Provincial Highway Vehicle Weight Management Review and New Policy Development in Saskatchewan

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ABSTRACT

Saskatchewan economy largely depends on bulk commodity export. Keeping transportation costs low is critical for the competitiveness of the economy. With the changes in provincial economy and transportation patterns, there has been a significant increase in truck traffic and increasing demand for primary weight highways in rural Saskatchewan. Saskatchewan had managed its highways with primary and secondary weight limits over 20 years. Depending on truck configurations, typically the gross vehicle weight allowed for primary weight is approximately 15-20% higher than for secondary weight and the payload increase for primary weight is about 24-50%. Many Saskatchewan rural areas are only served by secondary weight highway, which is viewed as a competitive disadvantage.

Higher vehicle weight will reduce freight transportation costs however it will also results in faster deterioration to the pavements. The size and weight of trucks allowed have been increased over the years to reduce transportation costs. The concerns of accelerated infrastructure deterioration and traffic safety are the main constraints for further change. How to improve highway transportation efficiency to support economic development while maintaining infrastructure sustainability has become an important policy issue.

Saskatchewan Highways and Transportation conducted a comprehensive review on weight management and developed a new policy framework in 2006. This paper describes the details of the review and policy development, including problem identification, criteria development, costs and haul benefit analysis. The new policy makes the process of designating primary highways rational, transparent, and consistent. The paper also discussed some related difficult policy and technical issues.

INTRODUCTION

Saskatchewan is a land-locked Canadian province and its economy is largely dependent on inter-provincial and international trade. A large portion of this trade is bulk commodity export, which includes grain, livestock, oil and gas, and other mining products. The surface transportation infrastructures, including road and rail, are essential arteries for the provincial economy.

In recent decades, Federal rail deregulation and grain handling system reform have quickened the pace of the transportation system consolidation and a relative shift from rail to road for grain transportation. Freight movements are now increasingly made by road in larger trucks, carrying heavier loads and moving longer distances. Increasingly diversified rural economy, new products and markets, just-in-time delivery, pricing of transportation options, new technologies have all led to a significant increase in truck traffic on provincial and municipal roads throughout Saskatchewan.

For over 20 years, Saskatchewan has managed its highways with primary and secondary weight limits according to a highway's structural capacity. Depending on truck configurations, typically the gross vehicle weight allowed for primary weight is approximately 15-20% higher than for secondary weight and the payload increase for primary weight is more significant, at about 24-

50%. Many Saskatchewan rural areas are only served by secondary weight highways, which is viewed as a competitive disadvantage. It is neither possible to upgrade all highways to primary weight standard due to financial constraint nor necessary due to low usage on many highways.

Higher vehicle weight will reduce freight transportation costs however it will also results in faster deterioration to the pavements. The size and weight of trucks allowed have been increased over the years to reduce transportation costs. The concerns of accelerated infrastructure deterioration and traffic safety are the main constraints for further increase in truck size and weight. As the province having one of the highest roadway mileages per person in Canada (approximately 0.20 km/person) and large amount of commodities to be transported, Saskatchewan has limited resources for roadway investment and preservation but high requirements for pavement performance. Both technical engineering and system policy management solutions are needed to support economic development while still preserving highway infrastructure. The challenge for the province is to find a good balance between the demands for higher vehicle weight for more highways to support economic development and for the financial sustainability of highway infrastructure.

Since 1995, Saskatchewan Highways and Transportation has received numerous requests for extension of primary weight highways from various communities, industries, and regions. Increased truck traffic has lead to deterioration of many roads to conditions that are unacceptable to the public. The provincial government decided to conduct a review for the primary weight issue in 2003. The review of the primary weight system is intended to establish a more rational and transparent weight management system, and will identify opportunities for primary weight system expansion. The review was completed and new policy was developed in 2006 (1).

BACKGROUND OF SASKATCHEWAN VEHICLE WEIGHT MANAGEMENT

It is important to have a good understanding of issues related to vehicle weight management in Saskatchewan for primary weight review and policy development. The related issues include regulatory aspect of vehicle weight management, historical evolvement of the current system, pavement design and performance, and provincial economy.

Regulatory Aspect of Vehicle Weight Management in Saskatchewan

Current primary weight highway system in Saskatchewan has several major components and it has gradually evolved over the years. Under the authority of ***The Highways and Transportation Act, 1997*** (2), maximum vehicle weight and dimensions are established to protect bridges, pavements, roadbeds, overpasses, other users of the roads, and to ensure vehicle stability. ***The Vehicle Weight and Dimension Regulations*** (3) provide detailed axle/vehicle weights allowed for different vehicle configurations on individual highways and road networks.

Weights allowed on public highways are separate from the registered weight of a vehicle. A heavy vehicle is usually registered to a specific weight determined by its business and the maximum weight it will generally carry according to ***The Vehicle Classification and Registration Regulations*** under ***The Highway Traffic Act*** (4).

In order to protect highway infrastructure and support economic development, all public highways are currently classified under one of the following categories in terms of vehicle weights allowed:

- Primary Weight Provincial Highways
- Secondary Weight Provincial Highways
- Year-Round Weight Restricted Highways
- Seasonal Weight Changes (reflect road strength: winter weight, spring road restrictions)
- Weight permits

Table 1 shows Saskatchewan highway lengths by weight classes in 2004. The existing primary weight highway network was initially established more than 30 years ago by a Federal initiative to promote highway weight harmonization across Canada. The primary weight highway network was initially only 3,100 km, and has been evolved gradually (1). Like in all other jurisdictions, almost all changes made are in one direction, which is the increased size of the primary weight highway system, or increased access to the primary weight system, or increased size /weight of trucks allowed on highways. The driving forces for these changes historically have been the carriers/shippers demanding for higher allowed weights to reduce their transportation costs, or the national and international harmonization drive for uniformed market access and increased productivity for transportation industry. The concerns of increased infrastructure damage and traffic safety are the main constraints for further changes. Over the last 20 years, the primary weight highway network had been largely steady, and changes to the network were mainly related to winter and spring weight limits and duration.

