Guidelines for Upgrading
Low Volume Roads
in Saskatchewan

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Abstract

In Saskatchewan, maintenance and reconstruction of the highway system has emerged as a great challenge due to the extensive network size. The entire roadway network in Saskatchewan is over 186,000 km in length. Approximately 26,000 km of this network is included in the provincial highway system. The majority of the provincial highway system is two-lane roads, 80% of which has an Average Annual Daily Traffic (AADT) of 1200 vehicles per day or less. Currently, departmental design standards do not provide the flexibility necessary to make operations, safety, and cost trade-offs on these Low Volume Roads (LVR).

LVRs provide access and links between the principal highway system and communities. Many of these highways were constructed 30 to 40 years ago for relatively low volumes of traffic with few heavily loaded trucks. With the shift from rail to road in commodity movement, many of these highways cannot meet the increased trucking demands. The LVR Guidelines were developed with the purpose of assisting the designer in choosing the appropriate combination of features, dimensions, and materials for upgrading low volume roads.

The paper discusses the methodology used in the development of the Guidelines including a definition for low volume roads specific to Saskatchewan. The integral part of the Guidelines is the assessment process that can be used by the designer to assess the existing road and determine the appropriate improvement needed for each road segment within the project. The designer is then guided to appropriate design parameters outlined in a design domain environment.

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1.0 Introduction

This document presents Low Volume Roads (LVR) Guidelines that are applicable for rehabilitation projects that fall under the LVR definition, as defined herein.

Background

In Saskatchewan, maintenance and reconstruction of the extensive highway network has emerged as a great challenge, requiring new and innovative solutions, processes, methods and practices by the Department of Highways and Transportation.

The entire roadway network in Saskatchewan is over 186,000 km in length. Approximately 26,000 km of this network is the provincial highway system. The majority of the provincial highway system is two-lane rural roads. In Saskatchewan, more than 80% of the highway traffic is carried on less than 20% of the provincial highway system. The Average Annual Daily Traffic (AADT) on the remaining 80% of the provincial highway system is 1200 vehicles per day or less.

In Saskatchewan, low volume roads provide access and links between the principal highway system and rural communities. These highways were constructed 30 to 40 years ago with the purpose of providing feeder links into the principal highway system for relatively low volumes of traffic with few heavily loaded trucks. Many of these highways were constructed to geometric standards that may not coincide with today's standards.

For Saskatchewan a LVR is defined as a Class 3, 4, or 5 road that had an Average Annual Daily Traffic (AADT) volume of 500 vpd or less. This constitutes approximately 56 % of the provincial highway network. (Figure 1)

When a section of highway meets the definition of a low volume road but has a Truck Average Annual Daily Traffic (TAADT) volume that exceeds 75 trucks per day, it may be excluded from the LVR Guidelines.

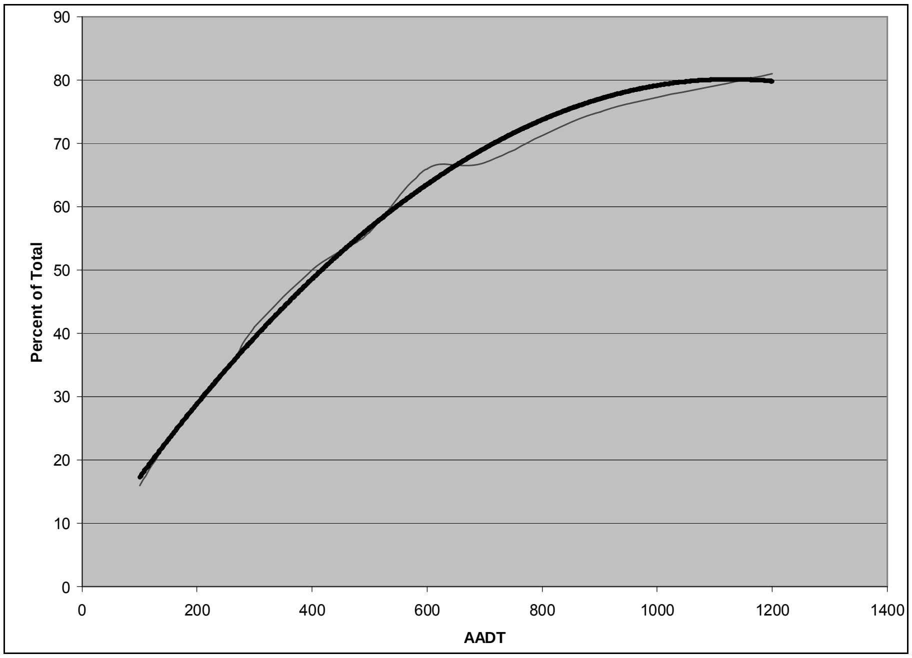

Figure 1 - AADT and Highway Length

With the shift from rail to road in commodity movement of agriculture, many of these highways cannot meet the increased trucking demands. The closure of rail lines and elevators has increased the amount of heavy truck traffic contributing to the deterioration of the highway system. Maintenance and rehabilitation of the highway system has emerged as great challenges due to the extensive size of the system. With the increasing volumes of heavy trucks, the department has had difficulty sustaining highways to provide the desired level of service. The general public will not accept the continued deterioration of the highway system.

