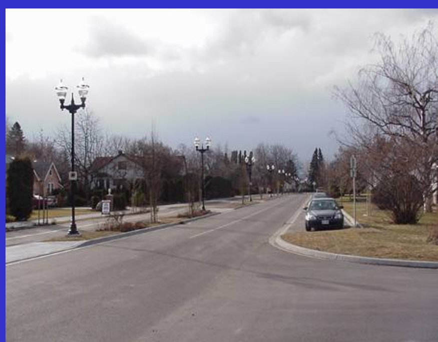

# Kamloops Safer City Final Road Form Guidelines

Prepared for

## Insurance Corporation of British Columbia

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December 2004

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*Final*
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# City of Kamloops Road Form Guidelines

Prepared for

**City of Kamloops & Insurance Corporation of British Columbia**

CH2MHILL

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# City of Kamloops
# Draft Road Form Guidelines

## 1.0 Introduction

These Road Form Guidelines have been developed in parallel with the Network Classification Strategy developed by Urban Systems. The road classification system used in that document forms the basis for these design guidelines. In addition, safer intersection planning guidelines have been developed in parallel with these guidelines and these should be referred to when assessing the issues associated with roadway segments and intersection design.

This document should also be read in conjunction with the City of Kamloops Engineering Design Manual, Section Two – Road Design and is intended for internal staff use.

The intent of these Road Form Guidelines is to provide guidance on those aspects of road form that have a bearing on safety for all road users.

The governing factors that influence safety of the roadway are considered to be as follows:

- Design speed
- Number of lanes
- Lane width
- Medians and median width
- Provision of on-street parking
- Provision for other modes
- Design consistency

Guidelines have been provided for both Urban and Rural roads.

## 2.0 Road Form Guidelines

### 2.1 Road Form Guidelines

Urban road form guidelines are presented in ***Table 2.1*** and rural road form guidelines are presented in ***Table 2.2***.

| | Table 2.1: Urban Guidelines | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Freeway/ Expressway | Arterial | | | Collector | | | Local | Industrial |
| | | Major | Minor | Downtown Commercial | Primary | Hillside | Neighborhood | | |
| 1.0 GENERAL<br>• Speed | Fig. 1 | Fig. 2 | Fig. 3 | Fig. 4 | Fig. 5 | Fig. 6 | Fig. 7 | Fig. 8 | Fig. 9 |
| – Design Speed (km/h) | 80 - 120 | 60 - 80 | 50 - 70 | 40 - 60 | 40 - 60 | 40 - 60 | 40 - 60 | 30 - 50 | 40 - 60 |
| – Ave. Operating Speed (km/h) | 60 - 110 | 50 - 70 | 40 - 60 | 30 - 50 | 30 - 50 | 30 - 50 | 30 -50 | 30 - 40 | 30 - 50 |
| – Max. Posted Speed (km/h) | 60-110 | 50-70 | 60 | 50 | 50 | 50 | 50 | 50 | 50 |
| • Right of Way Width (m)<br>(Typical) | > 38.6 | 29.8-37.8 | 27.4-36.3 | 23.6-34.7 | 16.2-30.3 | 23.2-38.1 4 lanes<br>21.4-31.3 2 lanes | 15.2-28.9 | 19.0-21.6 | 16.8-28.2 |
| 2.0 PROVISION FOR VEHICLES | | | | | | | | | |
| • Number of Lanes | 4 + | 4 | 4 | 2-4 | 2 | 2-4 | 2 | 2 | 2 |
| • Lane Width | | | | | | | | | |
| – Inside (m) | 3.7 | 3.5-3.7 | 3.3-3.7 | 3.3 | N/A | 3.5-3.7 | N/A | N/A | N/A |
| – Outside (m) | 3.7 | 3.5 - 3.7 | 3.3 - 3.7 | 3.3 | 3.3-3.5 | 3.5-3.7 | 3.0-3.5 | 3.0 - 3.3 | 3.5-3.7 |
| • Shoulders (Y/N) | Yes | No | No | No | No | No | No | No | No |
| • Shoulder Width | | | | | | | | | |
| – Inside (m) | 1.5 to 2.5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

| | Table 2.1: Urban Guidelines | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Freeway/ Expressway | Arterial | | | Collector | | | Local | Industrial |
| | | Major | Minor | Downtown Commercial | Primary | Hillside | Neighborhood | | |
| – Outside (m) | 2.5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| • Medians (Y/N) | Yes | Yes | Optional | Optional | Optional | Optional | Optional | No | No |
| • Median Width (m) | 3.6 min. | 2.0 to 6.0 | 2.0-4.5 | 2.0 to 4.5 | 2.0-4.5 | 2.0-4.5 | 2.0-4.5 | N/A | N/A |
| • Two Way Left Turn Lane (TWLTL) | No | No | Optional | No | Optional | Optional | No | No | Optional |
| • TWLTL Width (m) | N/A | N/A | > 3.5 | N/A | > 3.5 | > 3.5 | N/A | N/A | > 4.0 |
| • On-Street Parking | Not permitted | Not permitted | Permitted with restrictions | Permitted with restrictions | Permitted | Permitted | Permitted | Permitted | Permitted |
| • Parking Lane Width (m) | N/A | N/A | 2.6 to 2.8 | 2.4 to 2.8 | 2.6 to 2.8 | 2.6 to 2.8 | 2.4 to 2.8 | 2.4 | 2.8-3.5 |
| <u>3.0 PROVISION FOR CYCLISTS</u> | | | | | | | | | |
| • On-Street Bicycle Facilities | Prohibited | Bike or Wide Curb Lane | Bike or Wide Curb Lane | Bike or Wide Curb Lane | Bike or Wide Curb Lane | Uphill bike lane and downhill Wide Curb Lane | Shared or Wide Curb Lane | Shared Lane | Bike or Wide Curb Lane |
| • Wide Curb Lane Width (m) | N/A | 4.3 to 4.5 | 4.3 to 4.5 | 4.0 to 4.5 | 4.0 to 4.5 | 4.0 to 4.5 | 3.5 to 4.3 | N/A | 4.3-4.5 |
| • Bike Lane Width (m) | N/A | 1.5 to 1.8 | 1.5 to 1.8 | 1.2 to 1.8 | 1.2 to 1.8 | 1.2 to 1.8 | N/A | N/A | 1.2 to 1.8 |
| • Shared Lane Width (m) | N/A | N/A | N/A | N/A | N/A | N/A | 3.5 | 3.0 to 3.3 | N/A |

| | Table 2.1: Urban Guidelines | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Freeway/ Expressway | Arterial | | | Collector | | | Local | Industrial |
| | | Major | Minor | Downtown Commercial | Primary | Hillside | Neighborhood | | |
| 4.0 PROVISIONS FOR PEDESTRIANS | | | | | | | | | |
| • Sidewalk Facilities | None | 2 sides | 2 sides | 2 sides | 2 sides | 2 sides | 2 sides | 1 side; 2 sides in pedestrian area | 1 side |
| • Sidewalk Width (m) | N/A | 1.8 to 2.4 | 1.8 to2.4 | 2.4 | 1.5 to 1.8 | 1.5 to 1.8 | 1.5 to 1.8 | 1.5 to 1.8 | 1.5 to 1.8 |
| • Boulevard Width (m) | N/A | 3.0 | 3.0 | 1.5 to 3.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| • Border Areas (m) | N/A | 1.0 | 1.0 | 0.3 to 1.0 | 0.3 to 1.0 | 0.3 to 1.0 | 0.3 to 1.0 | 0.3 to 1.0 | 0.3 to 1.0 |
| 5.0 PROVISION FOR TRANSIT | | | | | | | | | |
| • Transit Service | Express service | Express & Local Service | Express & Local Service | Express & Local Service | Local Services | Express & Local Services | Local Services | Paratransit Services Preferred | Local Services |
| • Bus Bay/Pull Out | N/A | Yes | Yes | Preferred | No | No | No | No | No |
| 6.0 ROADSIDE SAFETY | | | | | | | | | |
| • Curb Type | Semi-mountable | Semi-mountable or barrier | Barrier | Barrier | Barrier | Barrier | Mountable (Rollover) | Mountable (Rollover) | Barrier |

| Table 2.2: Rural Guidelines | | | | | |
|---|---|---|---|---|---|
| | Freeway | Arterial | Collector | Local | Industrial |
| 1.0 GENERAL<br>• Speed | | | | | |
| – Design Speed (km/h) | 100 - 130 | 80 - 100 | 60 - 100 | 50 - 80 | 60-100 |
| – Ave. Operating Speed (km/h)<br>– | 70 -110 | 60 - 90 | 50 - 90 | 40 -70 | 50 - 90 |
| – Max. Posted Speed (km/h) | 60-110 | 50-70 | 50 | 50 | 50 |
| • Right of Way Width (m) (Typical) | 39.6 Flush<br>46.0 Depressed | 31.6 Flush<br>37.0 Depressed | 18.0 | 17.0 | 20.0 min. |
| 2.0 PROVISION FOR VEHICLES | | | | | |
| • Number of Lanes | 4 + | 4+ | 2 | 2 | 2 |
| • Lane Width | | | | | |
| – Inside (m) | 3.7 | 3.5 – 3.7 | N/A | N/A | N/A |
| – Outside (m) | 3.7 | 3.5 - 3.7 | 3.0 - 3.7 | 3.0 - 3.3 | 3.5 |
| • Shoulders (Y/N) | Yes | Yes | Yes | Yes | Yes |
| • Shoulder Width | | | | | |
| – Inside (m) | 1.5 | 1.0 to 1.5 | N/A | N/A | N/A |
| – Outside (m) | 3.0 preferable | 2.5 to 3.0 | 1.5 to 2.5 | 1.0 | ? |
| • Medians (Y/N) | Yes | Optional | No | No | No |
| • Median Width (m) | 2.6 min. Flush<br>6.0 Depressed | 2.6 min. Flush<br>6.0 Depressed | N/A | N/A | N/A |
| • On-Street Parking | No | No | Yes | Yes | Yes |
| • Parking Lane Width (m) | N/A | N/A | 2.4 | 2.4 | 2.8-3.0 |
| 3.0 PROVISION FOR CYCLISTS | | | | | |
| • On-Street Bicycle Facilities | Paved Shoulders | Paved Shoulders | Paved Shoulders and shared | Shared Lane | Paved Shoulders |
| • Paved Shoulder Bike Lane Width (m) | 2.5 min. | 1.5 to 2.5 | 1.5 to 2.5 | N/A | 2.0-2.5 |
| • Shared Lane Width (m) | N/A | N/A | 3.0 to 3.7 | 3.0 to 3.3 | N/A |
| 4.0 PROVISION FOR PEDESTRIANS | | | | | |
| • Pedestrians Accommodated? | Discouraged where alternative routes | Paved Shoulder | Paved Shoulder | Shared Lane | Paved Shoulder |
| 5.0 PROVISION FOR TRANSIT | | | | | |
| • Transit Service | Yes | Yes | Yes | Yes | Yes |
| • Bus Bay/ Pull Out | N/A | Yes | No | No | No |
| 6.0 ROADSIDE SAFETY | | | | | |
| • Minimum Clear Zone (m) | 11.0 | 7.5 | 4.5 | 2.0 | 4.5 |

## 2.2 Cross Sections

Typical cross sections for the various road classifications are shown on ***Figures 1 through 14***. These figures show cross sections developed utilizing the various cross section elements indicated in the Urban and Rural Guidelines Tables 2.1 and 2.2. A range of values is shown for these elements, together with a maximum/minimum right-of-way width. In some cases a desirable minimum right-of-way width is indicated, where using all minimum element widths across the section would otherwise result in a less than desirable overall width. "Desirable widths" may provide scope for the future addition or expansion of cross section elements such as parking and sidewalks, as well as provide additional room for snow storage etc.