Table 1 Saskatchewan highway lengths by weight limits in 2004

Highway Weight Limit	**Roadbed (2-lane km)**	**Centreline (km)**
Primary	8,147.24	7,083.05
15 km primary extension*	4,391.21	4,385.47
Secondary	12,534.84	12,534.84
Weight Restricted (bridge, weight, winter weight, etc.)	1190.90	1190.90

* The province allows primary weight on the first 15 km of secondary highways that intersect a primary weight highway.

Factors Affecting the Performance of Highway Infrastructure

Many factors affect the life and performance of highway infrastructure. These factors can be categorized broadly into three categories: traffic loading, pavement structure, and environmental conditions. There are also complicated interactions among these factors as well as many uncertainties. Pavement deteriorations, including rutting, fatigue cracking, shear failure, and increased roughness, are the result of the interactions of traffic loading, pavement materials, and environmental conditions.

The most common measure of traffic loading damage to pavement has been ESAL (Equivalent Single Axle Load), which is primarily dependent upon the axle weight, axle configurations, truck volume, and pavement types. Pavement deterioration can be seen as the result of the cumulative traffic loading ESAL on pavements over the design period. It is generally accepted that axle weight and ESAL equivalency factor follows a (third to) fourth power relationship for a given pavement type. For example, an equivalency factor of 3.84^{th} power has been used in Saskatchewan pavement design (5). According to this relationship, 10% increase in axle weight will result in 44% increase in pavement damage; a 2-axle six tire single unit truck hauling primary weight will cause 133% more damage than the same unit truck hauling secondary weight, although its GVW is only increased by about 20%. This is why highway engineers are always concerned for the increase in vehicle weight on highways.

Like in other jurisdictions, the highway pavements in Saskatchewan have been constructed to different structures according to subgrade conditions and forecasted traffic loading to achieve the cost effectiveness. Roadways in Saskatchewan may be constructed as one of following structures (5):

- AC (asphalt concrete) pavement of 15 year design life, consisting asphalt concrete, base and subbase;

- Granular pavements with different standards for 5 to15 years design life, consisting of base and subbase with a seal coat;

- TMS (Thin Membrane Surface), a thin layer of soft asphalt (40-50 mm) placed on top of subgrade to provide a dust free surface for rural light traffic; and

- Gravel roads, or compacted earth roads.

Different road structures have different capacities to handle vehicle weight. Even for the same type of structure, the load bearing capacity varies due to different subgrade, materials and environmental conditions. AC and granular pavements normally use high quality materials and are more expensive to build, and they can provide much better load bearing capacity. Over the years, TMS and other sub-standard pavements had been built to extend dust free highway network. These highways were never built to handle heavy truck traffic. If the heavy truck load is applied to non-structured roads (such as TMS) or low quality pavements, the risk of catastrophic failure (such as shear) will be high. With the rapid changes in economic activities, traffic loading patterns may have also changed after the roadways have been constructed. The changed transportation demand may not be matched with the timely and adequate pavement upgrading, which may lead to accelerated pavement deterioration.

Environmental conditions also have great impact on pavement deterioration. Low temperature can cause pavement thermal cracking; high temperature will soften the surface asphalt materials which lead to increased rutting and bleeding; and freezing-thaw-cycle can cause pavement frost action damage. Some environmental conditions when acting together with traffic loading will contribute to accelerated pavement deterioration. For example, some pavement structures are significantly weakened during the spring thaw period, the same weight trucks will thus cause

more damage to these structures during this time. On the other hand, the frozen ground makes pavement much stronger during the winter time, pavements can withstand heavier traffic load without extra damage. These seasonal pavement strength variations can be considered in vehicle weight management system to maximally use the extra pavement strength and minimize pavement damage.

New Economic Reality and Transportation Demand

In preparation for the primary weight review, the new provincial economic reality and the future transportation demand in the province was analysed.

Based on discussion with other provincial agencies, it is believed that the provincial economy is expected to grow mainly from expanded trade in natural resources, processing and manufacturing exports (1). Energy, minerals and forest products today are larger than agriculture and have become key driving forces to Saskatchewan economy. Many of the new entrants into the Saskatchewan economy operate in areas with commodities/volumes where trucking is the only viable means of transportation.

For the agricultural economy, regulated export grains are being replaced by new markets and products, which include grains and oilseeds, special crops, animals and animal feed. Agricultural value-added activities are increasingly complementing rural agriculture. With increasing diversification, the volume of products being moved continues to rise. Most of this movement is by road.