There are many proponents of the notion that improving the surface of the low volume roads, without implementing corresponding geometric improvements, will meet the challenges imposed by heavy grain haul on these rural highways and roads. However, there are geometric considerations related to safety, functionality, operation, and maintenance that should be examined in the formation of a rehabilitation policy for Saskatchewan's low volume roads.

Rural highway maintenance and rehabilitation strategies have raised serious concerns due to the large amount of highway that needs attention. There is not enough funding to rehabilitate the entire provincial highway system to department's current design standards. . Flexibility in designs required for sustainability of the infrastructure is needed and may have to be developed by balancing engineering with policy driven solutions. With limited resources, it is not possible to reconstruct every road in the province to existing geometric standards.

The public is perceived to have preference for surface conditions that provide for a smooth ride, over roadways and roadsides that meet all the current geometric standards. In Saskatchewan, the public is demanding a high speed surfaced road to get to and from their destinations regardless of the traffic volume. There is public pressure on the department to maintain good surface conditions on all highways, including low volume roads. This is a pressure being felt be many transportation agencies across Canada and the United States of America.

Purpose

The purpose of the Low Volume Roads Guidelines is to provide the designer with a rehabilitation strategy for low volume roads that recognizes the importance of infrastructure management and to assist the designer in cost-effectively rehabilitating a low volume road based on a balance between functionality, cost, safety, comfort, and mobility. The Low Volume Road Interim Guidelines allows for the maximization of available funds for the improvement of the provincial highway system.

To achieve its prime purpose, the LVR Guidelines:

- Emphasize flexibility in design through the use of the Design Domain Concept;
- Introduce the concept of highway corridor continuity and consistency;
- Outline an Assessment Process specific for low volume roads;
- Focus on the use of three Levels of Improvement; and
- Focus on the use of the LVR Design Matrix.

The LVR Guidelines shall provide the designer with a range of values that a geometrics design parameter may take. This range of values is less restrictive than the values generally used on higher volume roads. The designer is encouraged to strive for consistency of design criteria between the project segment and the remainder of the roadway corridor. The guidelines are intended to provide the designer with flexibility to retain the existing roadway and roadside design when they are performing well, but the guidelines also provide the flexibility to recommend improved designs where necessary to correct documented safety, operational, and preservation problems.

2.0 Guidelines Development

Level of Improvement Concept

An increasing number of jurisdictions classify travel corridor improvements into 3R/4R projects. The *TAC Canadian Guide to 3R/4R* states that a 3R project will incorporate one or more of resurfacing, restoration, and rehabilitation. A 4R project will also entail reconstruction, which will happen in conjunction with resurfacing, restoration, and rehabilitation.

The Vermont Agency of Transportation has a system that invokes various *Level of Improvement (LOI)* based, principally on the functional classification of the roads; some classes of roads are not eligible for certain types of improvement under the criteria. Under these criteria, transportation projects involving extensive improvements will only be considered in major corridors. The remaining corridors will be eligible for less extensive improvements based on their AADT, as well as their importance to state-wide mobility.

For LVR in Saskatchewan, a similar approach to Vermont has been developed. This approach is based on certain Levels of Improvement (LOI), dependant on the roadway geometrics, the current surface condition rating, as well as the ambient conditions of the travel corridor. It must be recognized that with limited resources, it is not possible to upgrade all LVR in Saskatchewan to the desirable design standards currently outlined in the Design Manual. The objective of various LOI is to maintain safe and efficient operations at the lowest capital costs possible, while ensuring corridor continuity and consistency.

The three LOI in Saskatchewan are Minor Upgrading, Major Upgrading, and Reconstruction. Some key information about the LOI system is:

- The largest percentage of projects is expected to be classified as Minor Upgrading;
- The accident history along the proposed project length is considered to be an indication of the current condition of the roadway and will facilitate the determination of its priority for improvements;
- A Field Review will be completed by an Assessment Team in order to evaluate the current state of the roadway and corridor, so that it can be classified for the various LOI;
- Signing and marking are required for all LOI in the LVR Criteria; and
- Reconstruction is an extreme measure that will seldom be used and only considered on a project by project basis.