It should be noted that there are several combinations for each cross section and not all permutations are shown. As noted in the guideline tables, for some classifications certain elements are optional, such as provision of a median, and the use of bike lanes or wide curb lanes. In general, the cross sections shown assume that provision for cyclists is required, and where either bike lanes or wide curb lanes are alternatives, both are typically shown on the cross sections (see Figures 2 to 6, and Figure 9). The sections also show the impact of providing for parking where this may be permitted.

Consequently, the right-of-way widths shown on the cross sections are indicative only and subject to change based on actual specific requirements. For example, the overall right-of-way width may be decreased where provision for bicycles or parking is not required. On the other hand, additional width may be required at intersections and to accommodate features such as turn lanes, bus bays, and clear zone requirements.

Other factors that should be taken into consideration include:

- Where bicycle lanes are to be provided adjacent to parked vehicles, the bike lane width should be a minimum of 1.5 m.
- Consideration should be given to using flatter sideslopes in rural situations to increase the degree of safety provided. Parking can be provided by extending the width of gravel shoulder providing drainage is addressed appropriately.
- The impact and cost effectiveness of utilizing roadside barrier should be compared to the consequences of providing adequate clear zone.

These cross sections do not show utility corridors or roadway and pavement drainage requirements. Refer to existing municipal standards and guidelines for these requirements.

# 3.0 Explanatory Notes

## 3.1 General

### 3.1.1 Speed

Reference should be made to Section 1.2.3 of the "Geometric Design Guide for Canadian Roads" (TAC, 1999) which deals with the topic of speed at length. In particular, it discusses the various types of speed such as "desired speed", "design speed", "operating speed", "running speed" and "posted speed", and how each of these is associated with the design process. The following summarizes some of the relevant points made in TAC, together with some further observations.

#### (i) The Importance of Speed

Managing speed is one of the most important tools we have for improving road safety. Research tells us that collision frequency will be reduced on roads that do not require drivers to make large speed adjustments and promote uniformity of speeds.

There is a difference between the traffic speed suitable for an arterial road compared to a residential street. In local and collector roads, we can expect a higher amount of pedestrians and cyclist activity and more unpredictable movements, such as children dashing out into roads. Under these circumstances, the impact speed is a critical factor in determining the number and severity of injury crashes. For pedestrians, the change from a survivable crash to a fatal one occurs at speeds between 50 km/h and 65 km/h. Evidence from the UK, shows that nine out of 10 pedestrians will die when hit by a car at 65 km/h; this death toll falls from five out of 10 at 50 km/h to one out of 10 at 30 km/h (reference 1). Reducing traffic speeds to around 30 km/h in local streets saves lives and helps to reinforce the road hierarchy by encouraging through traffic to stay on the arterial roads and not take shortcuts through residential streets.

Both actual speed and speed differential are important when seeking to improve road safety. While reducing the speed differential helps to prevent rear end type collisions, it does not increase the safety of pedestrians and cyclists sharing road space with motorists. A lower actual speed can give drivers time to avoid collisions and at the very least, it reduces the severity of injuries in a road crash. There is a great deal of evidence that the number of crashes and their severity increases with higher traffic speeds and decreases with lower traffic speeds. A study of 200 new 30 km/h speed limit zones in England, reduced from 50 km/h, showed that on average, the number of child pedestrians killed and injured fell by 70% (reference 2). The UK government also reported that the number of crashes rises approximately square to the increase in average speed. Drivers travelling much faster or slower than the average speed are more likely to be involved in crashes and this is measured by the speed differential. The aim is to bring the highest speeds down to under the speed limit thereby reducing actual speeds and their differential.

#### (ii) Design Speed

Design speed dictates the horizontal and vertical geometry of the roadway and is also an important criteria used to determine the appropriate lane width, intersection design, lighting, provision of mid-block left turns, commercial and residential access, provision for vulnerable road users and transit services. Typically, the higher class of road would have a higher design speed than the lower class. Major arterial roadways may have design speeds up to 100 km/h, depending on jurisdiction, whereas local roadways may be designed to as low as 30 km/h. Design speed therefore has an impact on the major road form elements, which all contribute to safe operation of the roadway. The road network should therefore also be classified by the design speed.

The design speed selected should be a logical one with respect to the topography and be consistent with the road function as perceived by the driver. Ideally, the design speed should be chosen to reflect the 85$^{th}$ percentile desired speed, and where possible a constant design speed should be used when designing a substantial length of road. It should be noted however that there are limitations to the design speed approach to roadway design, and some of these are discussed in TAC Section 1.2.3.7.

### (iii) Operating Speed

Operating speed, the speed at which a driver is observed operating a vehicle, is generally lower than desired speed since operating conditions are seldom ideal. Most drivers use their knowledge of the roadway system, posted speed limits, and characteristics such as number of accesses, roadway width and lane width, to deduce the appropriate operating speed for the road. Inconsistency in these factors can result in drivers failing to react to a change in conditions in time or result in speed differentials between vehicles; situations which are likely to increase the risk of collision. The aim therefore is to provide a reasonable degree of uniformity in operating speeds (and design and posted speeds) across the network for each type of road, so that driver expectation is met.

A key to establishing operating speed consistency is the ability to be able to predict operating speeds associated with geometric elements along the alignment. Some information is now available to assist designers in predicting operating speeds. Reference should be made to TAC Section 1.4.3 for further details.

### (iv) Posted Speed

The influence of posted speed on actual speeds is somewhat tenuous and relies firstly on the posted speed being regarded as "reasonable" by the driver, and secondly on enforcement. Drivers will not observe speed limits that are inconsistent with the nature and type of road, and setting of **artificially low posted speed limits** should be avoided. Some of the factors which affect a driver's perception of what is "reasonable" include road classification, alignment, environment (rural or urban), number of lanes and lane width, parked vehicles, presence of pedestrians and cyclists, roadside development, and sight distance. It is important therefore that, to be effective, the posted speed is consistent with the road environment, including the prevailing topographical and development conditions. The establishment of speed limits which are appropriate to the traffic environment, and seen to be reasonable by motorists, is key to reducing the mean speed of traffic and, all else being equal, the incidence of collisions.

As noted in TAC," … it is desirable to provide a reasonable degree of uniformity in the design speeds, operating speeds, and subsequently the posted speeds selected within each classification subgroup or group. For example, the posted speeds for all minor arterials within a municipality should be identical or near identical. Driver expectations are met in this manner".

### 3.1.2 Right-of-Way

In addition to the typical cross-section elements such as lanes (both for vehicles and bicycles), medians, sidewalks, boulevards and borders, additional right-of-way acquisition may also be desirable for other purposes such as utility placement, streetscaping, and maintenance considerations. It is however important to select a right-of-way width that is appropriate to the nature of the adjacent land use, particularly since land use can influence such elements as design speed.

The optical width (or surrounding environment) of the street can influence driver behavior. The optical width does not restrain traffic speed when the development is set back too far, for example to allow for parking at the front of the building. In ideal situations, parking would be located at the rear of developments so that the buildings become part of the street and shorten the distance for people walking. Collector roads ideally should have continuous development less than 10 metres from the roadside. Similarly, local streets should have a confined street scene with continuous residential development less than 10 metres from the roadside. Frequent access onto the roadway tells the driver that this is a place where they may encounter pedestrians and cyclists, and must exercise caution. Conversely, too much "openness" (caused by too great a setback space between the right-of-way and the building face, in conjunction with an overly wide right-of-way) may give the wrong message to drivers and result in inappropriate speeds.

## 3.2 Provision For Vehicles

### 3.2.1 Number of Lanes

The number of lanes is dependent upon the roadway function. For arterial roadways, where the function is to allow for high volumes of traffic to travel safely, there should be at least two lanes in each direction. The number of lanes is therefore dictated by mobility requirements. It should be recognized that provision of additional lanes on lower classes of roadway might encourage speeding and also lead to safety concerns, for example the presence of additional lanes results in increased exposure for pedestrians trying to cross the street. Wider roadways also increase the severance of adjacent neighborhoods.

For roadways with multiple lanes, one could operate as an HOV lane or transit bus lane. This would help to promote alternatives to the car and reduce traffic speeds.

### 3.2.2 Lane Width

Lane width is dictated by the roadway classification, design speed and type of vehicle to be accommodated. In terms of road safety, there is only a marginal increase in safety with lane widths above 3.3m and a probable decrease in safety beyond 3.7m (reference 3). Lane widths below 3.0m should be avoided unless traffic volumes and speeds are low or the travel lane is located alongside a bicycle lane. Care should be exercised when using lane widths between 3.0m and 3.5m because they can give ambiguous signals to drivers as to whether or not it is safe to overtake cyclists in roads with no bike lanes (reference 4). Note that most research on lane width relates to two-lane rural roads.

An indication of the relationship between single vehicle or opposite direction collisions and various lane widths on two-lane rural roads is indicated in TAC Section 2.2.2.2.

Wider lanes may provide more room for correction in near collision circumstances; however, drivers tend to drive faster on roads that have wider lanes. Conversely, narrow lanes force drivers to operate their vehicles closer to each other laterally than they would normally desire, increasing the discomfort for the driver, and have been shown to increase the number of encroachments.

Wider lane widths increase capacity because drivers choose shorter headways. This could lead to more rear-end type collisions - a common safety problem on links in urban areas.

Lane widths greater than 4.0m should be avoided since they may lead to confusion and improper lane usage in congested urban environments unless they are marked wide curb lanes, incorporating bicycle symbols on the right side of the lane at regular intervals to alert motorists to the potential presence of bicycles.

In local residential streets, the use of minimum travel (and parking) lane widths encourages low operating speeds, which is desirable where the priority is to support the living environment (i.e. pedestrians).

Roadway narrowing (for example by reducing lane widths) must consider school bus and emergency service access, and truck volumes. Narrow lanes are probably not appropriate if the road has heavy truck volumes, typically greater than 10% (reference 5).

Notes regarding Urban and Rural Road Form Guidelines tables:

- For urban roads, lane width is exclusive of gutter or offset dimensions
- Widths do not include a specific allowance for accommodating cyclists (refer to "Provision for Cyclists and Pedestrians" below)
- In retrofit projects, minimum values may be acceptable. However, consideration of the impact on safety needs to be considered, for example the anticipated vehicle types and cyclist volumes.
- Additional lane width may be required around tight curves to accommodate trucks.
- On four lane roads, it is usual to locate the wider lane on the outside alongside the curb and gutter to allow more room for trucks and bicycles.
- On freeways where trucks are prohibited from the median lane, the median lane width can be 3.5m.

Wider lane widths should be considered on hillside roads to accommodate fishtailing in limited traction conditions.

When reaching a decision on lane widths and other cross section elements, designers need to consider the impact on the following competing issues:

- Safety
- Capacity
- Road hierarchy, taking into account severance problems shouldered by the local community.

Choosing the most appropriate lane width and other cross-section elements should make the road self-explaining, so that drivers clearly understand what is expected from them.

The concept of a self-explaining, self-enforcing road is to select distinctive features such that the appearance of the road leaves the driver in no doubt as to what sort of facility they are on. By providing a roadway that is planned and designed in such a way, an appropriate and “consistent” speed for each road category can be achieved. For example, several wide lanes, one-way traffic, no bicycles and pedestrians, and the lack of intersections, clearly indicate a high speed freeway or expressway type facility. Distinctive features that “explain” the road include items such as number of lanes and lane width, presence or lack of cyclists and pedestrians, width of sidewalks, presence of medians, provision of on-street parking, and frequency of access. Researchers in Europe have singled out two aspects to which drivers seem particularly receptive: cycle paths and road width (reference 6).

