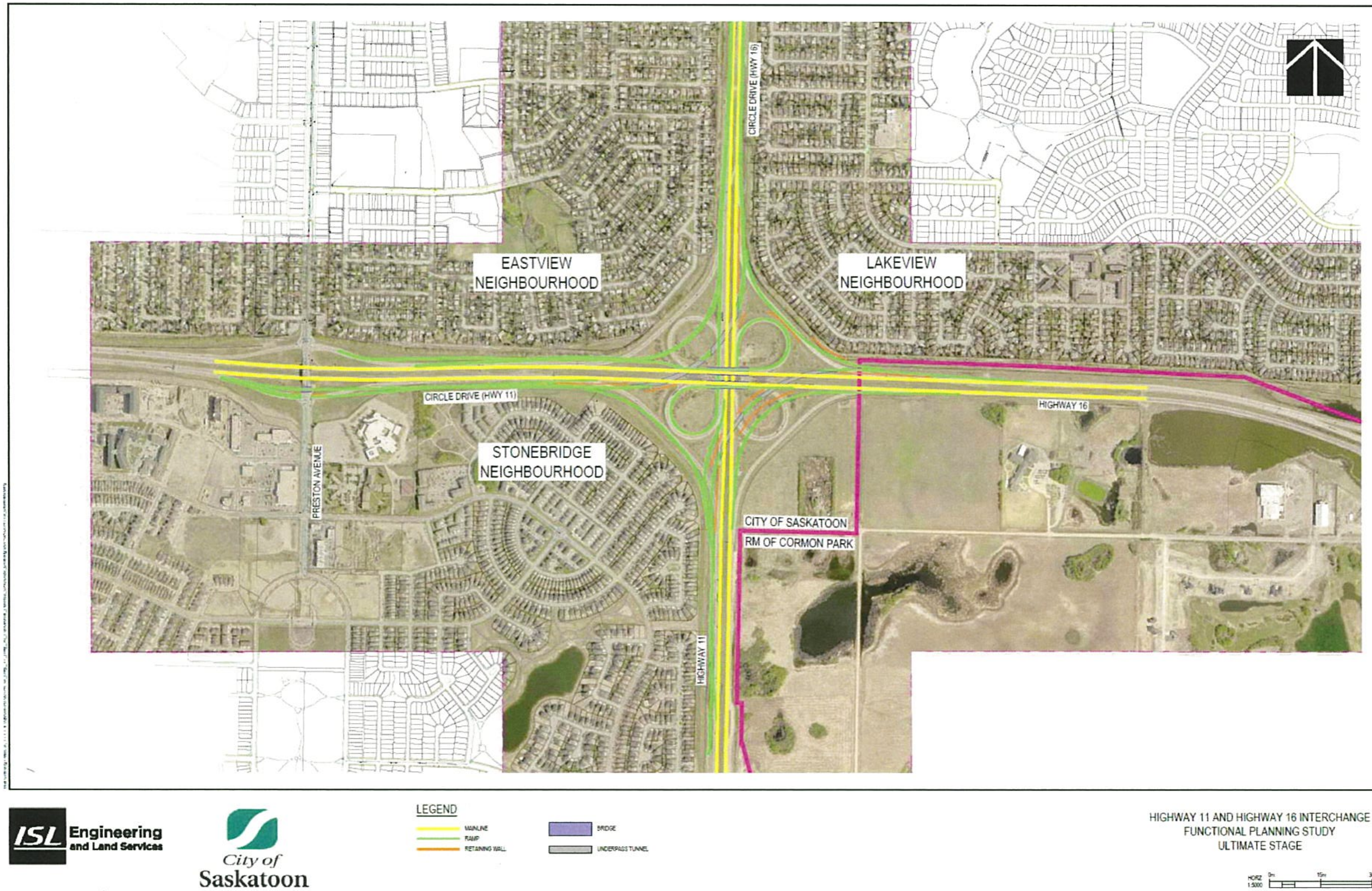


Figure 1. Study Area

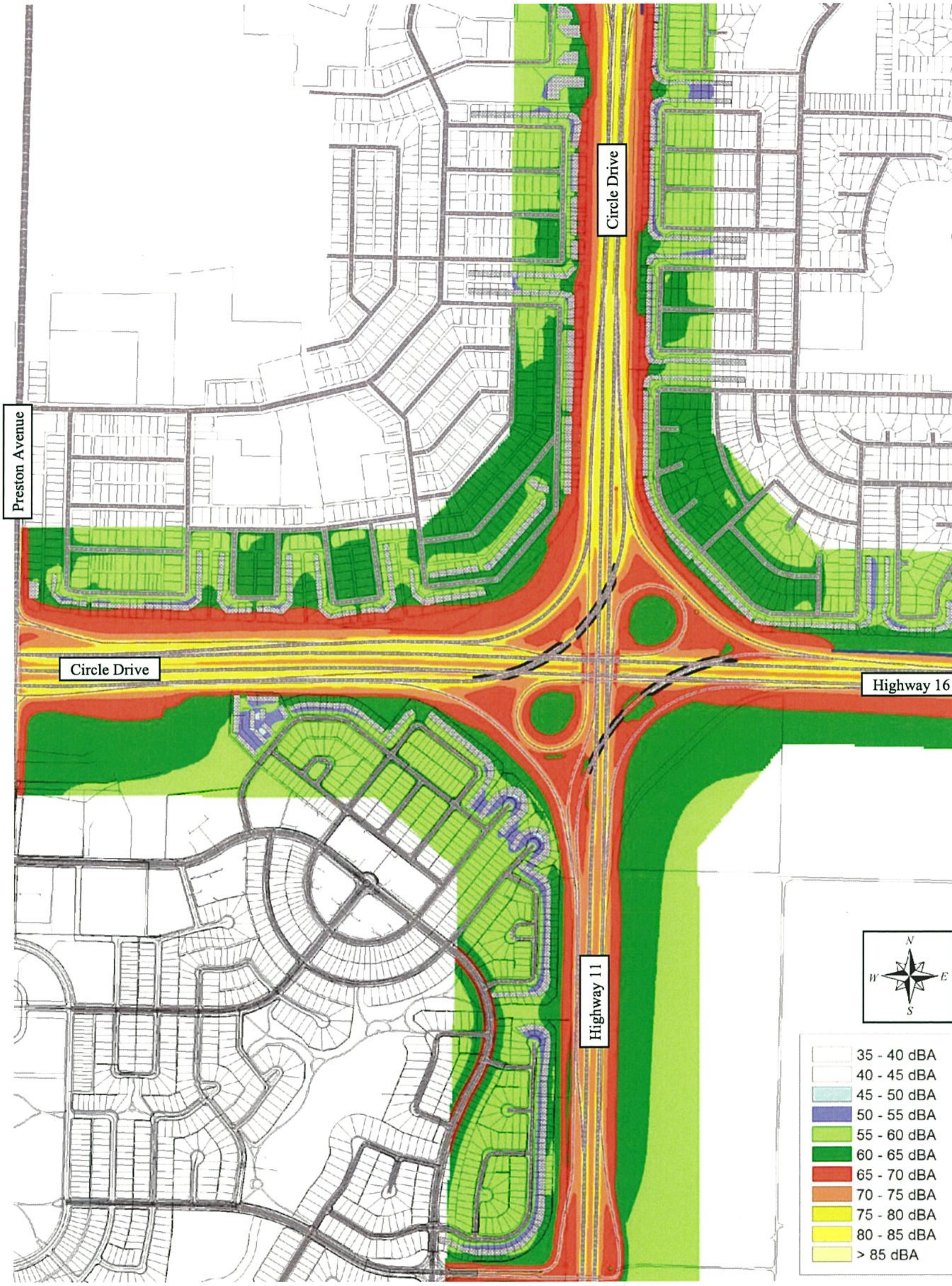


Figure 2a. *Future* Conditions *Without* Mitigation Noise Modeling Results, Overall Study Area (L_{dn})

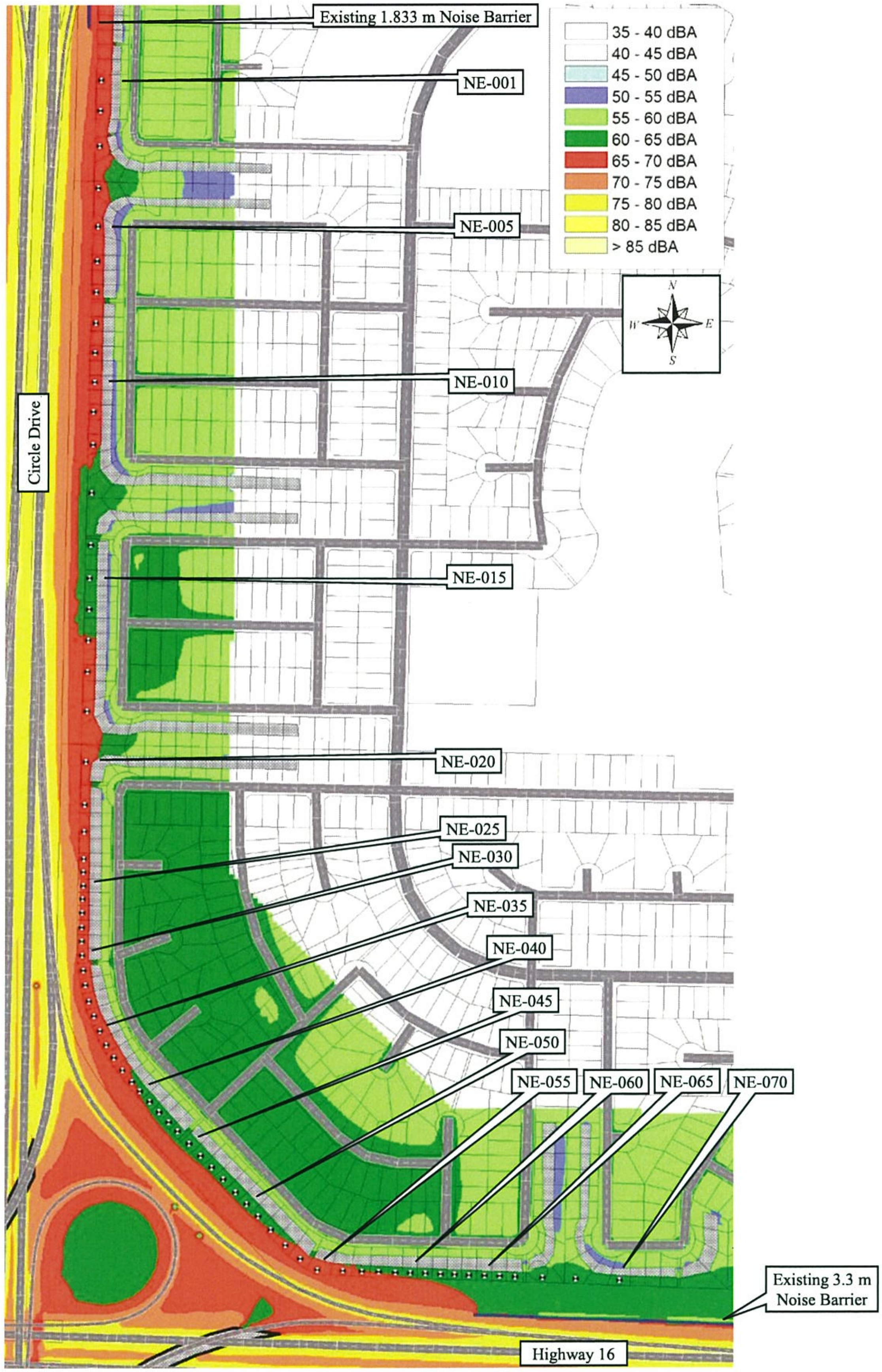


Figure 2b. *Future* Conditions *Without* Mitigation Noise Modeling Results, Northeast Receptors (L_{dn})

Figure 2c. *Future* Conditions *Without* Mitigation Noise Modeling Results, Northwest Receptors (L_{dn})

