Downgrade Passing Lanes on the Canadian Trans-Mountain Highway System

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ABSTRACT

Traffic operations on long steep downgrades on two-lane highways in mountainous terrain in Western Canada are becoming increasingly important from a safety and level-of-service perspective due to increasing volumes and higher percentages of heavy trucks and recreational vehicles in the traffic stream. Most steep upgrades on the primary trans-mountain highway system have been provided with climbing lanes. However, all climbing lane sections have a solid double centre-line (based on the AADT criteria of 4000) that prohibits passing in the downgrade direction. Many trans-mountain downgrades are long and steep enough (grades of 6% and longer than 6 km) that heavy vehicles must travel at crawl speed to avoid loss of control. The low speed combined with no passing zones over extended sections results in long platoons and a low level-of-service. Safety issues arise when frustrated drivers attempt to overtake. The Highway Capacity Manual (HCM2000) provides a procedure for determining passenger car equivalents for estimating the effect of heavy trucks operating at crawl speed on long, steep downgrades. However, geometric design guides such as the TAC Geometric Design Guide for Canadian Roads and the AASHTO Policy on Geometric Design of Highways and Streets do not provide guidelines for the planning and design of downgrade passing lanes or how to combine climbing lanes and downgrade passing lanes. This is considered a critical highway design issue as steep grades are located in difficult terrain where engineering a wide cross section is both challenging and costly.

Parks Canada has constructed downgrade-passing lanes on the Trans Canada Highway in the Kicking Horse Pass in Yoho National Park and on Beaver Hill in Glacier National Park. These downgrade-passing lanes complement the passing lane system on the Trans Canada Highway in the Mountain National Parks. The purpose of this paper is to report on the experience of Parks Canada in designing, constructing and operating downgrade-passing lanes. The paper also offers suggestions as to how climbing lanes and downgrade passing lanes could be combined on two-lane highways in mountainous terrain.

1.0 Introduction

Observations of traffic on the Trans Canada Highway (TCH) Kicking Horse Pass upgrade in Yoho National Park over the past two decades shows that trucks, and even some RVs, with their increasingly larger power to weight ratios, have little trouble keeping up to the average operating speed until almost a third of the way up the 8 km and 6 % upgrade. With the provision of a continuous climbing lane for the full length of the grade, the Level of Service on the up grade is “B”. In sharp contrast, downgrade traffic is characterized by long queues and operating speeds in the 30km/h range. Typically, the platoon leaders are heavy trucks or RVs. It is noted there are no passing zones or auxiliary lanes in the downgrade direction. As AADTs exceed 4,000, the centreline is a solid double in accordance with pavement marking guidelines for Parks Canada and BC. Observations record illegal passing maneuvers due to motorist frustrations with speeds 60-70km/h below the posted speed for distances up to 8km and more. Geometric design guidelines for two-lane highways do not currently include little guidance with respect to the provision or design of downgrade passing lanes.

Faced with an operational problem affecting level of service and safety, Parks Canada undertook a program to construct downgrade passing lanes on these two sections of highway and observe their overall performance in improving the situation

2.0 Trans-Mountain Highway System

The history of Western Canada and the establishment of many of Canada’s national park in Alberta and BC are linked to transportation corridors. As a result, major pan Canadian and such as the TCH and provincial highways pass through and within the boundaries of these federally owned and controlled lands. Sandwiched between Alberta and BC provincial highway and their respective standards and policies, Parks Canada finds itself with the challenge of providing a seamless transition for motorists. As such, it is Parks Canada that is responsible for the upkeep, maintenance and repair of approximately 1300 equivalent 2-lane km (or 1200 km) of highways and roads within the Canadian Rocky Mountain National Parks of Banff, Yoho, Kootenay, Jasper, Glacier, and Mount Revelstoke National Parks as shown in Figure 1. Of this total, approximately 500 equivalent 2-lane km (or 400 km) are major through highways that are part of provincial highway systems including the TCH.

The TCH is the major route that transverses the Canadian Rocky Mountain Parks of Banff, Yoho, Glacier, and Mount Revelstoke and provides access via the Icefields Parkway to Jasper National Park and the Yellowhead Highway and to Kootenay National Park via Highway 93 South within the provinces of Alberta and British Columbia. The TCH was officially opened in 1962 and at 7900 km in length is the longest paved highway in the world stretching from Pacific to Atlantic Oceans. The TCH was constructed as a two-way, two-lane highway, with 3.65 m lanes and 3.0 m paved shoulders. The design speed is 113 km/h and the nominal posted speed is 90 km/h, although posted speeds vary between 50 and 90 km/h. The highway passes through level, rolling and mountainous terrain.

