ACCOMMODATING COMMERCIAL AND OVER-DIMENSIONAL VEHICLES AT ROUNDABOUTS

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1.0 ABSTRACT

This paper builds upon one submitted for the 2009 conference that discussed “small” users (pedestrians and cyclists) and “large” users (trucks) of roundabouts. It covers the topic of large commercial vehicles at roundabouts in more detail.

Several horizontal design treatments exist to accommodate large commercial vehicles at roundabouts. This paper examines the use of widened entries and exits, partially-traversable truck aprons, gated pass-throughs, and right-turn by-pass lanes. Unlike single-lane roundabouts, no special geometric treatments are necessarily needed to physically accommodate large commercial vehicles at multi-lane roundabouts. However there are still a number of considerations in terms of lane use. This paper discusses whether to allow for trucks to overtrack adjacent lanes in a roundabout, and whether to install lane lines in the circulatory road.

Two case studies are then used to describe recent projects undertaken in northern Alberta to accommodate one or more over-dimensional vehicles through a roundabout. The first case study summarizes the preliminary design of a multi-lane roundabout to accommodate an over-dimensional vehicle making a through movement at the intersection of Highway 63 and Highway 69 in Fort McMurray, Alberta. The second case study summarizes the preliminary design of a single-lane roundabout to accommodate several over-dimensional vehicles making turning movements at the intersection of Highway 55 and Highway 892 west of Cold Lake, Alberta.

In both projects a number of the treatments described in this paper were employed to accommodate the vehicles without compromising the inherent safety benefits of the roundabout.

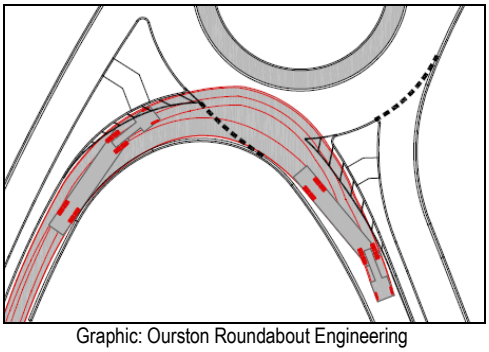
2.0 TRUCKS AT ROUNDABOUTS

2.1 TRUCK ACCOMMODATION TREATMENTS

Several horizontal design treatments exist to accommodate large commercial vehicles at roundabouts. They include widened entries and exits, partially-traversable truck aprons, gated pass-throughs, and right-turn by-pass lanes.

2.1.1 Widened Entries and Exits

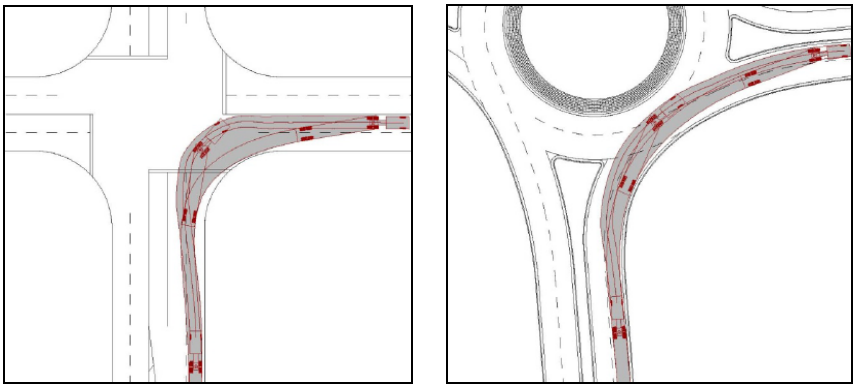
At single-lane roundabouts, trucks can be accommodated without encroachment outside the curbs by making the entries and exits wide enough for their swept paths, and using pavement markings to visually narrow the road. An example is shown in Figure 2.1. It is preferred to create most of the widening on the exit side, if possible, to not compromise speed control on the entry.



Graphic: Ourston Roundabout Engineering

Figure 2.1 Right turn at a single-lane roundabout.

At multi-lane roundabouts, trucks may need to swing wide and overtrack adjacent lanes when turning right, as illustrated in Figure 2.2. This is similar to practice at other intersections, and is often appropriate in more urban locations or where trucks are a low-to-average percentage of the vehicle mix (see later section on Truck Accommodation Philosophies). Truck drivers must execute this movement with caution, and drivers of light vehicles must give way to the larger vehicle.



Graphic: Ourston Roundabout Engineering

Figure 2.2 Truck right-turn swept paths.

2.1.2 Truck Aprons

Partially-traversable truck aprons are a design compromise to accommodate trucks at small roundabouts while still providing speed control for light vehicles. Truck aprons are usually installed around the central island, although outer truck aprons are sometimes employed. An example showing both is seen in Figure 2.3. Truck aprons should be capable of being mounted by large vehicles, but be unattractive to car drivers because they are raised and have a slope and/or textured surface.

Photo: Howard McCulloch, NYSDOT

Figure 2.3 Example central island and outer truck aprons. The outer apron is not curbed, and is likely to be overrun by light vehicles as well as large trucks.

Central island truck aprons are widely used at roundabouts and most guides depict them. Because of this, roundabout designers may assume that aprons are a required element at all roundabouts. However, if speed control and truck swept paths can be provided without an apron, then no apron is necessary. This should be kept in mind as truck aprons have a number of disadvantages:

- Care is needed in the design and construction of truck aprons so that they provide the necessary speed control for light vehicles, yet do not create under-clearance or stability problems for trucks.
- Pedestrians can mistake a central island truck apron for a sidewalk and wander into the circulatory road. Pedestrians may also not realize the purpose of an outer truck apron and wait to cross the road where trucks are likely to overtrack.
- Observations have shown that truck drivers are sometimes reluctant to use truck aprons. They may be unsure of their purpose, or think they look too nice to be driven over. A yellow edge line around a central island apron may make them even more reluctant because it reminds them of a road centreline that should not be crossed.

If roundabouts become small enough, then the need to accommodate certain vehicles may require that the entire central island be fully traversable. The result is a mini-roundabout.

2.1.3 Gated Pass-Throughs

An example of a gated crossing of a roundabout central island in the United Kingdom is shown in Figure 2.4. Gated crossings are usually installed when over-dimensional loads need to occasionally traverse a roundabout. They are also useful to maintain traffic during future work on the roundabout or approach roads.

Photo: Ourston Roundabout Engineering

Figure 2.4 Gated pass-through at a roundabout.