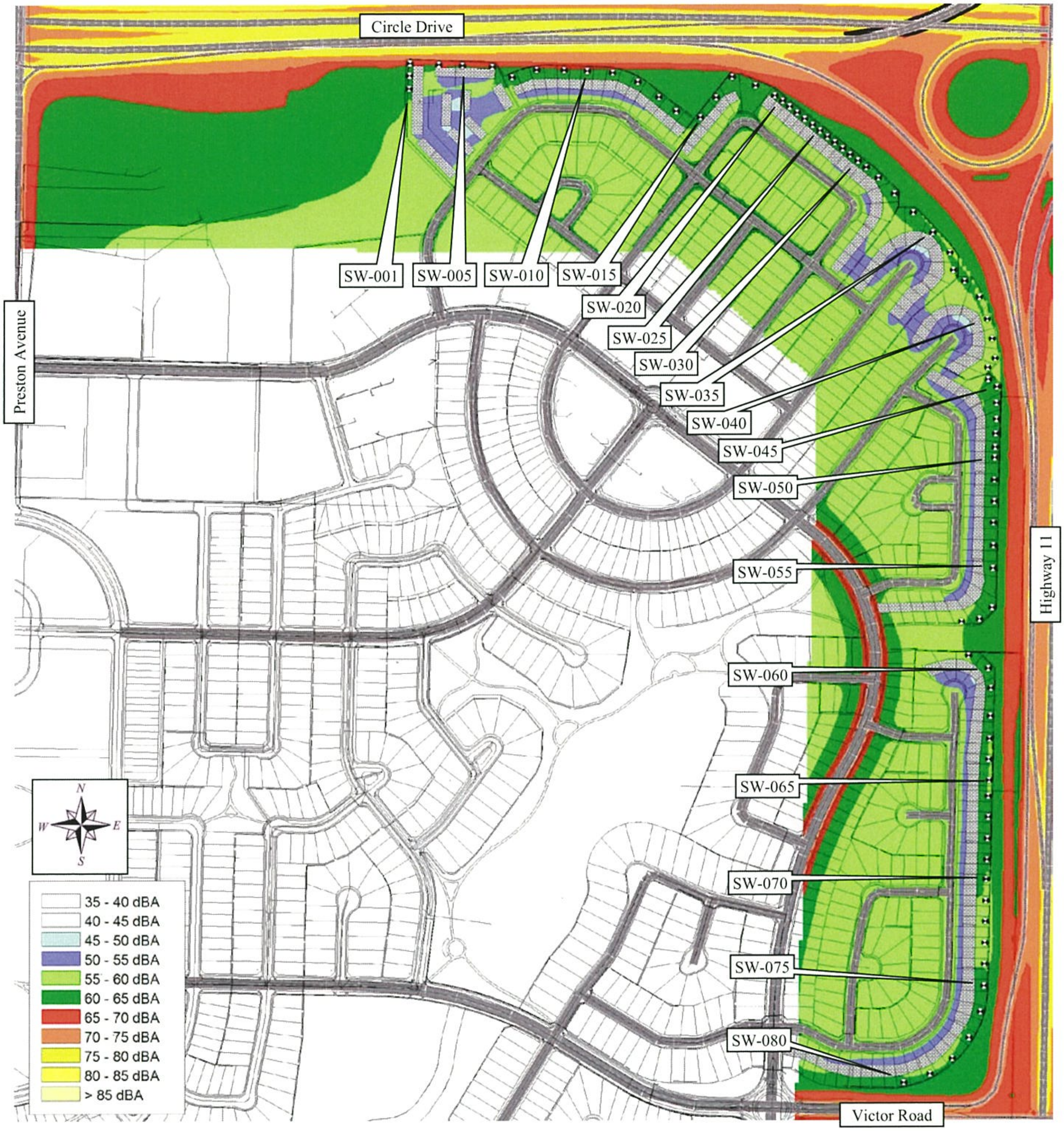


Figure 2d. *Future* Conditions *Without* Mitigation Noise Modeling Results, Southwest Receptors (L_{dn})

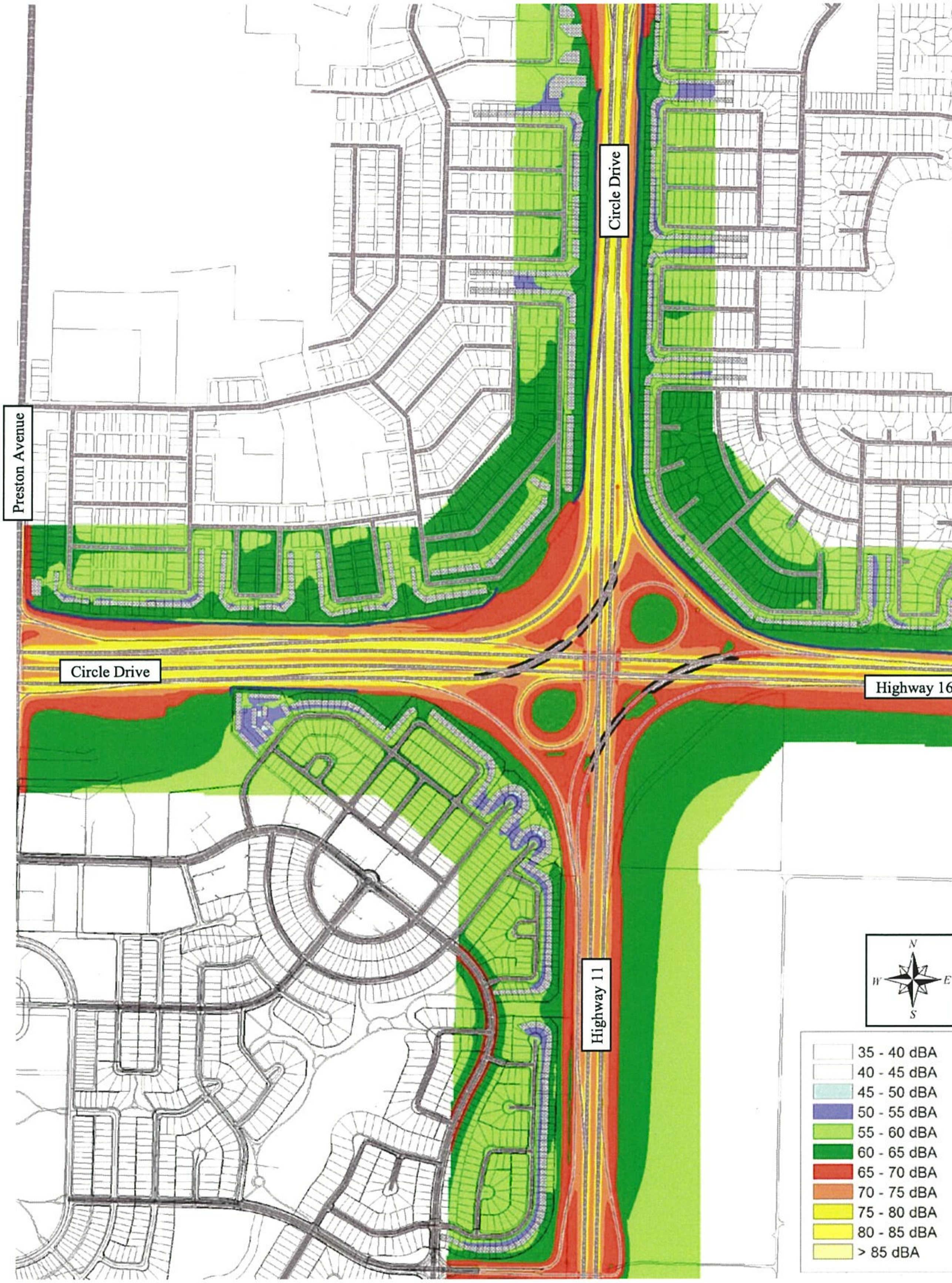


Figure 3a. *Future* Conditions *With* Mitigation Noise Modeling Results, Overall Study Area (L_{dn})

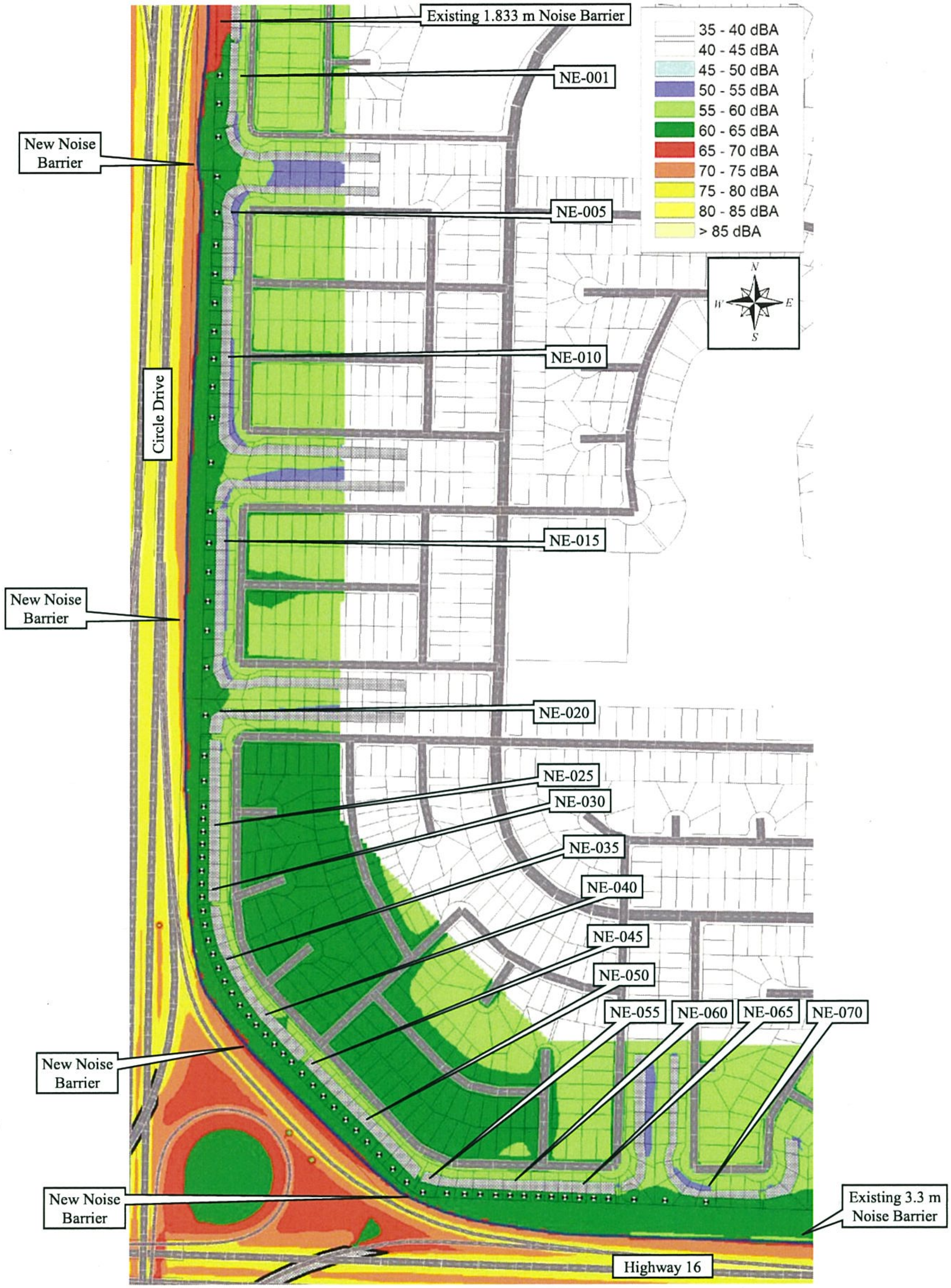


Figure 3b. *Future* Conditions *With* Mitigation Noise Modeling Results, Northeast Receptors (L_{dn})

Figure 3c. *Future* Conditions *With* Mitigation Noise Modeling Results, Northwest Receptors (L_{dn})

