Development of a Sustainable Road Surfacing Policy for Provincial Highways in New Brunswick

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Abstract

The New Brunswick Department of Transportation and Infrastructure is responsible for the rehabilitation and maintenance of approximately 19,650 km of provincially designated highways and roads. Nearly 85 percent of this network is hard surfaced including 9800 km of designated local highways and roads. Maintaining this local network at an acceptable standard requires a significant investment that has become increasingly challenging given current economic and fiscal constraints. Available funding is most often directed towards higher priority projects, while many low volume local asphalt roads are deteriorating with escalating rehabilitation costs. The Department's Long Term Investment Projection estimates an average of 300 km of asphalt rehabilitation is required annually over the next ten years to sustain the paved highway network. However, New Brunswick like other the provinces is implementing measures to reduce annual deficits and achieve spending efficiencies. In response, the Department undertook a study to develop a policy to ensure that the most appropriate surface type is selected in the future based on clearly defined and transparent level of service criteria that considered engineering suitability, least life-cycle cost, and functional / service characteristics. This paper documents the development of a multi-staged, screening pavement preservation decision making framework that will support the province to achieve a stronger position for achieving infrastructure sustainability.

Introduction

The New Brunswick Department of Transportation and Infrastructure (NBDTI) is responsible for the continual rehabilitation and maintenance of approximately 19,650 km of provincially designated highways and roads. As shown in Table 1, approximately 84% of these roads are paved with either an asphalt (37%) or chip seal (47%) surface, with the remaining 16% being gravel.

Table 1: Breakdown of NB Road Network by Surface Type (2011)

Road Class	Asphalt (km)	Chip Seal (km)	Gravel (km)	Total (km)
Arterial Highways*	2,900	0	0	2,900
Collector Highways	2,400	750	0	3,150
Local Numbered Highways	880	2,160	250	3,290
Local Named Roads	420	6,360	2,900	9,680
Ramps, Weigh Scales, etc.	630	0	0	630
Totals	7,230 (37%)	9,270 (47%)	3,150 (16%)	19,650

*Includes Public Private Partnerships

Maintaining this network at an acceptable standard requires a significant investment that has become increasingly challenging given the reality of current economic and fiscal constraints. While available funding is most often directed towards higher priority projects, many low volume local asphalt roads are deteriorating. Consequently, the cost of rehabilitating these roads continues to escalate as they will likely require full or partial reconstruction prior to rehabilitation.

The Department's Long Term Investment Projection (LTIMP) - the program used to develop the Department's short and long term pavement rehabilitation plan - indicates that an average of 300 km of asphalt rehabilitation will be required annually over the next ten years. Meanwhile, the Province of New Brunswick, like other governments across the country is implementing measures to reduce annual deficits and achieve spending efficiencies.

Given that significant funding increases are unlikely, the alternative for ensuring the future sustainability of the existing road network is to drastically reduce rehabilitation costs. This means converting existing asphalt roads (which typically cost in the vicinity of $300,000 per km to rehabilitate) to a chip seal surface (which typically cost $80,000 per km). There are many collector and local highways that currently have an asphalt surface despite having low traffic volumes. These roads represent prime candidates for conversion.

By adopting a formalized policy, NBDTI will ensure that the most appropriate surface type is selected for each road going forward based on clearly defined and transparent criteria that consider engineering suitability, least life-cycle cost, and functional / service characteristics (e.g. traffic levels, truck volumes, economic significance, land use, etc.).

The timing for implementing this policy is ideal given the:

- Overarching desire by government to reduce costs and rationalize infrastructure on the basis of levels of service;
- Potential transfer of the responsibility of selected local roads to municipalities or local service districts in the future;
- Deteriorated condition of the local road inventory;
- Substantial funding requirements for rehabilitation; and
- Need for more cost effective investment decisions based on delivering achievable and appropriate levels of service over the long term.

To develop the policy, a study was undertaken that included a review of existing practices and policies from other jurisdictions, an assessment of key factors to be considered, and the development of a multi-staged, screening decision making framework. Implementing the policy would result in the conversion of a significant portion of existing low volume asphalt surfaced roads to chipseal surfaces along with tighter controls on gravel road upgrading.