2.1.4 By-Pass Lanes

By-pass lanes are used to provide additional right-turn capacity without adding more lanes to the roundabout. They are also useful to allow additional space for truck right turns without making the entire roundabout larger or compromising on certain geometric parameters. Examples are shown in Figure 2.5.

Source: Google Earth

Figure 2.5 Free-flow and yield-controlled by-pass lanes.

In this roundabout, located in Vail, Colorado, it was not possible for trucks on some approaches to turn right within the roundabout. Here, the west by-pass is free-flow, and the east by-pass is yield-controlled. They both allow a wider and easier turn radius for trucks. In other designs the by-pass lanes can be internal to the roundabout, where entering drivers yield to circulating and exiting traffic and there is no physical channelization. Care should be taken in the design of such by-passes so that drivers in the right lane are not tempted to enter the roundabout.

3.0 TRUCKS AT MULTI-LANE ROUNDABOUTS

3.1 TRUCK ACCOMMODATION PHILOSOPHIES

Unlike single-lane roundabouts, no special geometric treatments are necessarily needed to physically accommodate large commercial vehicles at multi-lane roundabouts. However there are still a number of considerations in terms of lane use. They include whether to allow for trucks to overtrack adjacent lanes, and whether to install lane lines in the circulatory road.

3.1.1 Case 1 Roundabouts

With so-called Case 1 roundabouts, large commercial vehicles will track across adjacent lanes as they enter, circulate and exit. See Figure 3.1. This is analogous to other types of intersections where trucks will track across adjacent lanes as they make left or right turns. The difference with Case 1 roundabouts is that large trucks will need to do this for through movements as well.

Photo: Ourston Roundabout Engineering

Figure 3.1 Example of a Case 1 design. Note that the commercial vehicle requires the entire width to enter the roundabout.

There is an obvious disadvantage with Case 1 in that it may lead to side-swipe collisions between light vehicles and trucks through the roundabout entry. This can be mitigated by training truck drivers to straddle the entry lanes so that other drivers cannot drive beside them. This is easier to accomplish when a roundabout entry adds lanes through a flare (one lane flares to two, for example), than when these lanes are continuous (two lanes throughout, for example).

Not as obvious is that there are several advantages to Case 1 designs. They will likely be smaller than roundabouts where trucks can maintain their lane, with narrower entries and exits and higher entry angles. These features will act to increase a roundabout's overall safety potential through more speed control and better sight-to-the-left for entering drivers. Also, since Case 1 roundabouts are smaller they will occupy less land area and be less expensive to construct.

3.1.2 Case 2 Roundabouts

With Case 2 roundabouts large commercial vehicles can maintain their own lane through the entry, but not as they circulate and exit. See Figure 3.2. The entry will be wider than for a Case 1 design so that a light vehicle and a large truck can line up side-by-side, after which one vehicle will have to give way to the other upon proceeding into the roundabout. In some cases two large trucks can line up at the entry side-by-side, although this is relatively rare because it usually means that a Case 3 roundabout can be achieved.

Photo: Ourston Roundabout Engineering

Figure 3.2 Example of a Case 2 design. Note the entry gore striping to keep trucks from encroaching on the adjacent lane.

A disadvantage with Case 2 is that it may relocate side-swipe collisions from the entry to within the circulatory road. The probability should not be as high as with Case 1 designs because even when two vehicles line up side-by-side, one will naturally pull ahead. This will either be a faster passenger car, or the vehicle in the inner lane because it takes a

shorter path. Another disadvantage with a Case 2 design is that the wider entry will make it more difficult to achieve sufficient speed control.

The advantage of Case 2 designs is the ability to handle higher truck percentages more safely than Case 1 designs. They can therefore be considered more appropriate on roads with a high percentage of trucks and where the design compromises associated with accommodating them are reasonable.

3.1.3 Case 3 Roundabouts

With Case 3 roundabouts, large commercial vehicles can maintain their own lane as they enter, circulate and exit a multi-lane roundabout. See Figure 3.3. Usually this means a passenger car and a large truck can be accommodated side-by-side through the roundabout, although in extreme cases it may mean that two large trucks can be accommodated side-by-side.

Photo: MTJ Engineering LLC.

Figure 3.3 Example of a Case 3 design. Note the straight, wide entry and wide central island truck apron.

Case 3 roundabouts will be larger and faster than Case 1 and 2 roundabouts, and will require a central island truck apron to keep trucks in the inner lane as they circulate (unless the roundabout is made very large). Truck aprons are common at single-lane roundabouts but are not usually needed at multi-lane roundabouts. As mentioned in an earlier section, care is needed in the design and construction of truck aprons so that they provide as much speed control as non-traversable central islands, yet do not create under-clearance or stability problems for trucks.

Generally Case 3 roundabouts should only be considered when truck percentages are very high and the design compromises associated with accommodating them completely within their lanes are acceptable.

3.2 CIRCULATORY ROAD STRIPING

In most countries, multi-lane roundabouts have lane striping on the entries and exits, but not in the circulatory road unless special conditions make them necessary. This is analogous to signalized intersections not having lines continue through except to aid certain movements. Circulatory road striping tends to be the rule rather than the exception in the United States. Circulatory road striping is usually used Canada, but in Waterloo Region, Ontario, and in Nova Scotia it is not used except under special conditions. Interestingly, early designs in the U.S. (prior to 2001) did not have circulatory road striping at all.

Advantages of circulatory road striping:

- Provides a reminder to drivers to maintain their lane position while circulating;
- May improve lane utilization and therefore increase capacity;
- Educates drivers on how to correctly turn left (but only if approach signs and markings correctly assign lane choice); and
- Necessary for complex configurations with exclusive left turns to guide drivers through the roundabout.

Disadvantages of circulatory road striping:

- Can be tricky to design, and difficult to implement accurately in the field;
- Can lessen the potential to yield at entry because the striping looks like a continuation of the through road;
- May accentuate inherent path overlap problems;
- May necessitate truck aprons where not normally required; and
- Where the design does not allow for trucks to maintain their own lane in the circulatory road (Case 1 and Case 2), can encourage passenger car drivers to circulate next to trucks.

The decision to implement circulatory road striping at a multi-lane roundabout should therefore be made on a case-by-case basis.

An effort to counter the tendency for drivers of light vehicles to circulate next to trucks at roundabouts with circulatory road striping is seen in the British Columbia Ministry of Transportation sign in Figure 3.4.