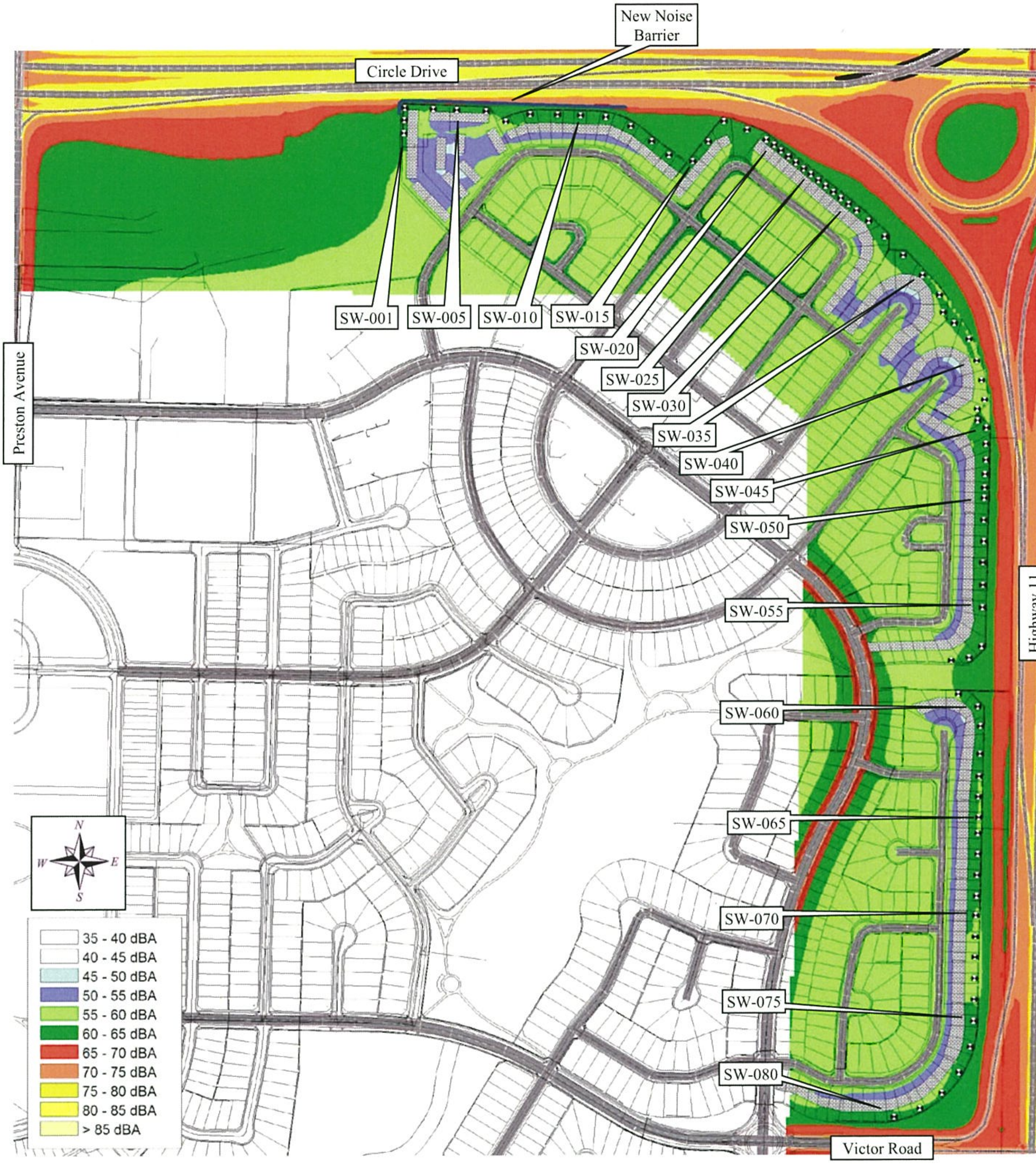


Figure 3d. *Future* Conditions *With* Mitigation Noise Modeling Results, Southwest Receptors (L_{dn})