Design Domain Concept

For many decades designers have depended on design standards to control the design process. These standards are based on the understanding of physics or empirical data at the time. Designers are now under pressure to reduce construction costs by using lower standards under the assumption that even minimum standards are acceptable. There have been many new developments and research findings that support a new design approach.

The design practitioner requires the flexibility to select the design dimensions that are appropriate for the ambient conditions. This may be provided under the **Design Domain**

Concept. The Design Domain Concept can be viewed as a range of values that a design parameter might take. At the lower end of the domain for a design parameter, the resulting designs may generally be considered to be less effective while at the upper end of the domain designs are generally more effective and operationally efficient. However, the resulting design may be more costly to construct. The use of this new design philosophy will allow the designers to select the appropriate geometrics to complement functionality and safety while optimizing the construction costs. Liability is safeguarded as engineering assessment will form the design basis, as opposed to strictly using standards.

The LVR upgrading guidelines utilizes the design domain concept to meet the design challenge for LVR in Saskatchewan. In doing so, the practitioner is guided in evaluating and balancing competing alternatives to arrive at the most appropriate design that reflects the local values and policy.

The judicious choice of design criteria is very important in the design process and in this respect it is essential that the designer has a good understanding of their origin and background. A design carefully prepared by a designer who has a good understanding, not only of the criteria, but also of their background and basis, and has judiciously applied them with regard for community values, will most likely generate the desired level of service and safety with acceptable economy.

3.0 Levels of Improvement

The three Levels of Improvement (LOI) for LVR are Minor Upgrading, Major Upgrading, and Reconstruction. All projects evaluated under the LVR Guidelines will fall under one or more of these levels. The objective of the LOI is to maintain safe and efficient operations at the lowest capital costs possible, while ensuring corridor consistency and continuity.

Defining the Levels of Improvement

Minor Upgrading is the lowest LOI and is applicable to specific physical, functional, and safety problems. The goal of Minor Upgrading is to sustain the existing roadway at the lowest possible capital cost. Minor Upgrading generally, does not include the acquisition of additional right of way (ROW) nor does it include any alterations to the roadside. Minor Upgrading does include changes to the subgrade that are limited to widening (e.g. notching) to accommodate a new surface structure.

A project where the existing road top width is wide enough (greater than 9.0 m wide) to accommodate a new structure without requiring subgrade widening will also fall under Minor Upgrading.

Major Upgrading is the work within the existing right of way (ROW) to return the roadway and roadside to a condition of adequate functionality. In certain instances minor

ROW acquisition may be involved. Major Upgrading includes the work described above plus:

- Changes to the subgrade that may include widening where borrow material is required;
- Short sections of improvement to horizontal and/or vertical alignments where supported by Engineering Analysis; and
- Minor ROW acquisition, but clear zones, roadside geometrics, and drainage should be accommodated to the extent possible without the acquisition of additional ROW.

Reconstruction involves the design, rebuilding, and major improvement of significant portions of the existing roadway structure. Reconstruction includes all of the work described above plus:

- Significant changes to the roadway's horizontal and/or vertical alignments;
- Subgrade performance improvements (e.g. grade rise); and
- The need to purchase and acquire additional ROW.

All LOI projects may include the addition of safety measures as determined by an Engineering Analysis.

4.0 Assessment Process

An Assessment Process has been developed in order to make effective decisions regarding the improvement of the LVR network in Saskatchewan.

Based on the need to upgrade a road due to surface deficiencies, a rehabilitation project will be initiated. If the rehabilitation project meets the LVR definition, the LVR Guidelines may be used and the Assessment Process will be followed.

The designer is responsible for the Assessment Process.

It is the responsibility of the designer to select an Assessment Team. The Assessment Team attends and participates in the Initiation Meeting and the Field Review.

Based on analysis provided by the Assessment Team during the Field Review, the designer will recommend one or more LOI for the project and will complete the LVR Design Authorization Report. The LVR Design Authorization Report is a project specific document that scopes the project taking into consideration all its key components and provides recommendations for the design.

Role and Responsibilities

4.1.1 Designer

The designer is responsible for guiding the design of the rehabilitation project from project initiation to project completion. Specific responsibilities include (but are not limited to):

- Assuring that the LVR Assessment Process in followed;
- Assembling the Assessment Team;
- Organizing and conducting the Initiation Meeting, including gathering the project Background Information and the LVR Roadway Evaluation Form;
- Conducting the Field Review, including guiding the Assessment Team through the Rating System;
- Applying the LOI Points System to establish one or more LOI; and
- Completing the LVR Design Authorization Report and submitting it for approval.