Current Practice Review

A review was undertaken of current practices, policies, and frameworks used by other highway agencies for selecting road surface. The review encompassed both a web-based literature review and survey of Canadian provincial highway agencies. The literature review was a high level web-based search focused on identifying factors and associated criteria used for selecting road surface type. The survey was focused on whether, and to what extent formalized criteria and / or polices exist with the following provinces contacted: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Nova Scotia, Newfoundland and Prince Edward Island.

Tables 2 to 4 present an overview of the current practices used by various provincial agencies for selecting road surface type. Of the eight agencies contacted, Nova Scotia and Northern Ontario were found to have the most comprehensive policies and frameworks in place. Both of these jurisdictions employ a weighting methodology that incorporates multiple factors to select the appropriate road surface type. Saskatchewan and British Columbia both have volume thresholds which serve as a guide for when a given road is a candidate for various surface treatments. In all remaining agencies, road surface type is selected on a case-by-case basis.

In the United States, most state agencies are only responsible for major highways (the vast majority of which having an asphalt or concrete surface). All secondary and tertiary roads are the responsibility of local or regional authorities, meaning that there are very few state-wide policies related to the selection of road surface treatment. South Dakota, Minnesota, and Ohio were found to have the most comprehensive policies in place.

Key findings from the literature review and agency survey include:

- Most agencies do not have comprehensive guidelines for selecting road surface type; rather decisions are made on a case by case basis;
- The majority of road surfacing policies only consider low volume roads;
- Traffic volume is the predominant screening factor considered by other agencies when selecting road surface treatment;
- Other screening factors commonly considered include agency costs, functional purpose, rural / urban setting, and impact on local business and long distance travel; and
- Some international agencies conduct detailed benefit-cost assessments for each surfacing project that take into account the full extent of road user costs.

A brief overview of established frameworks currently employed by selected highway agencies follows:

- **Nova Scotia** - has implemented a Low Volume Road Surface Evaluation Program as a means of objectively selecting the appropriate road surface type for all local roads with a traffic volume (AADT) of less than 500 vehicles per day. The program utilizes a spreadsheet tool to assess candidate surfacing projects by giving equal consideration to prevailing traffic volumes and the specific nature of roadside development.

- **Ontario** – a model was developed for the selection of surface type for low volume roads in the northern part of the Province. It incorporates five factors into the screening and selection guideline that includes traffic, impact on local residents, impact on local business activities, impact on long distance travel and agency costs. A Delphi Technique was used to assign weights to each of these screening factors and scoring assigned based on site specific characteristics. The total section score is obtained by adding the individual scores obtained for the five screening factors. Those sections with the highest score represent the best candidates for resurfacing.

- **South Dakota** - initiated a research study in 2002 to investigate surfacing criteria for low volume roads. The main outcome of the study was a macro-driven Excel-based spreadsheet that allows Departmental staff to compare the costs associated with various roads surface types (i.e. hot-mix asphalt, blotter, gravel, stabilized gravel) to determine which type is most economical under a specific set of circumstances. In addition to incorporating economic factors, the tool also allows for consideration of non-economic factors that are more subjective and difficult to quantify such as political factors, growth rates, housing concentration, mail routes, and truck traffic.

- **World Bank** - developed guidelines to assist countries in selecting the appropriate surface type for current unsealed roads. The overall framework consists of three steps. Step one assesses the demand for a paved surface using

a scoring methodology that takes into account physical factors, climate / soil, traffic demand, dust forming and community impacts. A number of surfacing options are then identified and evaluated against the site specific conditions for construction and maintenance, physical / social environment and surface performance. Each factor is assessed qualitatively to describe the suitability of a given surfacing option and those options identified as being the most suitable are short-listed for further evaluation. A financial (least life cycle cost) and economic comparison of all shortlisted alternatives is undertaken to identify the most cost-effective surface type.