### 3.2.3 Shoulders

Shoulders are normally provided on rural roads. They affect road safety by providing a potential recovery area, a refuge for stopped and disabled vehicles, an opportunity to improve sight distance, and they can help promote a sense of well-being on the part of the driver.

Shoulders should preferably be continuous along the roadway and be clearly identified from traveled lanes by using pavement edge striping, contrasting colour or texture of paving, or the use of rumble strips. These features enhance safety particularly during nighttime or inclement weather conditions. Rumble strips help to alert an inattentive driver, and should also be considered where there is a history of run-off-road collisions.

Information regarding the effect of shoulder width on safety is less conclusive than that for lane width. However, we can expect the number of collisions to reduce as the shoulder width increases because of the room for drivers to recover control of their vehicles. Roads with wider shoulders tend therefore to have fewer run-off- road and opposite direction collisions. In addition, wider shoulders also help to provide a greater lateral clearance for signs and guardrails, and increase the sense of openness along the roadway, contributing to driver ease and reduced stress.

On the other hand, wider shoulders may induce higher traffic speeds, which may lead to an increase in other types of collisions and to their severity. Wider shoulders may also result in more frequent stopping. Studies have also indicated that the safety effect of wide shoulders on level and straight roads is less than on sharp horizontal curves and on roads with steep grades.

Understanding the safety of shoulders therefore entails offsetting the advantages of giving more room for motorists to avoid collisions and room for broken down vehicles against the disadvantages of increased stopping on the shoulder, increased traffic speed and merging problems.

If a shoulder is installed, paved shoulders offer more safety than one consisting of soil or gravel. Both soil and gravel can lead to loss of control, particularly where drivers frequently pull over to allow faster traffic to overtake. Empirical studies show that the number of crashes and their severity increase when a shoulder width is 2.4 metres wide or more. A shoulder width of 1.8 metres is ideal in safety terms. Shoulders offer few safety advantages on straight, level roads, but can increase safety in the following circumstances:

- Roads with higher traffic volumes;
- Roads with bends or significant grades.

Shoulders are typically not used in urban situations, often because of the high cost of right-of-way. They are however desirable on freeways, expressways, and certain high-speed arterials with design speeds over 80 km/h.

### 3.2.4 Medians

Medians are desirable on higher order roads to separate the opposing streams of traffic and also to allow for left turn bays at intersections. Medians are also an important element in access management and where they are non-traversable are used to eliminate left-in and left-out turns from access onto arterial and primary collector roadways. On urban roadways, median widths typically vary from 2.0 metres between intersections and up to 6.0 metres at intersections, the additional width being required for left turn channelization. These widths allow for gutters or offsets from the edges of the travelled lanes.

Apart from separating traffic movements, a non-traversable median provides a central refuge for pedestrians in busy roads. It reduces the potential for head-on and rear end type collisions with vehicles turning left. They also help to reduce headlight glare. Medians on urban roads can be flush and painted or physical (raised). Physical medians offer the greatest safety for all road users, but painted medians give room for emergency service vehicles, safer maintenance and space for Police road checks. Medians should be visible day and night and in contrast to adjacent travel lanes.

Medians on rural roads can be flush and painted or depressed. Further comment on rural medians is provided below in section 3.2.5.

Medians for urban freeways are normally either flushed or raised with a median barrier. Along urban arterials median barrier is not normally used because it has to be terminated at some accesses and intersections, and the hazard of the barrier ends typically offsets the safety benefits of the median. Where median barrier is used on major arterials, a 1.0m offset between the barrier and lane edge is desirable.

A particular type of flush median is a two way left turn lane (TWLTL), which has the advantage of removing left turn vehicles from through lanes and decreasing the potential for rear-end collisions. It also provides a lane for emergency vehicles, an extra lane during construction, and can be used as a reversible lane during peak periods. Its disadvantages however include an increased potential for head-on collisions, possible driver confusion, a lack of pedestrian refuge, conflicting vehicle manoeuvres at driveways, and difficulties for left turning vehicles to find an acceptable gap.

In general, going from no median to a TWLTL decreases crashes, and replacing the TWLTL with a raised median further reduces collisions. The safety effects of median treatments depend however on its proper implementation and the appropriateness of the location. As a guideline, TWLTL's seem to work best in commercial areas, especially those with strip development, and in areas where there is a fairly high demand for left turns. Other candidates for TWLTL's are roads with low to moderate volumes and at least 28 driveways per km (reference 7) and arterials.

### 3.2.5 Median Width

Additional median width may be required to accommodate bridge piers, the placement of traffic control devices, and to provide adequate pedestrian refuge space in high pedestrian volume crossing areas. Additional width may also be required where heavy volumes of truck turning movements are anticipated.

Medians for rural freeways are usually depressed with a width of 6.0m or more, and with flat side slopes to reduce the possibility of an errant vehicle overturning. Slopes should be no steeper than 4:1 and desirably 10:1 or flatter. Wider medians, which eliminate the need for median barriers, provide additional safety by further reducing the risk of opposing vehicles colliding, and median widths of 20m or more are often used for rural freeways. A flush median without barrier, varying between 1.0m and 4.0m, may be appropriate for some rural highways with low to medium volumes and operating speeds. For higher speed rural arterials barriers are normally used with flush medians; the median width typically being 2.6m to provide a desirable 1.0m offset between the barrier and the lane edge.

### 3.2.6 On-Street Parking

On-street parking can cause safety and congestion problems on higher order roadways. This is due to drivers suddenly stopping and reversing into on-street parking lanes. Drivers opening doors without due care and attention are also a hazard to cyclists. In addition, research in the UK indicates that parked vehicles, or those in the process of parking or unparking, account for about 10 per cent of traffic collisions. Parked or parking vehicles are particularly associated with pedestrian casualties, since the vehicle impedes visibility between the approaching motorist and the pedestrian.

Based on the preceding comments, on-street parking should not be permitted on arterial roadways where the main function is movement of traffic. Major traffic generators along main roads should, where feasible, be required to provide off-street parking. Parking lanes are generally not used for roadways having design speeds of 70km/h or more.

Care should be taken when providing on-street parking on lower order roadways because the resultant wide road will have the potential to encourage speeding when there are no parked cars. Parking lanes should preferably be painted or provided by widening sections of the street. Parallel parking is safer than angle parking, although this is at the expense of parking capacity.

Consideration should also be given to snow clearing operations when determining the appropriate parking lane width. Snow accumulated at the side of the road not only reduces the available traveled lane width, but can also reduce the usable parking width. Since snow conditions can be present for several months of the year, additional parking lane width may be appropriate to provide safe operating conditions. In most urban situations it is preferable to widen the sidewalk or better still provide a boulevard to accommodate the snow, rather than widen lane widths.

On-street parking can help to slow traffic speeds assuming space is taken from the travel lane. However, some parking control may be required outside school entrances and close to intersections for example. Otherwise, parked vehicles can mask pedestrians, especially children crossing the roadway. For this reason and because crossing movements are more indiscriminate in local streets, traffic speeds of around 30 km/h are preferred where on-street parking is allowed. Unlike local streets, reducing speeds to around 30km/h is not always practicable on collector streets. However, a general 50km/h speed limit with consideration to localized lower speed limits at critical locations would help to protect the safety of pedestrians and other vulnerable road users.

Where there is parking provided along curbed roadways, curb extensions should be considered where pedestrians cross. These treatments typically apply on local and residential collector streets. Parking needs to be removed on the approaches to crosswalks to improve visibility for both drivers and pedestrians. As a guide, at least 6 m of parking should be removed both upstream and downstream from the crosswalk. At intersections, this distance should desirably be 9.0 to 15.0 m. The Institute of Transportation Engineers (reference 8) recommends restricting parking for a distance of 15 m for roads with speed limits of 55 to 70 km/h, and a distance of 30 m for speeds above 70 km/h. Well-designed curb extensions can reduce these distances and maximize the number of on-street parking spaces. In areas of regular snowfall, measures such as signing should be taken to ensure the curb extension is visible to snow plow operators.

In residential areas where on-street parking is necessary, consideration should be given to "grouping" parking nearby to create special "resident parking zones".

In industrial areas, large articulated trucks need lanes to be about 3.5 m wide. Unless parking is prohibited and enforced, an additional 2.8 (for permanent parking) to 3.5 (for off peak use only) will need to be provided as parking space.

## 3.3 Provision for Cyclists

On arterial roadways, with speeds of up to 70 km/h, collisions involving vulnerable road users such as cyclists can be extremely serious and can result in death or injury. Where a designated cycle route has been identified along an arterial, provision should be made for appropriate facilities. Ideally, bicycle facilities should be located along an adjacent collector or local road.

### (i) Provision for Cyclists in Urban Areas

In urban areas, the two basic choices for accommodating cyclists are using a wide curb lane or a bike lane (except on local roads and lower volume collector roads where cyclists can share the traveled lane). With wide curb lanes, bicycles share the roadway with other vehicles, and the additional width provides space for motorists, including truck traffic, to pass cyclists without changing lanes. Wide curb lanes do not include a white line separating bicycles from other traffic, but the addition of a painted bicycle lane symbol at regular intervals on the right side of the lane helps to alert motorists to the potential presence of bicycles.

Bike lanes on the other hand are intended for exclusive use by cyclists within a roadway, and are typically delineated from the adjacent traveled lane by a painted line, together with a bicycle lane symbol at regular intervals within the bike lane. Conditions are generally improved by designating separate areas for cyclists and motor vehicles. Marking bicycle lanes can also benefit pedestrians – as turning motorists slow and yield more to cyclists, they will also be doing so for pedestrians. Bike lanes can be established by reducing the number and/or width of vehicle travel lanes, prohibiting on-street parking, or widening the roadway (see Section 4 for further discussion on road space reallocation). As noted previously, narrowing the roadway by reducing lane widths encourages lower vehicle speeds.

Bike lanes also provide a buffer between motor vehicle traffic and pedestrians when sidewalks are immediately adjacent to the curb. In addition, since they reduce the space dedicated to motor vehicles, marked bike lanes may enhance safety for pedestrians who want to cross the street.

Comparative analysis carried out by the FHWA (reference 9) concluded that both dedicated bicycle lanes and wide curb lanes should be used to improve riding conditions for cyclists. The study goes on to recommend that assuming that there is adequate width, dedicated bicycle lanes should be used because they promote cycling (particularly for less experienced cyclists) and in general cyclists prefer them in comparison to wide curb lanes. In broad terms, wide curb lanes are more suited to locations where there is a critical mass of cyclists, where drivers and pedestrians frequently encounter cyclists and there would be frequent bike/bike conflicts in a bicycle lane.

Situations where marked wide curb lanes are preferred include:

- On roadways with low to moderate traffic volumes
- Where there are high volumes of turning movements
- Where on-street parking is provided
- Where frequent bus stops are provided
- With or without frequent driveways
- On roads with moderate speeds
- On steep downhill grades
- Where there is a high mix of larger vehicles and transit vehicles.

Situations where bike lanes are the preferred treatment include:

- On roadways with higher volumes and/or speeds
- Where there is no parking on roadways
- On roads that have limited bus service or stops
- Where there is limited driveway access
- On steep upgrades (but not steep downgrades)

Marked wide curb lanes should typically be 4.3m wide (not including the gutter). A minimum width of 4.0m is acceptable. Widths greater than 4.5m should be avoided as these may encourage vehicles to pass other vehicles to the right.

Bike lanes should typically be 1.5m wide (excluding the gutter). A minimum width of 1.2m may be acceptable. Where posted speeds are 70 km/h or more, the bike lane width should be 1.8m. Widths greater than 1.8m should be avoided as these may encourage vehicles to park in the lane.