Photo: Ourston Roundabout Engineering

Figure 3.4 "Truck Encroachment" warning sign.

4.0 OVER-DIMENSIONAL VEHICLES

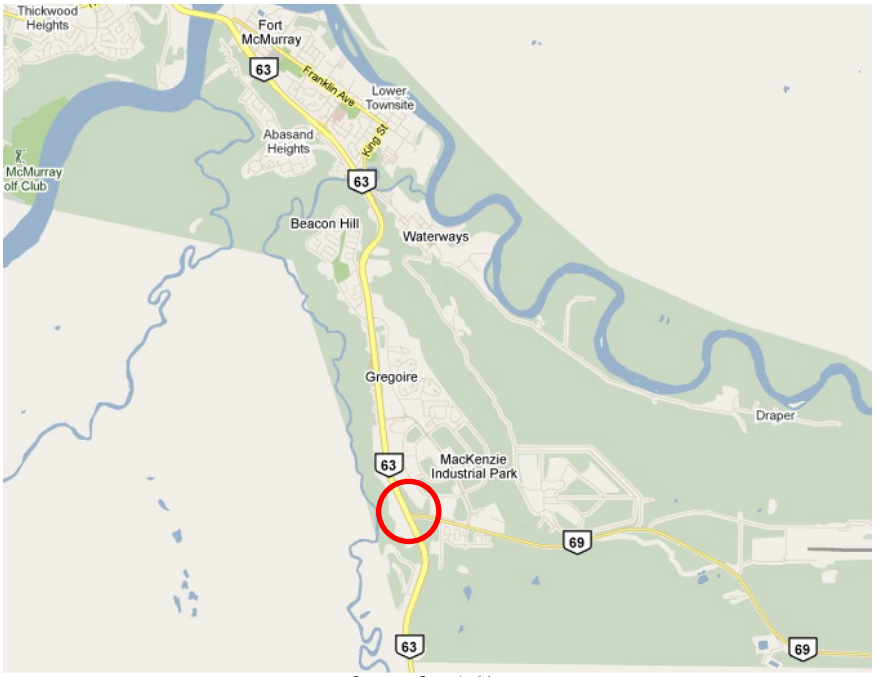
4.1 INTRODUCTION

The following two case studies describe projects undertaken in northern Alberta to accommodate one or more over-dimensional vehicles through a proposed roundabout. These over-dimensional vehicles were modelled using AutoTurn and AutoTrack turning movement software.

Alberta Transportation recently adopted a policy specifying that roundabouts must be considered the first choice at intersections where two-way stop control is not sufficient in terms of vehicle capacity or safety. However, in both case studies had it not been possible to accommodate the over-dimensional vehicles without compromising the inherent safety benefits of the roundabouts, then the roundabout alternatives would have been abandoned.

4.2 CASE STUDY: HIGHWAY 63/69, FORT MCMURRAY, ALBERTA

The first case study summarizes the preliminary design of a multi-lane roundabout to accommodate an over-dimensional vehicle at the intersection of Highway 63 and Highway 69 in Fort McMurray, Alberta. The location is set out in Figure 4.1. Highway 63 is a four-lane highway with a rural divided section through Fort McMurray. Highway 69 is a two-lane undivided highway that extends to a rapidly-developing residential and light industrial area to the east. The intersection is currently under two-way stop control, and is experiencing an acceptable collision history. There is no pedestrian or cyclist traffic at the intersection.



Source: Google Maps

Figure 4.1 Highway 63/69 and vicinity.

4.2.1 Design Vehicles

The over-dimensional vehicle was a “Coke Drum” transporter as shown in Figure 4.2, a vehicle that brings large storage tanks to oil sands projects in the Fort McMurray area. The transporter consists of two trailers each having 10 lines of wheels. Each line of wheels has 16 individual wheels arranged in sets of four. The set of trailers is referred to as a double 10-line 4-file combination. The load is simultaneously pushed and pulled by three to seven tractors, depending on terrain.

Photo: Alberta Transportation

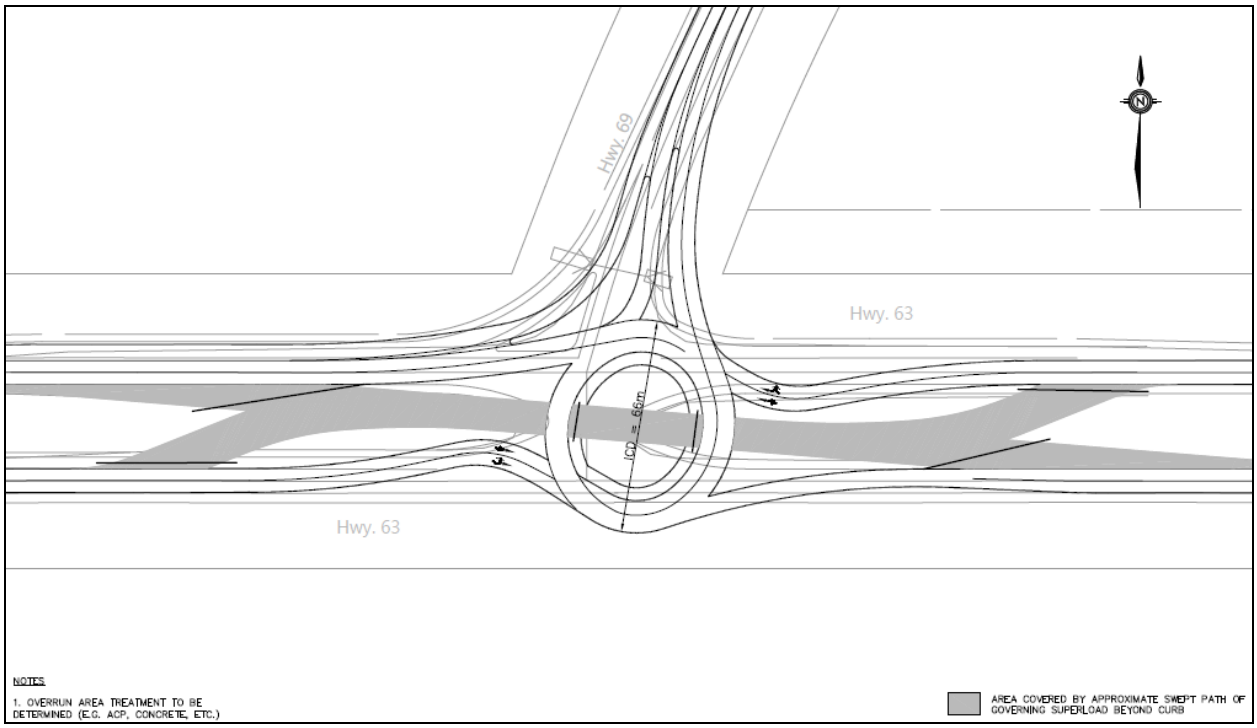
Figure 4.2 The “Coke Drum” transporter.