4.1.2 The Assessment Team

The responsibilities of the Assessment Team are summarized as:

- Attending the Initiation Meeting;
- Participating in the Field Review; and
- Providing input into completing the Roadway Evaluation Form.

Choosing the Assessment Team

The Assessment Team is a panel of experts that contribute their knowledge to the LVR project. The Assessment Team will be lead by the designer. The Assessment Team may include (but is not limited to):

- Regional Preservation Engineer;
- Regional Area Manager;
- Regional Section Supervisor of Operations;
- Materials Engineer;
- Design Specialist.

The primary guideline when choosing members for the Assessment Team is to include an expert to address any known operational or physical concerns within the project limits.

Initiation Meeting and Project Preparation

The purpose of the Initiation Meeting is to review the Background Information and to discuss all known operational and physical concerns.

4.1.3 Background Information

The designer is required to gather the project Background Information prior to the Initiation Meeting and is responsible for retrieving the LVR Roadway Evaluation Form and reviewing the LVR Design Matrix.

The Background Information required for the project Initiation Meeting is:

- Traffic Data – Request to Traffic Engineer;
- Collision History;
- Geometric Information – Existing Plans;
- Operational, Environmental, Social, and Economic Issues – Past Studies; and
- Surface Condition Ratings.

4.1.3.1 Traffic Data

Traffic data can be requested from the Traffic Engineer. The following traffic data is required:

- AADT (historical, current, and projected);
- % of commercial traffic and/or TAADT;
- Growth factors for the design life of the project (15 years);
- Equivalent axle loading (if available);
- Assumed traffic split; and
- Functional classifications.

4.1.3.2 Collision History

Collision data is obtained from the Traffic Accident Information System.

Assessment of the collision rates, collision types and the contributing factors may be used to influence additional improvements, with a LOI, that may be required to address safety concerns.

Collision rates over a minimum of ten years should be used for LVR, as well as the rates since the last improvement project if it was done during the last ten years. Collisions should be broken down into the number of collisions per location and the numbers of collisions that result in property damage, personal injury, or fatality. In addition, contributing factors to the collisions should be noted to gauge roadway deficiencies.

4.1.3.3 Geometric Information

Some geometric information should be taken from the existing plans of the project at the Region. These elements can have a significant effect on the scope of the project. They are as follows:

- Vertical Alignment: Sag and Crest K-values;
- Horizontal Alignment: Curve Radius and Superelevation;
- Gradient and Cross Slope;
- Hydraulic and Culvert Information; and
- Bridge Width.

When plans are not available, the above geometric elements are to be assessed with the Design Specialist during the Field Review. No field survey is required for the Assessment Process.

4.1.3.4 Operational, Environmental, Social and Economic Concerns

Operational concerns include:

- Operational problems at intersections including sight distance issues;
- Alignment and/or gradient issues; and
- Maintenance and preservation issues including snow removal.

Environmental concerns include:

- Heritage resource and wildlife considerations such as fisheries; and
- Physical geography issues including vegetation or land use concerns.

Roadway and roadside improvements are to be minimized to reduce any disruption to the environment.

Social and economic concerns include any issues raised by the Rural Municipality in which the project is located.

4.1.3.5 Surface Condition Ratings

Condition ratings can be obtained from the Region. The three most common pavement condition indicators used are the International Roughness Index (IRI), rutting and surface cracking.

Field Review

The purpose of the Field Review is to evaluate the current roadway and roadside of the project. Participants of the Field Review include the Designer and the Assessment Team. During the Field Review, the Roadway Evaluation Form in filled out.

Prior to the Field Review, the Background Information used in the Initiation Meeting will be used by the Designer to fill in certain sections of the Roadway Evaluation Form, which is described in detail to follow.

4.1.4 Roadway Evaluation Form

The purpose of the Roadway Evaluation Form is twofold:

1. To summarize the project's information, safety and operational issues, collision information, surface condition, and existing geometrics as assessed and measured in the field; and
2. To rate the geometric adequacy of each element as per the Rating System.

There are two Roadway Evaluation Forms: one for gravel highways with a design speed of 90 km/h and one for surfaced highways with a design speed of 100 km/h or 110 km/h. The only difference between the two forms is the ratings for the Plans Section.

4.1.4.1 Sections of the Roadway Evaluation Form

It is important to review the Roadway Evaluation Form prior to the Field Review. The Form is divided into six small sections: Primary, Safety, Surface, Field Checklist, Plans, and Additional. Not all sections are filled out during the Field Review. Specifically, the Primary and Plans Sections are filled out prior to the Field Review using the Background Information, however there are areas of the other sections that require information prior to and during the Field Review.