Where bicycle lanes are to be provided adjacent to on-street parked cars, a minimum bicycle/parking lane width of 3.9m should be used, assuming 2.4m for the parking lane and 1.5m for the bicycles. The preferred approach, however, is to provide marked wide curb lanes adjacent to parked vehicles. Adequate clearances should be allowed for the maneuvering of parking vehicles and people getting into and out of cars. A horizontal clearance of 600 mm should generally be maintained between a bikeway and any lateral obstruction.

On high-speed, high-volume roads it may be more appropriate to provide a multi-use path to physically separate both cyclists and pedestrians from motor vehicle traffic.

No separate provision is made for cyclists on local roads or lower volume collector roads as cyclists and motorists are able to safely share the road within the normal (standard) travel lane widths. Shared roadways are typically suitable in urban areas on streets with low speeds (40 km/h or less), or low traffic volumes (3,000 AADT or less, depending on speed and land use). In most cases, the only improvement required is signage identifying the road as a bicycle route.

### (ii) Provisions for Cyclists in Rural Areas

On rural arterial and collector roads cyclists are typically accommodated on a paved shoulder (or shoulder bikeway), which generally improves safety by providing a separate area for cyclists away from faster moving motor vehicles. Paved shoulders should generally be at least 1.5m wide, but should be wider where posted speed limits are 70 km/h or higher. With higher volumes (over 10,000 vehicles per day) and posted speeds over 80 km/h, a minimum width of 2.5m is recommended. On local roads and some collector roads, with lower traffic volumes (typically less than 3000 vehicles per day) and lower speeds, no specific treatments for cyclists are usually required and cyclists can share the traveled lane. Signage identifying the road as a bicycle route should be considered. However, where cyclist volumes are significant, consideration should be given to increasing the shared lane width to about 3.5m. Similarly, on steep grades additional width may be required to allow for inexperienced cyclists who may tend to wobble.

In certain circumstances, such as high-speed, high-volume roads (and depending on demand and availability of space), it may be appropriate to physically separate cyclists (and pedestrians) from motor vehicle traffic and provide a bike (or multi-use) path.

Where a multi-use path is used, the pathway should be wide enough so that faster-moving users can travel around slower-moving users, thereby avoiding conflict and collisions. A minimum path width of 4.0m is desirable. The path should preferably be hard-surfaced to accommodate all users, including wheelchair users and in-line skaters. Although the pathways are typically for two-way travel, painted centre lines should generally be avoided since they are often ignored and they can also contribute to conflicts when faster-moving users cross the centre line to pass slower-moving users.

## 3.4 Provision for Pedestrians

As noted in Sections 3.1 and 3.3, at higher speeds collisions involving vulnerable road users such as pedestrians can be extremely serious and can result in death or injury. Ideally, particularly at higher speeds, pedestrians should be separated from the roadway through use of a buffer. It is, therefore, very important that appropriate facilities be provided to accommodate pedestrians.

### (i) Provision for Pedestrians in Urban Areas

Most urban streets carry pedestrian traffic and are often provided with sidewalks. It is usual to provide sidewalks on both sides of arterial and collector roads.

On local streets, the number of pedestrians (and cyclists) is usually much higher. Within a self-explaining or self-enforcing 30km/h or lower speed limit, all road users can share the roadway, providing pedestrians have priority and this is clearly understood by motorists. However, in most circumstances, it is desirable to provide at least one sidewalk. Research in the U.S. (reference 10) indicates that based on exposure, local streets without sidewalks have 2.6 times more pedestrian collisions than expected. For streets with a sidewalk on only one side the number of pedestrian collisions was 1.2 times greater than expected. Therefore it is recommended that there be sidewalks on both sides of streets with pedestrian activity.

The appropriate width of the sidewalk will depend on local conditions and the anticipated volume and type of users. The desirable clear sidewalk width, based on two pedestrians passing side by side without touching, is 1.8m. The typical minimum width is 1.5m. However, adjustments should be made to allow for sidewalks adjacent to the curb (increase to 2.0 m), in commercial areas with high pedestrian volumes (2.4m minimum), at bus stops to accommodate waiting passengers (typically 3.0m), at intersections, and in other specific locations such as schools, parks, hospitals and recreational facilities (2.4 to 3.0m). Greater width should also be provided where significant numbers of seniors or wheelchair users are anticipated. Allowance should also be made for the presence of adjacent retaining walls and fences.

In areas of considerable snowfall, a clear sidewalk width of 1.8m offers advantages for snow cleaning operations, and the usable sidewalk width is less likely to be compromised by accumulated snow. When sidewalks are snowed in, pedestrians may walk in the road, putting them at risk.

It is preferable to provide a boulevard, or buffer zone, between the traveled lane and the sidewalk. Ideally the buffer on an arterial roadway should be 3.0 metres, with a 2.0 metre buffer used on lesser roads or where street trees are planted. This provides several safety benefits since it reduces the probability of a vehicle/pedestrian collision, it increases the safety for pedestrians and children at play, and it provides a space for snow storage thus allowing the sidewalks to remain usable for pedestrians. The boulevard can also help to improve sight lines between vehicle drivers and pedestrians. Boulevards are particularly important for streets with design speeds greater than 60 km/h. Where right-of-way is restrictive, consideration could be given to widening the sidewalk and eliminating the boulevard, or border, area.

Trees located in boulevards should not restrict sight lines, signs or street lighting (Refer to TAC Section 3.3.4). Trees should not be planted in boulevards less than 2.0 m wide unless adjacent to a parking lane where a minimum offset of 0.75 m is required.

In Kamloops, the boulevard area could be stamped concrete or similar "hard" landscaping. This provides differentiation between sidewalk and boulevard.

Curb extensions, or widening of the boulevard into the roadway at intersections and at mid-block crossing locations provides several safety benefits in that it decreases the roadway crossing distance (reduces the hazard exposure for pedestrians), provides additional space for pedestrians to stand, and improves visibility between drivers and pedestrians. Curb extensions also encourage motorists to travel more slowly as the restricted street width sends a visual cue to drivers. Care needs to be taken that the widening is made obvious to drivers and that parked vehicles on the approaches to the crosswalks are far enough away to not obstruct sight lines.

The border area between the back of the sidewalk and the edge of the right-of-way provides a comfortable separation between pedestrians on the sidewalk and any fences or building at the edge of the right-of-way. Similar to boulevards, the border area can be used to accommodate surface utilities and other fixed objects (signs, light poles, fire hydrants etc). From a vehicle traffic safety perspective it may be preferable to locate such objects in the border area rather than the boulevard, since the risk of them being impacted by a vehicle are minimized.

### (ii) Provision for Pedestrians in Rural Areas

Wide shoulders on both sides of a road are the minimum requirement for providing at least a possible place for people to walk. They are not as safe as paths or sidewalks, but they are better than nothing. Paved shoulders are preferred to provide an all-weather walking surface, since they also serve cyclists and improve the overall safety of the road. A 1.5m wide shoulder is acceptable for pedestrians along low-volume rural highways. Greater width, up to 2.5 to 3.0m, is desirable along high-speed roadways, particularly with a large number of trucks. An edgeline should be marked to separate the shoulder from the traveled lane.

An off-road path – paved or unpaved – can be an appropriate facility in rural or low-density suburban areas. Paths are generally set back from the roads and separated by a green area or trees. These facilities maintain a rural look, and are safer and more comfortable than a shoulder. They should however be easily accessible and direct; experience has shown pedestrians will walk on a road without sidewalks rather than follow a meandering pathway.

Consideration should also be given to the effect of snowfall, since where paved shoulders are utilized by pedestrians the available space for walking may be compromised by accumulated snow. This may lead to pedestrians walking in the traveled lanes, thus increasing the risk of a vehicle/pedestrian collision. On the other hand, where an off-road path is used, the space between the roadway and the path can be used for snow storage thus allowing the path to remain usable for pedestrians.

## 3.5 Transit

Transit routes are typically provided along arterial and collector routes with some penetration into the local street network in residential areas. Bus bays should be provided on arterial roads to ensure that buses can safely enter and leave an on-street stop. However, on collector streets, typical practice is not to provide separate bus pull-outs as it is often difficult for the driver to safely re-enter the traffic stream, particularly at peak periods.

Proper placement of bus stops is key to user safety. For example, placing the bus stops on the near-side of intersections or crosswalks may block the pedestrians view of approaching traffic, and the approaching drivers' view of pedestrians. Locating bus stops on the far-side of intersections or crosswalks usually encourages pedestrians to cross behind the bus, thus generally improving pedestrian safety since the sight distance restriction caused by the bus is eliminated.

## 3.6 Roadside Safety

US research (reference 11) has identified roadway departures as one of four major road-related safety issues, noting that "…crashes resulting from simply leaving the roadway, regardless of the underlying cause, represent a substantial portion of the total crash problem". Furthermore, Canadian research has shown that collisions with fixed objects account for approximately 30% of all fatal collisions in Canada and the United States (reference 12). These facts emphasize that the roadside environment, and its design, play a key role in improving road safety. For reference, City of Kamloops data (2001) indicates that off-road right collisions account for 11.1% of arterial collisions (third most common collision type), 14.9% of collector road collisions (the most common collision type), and 8.8% of local road crashes (fifth most common cause).

Methods of mitigating roadside collisions and their consequences include providing a recoverable area (for example applying the clear zone concept; typical on rural roads), and providing design elements that reduce the severity of any collisions that may occur. For example this could include providing breakaway supports, traffic barriers, or relocating utilities; typical on urban roads where constraints may make it impossible to locate the obstacle outside of the "clear zone".

Some general guidelines regarding urban applications are provided below. These are followed by comments relating to the "clear zone" concept.

- Barrier curbs can result in loss of vehicle control when hit at high speeds. They are therefore not generally used on urban freeways, expressways, and arterials with design speeds in excess of 70 km/h. Consider using semi-mountable curbs on these facilities. Neither barrier nor mountable curbs are desirable on roads with posted speeds of 90 km/h or higher, since errant vehicles may overturn or become airborne.

- Relocate obstacles to locations where they are less likely to get hit. Consider placing luminaires, utility poles and other street hardware in the border area rather than the boulevard. A better solution is to locate utilities underground.

- Use breakaway devices to reduce the severity of potential fixed-object collisions. However, consideration should be given to the possibility of pedestrians and cyclists being struck by falling breakaway hardware.
- Minimize the number of poles by combining usage, or increasing pole spacing where practical.
- Shield the obstacle with a traffic barrier if it cannot be eliminated, relocated or redesigned.

Generally accepted values for clear zone distances, based on design speed, traffic volume, and cut or fill slope values, are presented in TAC Table 3.1.3.1. Typical values for a recoverable fill slope of 4:1 are shown in the Rural Guidelines Table 2.2; reference should be made to TAC Table 3.1.3.1 for other situations. As noted in TAC these are not precise distances to be held as absolute, and must be considered in the context of site-specific conditions and practicality. In addition, analysis should be carried out to check the cost effectiveness of providing the clear zone compared to alternatives such as using roadside barrier. Guidelines for applying the clear zone concept are provided in TAC Section 3.1.4.

Ideally from a safety perspective the recoverable area should be free of all obstructions, however for operational, cost-effectiveness, or safety-related reasons, certain obstacles such as signs, signals or poles may need to remain within the clear zone. In these cases a breakaway device should be used to reduce the severity of any potential collision, or consideration given to shielding the obstacle with a barrier. In the case of utility poles, consideration should be given to minimizing the number of poles by combining usage, or increasing pole spacing where practical.

Tools are now available to enable explicit evaluation of alternative roadside design options. These tools include crash prediction models (which provide a way of estimating collision frequency and severity) and cost-effectiveness models (which provide a way of quantifying the life-cycle costs and benefits of the proposed safety measures). Discussion on the explicit analysis of roadside safety features is contained in TAC Section 3.1.2.

Reference should also be made to the work on Collision Prediction Models for different road forms in BC, presently being undertaken by Dr. Tarek Sayed at UBC.