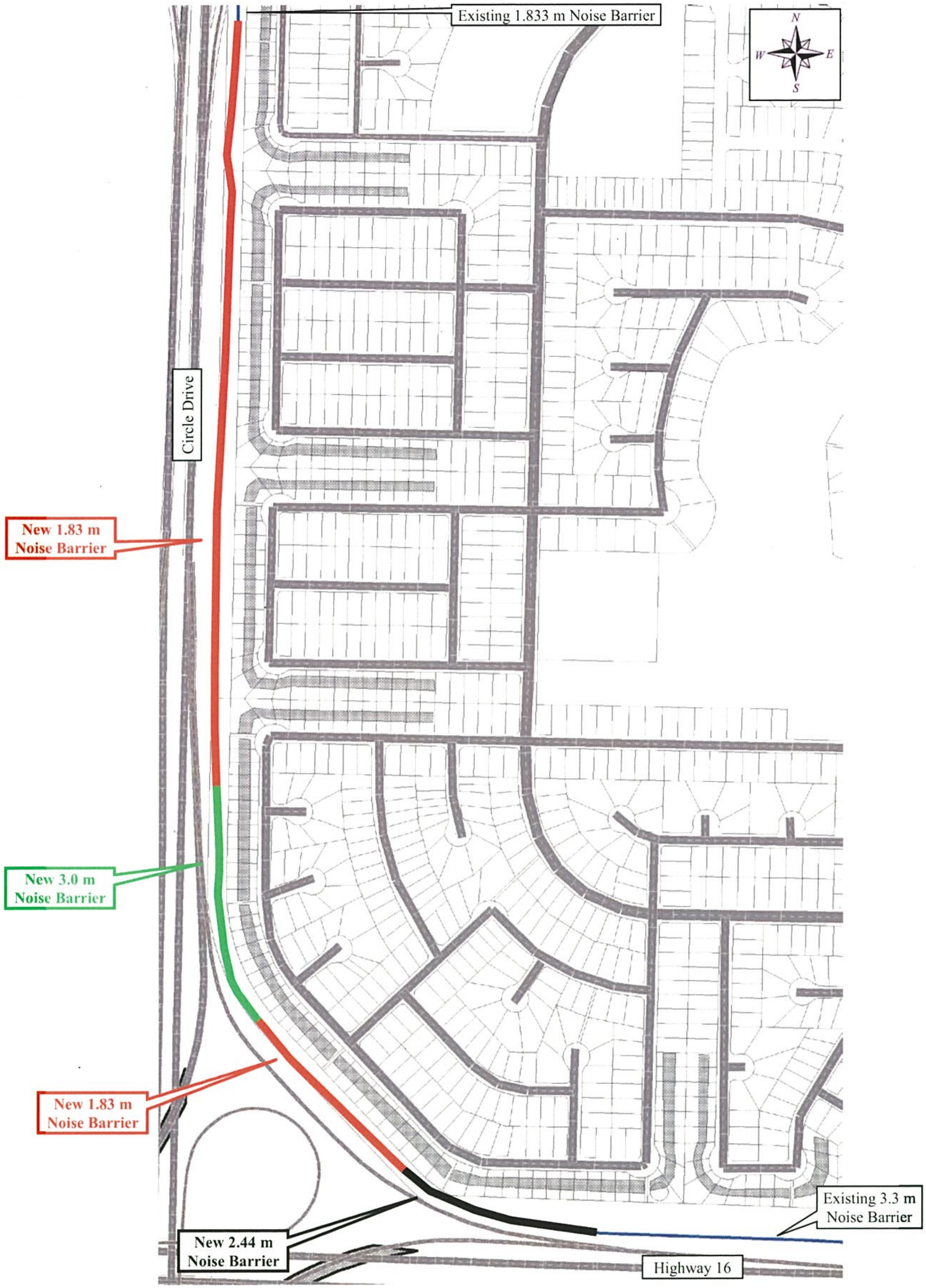


Figure 4. Noise Barrier Locations, Northeast Receptors

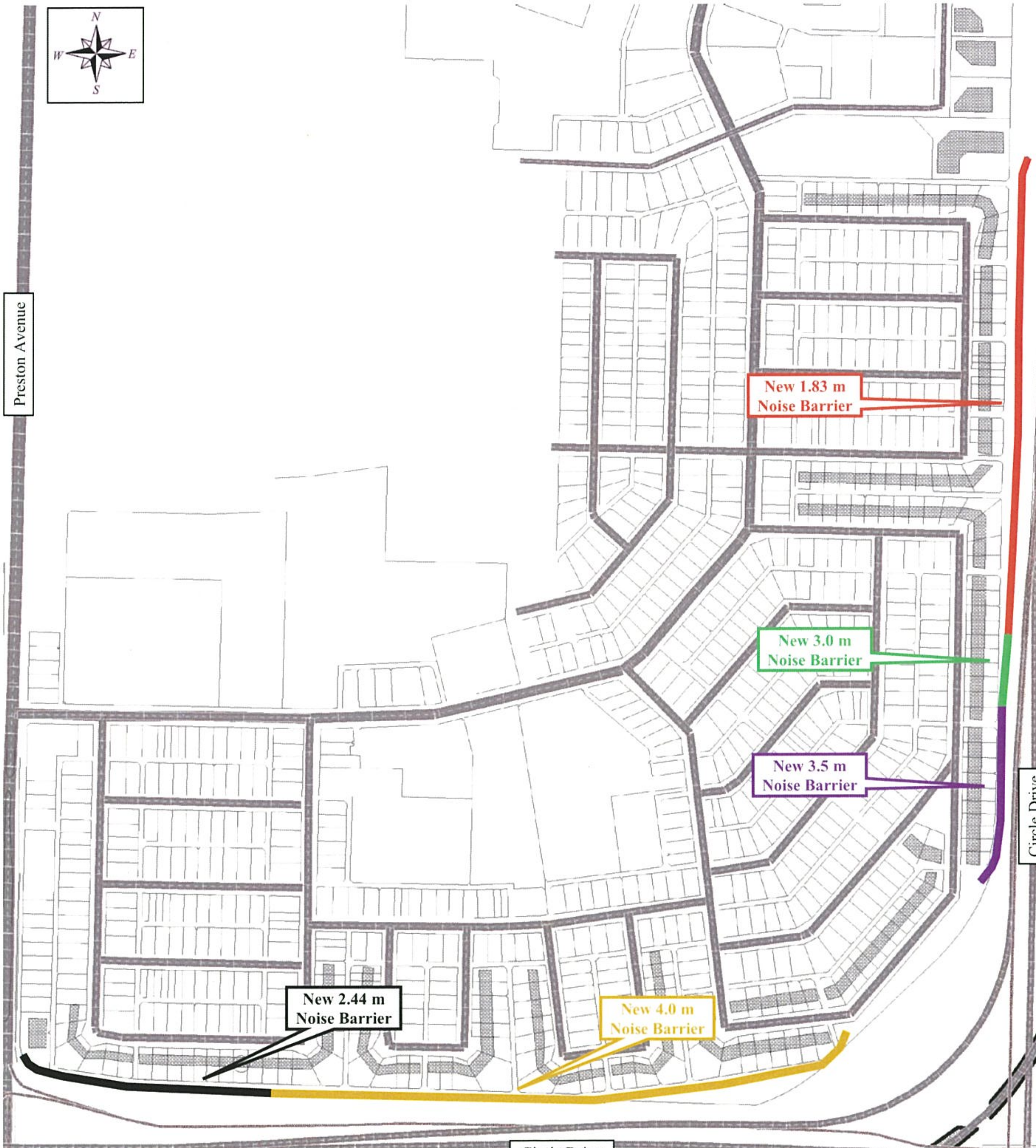


Figure 5. Noise Barrier Locations, Northwest Receptors

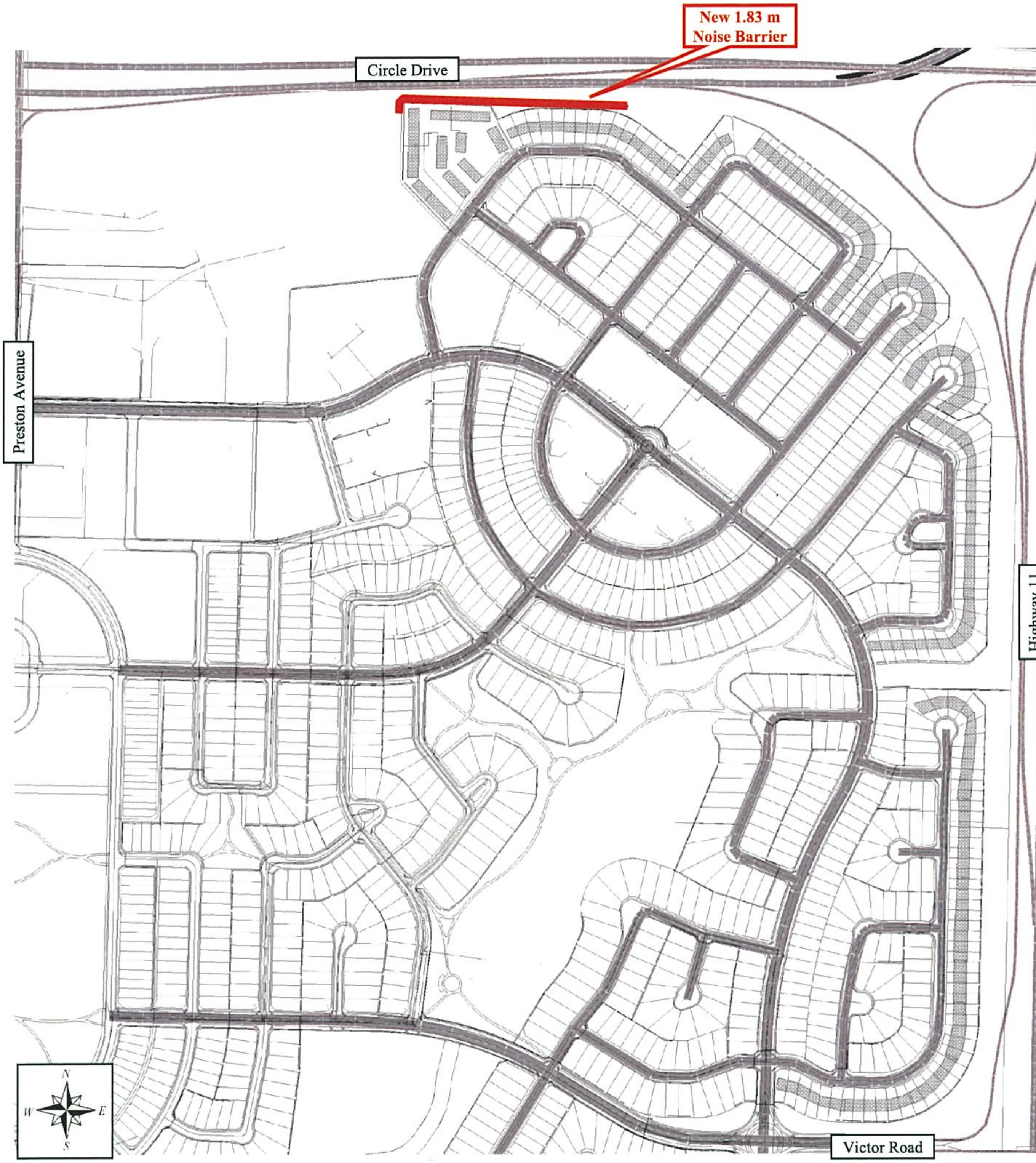


Figure 6. Noise Barrier Locations, Southwest Receptors

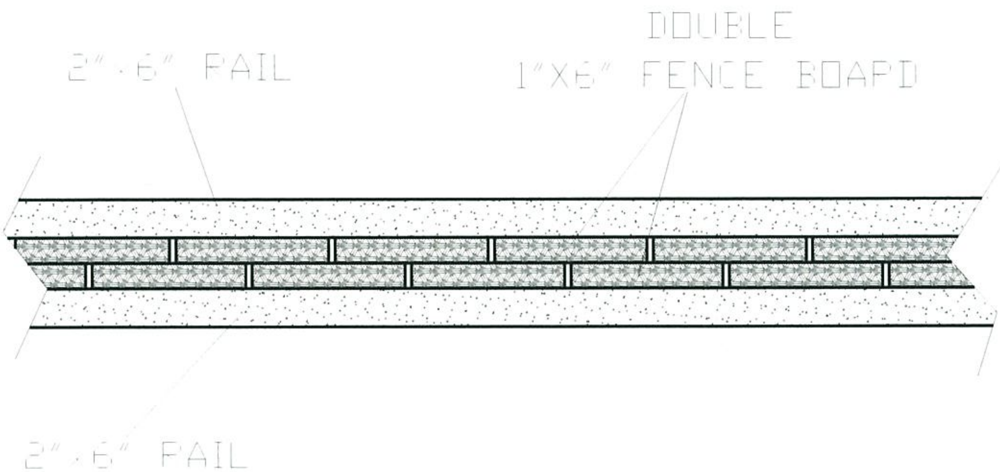


Figure 7. Minimum Recommended Wooden Fence Construction Sectional View

Appendix I NOISE MODELING PARAMETERS

Future Vehicle Traffic

Road	Day (Vehicles Per Hour)	Day % Heavy Vehicles	Night (Vehicles Per Hour)	Night % Heavy Vehicles	Speed (km/hr)	Total Volume (vehicles per day)
Circle Drive West of Preston Avenue (EB)	1492	7	273	7	90	24847
Circle Drive West of Preston Avenue (WB)	1864	8	341	8	90	31037
Circle Drive East of Preston Avenue (EB)	422	7	77	7	90	7033
Circle Drive East of Preston Avenue (WB)	841	8	154	8	90	14007
Highway 16 East of Highway 11 (EB)	667	10	122	10	100	11106
Highway 16 East of Highway 11 (WB)	1244	10	228	10	100	20703
Highway 11 South of Circle Drive (NB)	412	7	76	7	100	6862
Highway 11 South of Circle Drive (SB)	450	7	82	7	100	7486
Circle Drive at Highway 16 (NB)	327	7	60	7	90	5444
Circle Drive at Highway 16 (SB)	337	7	62	7	90	5609
Circle Drive South of Taylor Street (NB)	1558	6	285	6	90	25932
Circle Drive North of Taylor Street (SB)	1506	6	276	6	90	25068
Preston Avenue South of Circle Drive	721	4	133	4	60	12006
Preston Avenue at Circle Drive Bridge	240	4	45	4	60	4008
Preston Avenue North of Circle Drive	721	4	133	4	60	12006
Preston Avenue NB to Circle Drive NB (Ramp)	157	8	29	8	80	2606
Preston Avenue NB to Highway 16 EB (Ramp)	60	7	11	7	80	1000
Preston Avenue NB to Circle Drive WB Ramp	72	4	14	4	80	1209
Preston Avenue SB to Circle Drive NB (Ramp)	157	8	29	8	80	2606
Preston Avenue SB to Circle Drive WB Ramp	72	4	14	4	70	1209
Highway 11 NB to Preston Avenue NB (Ramp)	23	7	4	7	70	390
Highway 11 NB to Preston Avenue SB (Ramp)	23	7	4	7	70	390
Circle Drive SB to Preston Avenue NB (Ramp)	210	4	38	4	80	3490
Circle Drive SB to Preston Avenue SB (Ramp)	210	4	38	4	80	3490
Circle Drive EB to Preston Avenue SB Ramp	72	4	14	4	70	1209
Circle Drive EB to Preston Avenue NB Ramp	72	4	14	4	70	1209
Circle Drive EB to Highway 11 SB (Ramp)	118	7	22	7	80	1959
Circle Drive EB to Victor Road (Ramp)	56	7	10	7	80	936
Circle Drive EB to Circle Drive NB (Ramp)	896	7	164	7	80	14919
Highway 11 NB to Highway 16 EB (Ramp)	39	4	7	4	80	645
Highway 11 NB to Circle Drive WB (Ramp)	103	4	19	4	70	1710
Highway 16 WB to Circle Drive NB (Ramp)	351	12	64	12	80	5842
Highway 16 WB to Circle Drive SB (Ramp)	51	8	9	8	80	855
Circle Drive SB to Circle Drive WB (Ramp)	920	4	168	4	80	15315
Circle Drive SB to Highway 16 EB (Ramp)	206	18	38	18	70	3427
Circle Drive SB to Victor Road (Ramp)	56	7	10	7	80	936
Circle Drive North of Taylor Street NB	1558	7	286	7	90	25941
Circle Drive North of Taylor Street SB	1506	7	277	7	90	25077
Taylor Street West of Circle Drive EB	679	5	125	5	50	11307
Taylor Street West of Circle Drive WB	679	5	125	5	50	11307
Taylor Street East of Circle Drive EB	850	3	157	3	50	14156
Taylor Street East of Circle Drive WB	850	3	157	3	50	14156
Circle Drive NB to Taylor Street Ramp	411	4	76	4	50	6852
Taylor Street to Circle Drive NB Ramp	462	4	86	4	90	7707
Circle Drive SB to Taylor Street Ramp	516	4	96	4	50	8607
Taylor Street to Circle Drive SB Ramp	376	4	70	4	90	6277
Victor Road to Highway 11 NB (Ramp)	103	7	19	7	70	1716
Boychuk Drive North of Highway 16 (NB)	306	4	57	4	60	5108
Boychuk Drive North of Highway 16 (SB)	288	4	54	4	60	4808
Boychuk Drive South of Highway 16	300	4	56	4	90	5008
Boychuk Drive and Highway 16 Ramp	120	4	23	4	80	2009
Boychuk Drive and Highway 16 Ramp	120	4	23	4	80	2009
Boychuk Drive and Highway 16 Ramp	120	4	23	4	80	2009
Boychuk Drive and Highway 16 Ramp	120	4	23	4	80	2009
Boychuk Drive and Highway 16 Ramp	120	4	23	4	80	2009
Boychuk Drive and Highway 16 Ramp	120	4	23	4	80	2009
Collector Roads	300	4	56	4	60	5008
Residential Streets	12	3	3	3	50	209

General Noise Modeling Parameters

Parameter	Value
Modeling Software	CADNA/A (Version 2007, Build 159.4707)
Standard Followed	RLS-90 / ISO 9613-2
Ground Sound Absorption Coefficient	0.5
Wind Speed	1 - 5 m/s (3.6 - 18 km/hr)
Wind Direction	Downwind from all sources to all receptors
Temperature	10 °C
Humidity	70%
Topography	Used Digital Terrain Model Contours Provided by Client

Appendix II THE ASSESSMENT OF ENVIRONMENTAL NOISE (GENERAL)

Sound Pressure Level

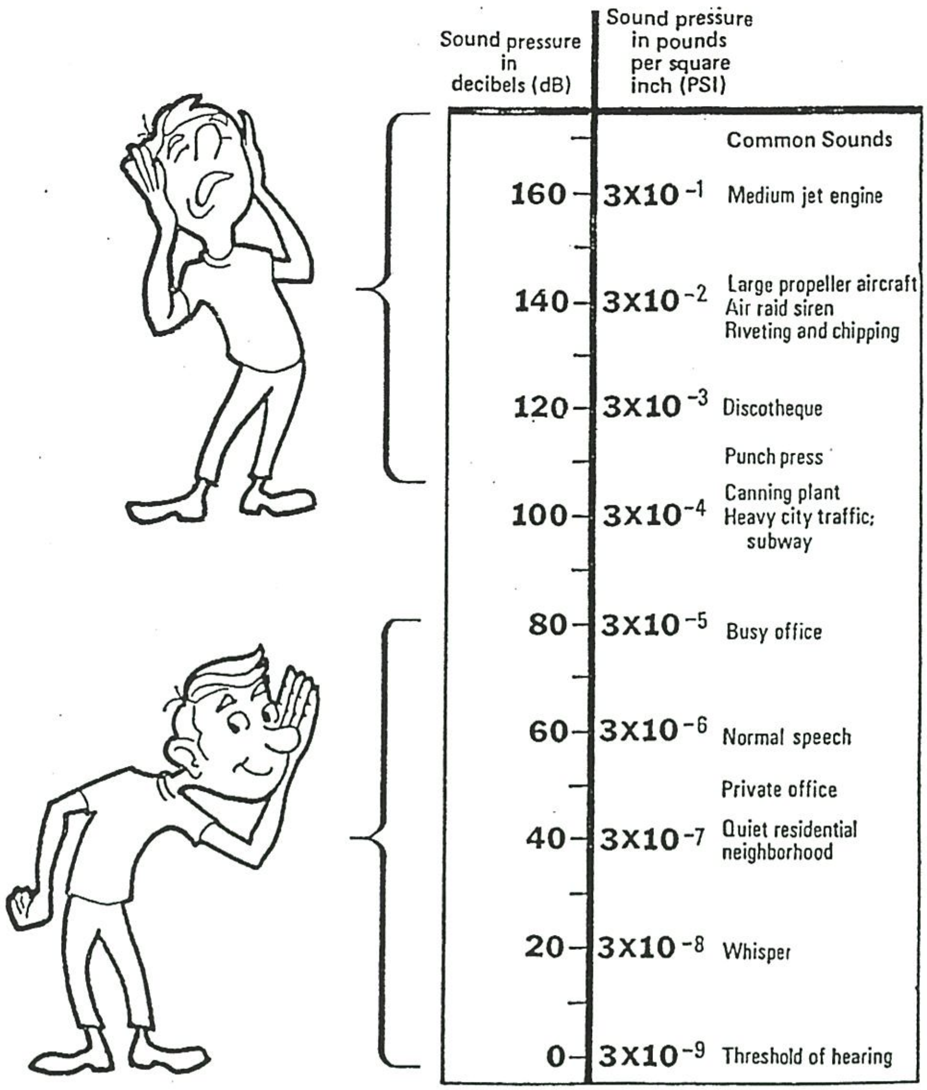
Sound pressure is initially measured in Pascal's (Pa). Humans can hear several orders of magnitude in sound pressure levels, so a more convenient scale is used. This scale is known as the decibel (dB) scale, named after Alexander Graham Bell (telephone guy). It is a base 10 logarithmic scale. When we measure pressure we typically measure the RMS sound pressure.

$$SPL = 10\log_{10}\left[\frac{P_{RMS}^{2}}{P_{ref}^{2}}\right] = 20\log_{10}\left[\frac{P_{RMS}}{P_{ref}}\right]$$

Where: SPL = Sound Pressure Level in dB
P_{RMS} = Root Mean Square measured pressure (Pa)
P_{ref} = Reference sound pressure level ($P_{ref} = 2 \times 10^{-5}$ Pa = 20 μPa)

This reference sound pressure level is an internationally agreed upon value. It represents the threshold of human hearing for "typical" people based on numerous testing. It is possible to have a threshold which is lower than 20 μPa which will result in negative dB levels. As such, zero dB does not mean there is no sound!

In general, a difference of 1 – 2 dB is the threshold for humans to notice that there has been a change in sound level. A difference of 3 dB (factor of 2 in acoustical energy) is perceptible and a change of 5 dB is strongly perceptible. A change of 10 dB is typically considered a factor of 2. This is quite remarkable when considering that 10 dB is 10-times the acoustical energy!