The **Primary Section** provides space for the majority of the project Background Information: control section, rural road class, traffic volume, terrain, design and operating speed, road condition, and length of highway evaluated. A project is evaluated by a kilometre per kilometre basis. For example, each kilometre in a 10 kilometre project would be evaluated separately (ten Roadway Evaluation Forms would be required).

The **Safety Section** provides space for the collision rate information and any site specific issues relating to safety or operation concerns.

The **Surface Section** provides space to describe the condition of the pavement in terms of rutting, roughness, cracking, and rating category.

The **Field Checklist** lists the geometric elements that are specifically to be evaluated in the field. They include lane width, shoulder width, total road top width, clear zone (ROW), ditch depth, ditch width, sideslope, and backslope. These elements are to be rated according to the accompanying ratings on the Form. Space is provided to record the existing measurement of the geometric element and to record the assigned rating for that element depending on the Rating System (also included on the Form, see Section 8.4.2).

The **Plans Section** lists geometric elements that are to be taken from the Highway Plans prior to the Field Review. They include:

- Horizontal alignment (curve radii);
- Vertical alignment (sag and crest K-values); and
- Gradient, cross slope, and bridge width (all when applicable).

Measurements of select geometric elements may be taken during the Field Review instead of from the plans when deemed necessary by the Designer. For example, if the superelevation was a concern prior to the LVR Assessment Process, the Assessment Team would measure it in the field and evaluate it accordingly. When plans are not available, the above geometric elements are to be assessed with the Design Specialist during the Field Review. A Rating System is included on the Form for the Plans Section, as it is for the Field Checklist.

The **Additional Section** provided on the Roadway Evaluation Form allows space for any additional information collected during the Field Review.

4.1.5 Rating System

A value between one and six will be assigned to each roadway and roadside geometric element located in the Field Checklist and the Plans Section of the Roadway Field Evaluation Form. The Rating System has been developed based on the department's LVR Design Matrix. The rating of each geometric element depends on the expertise and opinions of the Assessment Team on the Field Review to determine if individual roadway and roadside geometric elements are in good , fair or poor condition.

A value of 1 or 2 (poor) will be assigned to an element that is geometrically below a required value, in poor condition, or that poses a safety issue. A value of 3 or 4 (fair) will be assigned to an element that geometrically meets the minimum requirements of the roadway or roadside but may require improvement based on its condition. A value of 5 or 6 (good) will be assigned to an element that geometrically meets the upper design value or exceeds it.

The following sections provide guidelines to determining the rating for each geometric element. A summarized version of these guidelines is provided on the back of the Roadway Evaluation Form. A table listing the ratings for all elements is in Section 8.4.2.10.

4.1.5.1 Lane Width

Lane width is a critical geometric element as it is responsible for keeping vehicles on the roadway. Too narrow and drivers are uncomfortable with the closeness between their vehicle and opposing vehicles, and/or the road top edge. Too wide and the drivers may overdrive the road without considering the other geometric elements.

Lane width will be rated as follows:

- Poor (1-2): The lane width is less than 3.3 m wide;

- Fair (3-4): The lane width is between 3.3 m and 3.5 m (3.5 m is the desirable lane width);
- Good (5-6): The lane width is 3.5 m wide or greater.

4.1.5.2 Shoulder Width

The shoulder width provides a margin of safety that generally increases as the shoulder width increases. Depending on traffic volumes, collision reduction factors, and construction and maintenance costs, shoulder widening may cost-effectively improve safety (run-off-road).

Shoulder width will be rated as follows:

- Poor (1-2): The shoulder width is less than 0.3 m wide;
- Fair (3-4): The shoulder width is between 0.3 m and 0.5 m (0.5 m is the desirable lane width);
- Good (5-6): The shoulder width is 0.5 m wide or greater.

Other factors to be taken into account concerning the shoulders are their condition, cross slope, and the maintenance effort required to keep them at the optimum condition.

4.1.5.3 Horizontal Alignment

The horizontal alignment is to be rated poor if the curve radius falls below the minimum allowable curve radius. The minimum curve radius depends on the design speed. For design speeds of 110 km/h or 100 km/h, the minimum curve radius is 480 m. For design speed of 90 km/h, the minimum curve radius is 375 m

Horizontal alignment will be rated as follows:

- Poor (1-2): The curve radius is below the minimum curve radius;
- Fair (3-4): The curve radius is between the minimum curve radius and a radius of 1000 m;
- Good (5-6): The curve radius is greater than 1000 m.

The horizontal alignment may also be considered for LOI projects based on poor super-elevation, excessive collision rates and severity, and locations where horizontal and vertical alignment are superimposed.