The installation of traffic barriers generally leads to a decrease in collision severity but an increase in the frequency of minor collisions. Therefore, where it is cost effective, the designer should eliminate the need for barriers by, for example, clearing the roadside of obstacles, flattening embankment slopes, or introducing greater median separation. Use should be made of the cost-effectiveness techniques mentioned previously to evaluate the need for roadside barriers at site-specific locations.

Roadside barriers should be placed beyond the shy line offset, typical values of which are given in TAC Table 3.1.6.4. From a driver's perception, it is desirable to maintain a uniform clearance from the lane edge to the barrier and to other roadside obstacles.

# 4.0 Road Rehabilitation and Reconstruction

## 4.1 Introduction

Roadway rehabilitation and reconstruction provides opportunities for making changes to road form to address safety and user concerns. Typically, this situation will occur when the pavement requires major reconstruction at the end of the existing pavement life, or when underground utilities require replacement. Reconstruction allows for the following opportunities:

- To make changes to road form to better accommodate all users;
- To provide sidewalks;
- To provide bicycle lanes;
- To reduce the number of travel lanes through road space reallocation;
- To add turn lanes or two way left turn lanes; and
- To add or improve landscaping and other street beautification features; etc.

## 4.2 Road Space Reallocation

A recent development in the process of creating safer and more efficient ways to provide access and mobility for pedestrians, bicycle riders and transit users, as well as motorists, has been the re-assigning of road space without widening. This conversion of roadspace, commonly known as "road dieting", involves the "skinnying" up of existing streets by helping them lose lanes and widths, and enhancing facilities for other users such as pedestrians and cyclists. Typically, road dieting projects consist of modifying 4-lane roadways into two through lanes plus a middle TWLTL or a landscaped median, with the provision of bike lanes, wide sidewalks and/or on-street parking.

The ideal candidate for "road dieting" is typically a four-lane road carrying 12,000 to 18,000 vehicles per day, in particular those experiencing symptoms such as excessive speeds, high incidence of rear-enders, high pedestrian collision rates, and no bike facilities. Typical examples of treated roads are shown in **Appendix C**.

The problem with four-lane roadways is that they often generate excessive speeds and end up eroding the ability for transit, walking and bicycling to succeed. Pedestrians often have difficulties crossing four lane roadways since they have increased exposure time to traffic, and cyclists may find them too narrow to ride comfortably (reference 13). On the other hand, roads converted by road dieting can provide significant benefits to pedestrians by reducing crossing times and providing wider sidewalks and boulevards (or new sidewalks where none previously existed), and benefits to cyclists by providing designated bicycle facilities. Reducing the number of lanes (and lane widths) generally has a traffic calming effect, and may result in lower speeds, more uniform traffic flow, and reduced conflicts by, for example, eliminating weaving movements. The associated reduction in collisions may be due to lower speeds, less speed variability, less conflict points, improved sight distance for left-turning vehicles, less lanes for left-turning vehicles to cross, and the removal of left-turning vehicles from the through lanes.

Current research indicates that the effect on road safety of road dieting appears to be positive. In addition, there has been no evidence that collisions have migrated to parallel roads, and the Level of Service of treated roads has typically remained stable (reference 14).

# 5.0 Collision Reduction Factors and Desirable Design Elements

The foregoing text and tables give guidance regarding the various road form elements and their application with respect to different road classifications. Typical, or desirable, values are provided for these elements.

Although research has been carried out over several years, it is only in recent years that knowledge has started to emerge relating collision frequency to design parameters. The intention of this section is to provide an indication of how the choices in the variations of road form elements might affect future safety (in terms of collision reduction), and to provide guidance on which design elements are most desirable for road safety.

It should be noted however that many gaps in this knowledge exist and much more research is needed, particularly for use in Canada. There are also other shortcomings; for example the bulk of available research into the relationship between lane width and safety pertains to two-lane rural roads and little is known about the effects on multilane or urban roadways. In addition, difficulties arise when trying to separate out the effects of all the variables, such as lane width, shoulder width, surface type, pavement edge drops and other factors.

The above emphasizes the need to use care when applying collision modification or reduction factors. In addition, it should be remembered that although a variation in a specific road form element may greatly influence the occurrence of some types of collision, it may result in an increase or have little effect on others.

As noted in TAC, "….when choosing the value for a design parameter from a range of values, a balance must be found between increased costs and diminishing safety improvements as the value of the parameter changes. There comes a point at which the safety benefits are so small that money can be spent to better effect elsewhere."

For further information, refer to references 15 to 22 listed in Section 8.0 of this guide.

## 5.1 Collision Reduction Factors

The following tables provide an indication of the estimated reduction in collision frequency that may be anticipated from variations in key road form elements. The information is preliminary in nature and should therefore be used with caution. The values are typically provided in terms of percentage reduction, rather than a Collision Modification Factor (CMF), such as used in TAC or in the FHWA's Interactive Highway Safety Design Model (IHSDM) (e.g., TAC and IHSDM assign a CMF value of 1.0 to the nominal or base case, for example a lane width of 3.6m or shoulder width of 1.8m). In some cases, the estimated collision reductions are expressed in terms of higher or lower reduction (i.e. increasing or decreasing safety). In all cases, reference should be made to these Road Form Guidelines for application details and further design guidance.

| **Item** | **Action** [2, 3] | **Collision Reduction** [4, 5] |
|---|---|---|
| **Lane width** [1] | Widen lane 0.3m | Up to 15% |
| | Widen lane 0.6m | Up to 25% |
| | Widen lane 0.9m | Up to 35% |
| | Widen lane 1.2m | Up to 40% |

Notes:

1. Refer to Section 3.2.2. in these Guidelines for additional information. Note that most of the research regarding lane width is based on studies of two-lane rural roadways.

2. "Action" valid for lane widths between 2.4 and 3.7m, and traffic volumes of 100 to 10,000 vehicles per day. However, the benefit of lane widening tapers off as lanes get wider, and increases beyond 3.7m may be detrimental to safety. Reduction values should be applied accordingly.

3… .Little is known about the effect of lane width on multilane or urban roadways. Refer to TAC Section 2.2.2.2 for additional design guidance.

4 Reductions are for run-off road, sideswipe, and opposite direction collisions on two-lane roadways. Values shown should be adjusted proportionately if they are to be applied to all collisions.

5. Caution should be used when applying values. Because of the difficulty in eliminating the effects of all other safety affecting variables, the effect of increased lane width may be overestimated.

| **Item** | **Action** [2, 3] | **Collision Reduction** [4, 5, 6] |
|---|---|---|
| **Shoulder width**<br>**(Rural Roads)** [1] | Widen shoulder 0.6m | 10% - 15% |
| | Widen shoulder 1.2m | 20% - 30% |
| | Widen shoulder 1.8m | 30% - 40% |
| | Widen shoulder 2.4m | 40% - 50% |

Notes:

1. Refer to Sections 3.2.3. and 5.2.9. in these Guidelines for additional information. Note that most of the research regarding the provisions of shoulders is based on studies of two-lane rural roadways.

2. Shoulder width range 0 to 3.0m, in conjunction with lane widths of between 2.4 and 3.7m, and traffic volumes of 100 to 10,000 vehicles per day. However, the benefit of shoulder widening tapers off as shoulders get wider, and may result in

an increase in collision frequency and severity beyond widths of about 2.4m. Reduction values should be applied accordingly.

3. Refer to TAC Section 2.2.4.6 for additional design guidance.
4. Reductions are for run-off road, sideswipes, and opposite direction collisions on two-lane roadways. Values shown should be adjusted proportionately if they are to be applied to all collision types.
5. Values shown assume use of paved shoulders. Reduce by approximately 5% for unpaved shoulders.
6. Caution should be used when applying values. Because of the difficulty in eliminating the effects of all other safety affecting variables, the effect of increased shoulder width may be overestimated.

| **Item** | **Action** | **Collision Reduction** [2] |
|---|---|---|
| **Median** [1] | Changing from:<br>-No median to TWLTL | 10% - 30% [3] |
| | - TWLTL to Raised Median | 5% - 25% |
| | - No Median to Raised Median | 10% - 50%<br>50% - 100% Overtaking<br>90% - 100% Head-On<br>30% - 50% Rear-Ends<br>30% - 50% Adj. Approaches |

Notes:

1. Refer to Sections 3.2.4, 5.2.1, and 5.2.2 in these Guidelines for additional design information.
2. Reductions are for **all** collision types unless otherwise stated.
3. Depends on driveway density; larger reductions with highest densities. The reduction in access point related left-turn collisions is likely to vary between 60 – 95%.

| **Item** | **Provision for Cyclists** | **Collision Reduction (Consequence)** |
|---|---|---|
| **On-Street Bicycle Facilities** | Bike Lane<br>Or<br>Wide Curb Lane [1]<br>↓<br>No Provision<br>(Shared Lane) [2] | Higher (Increased Safety)<br>↓<br>↓<br>Lower (Decreased Safety) |

Notes:

1. Refer to Section 3.3 in these Guidelines for situations where wide curb lanes are preferred to bike lanes.
2. Shared lanes may be satisfactory on local roads and lower volume collector roads where speeds are low.

| Item | Provision for Pedestrians | Collision Reduction (Consequence) |
|---|---|---|
| **Sidewalks** [1] | Sidewalk with Boulevard<br>↓<br>Sidewalk without Boulevard<br>↓<br>Off-Road Path<br>↓<br>Shoulder<br>↓<br>Shared Street | Highest (Increased Safety)<br>↓<br><br>↓<br><br>↓<br><br>↓<br>Lowest (Decreased Safety) |

Notes:

1. Refer to Sections 3.4, 5.2.5, and 5.2.6 in these Guidelines for additional information on sidewalk design.

| Item | Action | Collision Reduction [2] |
|---|---|---|
| **On-Street Parking** [1] | Eliminate/Restrict Existing On-Street Parking | 10% - 20% [3]<br><br>20% - 30% Lane Change<br>20% - 30% Rear-Ends<br>20% - 30% Leaving Driveway<br>50% - 60% Hit Parked Car<br>30% - 40% Hit Pedestrian |

Notes:

1. Refer to Sections 3.2.6 and 5.2.3 in these Guidelines for additional information.
2. Reductions are for **all** collision types unless otherwise stated.
3. Based on estimate that on-street parking contributes to about 10 to 20% of traffic collisions.

## 5.2 Design Elements Desirable for Road Safety

There will be many situations where a compromise on various elements of the cross section will be required, due to right-of-way, topographic or other constraints. In general, from an entirely safety viewpoint, the suggested order for compromising cross-section elements is outlined below:

1. Reduce the number of lanes (refer to Section 4.2 regarding road space reallocation);
2. Reduce width of or omit border;
3. Reduce width of or omit boulevard;
4. Omit parking lane(s);
5. Reduce width of median and/or outer separation;
6. Use minimum parking and auxiliary lane widths;
7. Use minimum travel lane widths;
8. Use minimum sidewalk, bicycle lane width;
9. Omit median

Shoulders are not listed above because they are considered a "must have" safety item in a rural environment.

Judgement is required to determine which compromise to choose, bearing in mind the function of the road, local conditions, what is feasible, and the cost and impact of making changes to the community. In retrofit situations, some of these cross-section elements are probably too costly to change. In selecting items to compromise, consideration should be given to the collision history of the facility, and the collision reduction factors suggested in Section 5.1.

Further guidance is provided below to assist with the prioritization of those elements considered essential and therefore "must have" for a particular roadway.