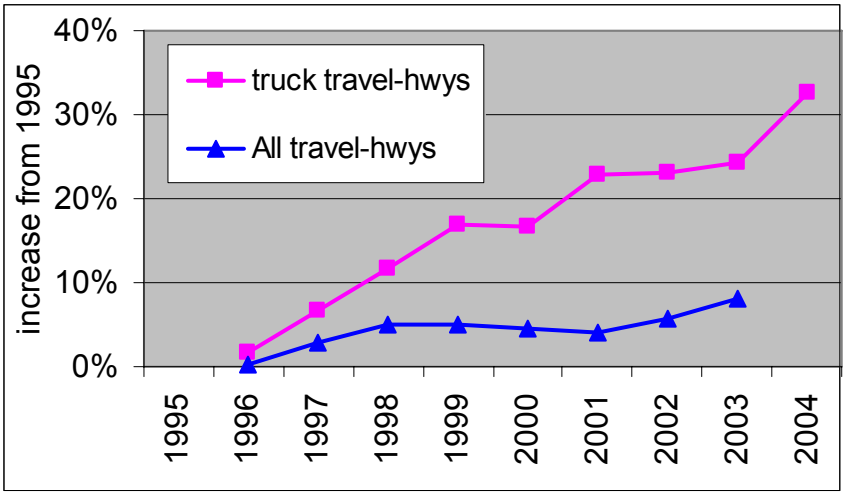

Figure 1 Total travel and truck travel increase on Sask. Highways between 1995 and 2004

As it can be seen in Figure 1, total travel on Saskatchewan highways only increased less than 10% between 1995 and 2004, while the truck travel on provincial highways increased about 33% in the same period. The truck travel trend is clearly pointed to further increase in the future. It is believed that railways are not likely to reduce road traffic due to the increasingly complex nature

of the trip patterns and special requirements for commodity transport. A rationalized and expanded primary weight highways network will certainly help improve commercial transportation efficiency.

Economic Reasons for Primary Weight Requirement in Saskatchewan

The costs of freight transportation on highways mainly include trucking and road infrastructure costs. Both of these costs vary by truck type, weight carried and road surface structure. As discussed earlier, higher vehicle weight (increased ESAL) will lead to much higher infrastructure costs due to the power relationship between axle weight and ESAL. For trucking costs, the major components include equipment depreciation, fuel consumption, repairs and maintenance, licensing and insurance, wages, and administration. The equipment depreciation, fuel consumption and wages are the most important cost components and they are all proportional to the number of trips or distance travelled.

Truck weight and dimension limits control the amount of payload on a truck. For high-density bulk commodities mostly seen in Saskatchewan, their unit weight price and storage are relatively cheap and are normally ordered in large quantity, the maximum payload usually is controlled by weight limits on highways. Because the increase in truck weight and dimension limits will increase the payload per trip, fewer truck trips are required to carry the same amount of freight. As a result, major components of trucking costs will be reduced and productivity will be increased. Comparing the primary and secondary weight, the GVWs of most truck types are just increased by 10% to 20%. However, the payload increase will be more significant, the increase may be in the range of 24% to 50% depending on truck configuration. That is why the demand for primary weight occurs throughout the province.

Many rural areas are served by secondary weight highways only and this has been identified as a competitive disadvantage. The challenge is to find a balance between a sustainable transportation system and higher weights that promote economic development.

PROBLEMS IDENTIFIED AND PRINCIPLES FOR NEW POLICY

To review current primary weight system and to develop a new policy framework for the primary weight system, it is critical to identify the major problems with the existing system. Extensive public and stakeholders consultations were conducted. Detailed internal discussion and analysis on the primary weight system was also conducted. Based on the consultation and system analysis, following major problems for the system were identified:

- **The extend of the primary weight highway system:** the current primary weight highway network is extensive, however it does not meet the demand of the Saskatchewan stakeholders, especially in rural areas. Figure 2 is a highway map with truck traffic levels and existing primary weight highways. It is clear that the primary weight highways covered most high truck traffic highways, but there are still areas and corridors where primary weight is not available for high truck traffic demand. This is largely due to changes in economic activities and transportation patterns in the province.