4.1.5.4 Right Of Way and Clear Zone

For LVR, the desirable clear zone width is that of the entire ROW. The ROW is wide enough to include all the cross-sectional elements of the highway. The TAC Guide suggests that 80% of run-off-the-road vehicles go less than 10 m off of the travel lane and 7% go farther then 15 m. The minimum ROW is 30 m for LVR AADT of 500 vpd or less.

Right of way width will be rated as follows:

- Poor (1-2): The ROW width is less than 30 m wide;
- Fair (3-4): The ROW width is between 30 m and 44 m;
- Good (5-6): The ROW width is 44 m wide or greater.

4.1.5.5 Ditch Depth

The ditch depth impacts costs associated with winter maintenance. A shallow ditch does not provide enough space for snow storage or proper drainage.

Ditch depth for a cut section will be rated as follows:

- Poor (1-2): The ditch depth is less than 0.8 m;
- Fair (3-4): The ditch depth is between 0.8 m and 1.0 m;
- Good (5-6): The ditch depth is between 1.0 m and 1.2 m.

Ditch depth is not rated in embankment (fill) areas.

4.1.5.6 Ditch Width

An adequate ditch width is required to provide a smooth transition from the sideslope to the backslope. Accident severity increases if adequate ditch width is not provided. Common ditch widths in Saskatchewan generally range from 3 m to 8 m.

Ditch width will be rated as follows:

- Poor (1-2): The ditch width is less than 3.0 m wide;
- Fair (3-4): The ditch width is between 3.0 m and 5.0 m;
- Good (5-6): The ditch width is 5.0 m wide or greater.

4.1.5.7 Sideslope

The sideslope is an important element in the safety rating of a highway's roadside. A steep sideslope can increase the severity of a run-off the road collision and conversely provide an acceptable recovery area if flat enough. In Saskatchewan the minimum sideslope rate is 3:1. Literature indicates this is a traversable slope. A slope of 4:1 or greater is recoverable.

Sideslope ratios will be rated as follows:

- Poor (1-2): The sideslope ratio is less than 3:1;
- Fair (3-4): The sideslope ratio is between 3:1 and 4:1;
- Good (5-6): The sideslope ratio is 4:1 or greater.

4.1.5.8 Backslope

Backslopes are not considered as critical as sideslopes, but a flatter backslope does improve snow clearing and aids in maintenance activities.

Backslope ratios will be rated as follows:

- Poor (1-2): The backslope ratio is less than 2:1;
- Fair (3-4): The backslope ratio is between 2:1 and 4:1;
- Good (5-6): The backslope ratio is 4:1 or greater.

4.1.5.9 Vertical Alignment

Vertical alignment consists of two vertical curves: crest vertical curves which occur on hills; and sag vertical curves which occur in valleys. For most designs, vertical alignment is not normally addressed unless the location has been identified as having a particularly high collision rate.

The vertical alignment rating depends on the surface type and the design speed. For a gravel highway with a design speed of 90 km/h, a sag curve is rated poor if the K-value is below 25, fair is the K-value is between 25 and 35, and good if the K-value is greater than 35. A crest curve is rated poor if the K-value is below 30, fair if the K-value is between 30 and 60, and good if the K-value is greater than 60.

For a surfaced highway with a design speed of 100 km/h or 110 km/h, a sag curve is rated poor if the K-value is below 35, fair if the K-value between 35 and 55, and good if the K-value is greater than 55. A crest curve is rated poor if the K-value is below 60, fair if the K-value between 60 and 110, and good if the K-value is greater than 110.

4.1.5.10 Ratings for all Elements

The Rating System is summarized in the table below; geometric elements and corresponding values and ratings are listed. This table is also on the Roadway Evaluation Form.

Table 1 – Summary of the Rating System

Geometric Element			Rating		
			Poor (1-2)	**Fair (3-4)**	**Good (5-6)**
1	**Lane Width**		< 3.3 m	3.3 - 3.5 m	≥ 3.5 m
2	**Shoulder Width**		< 0.3 m	0.3 - 0.5 m	≥ 0.5 m
*****	***Road top Width***		*< 7.2 m*	*7.2 - 8.0 m*	*≥ 8.0 m*
3	**Horizontal Alignment[1] (curve radius)**		< Minimum	Min. - 1000 m	> 1000 m
4	**Clear Zone/ROW**		< 30 m	30 - 44 m	≥ 44 m
5	**Ditch Depth**		< 0.8 m	0.8 - 1.0 m	1.0 - 1.2 m
6	**Ditch Width**		< 3.0 m	3.0 - 5.0 m	≥ 5.0 m
7	**Side-slope**		< 3:1	3:1 - 4:1	≥ 4:1
8	**Backslope**		< 2:1	2:1 - 4:1	≥ 4:1
9	**Vertical Alignment**				
	GRAVEL: Design Speed 90 km/h	**Sag**	< 25	25 - 35	≥ 35
		Crest	< 30	30 - 60	≥ 60
	SURFACED: Design Speed 100 km/h or 110 km/h	**Sag**	< 35	35 - 55	≥ 55
		Crest	< 60	60 - 110	≥ 110
Note:					
[1]*For a design speed of 90 km/h, the minimum curve radius is 375 m. For a design speed of 110 km/h or 100 km/h, the minimum curve radius is 480m.*					