There were two other design vehicles for this project. The first was a WB-41 or turnpike double. This is a long combination vehicle (LCV) with two standard 53-foot trailers and a sleeper cab in the tractor. The other was a WB-21 tractor semi-trailer. It was decided that WB-21’s would be accommodated through the multi-lane roundabout as per a Case 2 design (meaning they can maintain their own lane through the entry, but not as they circulate and exit).

4.2.2 Proposed Roundabout Concepts

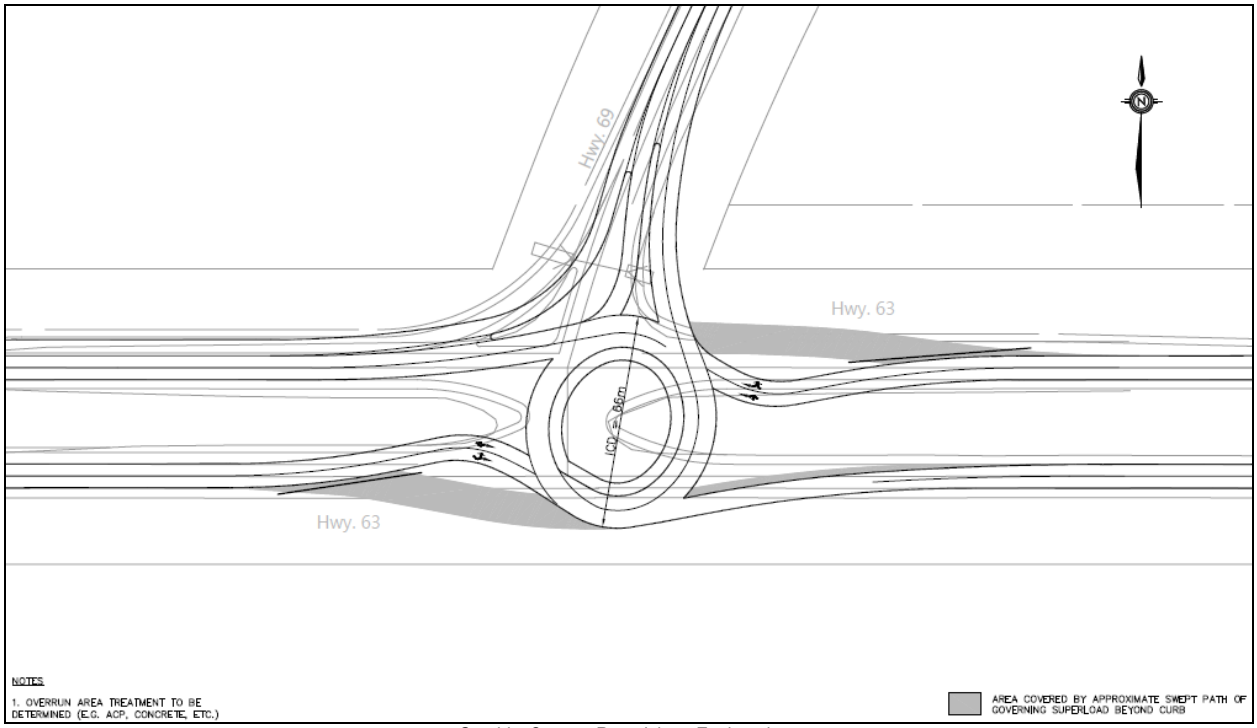
The Coke Drum transporter is restricted to operating on Highway 63 only. Therefore the roundabout had to allow northbound and southbound through movements.

Three multi-lane roundabout concepts were developed, as illustrated in Figures 4.3 to 4.5. They have inscribed circle diameters (ICD) ranging from 66 to 72 metres. Because the heaviest peak hour traffic movements are forecast to be to and from the north and east, the concepts have a dual left-turn southbound and a fully-channelized right-turn westbound. Provisions were made in the design to allow for an additional southbound through lane to be constructed should it be warranted by future traffic growth. The roundabout intersection will eventually be replaced by a grade-separated interchange once the lands to the east are further developed.