Identification of Potential Factors

Based on the review of current agency practices and literature, the most common factors used for selecting road surface treatments can be broadly grouped into the following five categories:

- Traffic Volumes;
- Commercial Traffic;
- Road Function;
- Adjacent Land Use / Development; and
- Agency Costs.

An assessment was completed for each data category including the rationale for including each factor in New Brunswick's road surface selection framework as well assess data availability for potential evaluation measures. The results are summarized in Table 5.

Workshops were held with the NBDTI to examine the factors in terms of applicability, benefits, data availability, coverage, and objectivity. It was agreed that all factors need to be considered, however it was also recognized that they is some inherent overlap between some factors and this needed to be taken into consideration when formalizing the framework. The existing frameworks were also assessed and while each framework had its own unique and attractive features, none represented the ideal solution for NBDTI due largely to data collection requirements.

A key outcome from the workshops was the identification of the following guiding principles to help define the vision and provide the context and scope for New Brunswick's framework in terms of how it would be implemented:

- Be based on a simple approach focused on initial screening;
- Be objective and quantifiable (rather than subjective);
- Not require significant data collection;
- Consider agency life cycle costs;
- Capture site specific requirements;
- Be definitive with some limited flexibility; and
- Allow for an upfront evaluation of policy.

Selection Framework

The New Brunswick Road Surfacing Policy is intended to provide a fair, objective, consistent, and transparent framework for selecting the appropriate surface type for a given road. This framework utilizes a two-staged approach that first applies a set of initial screening criteria to establish a preliminary recommendation as to whether the road should have an asphalt, chip seal, or gravel surface. The recommended surface type may then be upgraded only if warranted by certain site specific characteristics.

a) **Stage 1 - Initial Screening Criteria** - The initial screening criteria for selecting the appropriate road surface type is based on functional classification, traffic volumes, and daily truck volumes as detailed in Table 6. The thresholds for these factors (see Figure 1) have been selected using a least lifecycle costing approach for the various surface types.