Traffic volumes on this section of the TCH vary from a high Annual Average Daily Traffic (AADT) of 16,290 in 2003 at the Banff East Gate to a low of 4,580 at the Roger's Pass in Glacier National Park. Summer Average Daily Traffic (SADT) in 2003 at both locations was 23,500 and 9,160 in Banff and Glacier, respectively. Historical traffic data indicate a long-term linear growth trend of 1.5 to 1.8 % per annum (Parks Canada, 2004).

Traffic composition varies widely depending on season and time of day. Recreational vehicles can account for up to 25% of the traffic stream during daylight hours in summer months. Heavy trucks (semi-tractor trailers and combination units such as B-trains) can account for up to 50% of the traffic stream at night during winter months on the TCH in Glacier National Park.

3.0 Passing/Climbing Lane System

It is recognized that four laning (twinning) of the TCH, through the Rocky Mountain Parks may be inevitable in the very long term. The overall strategy adopted by Parks Canada is to extend the design life of the TCH as long as possible as a two-lane facility subject to maintaining safety and an acceptable level-of-service. This has been accomplished by constructing a passing and climbing lane system along with intersection improvements. The passing lane program will be followed by sequential twinning and grade separation of critical intersections [1, 2, 3, 4, and 5] as volumes warrant.

A small, decentralized organization, Parks Canada has opportunities to carefully consider highway improvements and the introduction of innovative solutions where larger highway organizations might be reluctant. Parks Canada pioneered the concept of a system of passing/climbing lanes in the early 1980s [6]. This was a departure from previous highway engineering practice, which considered only isolated climbing lanes on long steep upgrades. During the early days of the passing lane project, conventional highway engineering studies continually rejected passing lanes in favor of twinning. Analysis procedures of the day, such as the 1965 Highway Capacity Manual had served for two decades as the primary guide for determining the level-of-service on two-lane highways. The level-of-service analysis procedures in the 1965 HCM manual did not account for the effect of passing lanes on level-of-service. Therefore, it is not surprising that previous studies of the TCH by Transport Canada [(8)] rejected passing lanes in favor of twinning. Although the then just released 1985 Highway Capacity Manual [(9)] included a number of refinements, such as the introduction of percent time delayed, average speed instead of operating speed, and the effect of directional split, in determining the capacity and level-of-service on a two-lane highway the procedures still did not account of the effect of passing lanes on level-of-service.

In order to determine the need for passing lanes, and their effect on the level-of-service, a traffic simulation model of the TCH was utilized [(10)]. The simulation model used was the TRARR (Traffic on Rural Roads) model developed by the Australian Road Research Board [(11)]. The overall objective of the level-of-service analysis was to determine if the TCH, with low-cost operational improvements such as passing lanes and intersection improvements, could provide an acceptable level-of service until twinning was required [(12)].

The need and location of passing lanes on the TCH was based on a criteria of 60% time spent following, which corresponds to level-of-service C in the 1985 Highway Capacity Manual. In Glacier National Park, identification of potential passing lane locations was also based on the need to increase traffic storage capacity to hold vehicles safely during avalanche stabilization as well as the aforementioned level-of-service criteria [(13)].

The passing/climbing lane system on the TCH in the four Mountain Parks consists of 28 auxiliary lanes, as summarized in Table 1, providing an average spacing of 8.3 km, and 9.1 km between assured passing opportunities eastbound and westbound, respectively. While passing lanes and climbing lanes are classified as auxiliary lanes, they have two distinct functions. A climbing lane is an auxiliary lane provided for the diversion of slow vehicles from the through lane and hence the passing of slow vehicles on upgrades. A passing lane is an auxiliary lane to improve passing opportunities that are restricted due to roadway geometry, downhill grades, or lack of adequate gaps for passing in the oncoming traffic stream. A passing/climbing lane system consisting of 12 auxiliary lanes has been constructed on the Kootenay Parkway, and passing/climbing lane systems are under consideration for the Icefields Parkway between Lake Louise and Jasper.

The effect of the passing lane system has resulted in a 60% reduction in percent time spent following in the 500-700 veh/h range, thereby keeping the overall percent time spent following less than 60% and hence by definition, level-of-service C. A more important impact of the passing lane system is a 20-25% increase in the number of overtakings in the 500-700 veh/h range. A unique aspect of the passing lane system on the TCH are two downgrade passing lanes located on long downgrades in Glacier and Yoho National Parks.