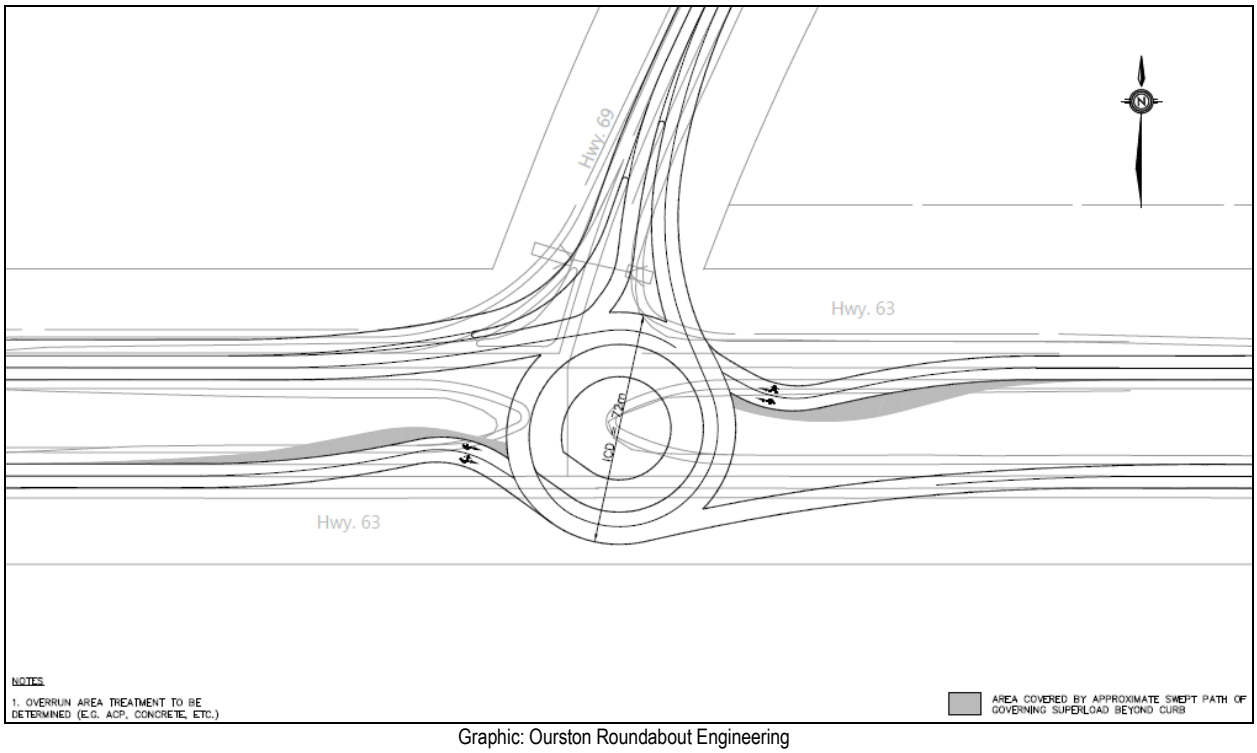
Graphic: Ourston Roundabout Engineering

Figure 4.3 Alternative 1 at Highway 63/69. Over-dimensional vehicles would be accommodated using a gated pass-through in the medians and central island.



Graphic: Ourston Roundabout Engineering

Figure 4.4 Alternative 2 at Highway 63/69. Over-dimensional vehicles would be accommodated using gated pass-throughs in the boulevard.



Graphic: Ourston Roundabout Engineering

Figure 4.5 Alternative 3 at Highway 63/69. Over-dimensional vehicles would be accommodated via widened entries on Highway 63.

With Alternative 1, over-dimensional vehicles would be accommodated via a gated median pass-through. A disadvantage of this alternative is a high construction cost due to the need to reinforce the road base through the rural highway median. In theory this alternative should provide the most favourable roundabout operations because its geometry is not influenced by the over-dimensional vehicle.

With Alternative 2, over-dimensional vehicles would be accommodated by gated boulevard pass-throughs. Compared to Alternative 1 more road structure would be required in the boulevards but less would be required in the median, thereby preserving more of the existing drainage features. This alternative should therefore be less expensive to construct. However approaching drivers will encounter the pass-through gates at a shallow angle. This may cause some driver expectancy issues depending on the type and conspicuousness of the gate system used, especially during periods of poor visibility.

With Alternative 3, over-dimensional vehicles would encroach on the splitter islands while staying within the outside curbs. The additional paved areas next to the splitter islands would demarcated with outer truck aprons to discourage use by other vehicles. From a safety perspective this alternative increases entry pavement widths and would provide less positive guidance, especially during periods of poor visibility, unless care is taken with the design of the outer truck aprons so they are not used by divers of other vehicles. Its advantage is that it should be the least costly of the three alternatives.

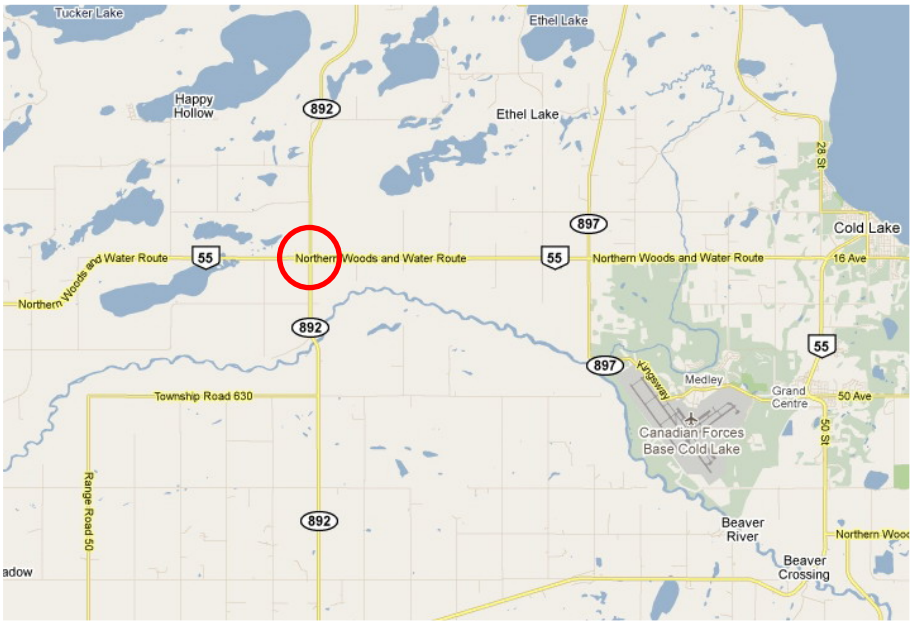
4.2.3 Preferred Alternative

Based on the advantages and disadvantages of the roundabout concepts as described, and discussions with Alberta Transportation, it was decided to select Alternative 3 as the preferred alternative.

The interim roundabout with a two-lane entry southbound will be constructed this year. It may be converted to an ultimate roundabout with an additional southbound through lane when warranted by future traffic growth. This conversion is expected to defer by several years the need to replace the intersection with a grade-separated interchange.

4.3 CASE STUDY: HIGHWAY 55/892, COLD LAKE, ALBERTA

The second case study summarizes the preliminary design of a single-lane roundabout to accommodate several over-dimensional vehicles at the intersection of Highway 55 and Highway 892 west of Cold Lake, Alberta. The site location is set out in Figure 4.6. Both highways are two-lane rural undivided facilities. The intersection is currently under two-way stop control, and is experiencing a poor collision history. There is no pedestrian or cyclist traffic at the intersection.