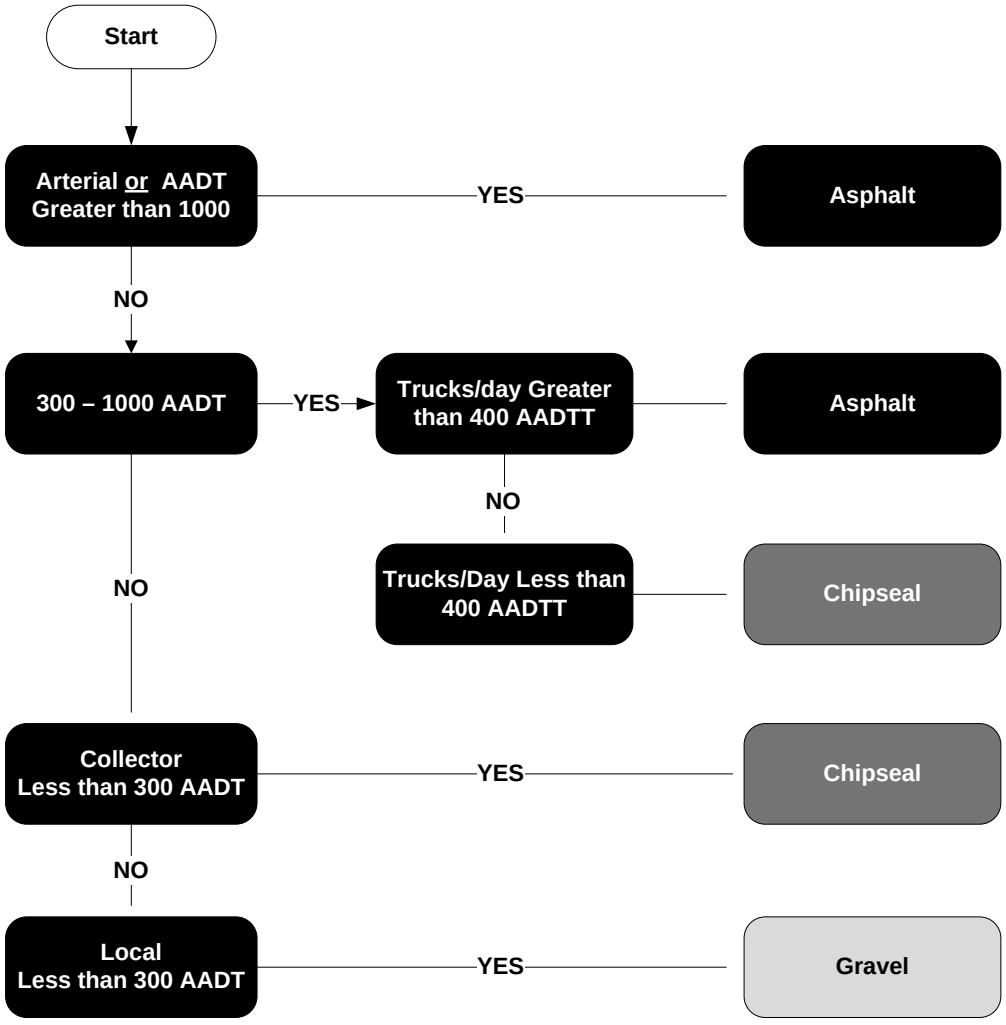

Figure 1: **Initial Screen Criteria Decision Key**

b) **Stage 2 - Site Specific Screening Criteria** - The preliminary surface type recommendation identified using the initial screening criteria may be upgraded to higher surface standard if warranted by certain site specific characteristics. These characteristics vary by functional classification and are to be viewed as "the exception to the rule". Table 8 outlines the site specific screening criteria for Collector and Local Highways and Named Roads.

Table 2: **Initial Screen Criteria Thresholds**

Road Class	Criteria
Arterial Highways	Does not apply
Collector Highways	A chipseal surfaced road may be upgraded to asphalt wherever one or more of the following conditions exist: • A grade of 7% of more is present that would result in construction stability issues; or • The existing pavement structure would result in a lower life-cycle cost for paving (e.g. locations with significant depths of asphalt where the cost of pulverization would offset the savings offered by surface treatment). •
Local Highways and Named Roads	A chipseal surfaced road may be upgraded to asphalt wherever one or more of the following conditions exist: • A grade of 7% of more is present that would result in construction stability issues; or • The existing pavement structure would result in a lower life-cycle cost for paving (e.g. locations with significant depths of asphalt where the cost of pulverization would offset the savings offered by surface treatment). A gravel surface road may be upgraded to a chipseal surface wherever one or more of the following conditions exist: • The road serves as a through road connecting two other provincially designated highways; or • The road provides direct access to a significant tourist destination.

Evaluation of Proposed Policy

An estimate of the potential cost savings of implementing the proposed road surfacing policy by applying the initial screening criteria over the existing road network was completed. The sensitivity of the traffic and truck volume thresholds was also evaluated where sufficient data was available.

The greatest potential cost savings of the proposed road surfacing policy are most likely to result from the conversion of existing asphalt roads to a chip sealsurface. Since it is the Department's intention that all arterial highways will continue to have an asphalt surface, low volume collector and local highways represent the best candidates for conversion.

NBDTI collects traffic data on all collector and local numbered highways. Table 9 depicts the respective proportions of these roads which currently have an asphalt surface and an AADT of less than 1000, 1500, and 2000 vehicles per day. As shown, nearly 30% of all existing asphalt collector and local numbered highways have an AADT of less than 1000. Since limited traffic count data was available for local named roads, the proportion of these roads having an asphalt surface and an AADT of less than 1000

vehicles per day was estimated based on the experience and local knowledge of District staff.

Table 3: Breakdown of Low Volume Collector and Local Numbered Highways

Road Class	Total Asphalt km	AADT< 1000	AADT < 1500	AADT < 2000
Collector Highways	2,400	580 (24%)	905 (38%)	1215 (51%)
Local Numbered Highways	885	365 (41%)	540 (61%)	645 (75%)
Totals	3,285	945 (29%)	1,145 (35%)	1,860 (57%)

Road Class	Criteria	Total Asphalt Km	Km > 400 Trucks per Day
Collector Highways	Less than 1000 veh / day	580	145 (25%)
Local Numbered Highways	Less than 1000 veh / day	365	80 (22%)
Local Named Roads	Less than 1000 veh / day and > 1 Km	130	30 (23%)
Totals		1,075	255 (24%)

NBDTI collects very limited truck count data outside of the arterial highway network. Consequently, prior to evaluating the proposed road surfacing policy a dataset was prepared with the assistance of Department staff to identify those roads which they believe carry an average of more than 400 trucks per day during the peak season.