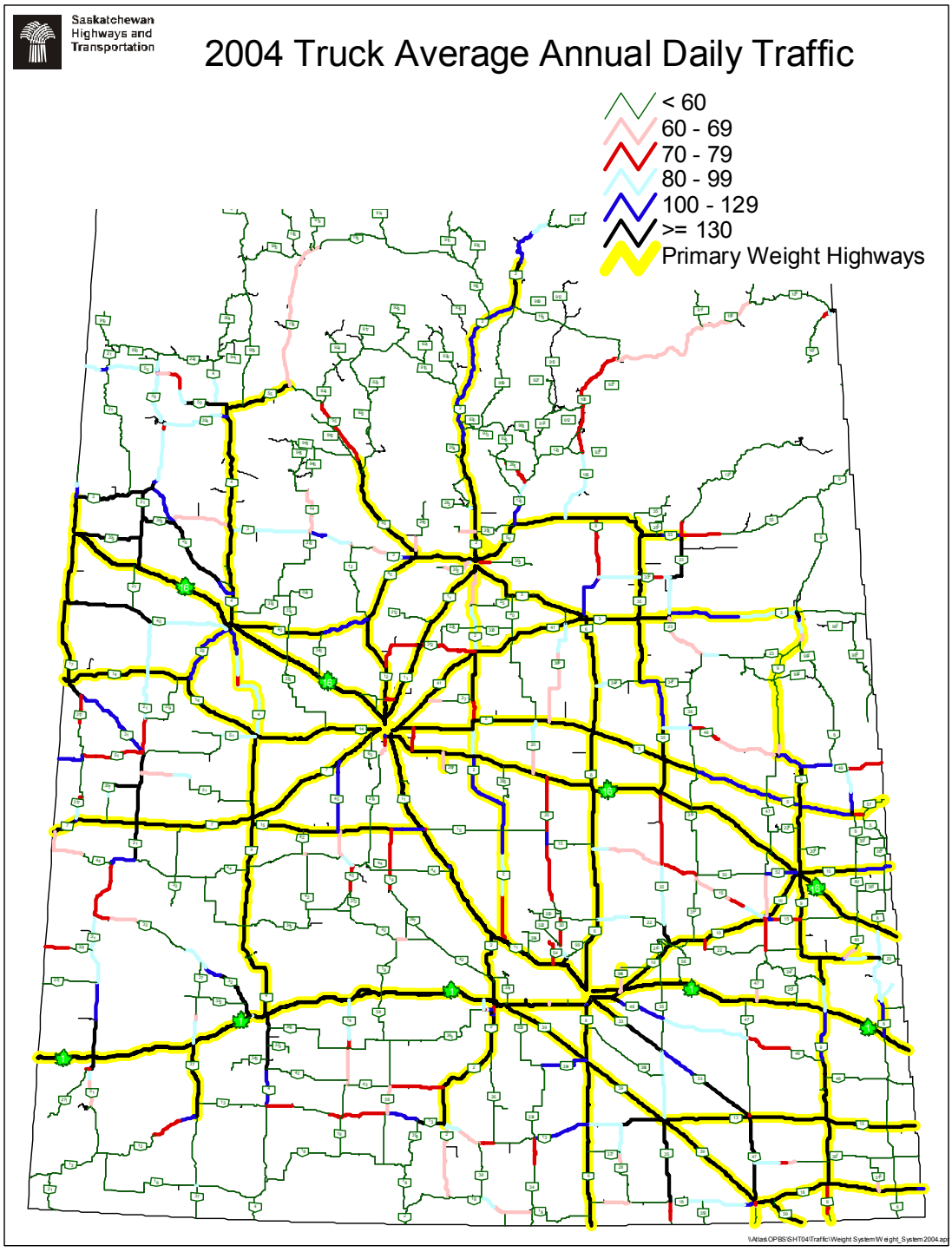

Figure 2 Highway Map with truck traffic levels and current primary weight highways in 2004

- **The management of the primary weight highway system:** there was no documentation, defined rationale, criteria, and review process for the system. As a result, the system can not meet the rapidly changing demands. There was also no long-term plan for the system.

- **The primary weight policy coordination:** there was little coordination between primary weight policy and overall economic development demand. Policy coordination for enforcement, partnership, design standard, and project prioritization could also be improved.

- **Many technical unknowns affected the primary weight related policy development:** such as how to estimate incremental costs by higher weight for different highway structures? Does speed affect pavement damage rate on granular pavement? etc.

Based on the assessment for the identified problem, some major principles for the new primary weight policy were established. One of the major principles is to balance the often conflicting requirements of supporting economic development of rural communities & industries and long term financial sustainability for the highway infrastructure system. Other major principles include criteria development for primary weight highways and a transparent review process to rationalize the network and to meet changing demand.

The objectives of the new policy are to provide a rational, transparent, and consistent primary weight system and review process to gradually meet the reasonable demand for primary weight highways in the province.

OPTIONS CONSIDERED FOR THE PRIMARY WEIGHT HIGHWAY NETWORK

The current highway network and primary weight system is evolved over many decades. The driving forces of these historical evolvements for the highway system have been to meet increased economical and social demands at the affordable costs. Several major options were generated and extensively analysed and debated during the policy development process in Saskatchewan Highways and Transportation. These options are:

1) **Maintaining current primary weight network (status quo):** By retaining the existing network there is no incentive or disincentive for economic development. The changed transportation demand patterns will not be addressed, and the increasing demands for primary weight will remain.

2) **Existing primary network, less 15 km extension, plus 3,000 km of logical links:** The existing 15 km primary weight extension of secondary highways from the intersection with a primary weight highway is an ad-hoc addition to the system. This option looks at reducing or eliminating this 15 km extension and then adding in an equivalent amount of roads on the basis of need or defined logical link. It may be a very difficult as businesses may have been established along the highway sections because of available primary weight.

3) **All structured pavement and gravel road primary, and no trucks on TMS:** This option would provide about 20,000 km highways that allow primary weight. The 6,700 km TMS will not allow any truck traffic. Forbid all truck operations on existing TMS surfaced highways will have significant negative impact on existing businesses located along these highways. It is also questionable whether this option can be implemented and enforced. The structured pavements may have very different load bearing capacity.

4) **The entire highway system at primary weight:** This option would have the entire 26,000 km long highway system at primary weight. Many roads were not constructed to carry these heavy loads. This would result in significant deterioration of the network. According to a consultant study (6), a very significant cost is required to upgrade the highway network to handle primary weight on the system.

5) **Modified existing weight management system –existing primary weight network, plus moderate primary highway expansion:** Although about 86% truck travel on provincial highways are served by primary weight highways, if considering truck trip O-D and truck trip on municipal roads (mostly allow secondary weight), the truck travel served by primary weight is just about 60% of the total truck travel in the province (1). This ratio is very low and it indicates the inadequate primary weight service in the province. This option will target the economic development area for primary weight expansion to limit the total cost. There is no negative impact on existing businesses. Major problems of existing system can be resolved. This is the recommended option.

NEW PROVINCIAL PRIMARY WEIGHT POLICY FRAMEWORK

The new provincial primary weight policy is not only about primary weight highway network. The new primary weight policy framework includes four major components that define primary weight highway network and a long term plan, provided a transparent mechanism for review, outlined enforcement and communication strategy, and a research plan. The four major components of the primary weight policy framework are:

1) **The new primary weight regime:** This includes existing primary weight highway network, newly defined criteria for primary weight highways, a moderate primary weight highway expansion plan, and tools for access to primary weight.