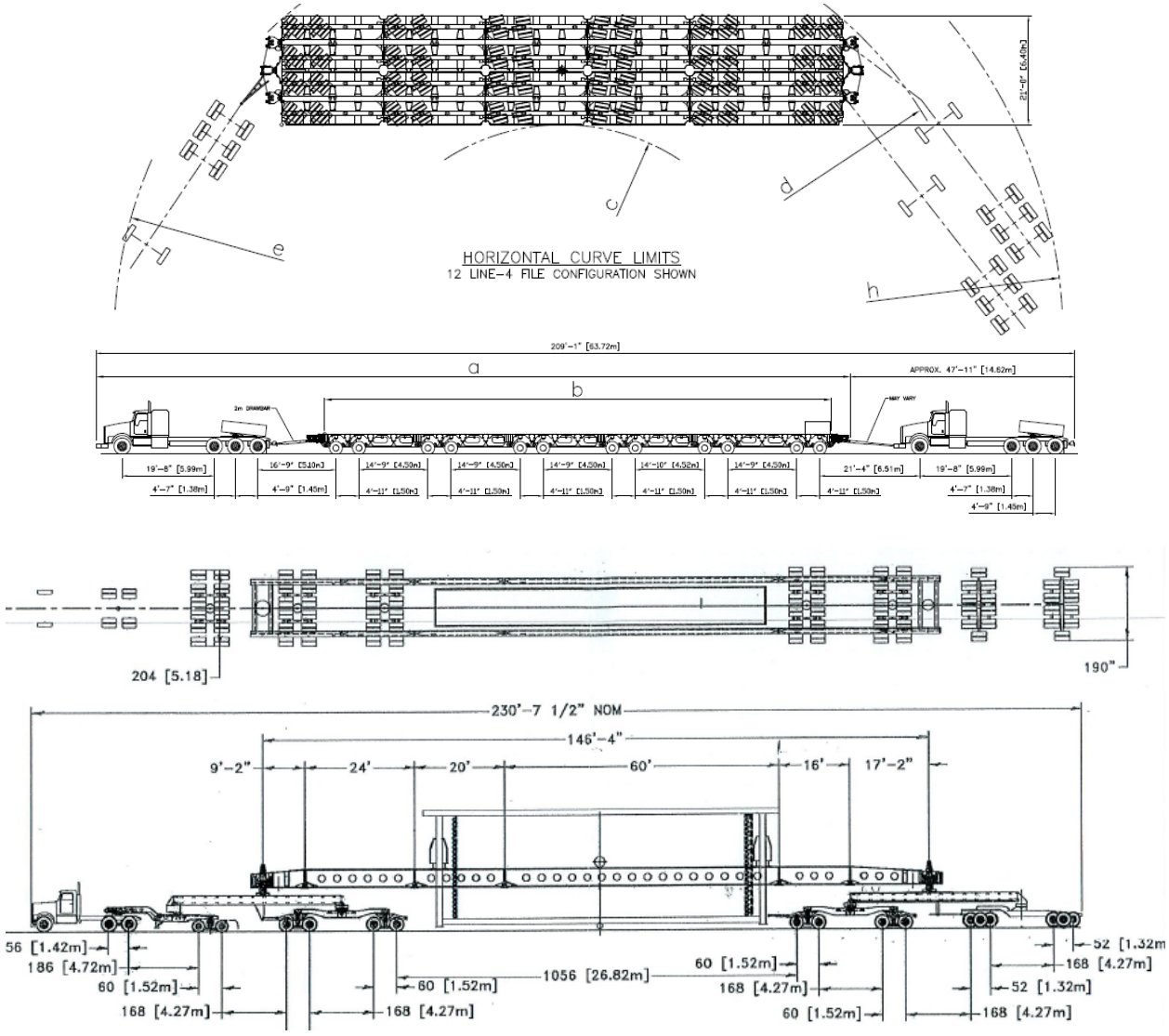
Source: Google Maps

Figure 4.6 Highway 55/892 and vicinity.

4.3.1 Design Vehicles

The over-dimensional vehicles were of several configurations depending on the needs of a large oil refinery operation north of the intersection. Seven vehicle configurations were modelled, and ultimately it was determined that two vehicles governed in terms of swept path (width) and turning radius (length). They were a 12-line 4-file combination, and a multi-axle transporter. They are shown in Figure 4.7. It is anticipated that future

configurations would not be significantly larger in any key dimension than these two vehicles.



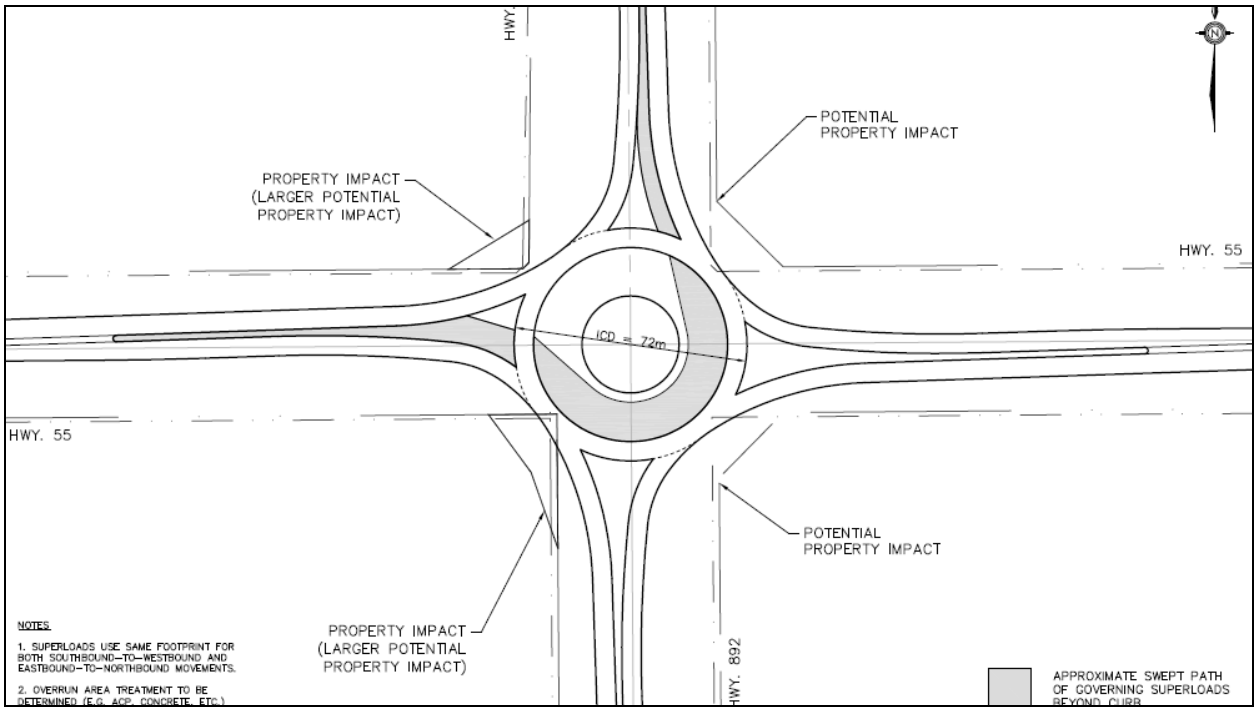
Source: Premay Equipment LP and Aspen Custom Trailers Inc.