Sound pressure in decibels (dB)
Sound pressure in pounds per square inch (PSI)
Common Sounds
160 – 3X10 -1 Medium jet engine
140 – 3X10 -2 Large propeller aircraft
Air raid siren
Riveting and chipping
120 – 3X10 -3 Discotheque
Punch press
Canning plant
100 – 3X10 -4 Heavy city traffic; subway
80 – 3X10 -5 Busy office
60 – 3X10 -6 Normal speech
Private office
40 – 3X10 -7 Quiet residential neighborhood
20 – 3X10 -8 Whisper
0 – 3X10 -9 Threshold of hearing

Frequency

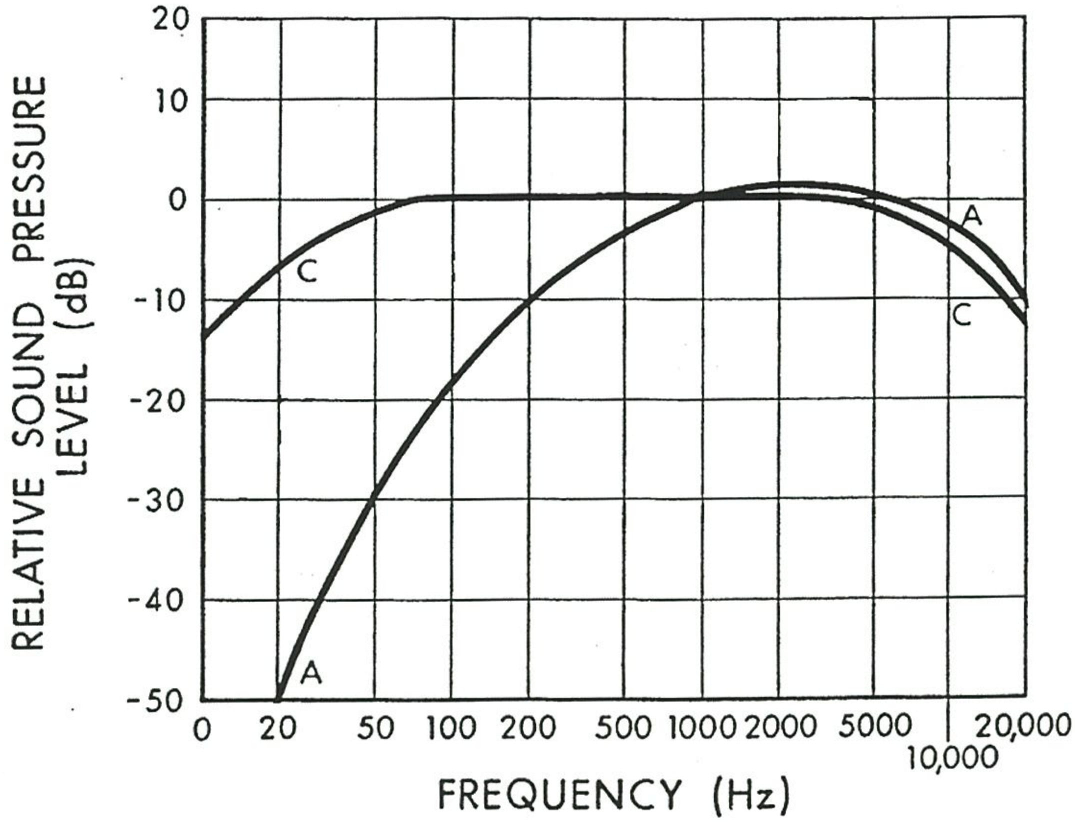
The range of frequencies audible to the human ear ranges from approximately 20 Hz to 20 kHz. Within this range, the human ear does not hear equally at all frequencies. It is not very sensitive to low frequency sounds, is very sensitive to mid frequency sounds and is slightly less sensitive to high frequency sounds. Due to the large frequency range of human hearing, the entire spectrum is often divided into 31 bands, each known as a 1/3 octave band.

The internationally agreed upon center frequencies and upper and lower band limits for the 1/1 (whole octave) and 1/3 octave bands are as follows:

Lower Band Limit	Whole Octave Center Frequency	Upper Band Limit
11	**16**	22
22	**31.5**	44
44	**63**	88
88	**125**	177
177	**250**	355
355	**500**	710
710	**1000**	1420
1420	**2000**	2840
2840	**4000**	5680
5680	**8000**	11360
11360	**16000**	22720

Lower Band Limit	1/3 Octave Center Frequency	Upper Band Limit
14.1	**16**	17.8
17.8	**20**	22.4
22.4	**25**	28.2
28.2	**31.5**	35.5
35.5	**40**	44.7
44.7	**50**	56.2
56.2	**63**	70.8
70.8	**80**	89.1
89.1	**100**	112
112	**125**	141
141	**160**	178
178	**200**	224
224	**250**	282
282	**315**	355
355	**400**	447
447	**500**	562
562	**630**	708
708	**800**	891
891	**1000**	1122
1122	**1250**	1413
1413	**1600**	1778
1778	**2000**	2239
2239	**2500**	2818
2818	**3150**	3548
3548	**4000**	4467
4467	**5000**	5623
5623	**6300**	7079
7079	**8000**	8913
8913	**10000**	11220
11220	**12500**	14130
14130	**16000**	17780
17780	**20000**	22390

Human hearing is most sensitive at approximately 3500 Hz which corresponds to the ¼ wavelength of the ear canal (approximately 2.5 cm). Because of this range of sensitivity to various frequencies, we typically apply various weighting networks to the broadband measured sound to more appropriately account for the way humans hear. By default, the most common weighting network used is the so-called "A-weighting". It can be seen in the figure that the low frequency sounds are reduced significantly with the A-weighting.



Combination of Sounds

When combining multiple sound sources the general equation is:

$$\Sigma SPL_n = 10\log_{10}\left[\sum_{i=1}^{n} 10^{\frac{SPL_i}{10}}\right]$$

Examples:

- Two sources of 50 dB each add together to result in 53 dB.
- Three sources of 50 dB each add together to result in 55 dB.
- Ten sources of 50 dB each add together to result in 60 dB.
- One source of 50 dB added to another source of 40 dB results in 50.4 dB

It can be seen that, if multiple similar sources exist, removing or reducing only one source will have little effect.

Sound Level Measurements

Over the years a number of methods for measuring and describing environmental noise have been developed. The most widely used and accepted is the concept of the Energy Equivalent Sound Level (L_{eq}) which was developed in the US (1970's) to characterize noise levels near US Air-force bases. This is the level of a steady state sound which, for a given period of time, would contain the same energy as the time varying sound. The concept is that the same amount of annoyance occurs from a sound having a high level for a short period of time as from a sound at a lower level for a longer period of time.
The L_{eq} is defined as:

$$L_{eq} = 10\log_{10}\left[\frac{1}{T}\int_0^T 10^{\frac{dB}{10}}\, dT\right] = 10\log_{10}\left[\frac{1}{T}\int_0^T \frac{P^2}{P_{ref}^2}\, dT\right]$$

We must specify the time period over which to measure the sound. i.e. 1-second, 10-seconds, 15-seconds, 1-minute, 1-day, etc. **An L_{eq} is meaningless if there is no time period associated**.

In general there a few very common L_{eq} sample durations which are used in describing environmental noise measurements. These include:

- L_{eq}24 - Measured over a 24-hour period
- L_{eq}Night - Measured over the night-time (typically 22:00 – 07:00)
- L_{eq}Day - Measured over the day-time (typically 07:00 – 22:00)
- L_{DN} - Same as L_{eq}24 with a 10 dB penalty added to the night-time

Statistical Descriptor

Another method of conveying long term noise levels utilizes statistical descriptors. These are calculated from a cumulative distribution of the sound levels over the entire measurement duration and then determining the sound level at xx % of the time.

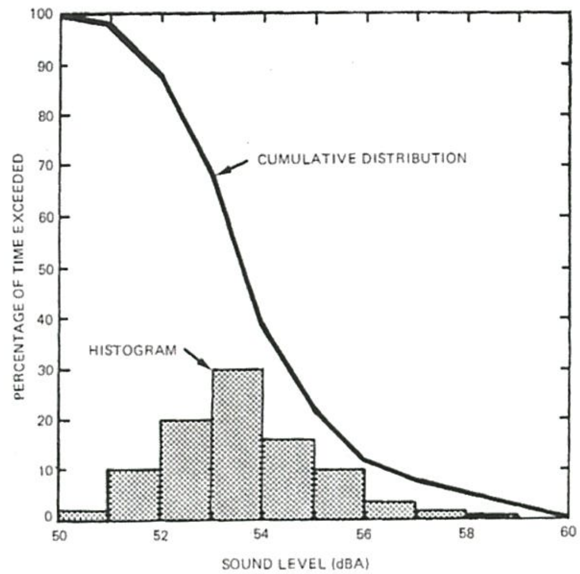


Figure 16.6 Statistically processed community noise showing histogram and cumulative distribution of A weighted sound levels.

Industrial Noise Control, Lewis Bell, Marcel Dekker, Inc. 1994

The most common statistical descriptors are:

L_{min} - minimum sound level measured
L_{01} - sound level that was exceeded only 1% of the time
L_{10} - sound level that was exceeded only 10% of the time.
- Good measure of intermittent or intrusive noise
- Good measure of Traffic Noise

L_{50} - sound level that was exceeded 50% of the time (arithmetic average)
- Good to compare to L_{eq} to determine steadiness of noise

L_{90} - sound level that was exceeded 90% of the time
- Good indicator of typical "ambient" noise levels

L_{99} - sound level that was exceeded 99% of the time
L_{max} - maximum sound level measured

These descriptors can be used to provide a more detailed analysis of the varying noise climate:

- If there is a large difference between the L_{eq} and the L_{50} (L_{eq} can never be any lower than the L_{50}) then it can be surmised that one or more short duration, high level sound(s) occurred during the time period.
- If the gap between the L_{10} and L_{90} is relatively small (less than 15 – 20 dBA) then it can be surmised that the noise climate was relatively steady.

Sound Propagation

In order to understand sound propagation, the nature of the source must first be discussed. In general, there are three types of sources. These are known as 'point', 'line', and 'area'. This discussion will concentrate on point and line sources since area sources are much more complex and can usually be approximated by point sources at large distances.

Point Source

As sound radiates from a point source, it dissipates through geometric spreading. The basic relationship between the sound levels at two distances from a point source is:

$$\therefore\ SPL_1 - SPL_2 = 20\log_{10}\left(\frac{r_2}{r_1}\right)$$

Where: SPL_1 = sound pressure level at location 1, SPL_2 = sound pressure level at location 2
r_1 = distance from source to location 1, r_2 = distance from source to location 2

Thus, the reduction in sound pressure level for a point source radiating in a free field is **6 dB per doubling of distance**. This relationship is independent of reflectivity factors provided they are always present. Note that this only considers geometric spreading and does not take into account atmospheric effects. Point sources still have some physical dimension associated with them, and typically do not radiate sound equally in all directions in all frequencies. The directionality of a source is also highly dependent on frequency. As frequency increases, directionality increases.

Examples (note no atmospheric absorption):

- A point source measuring 50 dB at 100m will be 44 dB at 200m.
- A point source measuring 50 dB at 100m will be 40.5 dB at 300m.
- A point source measuring 50 dB at 100m will be 38 dB at 400m.
- A point source measuring 50 dB at 100m will be 30 dB at 1000m.

Line Source

A line source is similar to a point source in that it dissipates through geometric spreading. The difference is that a line source is equivalent to a long line of many point sources. The basic relationship between the sound levels at two distances from a line source is:

$$SPL_1 - SPL_2 = 10\log_{10}\left(\frac{r_2}{r_1}\right)$$

The difference from the point source is that the '20' term in front of the 'log' is now only 10. Thus, the reduction in sound pressure level for a line source radiating in a free field is **3 dB per doubling of distance**.

Examples (note no atmospheric absorption):

- A line source measuring 50 dB at 100m will be 47 dB at 200m.
- A line source measuring 50 dB at 100m will be 45 dB at 300m.
- A line source measuring 50 dB at 100m will be 44 dB at 400m.
- A line source measuring 50 dB at 100m will be 40 dB at 1000m.