The primary weight highway criteria are developed to provide rational approach for designating new primary weight highways. Parameters used in primary weight highway criteria include being part of National Highway System, being part of provincial Principal Highway Network, major inter-jurisdiction connections, connect to cities and major population/ service centers, traffic and truck traffic level, Rural Road Classification levels, route length and spacing, and industrial sites measured by annual haul tonnage and employment level, etc. Meeting the criteria is essential to be qualified as primary weight highway candidates. Priority ranking of qualified candidates and staged implementation may be used depending on financial capability.

With regarding the design and construction standard of a highway section, there is no real difference in pavement design for primary and secondary weight highway pavements. The traffic loading is all converted to ESAL for pavement layer thickness design. Primary weight vehicles will generate higher ESAL/truck value, which can lead to a thicker design. The secondary highway pavement may also use lower standard in gradeline, and base materials. Since there was no long term plan to expand the primary weight highway network in the past, the new highway design and construction was normally built the highway to the current weight limit although incremental costs from a secondary to a primary weight highway pavement is relatively low. This has been a big issue during the stakeholder consultation and system assessment. It

was difficult to explain why the highway was upgraded but primary weight was still not allowed. A long-term primary weight highway expansion plan will assist the proper design standard use.

Based on the newly defined criteria for primary weight highways, a moderate primary weight highway expansion plan has been developed.

2) **A weight advisory committee:** To make the primary weight management system rational, transparent, consistent to public and stakeholders, and flexible to the rapid changing demand, a Weight Advisory Committee (WAC) is established. WAC has representatives from main stakeholders in the province for primary weight issues, such as municipalities, area transportation planning committee, regional economic development authorities, and industry. The WAC's work will not only make the primary weight policy transparent, but also bring the main stakeholders as part of solutions to primary weight issues. WAC's primary mandates include:

    - to review and advise on the criteria for primary weight highways;
    - to review requests/applications for new primary weight highway;
    - to review and advise on the long term plan and prioritization for implementation;
    - to review and recommend research and development plan related to primary weight;
    - to be consulted on weight compliance and communication strategy.

3) **An enforcement and communication strategy:** An enforcement strategy has to be part of weight policy framework to reduce overweight on highway system. A communication strategy is also important.

The damage to pavement increases exponentially with the increase of vehicle weight. Effective enforcement to reduce overweight is essential for the system's sustainability. Based on the provincial Axle Weight Survey (7) at 31 highway locations across the province, the overweight ratio (combined axle weight and GVW) is lower than 16% on primary weight highways and 23% for secondary highways. However, if considering allowable ESAL/truck, only about 3.3% trucks were above allowable ESAL (the ESAL of allowed axle and vehicle weight) on primary weight highways, and 10% trucks on secondary highways. Obviously, the overweight is not a big concern for the primary weight highways, and this is partly due to more visible enforcement of the primary weight highway network.

During the policy development, vehicle weight audits were conducted at five grain terminals to help understand the overweight problem for concentrate haul activities. It should be noted that most trucks will need to make at least a portion of their trip on a secondary weight highways or municipal roads during their grain delivery. The audited result showed that the portion of trucks over secondary weight was between 40% and 75%, and trucks over primary weight were about 14% (1).

Both the axle weight survey and terminal audit results indicateed that the overweight problem is more prevalent on secondary highways and during concentrated haul. The enforcement effort has been low for secondary highways and it is difficult to monitor concentrated haul. The nature of concentrated haul is capable of inducing higher pavement damage than background traffic due

to large vehicles used, fully loaded status, and happened in a short period of time. If the haul occurs during spring period or other wet time, the damage to pavement will be even greater. The new effort of enforcement need to focus more on reducing overweight of concentrated haul and on secondary highways. The new strategy may include increased enforceable audit activities to businesses involving concentrated haul, and promote self-enforcement for stakeholders.

Communication strategy consists of a stakeholder awareness program and an information dissemination initiative. The stakeholder awareness program should educate the public and stakeholders about infrastructure costs and vehicle weight impact on pavement deteriorations. The information dissemination initiative should be developed to help local communities, businesses, shippers/carriers to understand alternatives for primary weight access. It should also assist truckers to find the best primary weight routes for their haul activities.

4) A research plan to gradually understand the related unknowns

During primary weight policy development, it was recognized that many challenges in Saskatchewan are quite unique, due to our demographic and geographic conditions. Some of the unique conditions include a land locked location, the highest mileage of roadways per capita, and high raw commodity transportation demand. It is therefore unlikely that we can get useful answers from "literature search" for these challenges. Research on some unique topics related to primary weight is therefore justified. A list of potential research topics were developed (1).

PRIMARY WEIGHT HIGHWAY EXPANSION PLAN

The existing primary weight highway network has largely been in place since 1985. Rural economic activities have been diversified and truck traffic pattern has also changed significantly. The new commercial traffic corridors and links have emerged as highways with high truck traffic. Figure 2 shows clearly the gaps of existing primary weight highway network and newly emerged corridors and links that should be considered for primary weight.

Identification of New Primary Weight Highway Candidates

The criteria for primary highways and GIS traffic level map are used to assist in identifying new primary highway candidates. The following major factors are particularly important:

- the traffic and truck traffic levels (AADT and TAADT): the truck traffic level (TAADT 70) for the new primary weight highway candidates is established to be consistent with truck traffic level on the existing primary highways and to be a reasonably high truck traffic level threshold at the currently secondary highways.
- the formation of new primary weight highway corridors in areas or directions that are not served by the current primary weight highway network;
- logical links that connect to communities with significant commercial traffic;
- to connect neighboring jurisdictions' primary weight highways.