Figure 4.7 The governing over-dimensional loads. The top vehicle is a 10-line 4-file combination, and the bottom is a multi-axle transporter.

The “normal” design vehicle was a WB-21 for all movements.

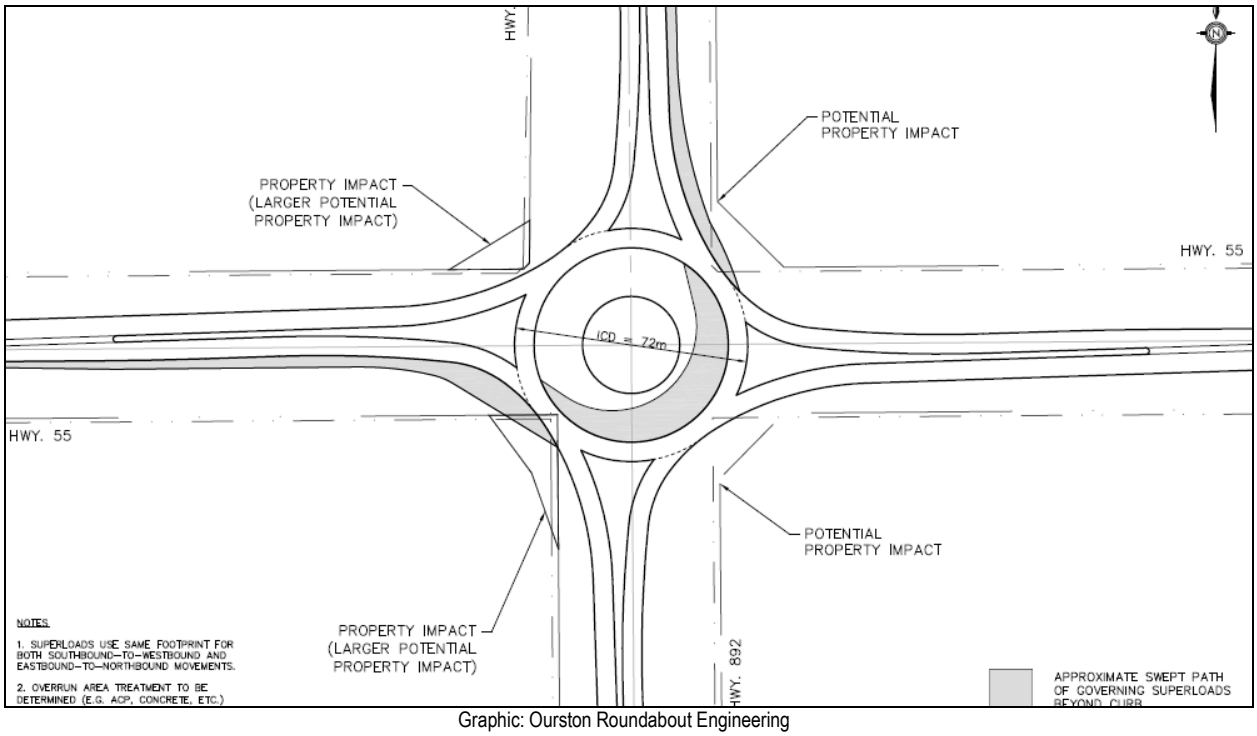
4.3.2 Proposed Roundabout Concepts

The various over-dimensional vehicles currently make the left turn movement eastbound on Highway 55 to northbound on Highway 892, and the return right-turn movement. In response four single-lane roundabout concepts were developed, as illustrated in Figures 4.8 to 4.11.



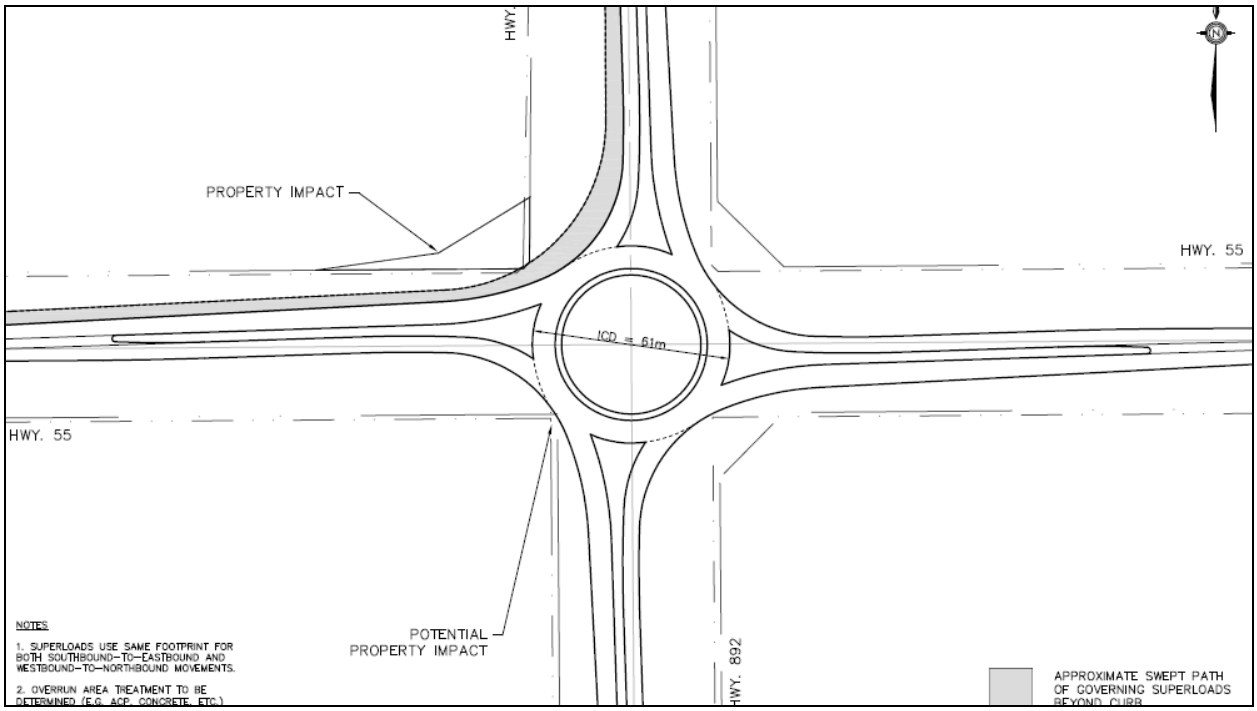
Graphic: Ourston Roundabout Engineering

Figure 4.8 Alternative 1A at Highway 55/892. Over-dimensional vehicles would be accommodated within the roundabout using wide central island and splitter island truck aprons.