Atmospheric Absorption

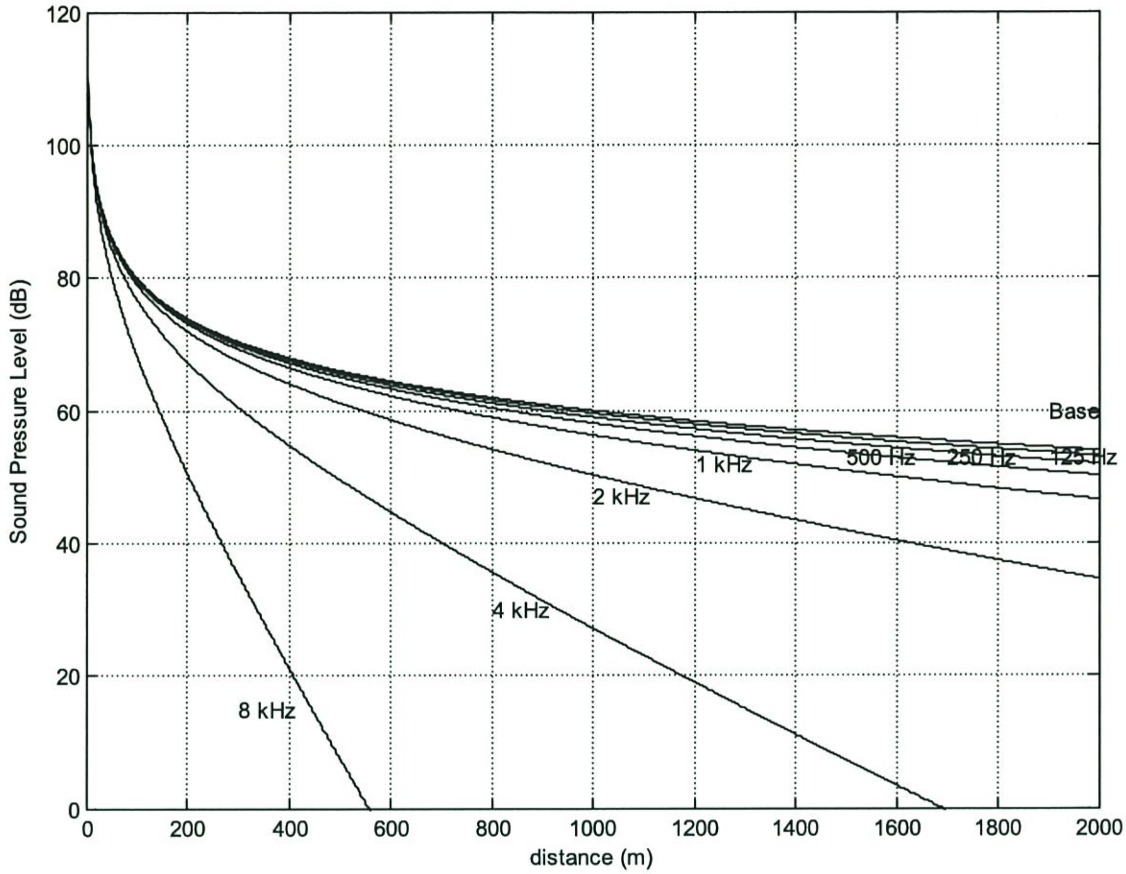
As sound transmits through a medium, there is an attenuation (or dissipation of acoustic energy) which can be attributed to three mechanisms:

1) **Viscous Effects** - Dissipation of acoustic energy due to fluid friction which results in thermodynamically irreversible propagation of sound.
2) **Heat Conduction Effects** - Heat transfer between high and low temperature regions in the wave which result in non-adiabatic propagation of the sound.
3) **Inter Molecular Energy Interchanges** - Molecular energy relaxation effects which result in a time lag between changes in translational kinetic energy and the energy associated with rotation and vibration of the molecules.

The following table illustrates the attenuation coefficient of sound at standard pressure (101.325 kPa) in units of dB/100m.

Temperature °C	Relative Humidity (%)	Frequency (Hz) 125	250	500	1000	2000	4000
30	20	0.06	0.18	0.37	0.64	1.40	4.40
	50	0.03	0.10	0.33	0.75	1.30	2.50
	90	0.02	0.06	0.24	0.70	1.50	2.60
20	20	0.07	0.15	0.27	0.62	1.90	6.70
	50	0.04	0.12	0.28	0.50	1.00	2.80
	90	0.02	0.08	0.26	0.56	0.99	2.10
10	20	0.06	0.11	0.29	0.94	3.20	9.00
	50	0.04	0.11	0.20	0.41	1.20	4.20
	90	0.03	0.10	0.21	0.38	0.81	2.50
0	20	0.05	0.15	0.50	1.60	3.70	5.70
	50	0.04	0.08	0.19	0.60	2.10	6.70
	90	0.03	0.08	0.15	0.36	1.10	4.10

- As frequency increases, absorption tends to increase
- As Relative Humidity increases, absorption tends to decrease
- There is no direct relationship between absorption and temperature
- **The net result of atmospheric absorption is to modify the sound propagation of a point source from 6 dB/doubling-of-distance to approximately 7 – 8 dB/doubling-of-distance (based on anecdotal experience)**



Atmospheric Absorption at 10ºC and 70% RH

Meteorological Effects

There are many meteorological factors which can affect how sound propagates over large distances. These various phenomena must be considered when trying to determine the relative impact of a noise source either after installation or during the design stage.

Wind

- Can greatly alter the noise climate away from a source depending on direction
- Sound levels downwind from a source can be increased due to refraction of sound back down towards the surface. This is due to the generally higher velocities as altitude increases.
- Sound levels upwind from a source can be decreased due to a "bending" of the sound away from the earth's surface.
- Sound level differences of ±10dB are possible depending on severity of wind and distance from source.
- Sound levels crosswind are generally not disturbed by an appreciable amount
- Wind tends to generate its own noise, however, and can provide a high degree of masking relative to a noise source of particular interest.

Temperature

- Temperature effects can be similar to wind effects
- Typically, the temperature is warmer at ground level than it is at higher elevations.
- If there is a very large difference between the ground temperature (very warm) and the air aloft (only a few hundred meters) then the transmitted sound refracts upward due to the changing speed of sound.
- If the air aloft is warmer than the ground temperature (known as an *inversion*) the resulting higher speed of sound aloft tends to refract the transmitted sound back down towards the ground. This essentially works on Snell's law of reflection and refraction.
- Temperature inversions typically happen early in the morning and are most common over large bodies of water or across river valleys.
- Sound level differences of ±10dB are possible depending on gradient of temperature and distance from source.

Rain

- Rain does not affect sound propagation by an appreciable amount unless it is very heavy
- The larger concern is the noise generated by the rain itself. A heavy rain striking the ground can cause a significant amount of highly broadband noise. The amount of noise generated is difficult to predict.
- Rain can also affect the output of various noise sources such as vehicle traffic.

Summary

- In general, these wind and temperature effects are difficult to predict
- Empirical models (based on measured data) have been generated to attempt to account for these effects.
- Environmental noise measurements must be conducted with these effects in mind. Sometimes it is desired to have completely calm conditions, other times a "worst case" of downwind noise levels are desired.

Topographical Effects

Similar to the various atmospheric effects outlined in the previous section, the effect of various geographical and vegetative factors must also be considered when examining the propagation of noise over large distances.

Topography

- One of the most important factors in sound propagation.
- Can provide a natural barrier between source and receiver (i.e. if berm or hill in between).
- Can provide a natural amplifier between source and receiver (i.e. large valley in between or hard reflective surface in between).
- Must look at location of topographical features relative to source and receiver to determine importance (i.e. small berm 1km away from source and 1km away from receiver will make negligible impact).

Grass

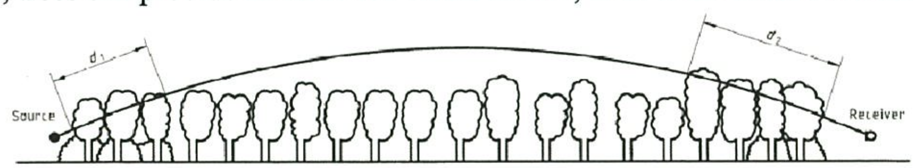
- Can be an effective absorber due to large area covered
- Only effective at low height above ground. Does not affect sound transmitted direct from source to receiver if there is line of sight.
- Typically less absorption than atmospheric absorption when there is line of sight.
- Approximate rule of thumb based on empirical data is:

$$A_g = 18\log_{10}(f) - 31 \qquad (dB/100m)$$

Where: A_g is the absorption amount

Trees

- Provide absorption due to foliage
- Deciduous trees are essentially ineffective in the winter
- Absorption depends heavily on density and height of trees
- No data found on absorption of various kinds of trees
- Large spans of trees are required to obtain even minor amounts of sound reduction
- In many cases, trees can provide an effective visual barrier, even if the noise attenuation is negligible.



NOTE — $d_f = d_1 + d_2$

For calculating d_1 and d_2, the curved path radius may be assumed to be 5 km.

Figure A.1 — Attenuation due to propagation through foliage increases linearly with propagation distance d_f through the foliage

Table A.1 — Attenuation of an octave band of noise due to propagation a distance d_f through dense foliage

Propagation distance d_f	Nominal midband frequency Hz							
m	63	125	250	500	1 000	2 000	4 000	8 000
	Attenuation, dB:							
$10 \leq d_f \leq 20$	0	0	1	1	1	1	2	3
	Attenuation, dB/m:							
$20 \leq d_f \leq 200$	0,02	0,03	0,04	0,05	0,06	0,08	0,09	0,12

Tree/Foliage attenuation from ISO 9613-2:1996

Bodies of Water

- Large bodies of water can provide the opposite effect to grass and trees.
- Reflections caused by small incidence angles (grazing) can result in larger sound levels at great distances (increased reflectivity, Q).
- Typically air temperatures are warmer high aloft since air temperatures near water surface tend to be more constant. Result is a high probability of temperature inversion.
- Sound levels can "carry" much further.

Snow

- Covers the ground for approximately 1/2 of the year in northern climates.
- Can act as an absorber or reflector (and varying degrees in between).
- Freshly fallen snow can be quite absorptive.
- Snow which has been sitting for a while and hard packed due to wind can be quite reflective.
- Falling snow can be more absorptive than rain, but does not tend to produce its own noise.
- Snow can cover grass which might have provided some means of absorption.
- Typically sound propagates with less impedance in winter due to hard snow on ground and no foliage on trees/shrubs.

Appendix III SOUND LEVELS OF FAMILIAR NOISE SOURCES

Used with Permission Obtained from the Alberta Energy Regulator Directive 038 (February, 2007)

Source[1]	Sound Level (dBA)
Bedroom of a country home	30
Soft whisper at 1.5 m	30
Quiet office or living room	40
Moderate rainfall	50
Inside average urban home	50
Quiet street	50
Normal conversation at 1 m	60
Noisy office	60
Noisy restaurant	70
Highway traffic at 15 m	75
Loud singing at 1 m	75
Tractor at 15 m	78-95
Busy traffic intersection	80
Electric typewriter	80
Bus or heavy truck at 15 m	88-94
Jackhammer	88-98
Loud shout	90
Freight train at 15 m	95
Modified motorcycle	95
Jet taking off at 600 m	100
Amplified rock music	110
Jet taking off at 60 m	120
Air-raid siren	130

[1] Cottrell, Tom, 1980, *Noise in Alberta*, Table 1, p.8, ECA80 - 16/1B4 (Edmonton: Environment Council of Alberta).

SOUND LEVELS GENERATED BY COMMON APPLIANCES

Used with Permission Obtained from the Alberta Energy Regulator Directive 038 (February, 2007)

Source[1]	Sound level at 3 feet (dBA)
Freezer	38-45
Refrigerator	34-53
Electric heater	47
Hair clipper	50
Electric toothbrush	48-57
Humidifier	41-54
Clothes dryer	51-65
Air conditioner	50-67
Electric shaver	47-68
Water faucet	62
Hair dryer	58-64
Clothes washer	48-73
Dishwasher	59-71
Electric can opener	60-70
Food mixer	59-75
Electric knife	65-75
Electric knife sharpener	72
Sewing machine	70-74
Vacuum cleaner	65-80
Food blender	65-85
Coffee mill	75-79
Food waste disposer	69-90
Edger and trimmer	81
Home shop tools	64-95
Hedge clippers	85
Electric lawn mower	80-90

[1] Reif, Z. F., and Vermeulen, P. J., 1979, "Noise from domestic appliances, construction, and industry," Table 1, p.166, in Jones, H. W., ed., *Noise in the Human Environment*, vol. 2, ECA79-SP/1 (Edmonton: Environment Council of Alberta).