LOI Points System

The LOI Points System is applied by the Designer after the Field Review is complete. The LOI Points System uses the ratings of the geometric elements acquired during the Field Review.

The purpose of the LOI Points System is to recommend which LOI each project segment falls under based on the ratings assigned to each geometric element in the Field Review.

Most geometric elements will not require improvements on their own, but when put into a combination with other elements, improvement may be warranted. Specific element combinations play vital roles in safety.

The ratings between one and six for each element will be multiplied by a different weight factor for each geometric element. The values obtained are to be summed to obtain a final point total that is used to determine the LOI for that project.

4.1.6 Weight Factors

The geometric criteria used to evaluate the LOI required are listed in the table below along with a weight factor that assigns a weighted value to each geometric element.

Table 2 – Weight Factors for Geometric Elements

Element	Factor
Lane Width	1.5
Shoulder Width	1.5
Horizontal Alignment (curve radius)	1.5
Right of Way (Clear Zone)	1.5
Sideslope	1.3
Ditch Depth	1.2
Ditch Width	1.2
Backslope	0.7
Vertical Alignment (sag and crest K-values)	0.6
TOTAL	11.0

The *TAC Canadian Guide to 3R/4R* identifies the following as the critical geometric criteria: lane width, shoulder width, horizontal alignment, clear zone, and surface condition. Since the surface condition of a road would drive the initiation of a project, it was not assigned a weight factor. The other four critical geometric criteria were assigned a weighted value of 1.5. The sideslope is critical to errant vehicle recovery and is weighted 1.3. Ditch depth and ditch width were assigned a weighted value of 1.2 based on the role the play in snow storage and errant vehicle recovery. The backslope and vertical alignment were assigned weighted values less than one.

The ratings for each geometric element are taken from the Roadway Evaluation Form (Rating System) and inputted into the LOI Points System Spreadsheet. From there, the ratings are multiplied by corresponding weight factors and a final point total is determined and used to establish a corresponding LOI.

4.1.7 Choosing the LOI

The LOI Points System can result in maximum of 66 points when all geometric elements of a project are rated 6 (good). No upgrading is necessary on roads with 66 points unless there are special circumstances particular to the road such as high accident rates. The final point totals and corresponding LOI are listed in the table below.

Table 3 – Final Point Totals for the LOI Points System

LOI Points System Final Point Totals	LOI
50 - 66	Minor Upgrading
25 - 50	Major Upgrading
0 – 25	Reconstruction

The points required for each LOI were established based on a sensitivity analysis. The sensitivity analysis involved putting together numerous combinations of ratings for the geometric elements and calculating the Final Point Totals. These Final Point Totals were compared to the rating combinations as defined by a LOI. These thresholds may be refined during Pilot Projects.

4.1.8 Geometric Element Combinations

When a combination of geometric elements do not meet the desirable parameter and are rated poor, improvement may be warranted based the safety role the elements play when their effects are considered in combination with one another.

4.1.8.1 Lane Width and Shoulder Width

The width of the lanes and shoulders provide the area that the driver uses to manoveur their vehicle on the highway. If the lane and shoulder width are not in an overall **fair** condition, collisions may increase.

When the lane and shoulder width are both rated **poor**, Minor Upgrading is suggested.

4.1.8.2 Ditch Geometrics

The ditch geometrics include: sideslope, ditch width, ditch depth, and backslope.

When all these elements are constructed to standard or above standard and rated **good**, the severity of run-off-the-road accidents collisions is reduced by providing a forgiving roadside. When all these elements are constructed below standard and rated **poor**, the roadside poses a safety risk.

If one of the ditch geometric elements is below standard and rated **poor**, then the other elements (if constructed to or above standard) may mitigate the risk the element below standard poses. For example, assume the backslope was 2:1, therefore rated **poor**, and the sideslope was recoverable (4:1), the ditch depth was 1.0 m, and the ditch width was greater than 5.0 m, therefore rated **good**. Although the backslope is steep, the rest of the ditch geometrics (all rated **good**) may mitigate the risk the steep backslope poses.