### 5.2.1 Medians

Not a must have, but likely desirable under certain circumstances, including:

- For access management purposes, particularly on main corridors.
- On streets with heavy traffic volumes.
- On wide streets to aid pedestrians crossing (provide a pedestrian refuge)
- Where there are significant crossing pedestrians (refuge)
- Where there are significant left turners (provides space for developing left turn lane)

### 5.2.2 Two-Way Left Turn Lanes

These are desirable where there is a high demand for left turns, particularly through areas with commercial strip development, and relatively high access density.

### 5.2.3 On-Street Parking

On-street parking should be considered where off-street parking opportunities are limited and as a result there will be a high demand for parking.

On-street parking can also:

- Provide a buffer between traffic and pedestrians;
- Support economic activity in commercial areas;
- Reduce the need for on-site parking; and
- Can help to reduce speeds by introducing "friction" and reducing width of overly wide streets.

### 5.2.4 On-Street Bicycle Facilities

- For major and minor arterials bike lanes are preferable where traffic volumes and/or travel speeds are higher. However, it is preferable that bicycle routes should be located on adjacent collector and local roads.
- On-street bicycle facilities should be considered for downtown commercial streets if there is sufficient width.

The choice of a shared or wide curb lane will depend upon issues such as volumes and speed. Where speeds are low (40 km/h or less), or volumes are low (3000 ADT or less), a normal (standard) width "shared" lane may suffice and no additional widening is required.

### 5.2.5 Sidewalk Facilities

- Sidewalks should be provided on both sides for all arterials and collectors.
- Sidewalks are also essential in areas with significant pedestrian volumes, (e.g. shopping areas, residential areas, etc.). Sidewalk continuity is also an important consideration in these areas.
- On some low speed, low volume local roads it may be possible for pedestrians to share the roadway. However, sidewalks on at least one side are desirable for new construction in such areas especially adjacent to schools.

### 5.2.6 Boulevard

Boulevards are desirable where pedestrians are next to a high traffic volume/high speed facility (say 60 km/h or more). Boulevards should be provided for all new major arterials and if right-of-way is available, should also be provided for minor arterials.

Boulevards are also desirable where there are significant pedestrian volumes, and where there is no parking "buffer". However, if right-of-way is restricted, consideration could be given to eliminating the boulevard and compensating by widening the sidewalk.

It should be noted that a boulevard does also provide a storage area for snow.

### 5.2.7 Border Areas

Border areas (the space between sidewalk and right-of-way boundary) are generally dependent upon the jurisdiction. Existing City of Kamloops standards maintain a minimum border of 0.3 m and it is therefore recommended that at least a minimum width of 0.3 m be maintained in all areas.

### 5.2.8 Bus Bay/Pull Out

Bus bays/pull outs should be provided on major high volume arterials. They reduce the risk of rear ends, and a stopped bus does not impede flow. A bus may however have difficulty rejoining traffic if volumes are high. This may be mitigated by use of nearby traffic signals to ensure sufficient gaps. It may also be mitigated by use of specific bus right-of-way legislation.

### 5.2.9 Shoulders (Rural Roads)

Shoulders are a must-have, and preferably should be paved. This is a minimum requirement to accommodate pedestrians and bicycles. Where volumes of pedestrians and bikes are significant, or where traffic volumes are high and there are significant pedestrian/cyclist volumes, a separate path (multi-use) is desirable.

# 6.0 Safer Road Form Development Process

The design development process to be used for all approvals in shown in ***Figure 6.1***. This process ensures that the designer makes explicit reference to road safety for all design submissions. Municipal staff will provide guidance where required. Two checklists are included with these design guidelines that will assist with explicit consideration of safety during the design development process:

- Appendix A – Road Form Check List. This will be used by municipal staff for reviewing and approving design submissions prepared either in-house or by external resources.
- Appendix B – Design Submission Check List. This checklist should be used by the designer during the preparation of design submissions. The designer should confirm that the issues listed have been complied with and that the various design elements satisfy the appropriate design standards or guidelines. Where violations of the design standards or guidelines occur, these should be noted by the designer together with an explanation for the rationale behind the exception.

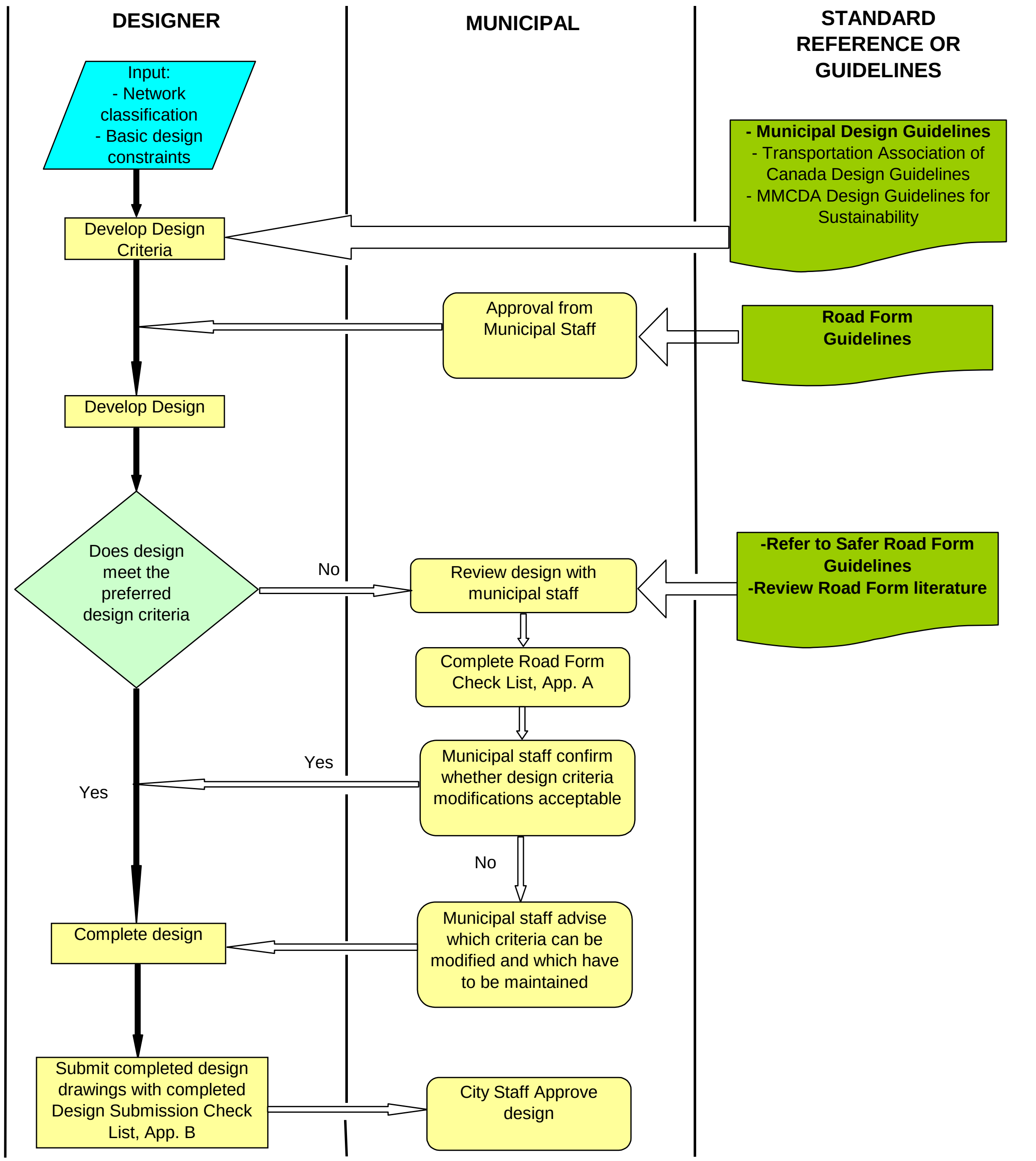


**Figure 6.1 – Safer Road Form Development Process**

# 7.0 Road Form Screening

During the planning and approvals process, municipal staff will be required to make decisions about road form that have not only cost implications but also implications to the long term development of the road network. The screening processes used to make the appropriate decisions are presented below.

TABLE 7.1
Road Segment Screening

| Roadway Segment | Meets Current Classification Requirement | | Meets Ultimate Classification Requirement | | Comment | Action |
|---|---|---|---|---|---|---|
| | Yes | No | Yes | No | | |
| Road 1 | x | | x | | Fine | None |
| Road 2 | x | | | x | Fine for now | A. Future Upgrade ( see Table A) |
| Road 3 | | x | x | | Over-Built | B. Road Form Review (see Table B) |
| Road 4 | | x | | X | Deficient | C. Mitigate (see Table C) |

TABLE A
Future Upgrade Decisions

| Category | Action | Design Decision |
|---|---|---|
| A | Decide to "live" with it – maybe not too serious, or not feasible to change | No action required at the design stage |
| A1 | Upgrade as part of upcoming planned development or project (e.g. rehab) | Review opportunities for reallocating road space to make safer use of existing cross section without compromising the long term needs |
| A2 | Actively monitor volumes & land use;<br>Set thresholds to trigger upgrade | Volumes will trigger changes to laning, provision of turn lanes and/or facilities for vulnerable road users |
| A3 | Plan / budget for upgrade within next five years | See A1 |
| A4 | Long–term future upgrade – no current action required – normally piggyback on rehab or other project | Review opportunities for road space reallocation |

TABLE B

Road Form Review Decisions

| Category | Action | | Design Decision |
|---|---|---|---|
| B | Conduct a Road Form Review: Efficiency, Safety, Functionality, Livability.<br><br>Select one of the following actions… | | |
| | **Review Result** | **Action** | |
| B1 | Significant speeding / safety concerns | Mitigate (Table C) | • Can the existing road section be modified to eliminate lanes, or reduce lane width?<br>• Can turn lanes and/or TWLTL be added to provide for safer left turn movements?<br>• Can bicycle lanes be added or improvements made to pedestrian facilities? |
| B2 | Livability / urban form/ minor safety concerns | Consider traffic calming or road dieting projects | • Curb extensions?<br>• Restriping to narrow lanes and provide for bike lanes? |
| B3 | No concerns | No action required | |

TABLE C
Road Form Mitigation Decisions

| Category | Action | | |
|---|---|---|---|
| C | Conduct a Road Safety Review:<br><br>Select one of the following actions… | | |
| | **Review Result** | **Action** | **Design Decisions** |
| | C1: Significant Safety Concerns | In-depth study to identify causes if needed; implement immediate mitigation measures where required; plan short, medium and long term mitigation measures and upgrading (Table A) or re-classification; monitor results | • Scope of design dependent upon results of study. |
| | C2: Minor Safety Concerns | Monitor safety performance on an annual basis; consider in-depth safety study in the future if needed; plan upgrading (Table A) or re-classification | |

# 8.0 References

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18. Miscellaneous Unpublished Papers by Ezra Hauer. http://www.roadsafetyresearch.com/

19. Road Form Literature Research – Unpublished Paper by Annick Davies

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21. Development of South Dakota Accident Reduction Factors, South Dakota D.O.T. http://www.state.sd.us/Applications/HR19ResearchProjects/Projects/SD1998_13_final_report.pdf

22. Safety Evaluation of Different Kinds of Cross-sections on Rural Two-Lane Roads, VTT Communities and Infrastructure, Finland. http://www.vtt.fi/rte/projects/yki6/safestar/safestar_d41.pdf

# Appendix A
# Road Form Check List

# Appendix A
# Road Form Check List

This checklist should be used by City staff when reviewing and approving design submissions prepared either in-house or by external resources.