The potential cost savings of implementing the proposed surfacing policy was estimated by applying the initial screening criteria over the existing road network. The following assumptions were also made to simplify the analysis:

a) Given the limited data available for existing gravel and low volume chip seal roads, the evaluation only considered the conversion between an asphalt and chip seal surface. However, it is recognized that converting between these two surface types will have by far the greatest cost implications;

b) AADT and truck traffic were taken from the most recent available NBDTI count data and supplemented with the estimates provided by District staff; and

c) Arterial highways were not included in the evaluation since they will all continue to have asphalt surface if the proposed policy is implemented.

Based on these assumptions, approximately 800 km of existing asphalt surface roads (13%) that would be considered candidates for conversion to chip seal under the proposed surfacing policy.

Using the same criteria, the number of existing chip seal roads that would be candidates for conversion to asphalt was also estimated for collector and local numbered roads based on the following additional assumptions:

a) On collector and local numbered highways where traffic data was not available, it was assumed that the AADT was less than 1000 vehicles per day;

b) 2.5% of all local named roads have an AADT > 1000 vehicles per day (i.e. half of the percentage for local numbered roads);

c) Trucks volumes on all existing chip seal roads are less than 400 trucks per day.

These are all considered to be valid assumptions based on knowledge of NBDTI's functional classification criteria and traffic monitoring program. The results from this analysis indicated nearly 400 km of existing chip seal roads would be potential candidates for conversion to asphalt under the proposed policy.

It should be noted that the candidate sections of road for conversion indicated were identified by applying the initial screening criteria only. Actual numbers may be slightly impacted by certain site specific criteria. Furthermore, traffic volumes used in the screening were based on estimated values only in many instances (as opposed to actual counts) and would therefore be subject to field verification.

Estimated Cost Savings

Based on the application of the initial screening criteria; implementing the proposed surfacing policy is expected to result in:

- 880 km of existing asphalt roads being candidates for conversion to chip seal; and
- 400 km of existing chip seal roads being candidates for conversion to asphalt.

This scenario has the potential to reduce rehabilitation costs by an estimated $92 million over a 20 year analysis period, or $4.6 million annually (undiscounted $2011). These cost savings were derived from a life-cycle costing analysis undertaken over a 20 year period and based on the following assumptions:

- Asphalt surfaces would have a 20 year life cycle for low volume roads and therefore require one rehabilitation cycle during the analysis period at a cost of $300,000/km; and
- Chip seal surfaces would have a 12 year life cycle and therefore require two cycles of rehabilitation during the analysis period at total cost of $110,000/km.

A sensitivity analysis was also conducted to estimate the potential impact of increasing the traffic volume threshold in the initial screening criteria from 1,000 to 1,500 vehicles per day. This would result in an additional 250 km of existing asphalt surface roads becoming potential candidates for conversion to chip seal and 75 km would no longer be candidates for converting from chip seal to asphalt. The estimated net impact could be as much as an additional $1.7 million annual cost avoidance in excess of the $4.6 million.

Summary

The proposed framework consisted of a two-staged screening approach, which included both initial screening criteria and site specific screening criteria. The initial screening criteria were based on a given road's functional classification, daily traffic volumes, and daily truck volumes. The site specific screening criteria allows for the consideration of other roadway characteristics such as the presence of steep grades, the significance to tourism, etc. The factor thresholds contained in the initial screening criteria were selected using a least lifecycle costing approach for the various surface types.