Appendix I

Detailed Cost Estimates

ISL Engineering and Land Services

Highway 11 and Highway 16 Interchange
Opinion of Probable Cost - Functional Planning Study - April 2017
Stage 1 Improvements

	Cost Items	Unit Price ($)	Unit	West Zone		South Zone		East Zone		North Zone		Interchange Zone	
				Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1.0 - Roadways													
1.1	Remove Existing Asphalt Pavement Surface	$ 0.50	m^2-cm	28,690	$14,345					22,160	$11,080	49,940	$24,970
1.2	Remove Existing Granular Base Structure	$ 21.00	m^3	350	$7,350					270	$5,670	600	$12,600
1.3	Granular Base Course	$ 35.00	t	18,100	$633,500			3,360	$117,600	3,370	$117,950	18,310	$640,850
1.4	Asphalt Concrete Pavement	$ 110.00	t	6,770	$744,700			1,260	$138,600	1,260	$138,600	6,850	$753,500
1.5	Line Painting	$ 5.00	m	5,360	$26,800			1,000	$5,000	1,000	$5,000	5,420	$27,100
			Section 1.0 Roadways - Subtotal:		**$1,426,695**		**$0**		**$261,200**		**$278,300**		**$1,459,020**
2.0 - ITS													
	Sensors at Vic Boulevard Interchange	$ 200,000.00	each		$0	1	$200,000					0	$0
	Signals on Highway 16	$ 250,000.00	each		$0							1	$250,000
			Section 2.0 ITS - Subtotal:		**$0**		**$200,000**		**$0**		**$0**		**$250,000**
			Subtotal:		$1,426,695		$200,000		$261,200		$278,300		$1,709,020
			15% Engineering:		$214,000		$30,000		$39,000		$42,000		$256,000
			30% Contingency:		$492,000		$69,000		$90,000		$96,000		$590,000
			Total Zone Costs:		**$2,132,695**		**$299,000**		**$390,200**		**$416,300**		**$2,555,020**
			Total Stage 1 Costs:	**$5,793,215**									

<u>Assumptions:</u>
Existing pavement assumed to be 250mm ACP/300mm GBC
New pavement structure assumed to be 200mm ACP/400mm GBC
Seeding and topsoiling will cover 70% of project area
No clearing/grubbing required

ISL Engineering and Land Services

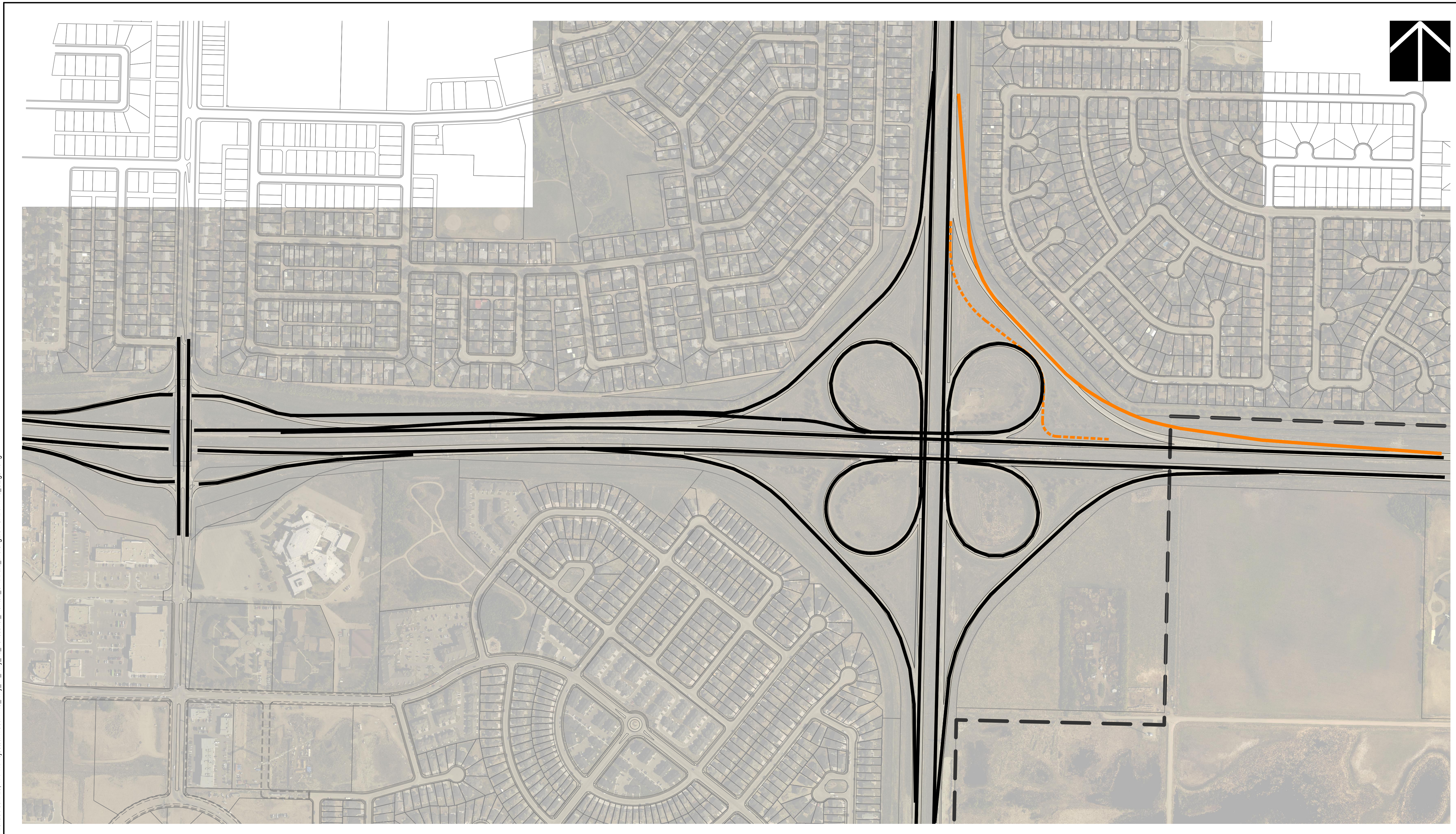
Highway 11 and Highway 16 Interchange
Opinion of Probable Cost - Functional Planning Study - April 2017
Ultimate Stage

	Cost Items	Unit Price ($)	Unit	West Zone		South Zone		East Zone		North Zone		Interchange Zone	
				Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
1.0 - Roadways													
1.1	Remove Existing Asphalt Pavement Surface	$1	m^2-cm									$2,456,390	$1,228,195
1.2	Remove Existing Granular Base Structure	$21	m^3									$29,480	$619,080
1.3	Common Excavation	$15	m^3	$61,210	$918,150	$30,610	$459,150	$30,610	$459,150	$30,610	$459,150	$459,050	$6,885,750
1.4	Waste Excavation - Haul Offsite	$25	m^3	$27,130	$678,250	$13,570	$339,250	$13,570	$339,250	$13,570	$339,250	$203,450	$5,086,250
1.5	Granular Base Course	$35	t	$49,350	$1,727,250	$25,360	$887,600	$26,140	$914,900	$110,190	$3,856,650	$131,280	$4,594,800
1.6	Asphalt Concrete Pavement	$110	t	$18,450	$2,029,500	$9,480	$1,042,800	$9,780	$1,075,800	$41,200	$4,532,000	$49,080	$5,398,800
1.7	Curb and Gutter	$180	m									$4,770	$858,600
1.8	Line Painting	$5	m	$16,800	$84,000	$8,240	$41,200	$8,360	$41,800	$32,870	$164,350	$41,230	$206,150
1.9	Median Barrier	$240	m^2									$420	$100,800
1.10	Guard Rail	$120	m									$2,190	$262,800
	Section 1.0 Roadways - Subtotal:				**$5,437,150**		**$2,770,000**		**$2,830,900**		**$9,351,400**		**$25,241,225**
2.0 - Noise Barrier Walls													
2.1	Install New Noise Barrier - 1.83m height	$500	m^2	510	$255,000					2,600	$1,300,000	419	$ 209,500
2.2	Install New Noise Barrier - 2.44m height	$500	m^2	747	$373,500							568	$ 284,000
2.3	Install New Noise Barrier - 3.00m height	$500	m^2							677	$338,500	414	$ 207,000
2.4	Install New Noise Barrier - 3.50m height	$500	m^2									752	$ 376,000
2.5	Install New Noise Barrier - 4.00m height	$500	m^2	713	$356,500							2,139	$ 1,069,500
	Section 2.0 Noise Barrier Walls - Subtotal:				**$985,000**						**$1,638,500**		**$2,146,000**
3.0 -Retaining Walls													
3.1	Retaining walls where required	$ 1,500	m^2									12,100	$18,150,000
	Section 3.0 Retaining Walls - Subtotal:												**$18,150,000**
4.0 - Bridges													
4.1	EB Mainline Bridge over Hwy 11/16 - 2:1 headslopes	$4,500	m^2									2,290	$10,305,000
4.2	WB Mainline Bridge over Hwy 11/16 - 2:1 headslopes	$4,500	m^2									2,540	$11,430,000
4.3	NB Bridge over WB-SB Directional Ramp	$4,500	m^2									470	$2,115,000
4.4	NB Bridge over EB-NB Directional Ramp	$4,500	m^2									600	$2,700,000
4.5	SB Bridge over EB-NB Directional Ramp	$4,500	m^2									670	$3,015,000
4.6	SB Bridge over WB-SB Directional Ramp	$4,500	m^2									470	$2,115,000
4.7	SB Bridge over EB-NB Directional Ramp	$4,500	m^2									320	$1,440,000
4.8	Preston Ave over Hwy 11 (Circle Drive)	$4,000,000	Lump Sum	1	$4,000,000								
	Section 4.0 Bridges - Subtotal:				**$4,000,000**								**$33,120,000**
5.0 - Tunnels													
5.1	EB to NB Ramp Tunnel	$ 36,900,000	Lump Sum									1	$36,900,000
5.2	WB to SB Ramp Tunnel	$ 35,800,000	Lump Sum									1	$35,800,000
	Section 5.0 Tunnels - Subtotal:												**$72,700,000**
6.0 - Utilities													
6.1	TransGas - Directional drill new crossing	$2,000,000	Lump Sum									1	$2,000,000
6.2	CoS Water - Lower 160m of watermain	$500,000	Lump Sum									1	$500,000
6.3	Saskatoon Light and Power - Full lighting of interchange and approaches	$3,000,000	Lump Sum	0.2	$600,000	0.2	$600,000	0.2	$600,000	0.2	$600,000	0.2	$600,000
	Section 6.0 Utilities - Subtotal:				**$600,000**		**$600,000**		**$600,000**		**$600,000**		**$3,100,000**
7.0 - Drainage													
7.1 Storm Sewer													
7.1.1	Supply & Install 1500mm Class III Concrete storm sewer, open trench installation (0-4 m depth)	$1,700	m									550	$935,000
7.1.2	Supply & Install 1500mm Class III Concrete storm sewer, open trench installation (4-5 m depth)	$1,900	m									300	$570,000
7.1.3	Supply & Install 1500mm Class III Concrete storm sewer, open trench installation through berm (6-7 m depth)	$2,400	m									30	$72,000
7.1.4	2400mm diameter Manhole	$7,500	v.m.									16	$120,000
7.1.5	3000mm diameter Manhole	$10,000	v.m.									3	$30,000
7.1.6	Connect storm to existing Manhole	$25,000	Lump Sum									1	$25,000
7.2 Highway Interchange Ramp Dry Pond													
7.2.1	Dry pond excavation cut	$14	m^3									15,000	$210,000
7.2.2	Dry pond MH control structure and outlet connections	$90,000	Lump Sum									1	$90,000
	Section 7.0 Drainage - Subtotal:												**$2,052,000**
8.0 - Landscaping													
8.1 Topsoil and Seeding		$300,000	Lump Sum	0.2	$60,000	0.2	$60,000	0.1	$30,000	0.2	$60,000	0.3	$90,000
	Section 8.0 Landscaping - Subtotal:				**$60,000**		**$60,000**		**$30,000**		**$60,000**		**$90,000**
9.0 - Traffic Accomodation													
9.1	Detours and temporary traffic control	$1,000,000	Lump Sum	0.2	$200,000	0.2	$200,000	0.2	$200,000	0.2	$200,000	0.2	$200,000
	Section 9.0 - Subtotal:				**$200,000**		**$200,000**		**$200,000**		**$200,000**		**$200,000**
10.0 - Right-of-way													
10.1	78S27733 - Circle Drive Alliance Church	$170,000	Lump sum	1	$170,000		$0		$0		$0		$0
10.2	101961851 MR18 - Mark Thompson Park	$290,000	Lump sum	1	$290,000		$0		$0		$0		$0
	Section 10.0 - Subtotal:				**$460,000**		**$0**		**$0**		**$0**		**$0**
	Subtotal:				$11,742,150		$3,630,000		$3,660,900		$11,849,900		$156,799,225
	15% Engineering:				$1,761,000		$545,000		$549,000		$1,777,000		$23,520,000
	30% Contingency:				$3,913,000		$1,253,000		$1,263,000		$4,088,000		$54,096,000
	Total Zone Cost:			**$17,416,150**		**$5,428,000**		**$5,472,900**		**$17,714,900**		**$234,415,225**	
	Total Project Cost:							**$280,447,175**					

Assumptions:
Existing pavement assumed to be 250mm ACP/300mm GBC
New pavement structure assumed to be 200mm ACP/400mm GBC
Seeding and topsoiling will cover 70% of project area

Appendix J

Construction Staging



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ISL Engineering and Land Services