**Project Name:** ______________________________________________

**Project Location**: ______________________________________________

**Project Number:** ______________________________________________

**Reviewed by:** ______________________ **Date:** ________________

**Approved by:** ______________________ **Date:** ________________

## A. Speed

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Is design speed logical with respect to topography and consistent with the road function as perceived by the driver? | | |
| 2. | Has the continuity of the design speed and the posted speed been checked? | | |
| 3. | Have operating speeds for facility been predicted? | | |
| 4. | Does expected operating speed meet driver expectations (i.e. consistent to similar types of road elsewhere across the network)? | | |
| 5. | Are posted speed limits appropriate to the traffic environment and likely to be perceived as reasonable by the motorist? | | |
| 6. | Is posted speed reasonably consistent with speed limits on similar roads across the network (and in neighbouring jurisdictions)? | | |
| 7. | Is the posted speed on each curve adequate? | | |

# B. Cross-Section/Parking/Sight Lines

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Are design parameters consistent (e.g. in cross section, alignment and at intersections)? | | |
| 2. | Are design standards consistent with adjacent road network, especially at tie-ins? | | |
| 3. | Has the cross section been checked to confirm it is suitable for the ultimate requirements of the road, including:<br>• classification<br>• design speed<br>• level of service / peak service volume? | | |
| 4. | Can adjustments in dimensions be made for future expansion possibilities? | | |
| 5. | Is the lane width sufficient for design speed, classification, and all vehicle types? Have emergency vehicles, school buses, and trucks been considered? | | |
| 6. | Is the number of lanes appropriate for the roadway function? | | |
| 7. | Has consideration been given to the impact of lane width on cyclists? | | |
| 8. | Are shoulder widths adequate for all vehicle and road users? | | |
| 9. | Is shoulder treatment appropriate for road classification? | | |
| 10. | Are shoulders continuous along the roadway, and are they clearly identified from travelled lanes? | | |
| 11. | Is sufficient pavement width provided along curves where off-tracking characteristics of vehicles are expected? | | |
| 12. | Is type of median chosen appropriate? (e.g. for classification and for width available) | | |
| 13. | Does median width allow for future inclusion of left turn lanes? | | |

# B. Cross-Section/Parking/Sight Lines (continued)

| | | | |
|---|---|---|---|
| 14. | Does median width provide adequate pedestrian refuge, particularly where large crossing volumes are anticipated? | | |
| 15. | Are slopes of grass median adequate? | | |
| 16. | Are median barrier offsets in the correct range of values? | | |
| 17. | Have off-street parking opportunities been explored? | | |
| 18. | Have measures been taken to address potential speeding when on-street parking spaces are unused (i.e. resulting from "wide road" appearance)? | | |
| 19. | Has parking been removed on approaches to crosswalks, intersections, and near school entrances? | | |
| 20. | Are all sight distances adequate for all movements and road users? | | |
| 21. | Are there any upstream or downstream features which may affect safety? (i.e. "visual clutter", parking, high volume driveways) | | |
| 22. | Could sight lines be temporarily obstructed by parked vehicles, snow storage, seasonal foliage, etc? | | |
| 23. | Has snow fall accumulation been considered in the design? (i.e. storage, sight distance around snow banks, impact on usable lane width, parking width and sidewalk widths, pedestrian access, etc. | | |
| 24. | Does the combination of cross-section elements make the road self-explaining and complement driver expectations? | | |

## C. Cyclists and Pedestrians

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Are pedestrian routes complete throughout the scheme, and do they facilitate all users (e.g. visually impaired and mobility handicapped)? | | |
| 2. | Has a boulevard been provided to separate pedestrians from motor vehicles? | | |
| 3. | Does sidewalk width address special cases (e.g. high pedestrian volume areas, bus stops, intersection areas, crosswalks, specific locations such as schools, parks, hospitals, seniors homes, and recreational facilities)? | | |
| 4. | Does sidewalk width consider snow accumulation/storage? | | |
| 5. | Has consideration been given to providing an off-road path in rural areas (instead of a shoulder)? | | |
| 6. | Has the visibility to and from pedestrian crossing locations been checked? | | |
| 7. | Have curb extensions been considered where pedestrians cross? | | |
| 8. | Is provision for cyclists consistent with similar facilities across the road network? Is treatment consistent with adjacent road system (i.e. at interfaces)? | | |
| 9. | Are shoulders wide enough to accommodate cyclists/pedestrians where required? | | |
| 10. | Are bike lanes clearly identified? | | |
| 11. | Has allowance been made for cyclists passing parked, or parking, vehicles? | | |
| 12. | Have shared lane or bike lane widths been widened on steep grades to allow for "wobble"? | | |

## D. Transit

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Are bus stops located on the far-side of intersections and crosswalks? | | |

# E. Roadside Safety

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Is the clear zone of adequate dimensions, and have site-specific locations been addressed? | | |
| 2. | Are there non-traversable or fixed object hazards (temporary or permanent) within the clear zone? | | |
| 3. | Have breakaway devices been provided where it is impossible to locate poles, signs, etc. outside of the clear zone? | | |
| 4. | Has the location of all service and utility poles, signal poles, and fixed objects been considered in terms of safety? Can they be relocated to where they are less likely to be hit (e.g. in the border area)? | | |
| 5. | Can utilities be located underground? | | |
| 6. | Is adequate protection provided where required? (e.g. barriers) | | |
| 7. | Has consideration been given to minimizing the number of poles by combining usage, or increasing pole spacing? | | |
| 8. | Are sight lines obstructed by signs, poles, bridge abutments, buildings, etc. | | |
| 9. | Are required clearances and sight distances restricted due to landscaping elements? (consider also future plant growth) | | |
| 10. | Are barrier treatments consistent throughout? | | |
| 11. | Are barrier offsets adequate? | | |
| 12. | Does barrier obstruct sight lines? | | |
| 13. | Has an explicit evaluation of alternative roadside design options been completed (e.g. use of crash prediction and cost-effectiveness models)? | | |

# E. Roadside Safety (continued)

| | | | |
|---|---|---|---|
| 14. | Has consideration been given to safe access and servicing arrangements for signals, street furniture, public utility equipment, etc.? | | |
| 15. | Are curb types appropriate for this facility and design speed? | | |

Comments: ______________________________________________

# Appendix B
# Design Submission Check List

# Appendix B
# Design Submission Check List

This checklist should be used by the designer during the preparation of design submissions. The designer should confirm that the issues listed have been complied with and that the various design elements satisfy the appropriate design standards or guidelines. Where violations of the design standards or guidelines occur, these should be noted in the appropriate column and/or cross-referenced to the comments sheet at the back of this Appendix where full details should be provided.

**Project Name:** ____________________

**Project Location**: ____________________

**Project Number:** ____________________

**Deliverable:** ____________________

**Checked by:** ____________________ **Date:** ____________________

**Reviewed by:** ____________________ **Date:** ____________________

**Approved by:** ____________________ **Date:** ____________________

## A. Speed

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Is the design speed in accordance with the City's design guidelines and logical with respect to the topography and traffic environment? | | |
| 2. | Are design speed changes consistent and logical? | | |
| 3. | Have operating speeds for facility been predicted? | | |
| 4. | Have posted speed limits been checked to ensure they are appropriate for the conditions and adequate for each curve? | | |
| 5. | Are posted speeds consistent with speed limits on similar roads? | | |

# B. Cross-Section/Parking/Sight Lines

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Are cross-section elements in accordance with the City's design guidelines for the road classification and design speed, including:<br>• number of lanes and lane width?<br>• shoulders and shoulder width?<br>• medians and median width?<br>• sidewalks?<br>• boulevards and borders? | | |
| 2. | Has the cross-section been checked to confirm it is suitable for the ultimate requirements of the road (i.e. future expansion)? | | |
| 3. | Does lane width accommodate larger vehicles such as emergency vehicles, school buses and trucks? | | |
| 4. | Have all turning movements been checked with the design vehicle templates? | | |
| 5. | Is on-street parking provided and if so, is it in accordance with the City's design guidelines? | | |
| 6. | Has sight distance been checked:<br>• on horizontal and vertical curves?<br>• at intersections?<br>• at accesses? | | |
| 7. | Has visibility been checked where signs, poles, bridge abutments, snow storage, buildings, controller boxes, and on-street parking, etc. may obstruct sight lines? | | |
| 8. | Have stopping sight distances been confirmed where median and roadside barriers are used? | | |

# C. Cyclists and Pedestrians

| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Have all pedestrian requirements been addressed (e.g. along the road and across the road), and are routes complete and facilitate all users? | | |
| 2. | Does sidewalk width address special cases (e.g. high pedestrian volume areas, crosswalks, bus stops, schools, etc.) | | |
| 3. | Has the visibility to and from pedestrian crossing locations been checked? | | |
| 4. | Have boulevards and border areas been provided? | | |
| 5. | Has snow accumulation/storage been considered? | | |
| 6. | Is there a requirement to provide for cyclists? If so, does provision for cyclists meet City guidelines? | | |
| 7. | Are cyclist facilities clearly identified (e.g. does pavement marking and signing meet City guidelines)? | | |

# D. Transit

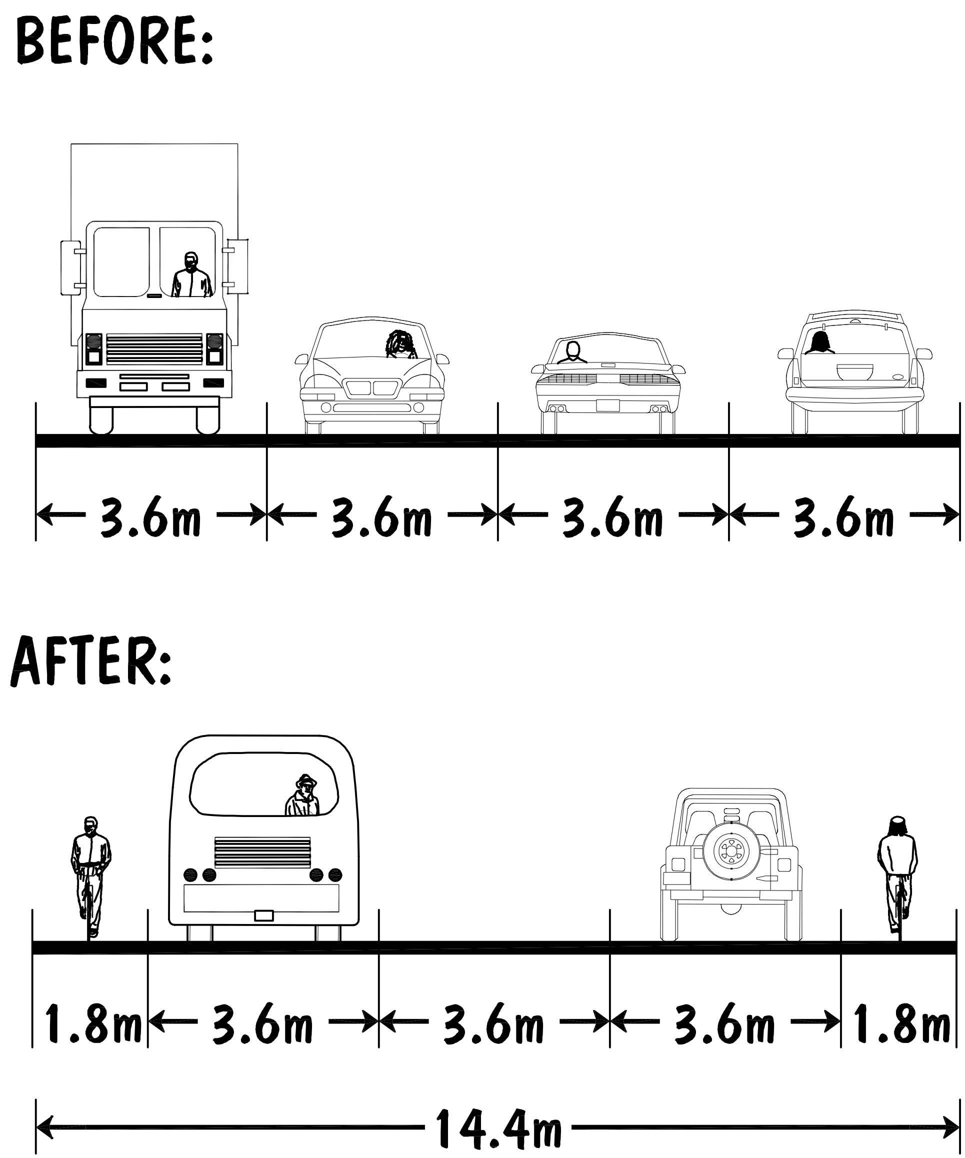
| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Have transit requirements been addressed, including:<br>• bus bay/pull outs?<br>• Locations (e.g. on far side of intersections and crosswalks)?<br>• Space for waiting transit users (e.g. widened sidewalk area)? | | |
| 2. | Has snowfall accumulation been considered in the design? | | |