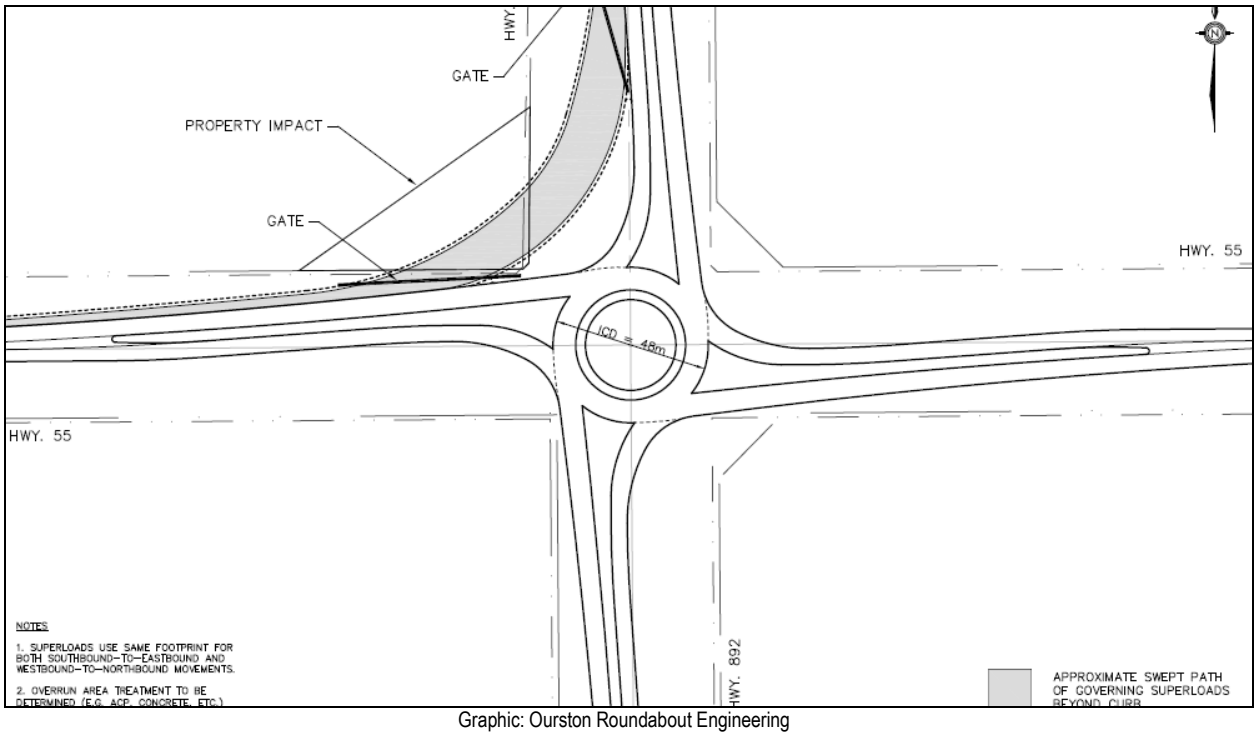
Graphic: Ourston Roundabout Engineering

Figure 4.9 Alternative 1B at Highway 55/892. Over-dimensional vehicles would be accommodated within the roundabout using wide central island and outer truck aprons.



Graphic: Ourston Roundabout Engineering

Figure 4.10 Alternative 2 at Highway 55/892. Over-dimensional vehicles would be accommodated bi-directionally via an outside truck apron.



Graphic: Ourston Roundabout Engineering

Figure 4.11 Alternative 3 at Highway 55/892. Over-dimensional vehicles would be accommodated bi-directionally via a by-pass of the roundabout.

Alternative 1 has an ICD of 72 metres, the minimum required to accommodate the multi-axle transporter through the roundabout based on turning radius. Alternative 1A shows over-dimensional vehicles encroaching on the central island and splitter islands while preserving the outside curb. Alternative 1B shows over-dimensional vehicles instead using a wide outer truck apron. Both would require a wide central island truck apron.

From a safety perspective, neither roundabout would be ideal. Because of the size of the roundabout very fast right turns would be possible for all traffic, with resulting low yield potential. The geometric solution to this problem would be to provide flat exits, but this would require significant extra right-of way and push tie-ins to the existing cross-section much further back, thereby inflating construction costs and property impacts.

Alternative 2 has an ICD of 61 metres. Over-dimensional vehicles would use as much of the pavement as possible and track along a widened outside shoulder or outer truck apron for both left-turn and right-turn movements. This alternative exhibits acceptable roundabout geometry, although fast right turns would still be possible.

Alternative 3 has an ICD of 48 metres, an appropriate diameter for a single-lane rural roundabout. Over-dimensional vehicles would be accommodated by a channelized by-pass of the roundabout that would be gated when not in use. A westbound left-turning vehicle would approach the roundabout along the exit, avoiding the splitter island, turn into the by-pass, exit along the southbound approach while avoiding the splitter island, and continue northbound. A southbound right-turning vehicle would do the same in reverse.

This alternative exhibits the best overall roundabout geometry, as no compromises were made to accommodate the over-dimensional vehicles. The primary disadvantage is that additional property would be required in the northwest quadrant of the intersection for the by-pass.

4.3.3 Preferred Alternative

Based on the advantages and disadvantages of the roundabout concepts as described, and discussions with Alberta Transportation, Alternative 3 was recommended as the preferred alternative. It will be constructed this year.

5.0 CONCLUSIONS

Several horizontal design treatments exist to accommodate large commercial vehicles at roundabouts. This paper examined their use and discussed considerations in terms of lane use at multi-lane roundabouts. This paper also described two recent projects undertaken in northern Alberta to accommodate one or more over-dimensional vehicles through a roundabout.

In both projects a number of the horizontal design treatments described in this paper were employed to accommodate the vehicles without compromising the inherent safety benefits of the roundabout.