City of Saskatoon

LEGEND

- UNDER CONSTRUCTION
- CONSTRUCTION DETOUR
- OPERATIONAL
- REMOVALS OR CLOSED
- SIGNALS

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE
FUNCTIONAL PLANNING STUDY

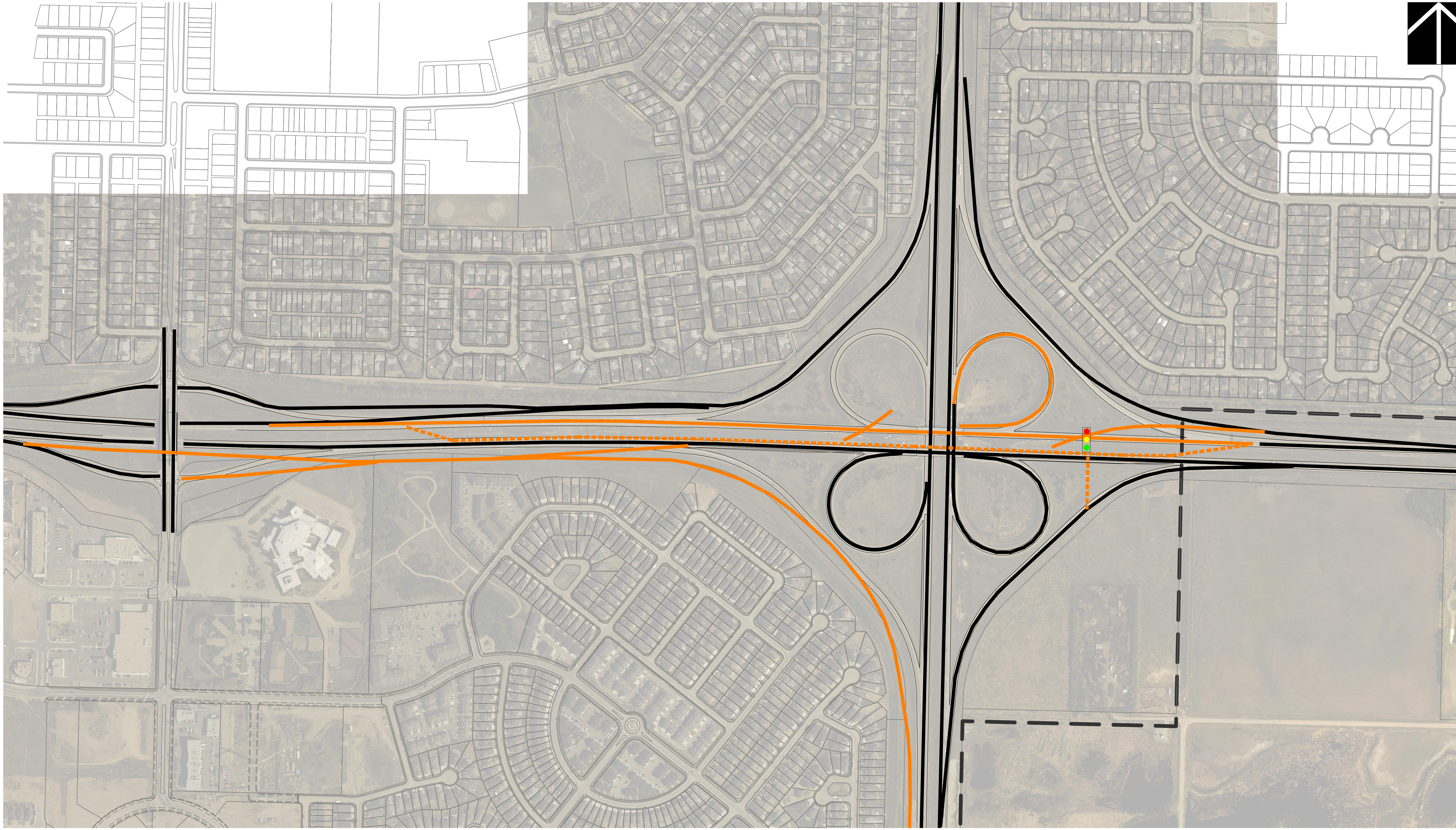
ULTIMATE CONFIGURATION - CONSTRUCTION STAGING

PART 1

1:3000

EXHIBIT J1

JUNE 2017



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City of Saskatoon

LEGEND

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- SIGNALS

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

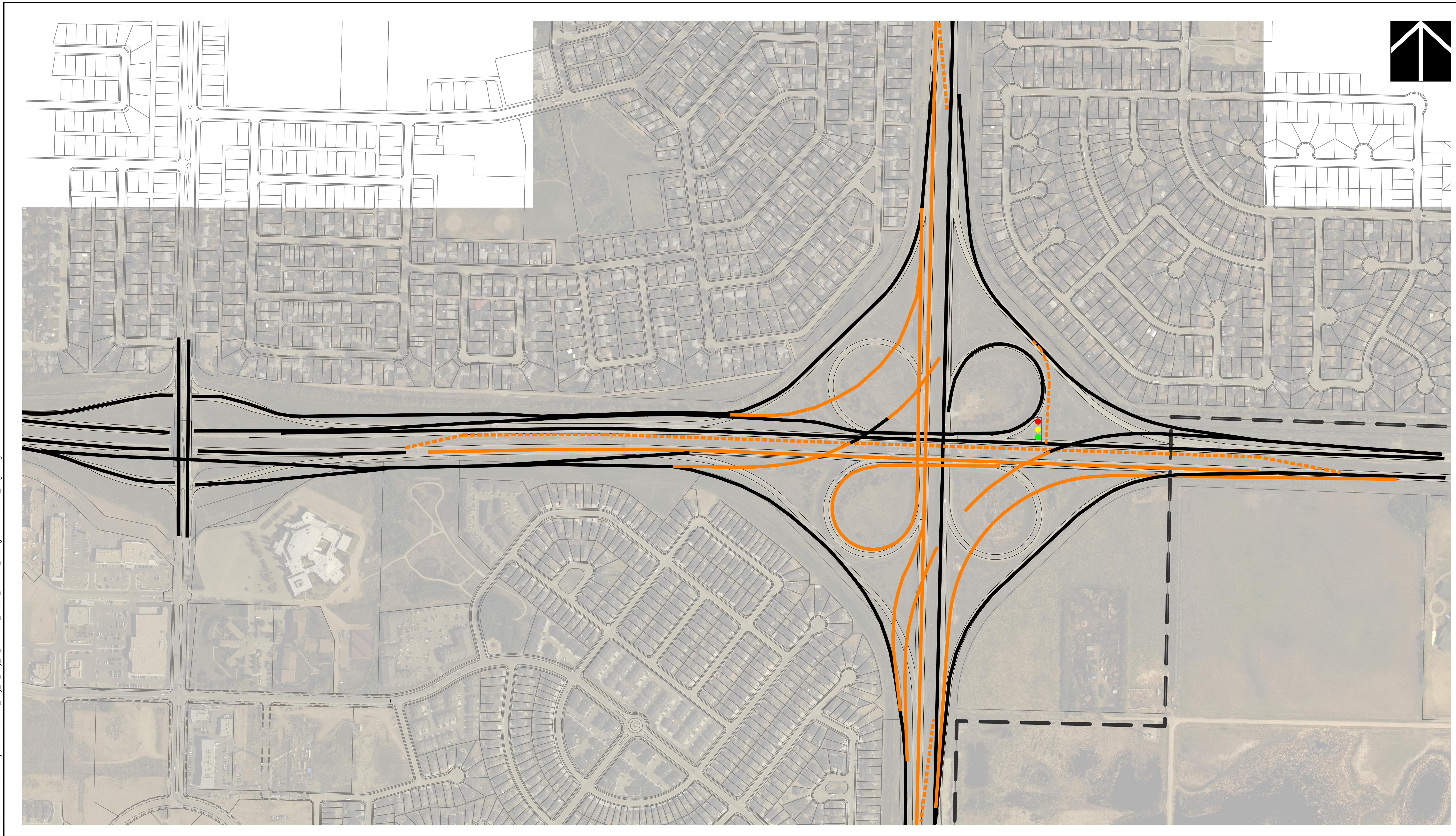
ULTIMATE CONFIGURATION - CONSTRUCTION STAGING

PART 2

1:3000

EXHIBIT J2

JUNE 2017



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ISL Engineering and Land Services

City of Saskatoon

LEGEND

- UNDER CONSTRUCTION
- CONSTRUCTION DETOUR
- OPERATIONAL
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- SIGNALS

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

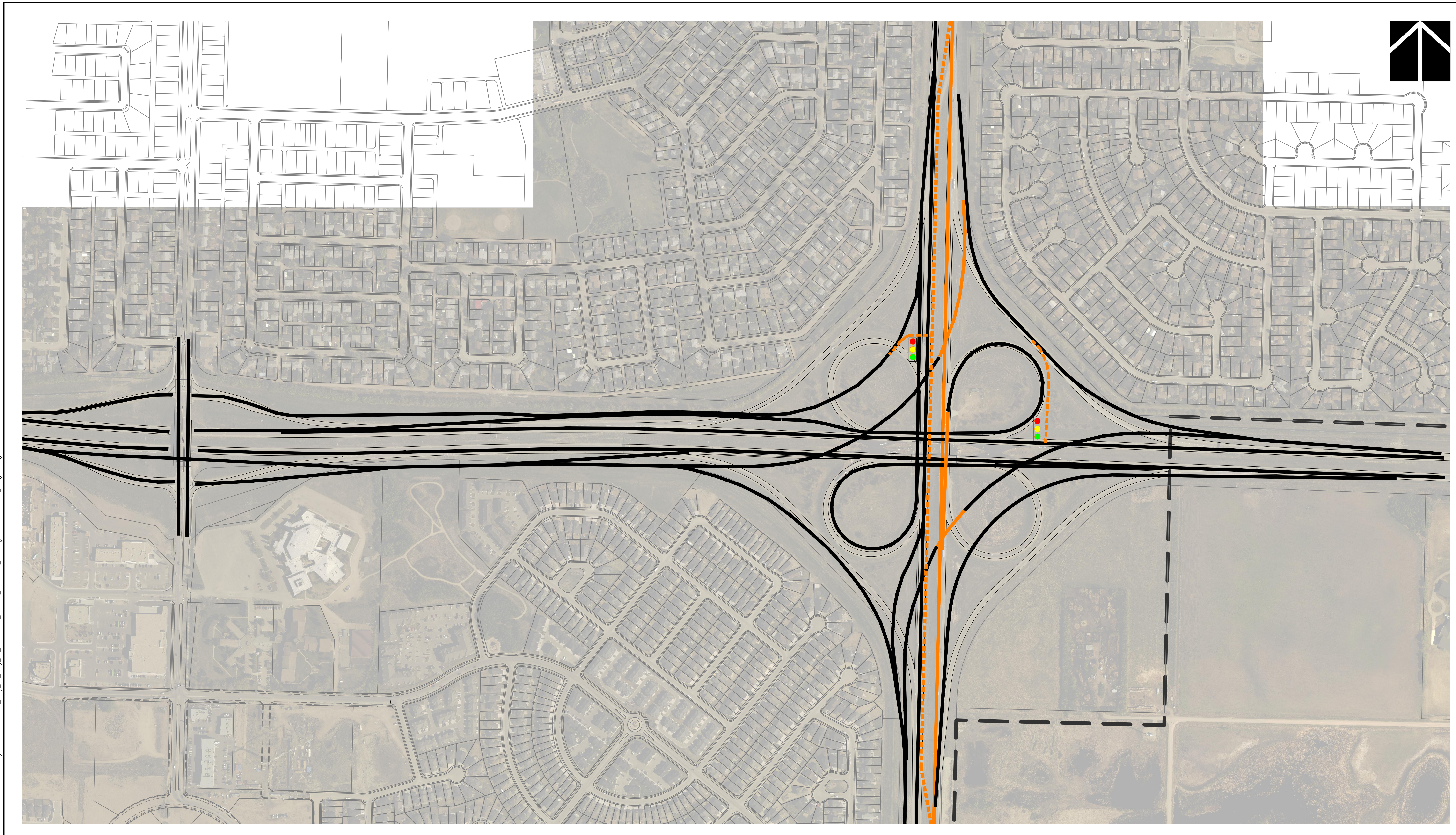
ULTIMATE CONFIGURATION - CONSTRUCTION STAGING

PART 3

1:3000

EXHIBIT J3

JUNE 2017



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ISL Engineering and Land Services

City of Saskatoon

LEGEND

UNDER CONSTRUCTION

CONSTRUCTION DETOUR

OPERATIONAL

REMOVALS OR CLOSED

SIGNALS

HIGHWAY 11 and HIGHWAY 16 INTERCHANGE FUNCTIONAL PLANNING STUDY

ULTIMATE CONFIGURATION - CONSTRUCTION STAGING

PART 4

1:3000

EXHIBIT J4

JUNE 2017