It was found that the greatest potential cost savings of the proposed road surfacing policy are most likely to result from the conversion of existing asphalt roads to a chipseal surface. Based on applying the proposed screening criteria, 880 km of existing asphalt roads were identified as candidates for conversion to chip seal and 400 km of existing chip seal roads candidates for conversion to asphalt. The proposed policy was estimated to reduce pavement rehabilitation costs by $92 million over the next 20 years, or $4.6 million annually. A further increase of the traffic volume threshold criteria to 1,500 vehicles day has the potential to provide an additional $1.7 million in savings annually.

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Table 4: **Overview of Current Canadian Practices for Selecting Road Surface Type**

Province	Policy	Factors Considered	Defined Criteria	Framework Followed
Newfoundland & Labrador	No formal policy	• Traffic volumes • Functional Classification • Public Support	No	Each road is assessed on a case by case basis using engineering judgement.
Prince Edward Island	No formal policy	• Traffic volumes	No	Each road is assessed on a case by case basis using engineering judgement.
Nova Scotia	Yes	• Traffic Volumes • Roadside Development	Yes	Weighting methodology
Ontario	Northern Region only	• Traffic Volumes • Functional Classification	Yes	Weighting methodology
Manitoba	No formal policy	• Traffic Volumes • Functional Classification	Some	Each road is assessed on a case by case basis using engineering judgement.
Saskatchewan	Yes	• Traffic Volumes • Truck Traffic	Yes	Volume threshold as per Policy 310-04
Alberta	No formal policy	• Traffic Volumes • Public Support	No	Each road is assessed on a case by case basis using engineering judgement.
British Columbia	Yes	• Traffic Volumes • Functional Classification	Yes	Volume threshold

Table 5: Traffic Criteria for Road Surfacing (Selected Agencies)

Agency / Source	Traffic Volume Criteria
Nova Scotia	Unless road development dictates otherwise: AADT<300 = gravel, AADT 300-500 = double chip seal and AADT>500 = asphalt
Manitoba	All Primary Arterials are asphalt or concrete Secondary Arterials: AADT<500 = surface treatment (chip seal); AADT>500 = asphalt or concrete Collectors: AADT 300-1000 = surface treatment (chip seal); AADT>1000 = asphalt or concrete
Saskatchewan	Primary Roads: AADTT > 50 trucks/day = asphalt; Secondary Roads: AADTT > 75 trucks/day = asphalt; AADT 200-300 = gravel
Ontario	Arterials and Freeways: Hot mix asphalt Secondary Highways: AADT <200 = gravel; AADT 200-1000 = surface treated; AADT 1000-1500 = cold mixed asphalt; AADT > 1500 = hot mix asphalt
British Columbia	Graded Aggregate Sealcoats: SADT = 1,500 to 4,000; Asphalt: SADT > 4000; Chip Seal: not permitted on any roads
South Dakota	Gravel: <150 vpd; Surface treated: 150-660 vpd; Hot mix asphalt: >660 vpd
Ohio	Chip seal only permitted on routes < 2,500 AADT
Minnesota	Paved surface should be considered when ADT >200 vpd
Missouri (Cole County)	ADT must be greater than 125 vpd for roads to be paved
National Park Service	Roads with ADT > 400 should be paved
Kentucky Transportation Center	Minimum ADT to justify paving ranges from 50 to 400 vpd Types of traffic should also be considered

Table 6: Additional Criteria for Road Surfacing (Selected Agencies)

Factor	Agency / Source
Agency costs	• Northern Ontario • South Dakota • FHWA Context Sensitive Roadway Surfacing Guide
Road Functional Classification	• British Columbia • Ontario • Manitoba • Saskatchewan • Newfoundland & Labrador • Kentucky
Urban / Rural Setting	• FHWA Context Sensitive Roadway Surfacing Guide
Climate	• FHWA Context Sensitive Roadway Surfacing Guide
Impact on Nearby Residents	• Northern Ontario • Nova Scotia
Impact on Local Businesses	• Northern Ontario • Nova Scotia
Impact on Long Distance Travel	• Northern Ontario • Nova Scotia
Urban / Rural Setting	• FHWA Context Sensitive Roadway Surfacing Guide