A total length about 3,000 km highway sections has been identified as candidates for new primary weight highways based on the criteria and system analysis. The local communities'

"wish-list" for primary weight highways during the stakeholder consultation has been considered in the process of identifying candidates.

The new primary highway candidates were then divided into two groups. The first group of new primary highway candidates consists of only highways with structured pavements and verified as performing well under current traffic conditions by regional preservation engineers. The remaining new primary weight highway candidates are either having inadequate TMS surface or other poor performing pavements. The first group of primary weight highway candidates is considered for immediate implementation of primary weight (Phase I) while the second group of highways should be upgraded or constructed before primary weight can be allowed (Phase II, or long term expansion plan).

Figure 3 shows Saskatchewan primary weight highway network and expansion plan. It is clear from the map that new primary weight highways improved the primary weight highway system significantly and covered the highest truck traffic routes in the current secondary weight highway network.

Implementation Strategy for Primary Weight Expansion Plan

To implement Phase I 1189 km primary weight highway expansion, the fact that these highway pavement structures were not designed for primary weight operation had to be considered. There are some factors that affect these pavements' load bearing capacity, for example,

- The ESAL equivalency factor (ESAL/truck) is normally higher for primary weight highways than for secondary highways during design;
- For the given design load and subgrade strength, different pavement types may use different base thickness even the total granular thickness is the same (5);
- Most of the new primary weight highway candidates are granular structured pavements, which is more susceptible to frost damage, and
- Lower standard type of pavement may use lower gradeline, this may affect the pavements' drainage capability and therefore its performance.

Although the risk of catastrophic failure is low, the increased weight on the highways will lead to a shorter pavement life. It is therefore justified to take a cautious approach to the Phase I implementation. The adopted cautious approach includes the following:

- the primary weight will be allowed for 9 months of the year (except April, May, June). The pavement damage during the springtime may contribute to more than 60% of the overall annual pavement damage (8). 9-month primary weight will provide majority of time for primary weight access and also minimizing the risk of premature failures for these highways.
- no 15 km extension of primary weight onto intersecting secondary highways for these newly expanded primary weight highways.
- monitor these new seasonal primary weight highways closely in the next three to five years.