# E. Roadside Safety

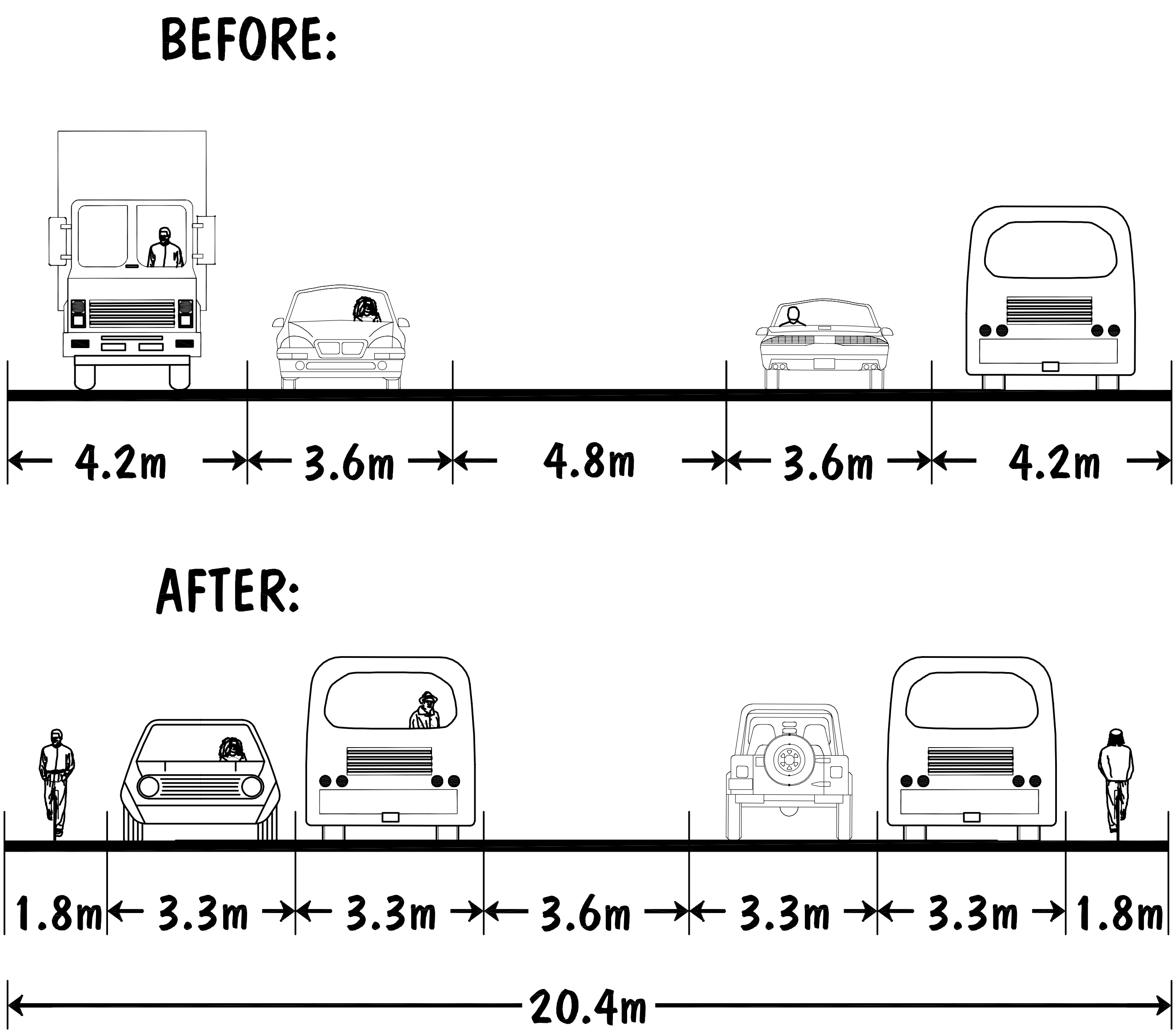
| | Description | Y/N | Note |
|---|---|---|---|
| 1. | Have clear zone requirements been achieved? | | |
| 2. | Has the location of all service and utility poles, signal poles, and fixed objects been considered in terms of safety? | | |
| 3. | Has consideration been given to locating utilities underground and relocating fixed object hazards to where they are less likely to be hit? | | |
| 4. | Have breakaway devices been provided where it is impossible to locate poles, signs, etc. outside of the clear zone? | | |
| 5. | Have barrier warrants been checked? | | |
| 6. | Does barrier placement meet City standards and/or guidelines, and are barrier treatments consistent throughout? | | |
| 7. | Is landscaping in accordance with the appropriate design standards? | | |
| 8. | Has landscaping design been checked to ensure clearances and sight lines are not restricted? | | |

Comments: ____________________________________________

# Appendix C
# Road Space Reallocation

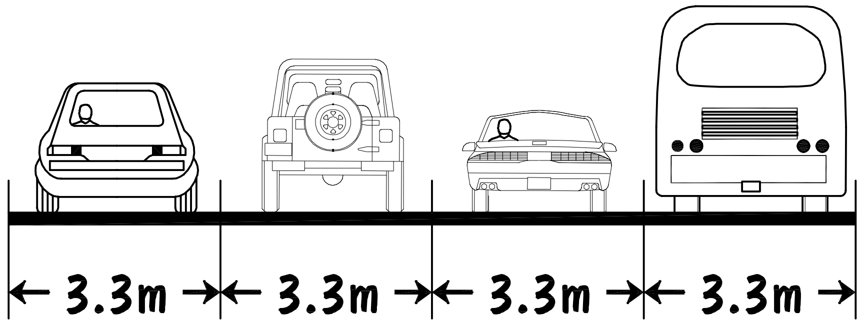



Reducing
Travel Lanes
Figure C1

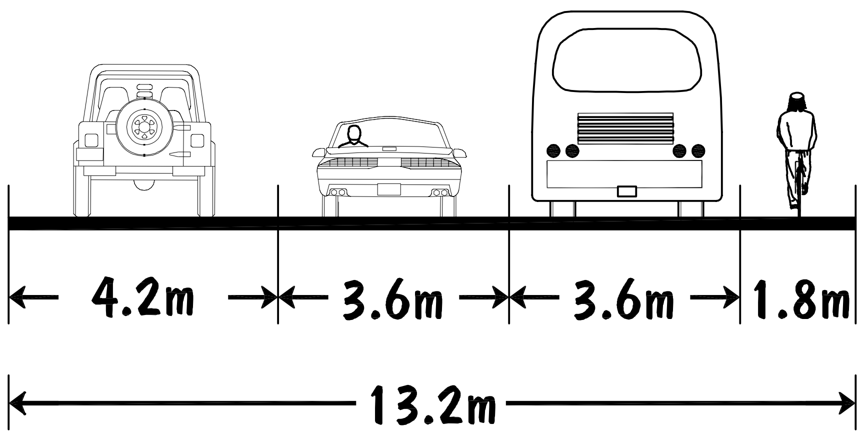



Narrowing
Travel Lanes
Figure C2

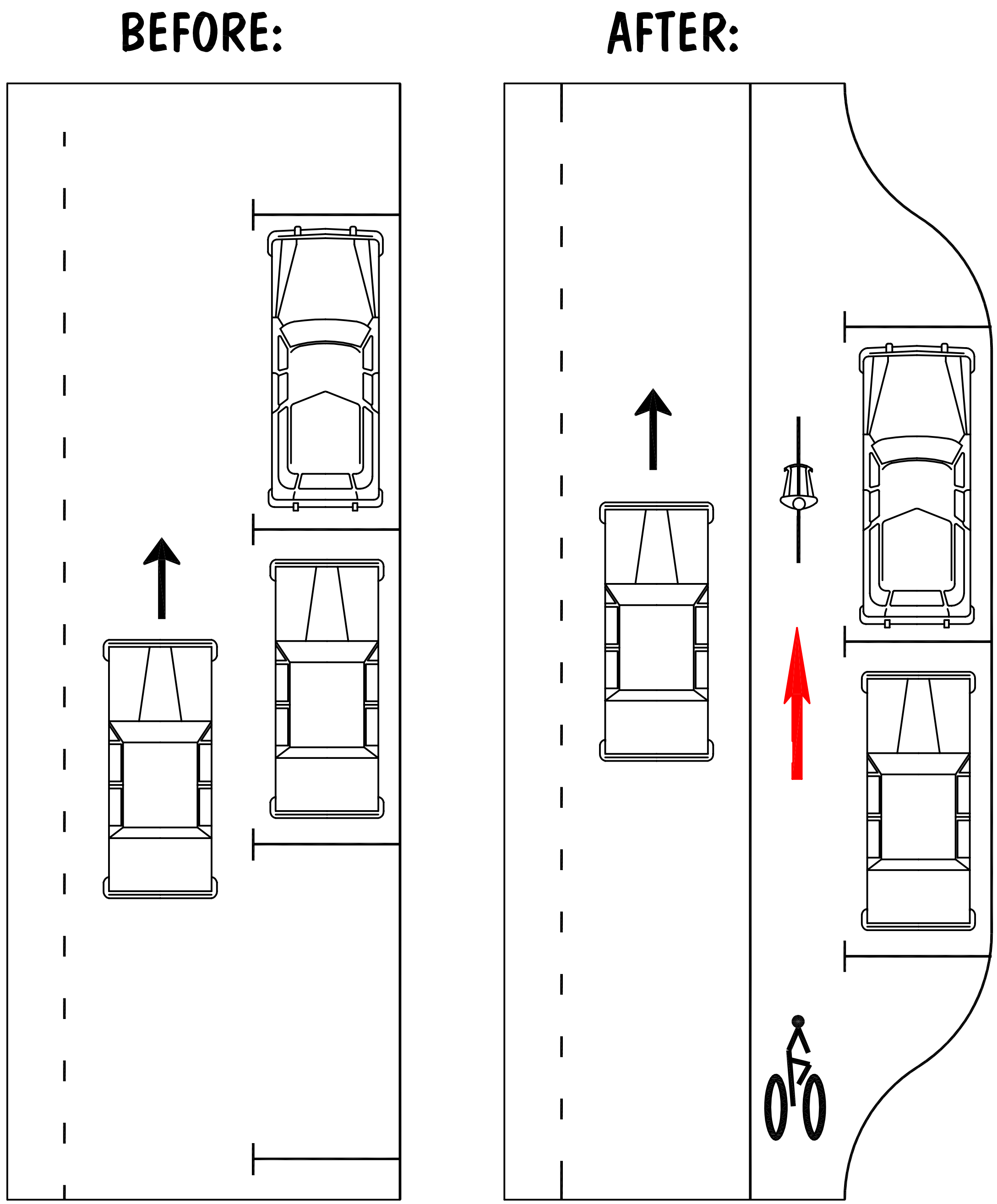
## BEFORE:




## AFTER:




One-way
Couplet
Figure C3




Re-allocate
Road Space
Figure C4