Table 7: **Assessment of Potential Factors**

Factor	Rationale	Potential Measure	Data Availability
Traffic Volumes	Roads with the highest usage should provide the best level of service to minimize road user costs.	Average Annual Daily Traffic (AADT)	AADT available from NBDTI count program for all arterial, collector and local numbered highways. Limited count data available for local named roads.
Commercial Traffic	Heavy vehicles cause the most significant damage to roads. Roads with high volumes of truck traffic require additional strength to minimize damage to the road surface	Average Annual Daily Truck Traffic (AADTT)	Regular traffic monitoring program only collects truck volumes at the 38 permanent count locations. Sporadic data is available for several locations where truck counts have been undertaken by special request.
		Designated Truck Routing	NBDTI does not have a designated truck network. However, the department maintains a list of routes where trucks are not permitted.
		Presence of a commercial traffic generator (e.g. mill, woodlot, etc.)	Requires site specific assessment
Road Functional Classification	Roads with a higher functional classification are generally expected to have a higher standard of surface treatment	Functional Classification	Each designated road in the NBDTI network is classified as arterial, collector, numbered local, and named local. Classification information is available in spatial format.
		Posted Speed	Posted speed is available for all arterials and collectors on Road Life Studies, which are subsequently being discontinued in 2010.
Land Use Development	Road users tend to have greater expectations regarding road surfaces located in urban environments. Gravel roads (which produce dust) and chip seal roads (which can result in flying stones) are generally less acceptable in densely populated areas. Roads that service significant tourist destinations, recreational areas, or scenic routes should also have a higher surface quality.	Presence of year-round dwellings	Requires site specific assessment
		# of roadside accesses / residences per km	Requires site specific assessment
		Significant Tourism Route	Requires site specific assessment
		Urban versus Rural	Requires site specific assessment
Agency Costs	An evaluation of agency costs is necessary to ensure that long term life cycle costs are optimized.	Least Life Cycle Cost	Requires site specific assessment of construction and maintenance costs.

Table 8: **Framework – Initial Screening**

Factor	Definition	Rational	Data Source
Functional Classification	Under the provincial functional classification system, each road in the provincial network is classified into one of the following three categories: • Arterial Highways provide a continuous, integrated highway network for long distance intra and inter provincial travel and are intended to provide primarily a traffic mobility function. • Collector Highways generally service intra provincial travel with trip lengths and traffic volumes reflecting regional activity. They form an integrated network throughout developed areas and provide direct traffic service to major resource areas and smaller towns and villages. • Locals Highways provide direct access to individual land uses and link with arterials and collectors to form an integrated highway network which reflects a balance between land accessibility and traffic mobility.	Roads serving the greatest functional purpose are generally expected to have a higher standard of surface treatment.	• Arterials are designated as Routes 001 to 095; • Collectors are designated as Routes 100 to 199; and • Locals are designated as Routes 205 to 970 (numbered locals) and also include any provincial routes without a designated route number (named locals).
Daily Traffic	The average number of vehicles travelling on a given section of road each day. In most instances, average annual daily traffic (AADT) can be used as a representative measure; however on roads with highly seasonal fluctuations in traffic, the average daily traffic during the peak month (MADT) may be used instead.	Roads with the highest usage should provide the best level of service to minimize road user costs.	The NBDTI Traffic Flow Map (produced annually) depicts AADT volumes for all arterial, collector, and local numbered highways. Site specific counts may be used at other locations for which data is not available.
Daily Truck Volumes	The average number of trucks (or other heavy vehicles) travelling on a given section of road each day. In most instances, average annual daily truck traffic (AADTT) can be used as a representative measure; however on roads with highly seasonal fluctuations in trucks (e.g. resource roads), the average daily truck traffic during the peak month (MADTT) may be used instead.	While passenger vehicles represent the majority of users on the provincial road network, heavy vehicles result in the most substantial damage to a road's surface. Consequently, roads with high volumes of trucks and other heavy vehicles require additional strength to prevent accelerated surface damage.	The NBDTI Traffic Flow Map depicts AADTT at permanent count locations only, which are located primarily on arterial highways. Site specific counts may be used at other locations for which data is not available.