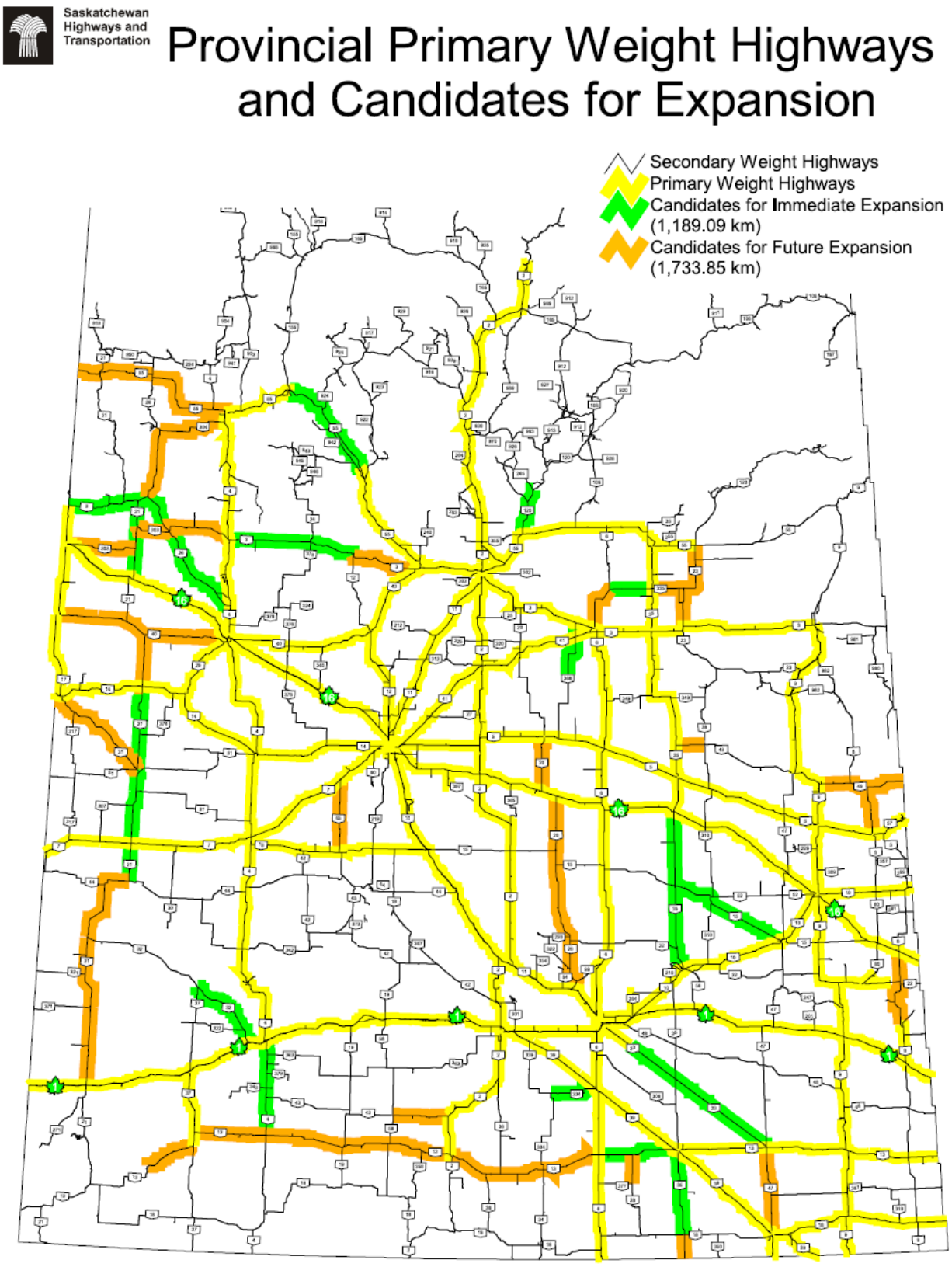

Figure 3 Saskatchewan primary weight highway expansion plan

For the Phase II primary weight expansion, primary weight can only be allowed after these highways have been upgraded. It is not possible to upgrade them at the same time, a prioritization method and review process by the WAC has been established.

Incremental Infrastructure Costs Analysis for Phase I

The implementation of new primary weight highways will generate benefits for Saskatchewan economy (through truck haul savings and increased competitiveness) and incur incremental infrastructure costs to the province. Two methods were used to estimate the incremental infrastructure costs due to primary weight allowed on the currently secondary highways for implementing the Phase I primary weight highway expansion. The two methods used are Saskatchewan Trucking Program Method and Ontario Marginal Cost Method for infrastructure costs. The truck haul benefit is calculated by using the Saskatchewan Trucking Program method.

Saskatchewan Trucking Program method for infrastructure costs has been used in the department for many years for transportation partnership agreement with trucking industry and as the basis for charging overweight permission. Since the highway pavement were already constructed in the past for secondary weight operation and there is no upgrading for allowing the primary weight, only incremental cost of extra pavement deterioration is considered. To use the method, several parameter values have to be established. The method requires the "payload ton-km" to be calculated for both primary and secondary weight scenarios, which needs many not readily available data. Extensive effort was made to derive these data from the traffic monitoring program and to avoid using assumed values. These data include:

- **average vehicle classification:** using the Sask. Axle Weight Survey (7) data for the analyzed type of highways, the average proportion of vehicle classifications are about 28%, 48%, and 24% respectively for single unit, single trailer, and multi-trailer trucks.
- **the proportion of trucks likely to be loaded at primary weight:** this data is estimated by the proportion of trucks loaded to above secondary weight on primary weight highways based on the same data source. The proportion is in the range of 24% to 30% for different types of highways. 27% is used in this analysis.
- **the proportion of each primary weight loaded truck type:** this is derived from average vehicle classification and the proportion of trucks loaded at primary weight. They are 11.8%, 49.2%, and 39% respectively for single unit, single trailer, and multi-trailer trucks (10).
- **the average tare weight and allowed GVW of each truck type:** based on Saskatchewan empty truck survey and Saskatchewan Vehicle Weight and Dimension Regulation (10).
- **Trucking Program established unit cost ($/payload ton-km):** Unit costs to infrastructure per payload-ton-km for different truck configurations are provided in the range from 0.0060 for primary weight multi-trailer trucks on primary weight highways to 0.06155 for primary weight single unit trucks on secondary highways (10). The unit cost is developed by using the incremental structure requirement due to additional ESAL as a result of primary weight vs secondary weight haul for a given amount of commodity.

The annual incremental infrastructure costs for the new primary weight segment of highways can be calculated as following:

$$AIIC_j = \sum [TAADT_j \times TLP_i \times L_j \times D_{6-m} \times (PP_i \times UC_{PS} - SP_i \times UC_{SS})] \quad \text{(Eq - 1)}$$

Where,

$AIIC_j$ = Annual incremental infrastructure costs for highway segment j.
$TAADT_j$= truck annual average daily traffic for highway segment j,
TLP = % truck loaded to primary weight,
i = truck type, single unit = 1, single trailer = 2, multi-trailer = 3
PP_i = primary payload for truck type i in ton,
L_j = highway segment j length in km,
D_{6-m} = days in 6-month (9-month primary weight, including 3 months winter weight that is same for both primary and secondary weight highways)
UC_{PS} = unit cost for primary weight on secondary highways
SP_i = secondary weight payload for truck type i in ton,
UC_{SS} = unit cost for secondary weight on secondary highways,

Considering the new primary weight vehicles will also travel on the existing primary weight highways after travel through these new segments of primary weight highway, these travels would have been in secondary weight without the expansion these new primary weight highways. These incremental primary weight travels will incur extra pavement consumption to the existing primary weight highways. This extra pavement cost to existing primary weight highways largely depends on the distances these primary weight vehicles will travel. The average trip distances for each type of trucks loaded to above secondary weight on different classes of highways were derived from analysis of the O-D data of Axle Weight Survey (9). The average primary weight truck trip distances are 111 km, 322 km, and 390 km respectively for single unit, single trailer, and multi-trailer trucks (1). The incremental infrastructure costs of existing primary weight highway by the additional primary weight trucks can be calculated by using the average trip distance of the additional primary weight trucks and 26% of unit trucking costs for primary weight trucks on primary weight highways. The 26% value is used because the ESAL value is increased by about 26% between primary and secondary weight for a given amount of commodity to be transported by the same truck type (1).