When more than one ditch geometric is rated **poor**, Major Upgrading is suggested in conjunction with a collision analysis.

4.1.8.3 Lane Width, Shoulder Width, and Sideslope

If the lane width and the shoulder width are reduced in combination with a sideslope that is not recoverable, the severity of run-off-the-road collisions may increase. A narrow road top width does not allow space for a vehicle to pull over. Therefore, when a driver manoeuvres the vehicle to avoid an obstacle in the roadway, they may run off the road. In such a case, a recoverable sideslope is desirable to return the vehicle back to the roadway.

When the lane width, shoulder width, and the sideslope ratio are rated **poor**, Minor Upgrading or Major Upgrading is suggested.

4.1.8.4 Horizontal Alignment (Curve Radius)

Horizontal alignment is dependant upon the speed at which vehicles are attempting to navigate the curve as well as the tangents leading into the curves.

When the curve radius is less than the minimum required and rate **poor**, Reconstruction is suggested in conjunction with an Engineering Analysis.

4.1.8.5 Horizontal Alignment Superimposed with Vertical Alignment

When horizontal alignment and vertical alignment are superimposed, Reconstruction may be considered in conjunction with an Engineering Analysis.

4.1.8.6 Summary of LOI for Geometric Element Combinations

The following table summarizes the recommended LOI for geometric element combinations when they are rate poor.

Table 4 – Summary of LOI for Geometric Element Combinations

Geometric Element Combination	Recommended LOI
Lane Width and Shoulder Width	Minor Upgrading
Ditch Width, Backslope, Sideslope, and Ditch Depth	Major Upgrading
Lane Width, Shoulder Width, and Sideslope	Minor Upgrading or Major Upgrading
Shoulder Drop and Narrow Lane Width	Minor Upgrading
Horizontal Alignment (Curve Data)	Reconstruction
Horizontal Alignment Superimposed with Vertical Alignment	Reconstruction

4.1.9 Applying the LOI Points System

An Excel Spreadsheet has been developed for easy application of the LOI Points System. The ratings for each geometric element are taken from the Roadway Evaluation Form (Rating System) and inputted into the LOI Points System Spreadsheet. From there, the ratings are multiplied by corresponding weight factors and a final point total is determined and used to establish a corresponding LOI.

Establishing the LOI and the Design Element Parameters

The results of the LOI Points System process in conjunction with an Engineering Analysis will provide the Designer with the guidance to select the appropriate LOI for each segment of the project. The final point totals of the LOI Point System will determine a LOI for each 1 km segment of the project. Based on the LOI, the kilometre segments will be grouped together for constructability purposes. If there is great variance between the LOI for each 1 km segment, it is the Designer's responsibility to determine the LOI that will be applied over a group of segments.

The Engineering Analysis may include a collision analysis, an analysis of operational concerns, and a cost/benefit analysis. The Engineering Analysis will draw attention to any areas within a project that are of concern to the designer. These must be accounted for when choosing what LOI (or how many) will be applied over a highway corridor.

For example, the Points System Process may warrant a LOI of Minor Upgrading for all segments of a LVR project. However, the collision analysis (conducted within the Engineering Analysis) may reveal excessive run-off-the-road collisions over the last few kilometres of the project. Upon examining these collisions and their corresponding rates, it may be revealed that a flatter sideslope would greatly reduce the severity and number of collisions at this location. Therefore, for the last few kilometres, a LOI of Major Upgrading would be established based on Engineering Analysis, not on the LOI Points System.

Once the LOI(s) has been established, the Design Element Parameters for the LVR may be chosen using the LVR Design Matrix. The range of values listed for each geometric element in the Design Matrix provides the opportunity for the designer to use the Design Domain Concept when selecting the Design Element Parameters.

The LOI(s) and the Design Element Parameters are to be included and recommended in the LVR Design Authorization Report.

5.0 Risk Mitigation

There may be instances, for various reasons, that the designer must select a design element parameter that is below the minimum value. The designer is encouraged to manage the risk by employing mitigation methods. These methods may consist of roadside improvements and/or traffic devices (including ITS options) that mitigate the risk posed when the LVR geometrics fall below the minimum.

6.0 Surfacing Strategies

The Field Review is critical. The designer should be looking at the condition of the road surface and including a detailed summary of the review in the Assessment Process as well as the surfacing design.

A surfacing design should not have the same surface treatment recommendation for the whole project length unless the road is performing the same. More time should be spent identifying different conditions and recommending structures so the whole section will perform the same over time (life cycle). The surfacing design should include a broad selection of surface treatment options, from seals to non-structural to structural surface treatments with a prediction of the performance of each based on the expected mode of failure.

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