The result of incremental infrastructure costs per year by using the Saskatchewan Trucking Program method for Phase I 1189 km 9-month primary weight highway expansion is about $1.799 million/year.

In a study to estimate impact on pavement due to changes in vehicle weight regulations on Ontario highways (10), the researchers developed a marginal cost method to calculate incremental costs due to weight limit changes on highways. The researchers classified the highways in Ontario into twenty different classes based on their traffic levels and functions, and

climatic conditions. The statistically based marginal equivalent annual costs per ESAL-km functions are developed for each category of highways and for new and in-service pavements.

To apply the Ontario method, the Northern Ontario highways functional category 5N (rural collector, TAADT 96, 4 trucks with 6+ axles) in-service pavement function was chosen because its similarity in climatic and traffic conditions to the considered highways in Saskatchewan. The Marginal Equivalent Uniform Annual Costs per lane per ESAL-km for 5N is $0.0563. ESALs for every highway sections are calculated for both secondary and primary weight scenarios. The total marginal equivalent uniform annual cost is about $1.951 million, which includes the incremental costs on these new primary weight highways and the impact of additional primary weight trucks on the existing primary weight highways.

It is expected that different methods will generate different incremental infrastructure cost results. The small difference between the results from the two different methods provided reasonable confidence to the estimated range of actual incremental costs. It should be noted that the infrastructure cost analysis did not consider the three month spring time differently from other time when the primary weight would have incur more damage to the new primary weight pavement. This is due to the fact that ESAL is an annual average pavement damage measure. This fact makes the estimated incremental infrastructure costs on the conservative (high) side.

Trucking Haul Benefits Analysis for Phase I

Saskatchewan Trucking Program has developed trucking costs on primary weight and secondary weight hauls for different truck configurations. These costs are based on information gathered about truck capital & depreciation, fuel consumption, repairs and maintenance, and license and insurance costs. The unit trucking costs are developed and they are used in the trucking program to estimate trucking costs under various operating conditions over the years. The trucking industry seems to accept the result. The unit trucking costs are very sensitive to fuel cost. The range of trucking unit costs (in $/payload ton-km) is from 0.036 for multi-trailer primary weight trucks to 0.132 for single unit secondary weight trucks (10) based on fuel price of $0.785/liter.

It should be noted that the trucks will be benefited for the entire trip distance for the primary weight loading, not just the length of the highway section that is newly designated as primary weight highway. In order to not overestimate the benefit, the proportion of primary weight trucks was also used. The proportion of different truck types are the same as for infrastructure costs analysis. The trucking haul benefit from the Phase I 1189 km primary weight highway expansion was calculated as $19.513 million/year (1).

Costs and Benefits Comparison for Phase I

Although the amount of estimated incremental infrastructure cost is not very significant, it should be noted that this would be an incremental cost to the existing infrastructure deficit. This will negatively affect the highway infrastructure's long term sustainability. However, the cost and benefit results show that the benefits from the savings of trucking haul is about ten times of the incremental infrastructure costs from the Phase I primary weight highway expansion. It is understood that this benefit will be for the private shippers and carriers, it will not come directly

to Saskatchewan Highways and Transportation, it will also improve the competitiveness of the economy and therefore a significant support to the provincial economy. Considering the high benefit/cost ratio and the following factors:

- these highways are carefully selected to improve the primary weight highway network and access; this moderate system expansion will support the economic development in the most needed areas and partly satisfy stakeholders' demand;
- these highways all have structured pavements, they have been assessed as having very low risk of dramatic failure, and a very cautious approach was taken in expansion candidate selection and to only allow seasonal primary weight;
- the expansion of primary weight highways is likely attract heavy trucks form other secondary highways, and thus reduce damage to other highways, and
- this will be the beginning of the process to rationalize the primary weight highway system and to make the system more consistent and responsive to changing demand.

It is the conclusion of this study that this moderate primary weight highway expansion is a good balance between preserving infrastructure and supporting economic development, and therefore a good public policy option. The primary weight highway expansion is justified.

CONCLUDING REMARKS AND ISSUE DISCUSSIONS

The new policy has been implemented since July 2006. It is believed that the new policy framework has balanced the demand for supporting economic development with financial sustainability of infrastructure. The new policy has made the process of designating primary weight highways rational, transparent, and consistent. The province has committed to a ten year investment program to expand primary weight highways according to the long term plan developed in this study. The WAC has been established and prioritization method for upgrading highways to primary weight has been adopted. The general reactions to the new policy have been positive. However, there is a risk of rising public expectation.

Saskatchewan still faces the challenge of continuing to support existing infrastructures that service large rural land areas, while supporting significantly different and new demands of rapidly growing value added and supply-chain linked industries in more areas. Saskatchewan Highways and Transportation is working with municipal governments in partnership to provide more options for primary weight access. However, there are still many difficult policy and technical issues. One policy issue is how to balance the equitable and fair primary weight system access with the support to the economic development. The problem is that the more developed areas would generate more traffic, while less developed areas tend to have low traffic demand. Only providing primary weight access to the more developed areas does not seem to be consistent with highway infrastructure as a public utility. The rural communities also argued that the lack of good highway is part of the reason why they have difficulty to attract new economic development activities.

There are also difficult technical issues involving vehicle weight management on highways. The stakeholders often come up with innovative vehicle axle configurations and tire arrangement to increase their productivity; however, it is sometimes difficult to assess the impact of each axle

configurations on different pavement structures, especially on thin structure roads. Often, popular belief of some anecdotal evidences regarding vehicle weight impact on roads (such as speed vs. weight) is not well understood. More research is needed.

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