Construction on the passing lanes involved shifting the highway centreline by approximately 1.75 m and constructing pavement widening on one or both sides depending on terrain, environmental constraints and existing shoulder width. Shoulder widths were reduced to 1.2 m in the passing zone to minimize environmental impacts and costs. Costs in 1994 were approximately $90,000/km Cdn for widening on one side and about $125,000 Cdn for widening on both sides, excluding final full width overlay. Full width overlay of highway once widened, added another $150,000/km Cdn. Depending upon the selected option, costs range between one tenth and one quarter the cost of twinning (excluding environmental mitigations).

The need for twinning is based on maintaining an acceptable level of service and highway safety. The passing lane system on the TCH helped extend the design life of the highway as a two-lane facility by approximately 15 years. However, steadily increasing commercial, private, and tourist traffic have ultimately led to the need to commence twinning the TCH in Banff in phases over the past decade. The latest 10 km stretch between Lake Louise and Castle Mountain Interchanges is scheduled to commence construction in 2005. Issues related to twinning and environmental impacts are fully described in other articles [1,2,3,4,5].

4.0 Downgrade Operational Problems

The lowest levels-of-service (LOS) on two-lane highways in the mountainous sections of Western Canada is often found on long downgrade sections. The reasons may be varied but they are usually a combination of the following factors. Firstly, most downgrades on two-lane highways with an average annual daily traffic (AADT) over 4000 are signed and marked to prohibit passing in the downgrade direction when an auxiliary lane (climbing lane) is present in the upgrade direction. It is noted that most long steep upgrades on the primary highway network of Western Canada have climbing lanes. On lower volume downgrades passing is often prohibited due to a lack of adequate sight distance due to the winding nature of mountain highways.

Secondly, trucks tend to move more slowly on downgrades. While not a regulation, motor transport associations recommend to drivers and British Columbia Ministry of Transportation even posts an advisory sign on steep downgrades that trucks use their four way flashers and proceed downhill at no more than 30 kph to avoid overheating and exceeding truck braking capacity. The lack of passing opportunities combined with slow moving vehicles such as trucks and recreational vehicles result in the formation of platoons, increasing the percent time spent following, and hence a low level of service. The overall result is that the lowest level-of-service can often be observed on downgrades, as the upgrades have climbing-lanes and rolling sections have either an acceptable percent of passing zones or passing lanes.

The Highway Capacity Manual (HCM2000) [(14)] notes that any downgrade of 3 percent or more and a length of 1.0 km or more must be analyzed as a specific downgrade. This includes all downgrades on directional segments in mountainous terrain. For most specific downgrades, the grade adjustment factor is 1.0 and the heavy vehicle factor is the same as that for level or rolling terrain. Specific downgrades in mountainous terrain that are long and steep enough that some heavy vehicles must travel at crawl speeds to avoid loss of control. When this occurs the heavy vehicle adjustment factor is based on the difference between free-flow speed and directional flow rate. For example for a speed difference of 40 km/h and a flow rate of 300 – 600 pc/h the passenger car equivalent is 9.6 for a speed difference of 60 km/h and the same flow rate the passenger car equivalent is 23.1.

The HCM does not provide guidance regarding the location of downgrade passing lanes or their impact on level of service within a passing/climbing lane system. Simulation can however provide quantitative insight into the effect of downgrade passing lanes on level-of-service in those cases where the downgrade auxiliary lane is part of an overall passing/climbing lane system. A research study [(15, 16)] of long, steep downgrades on the TCH determined that the World Bank micro transitional speed prediction model was found to be a good supplement to the TRARR two-lane highway micro-simulation model for estimating traffic flow characteristics on downgrades.

While runaway trucks are a concern on long steep downgrades, the main concern on most high volume primary two-lane highways is the high platooning levels and deteriorating LOS. However, traffic operations on long steep downgrades on two-lane highways are becoming increasingly important due to increasing volumes and the higher percent of slow moving vehicles such as recreational vehicles and heavy trucks in the traffic stream. Compounding the slow moving vehicle platooning problem is the fact that most downgrades on the primary highway system is Western Canada are long no-passing zones. It is noted that most upgrades on the primary highway system have climbing lanes, and passing lanes are being built on level tangent sections that have extended no-passing zones. Estimating the effect of passing lanes, climbing lanes, and downgrade passing lanes is possible using simulation models such as TRARR and has been documented [17] for the Trans-Mountain highway system and two-lane highways in mountainous terrain in California [18, 19].

5.0 A Framework for the Planning and Design Downgrade Passing Lanes

5.1 Literature Review

Geometric design guides such as TAC [21] or AASHTO [22] do not provide guidance for the planning and design of downgrade passing lanes except for the following statement:

"Under certain circumstances there should be consideration of additional lanes to accommodate trucks in the downgrade direction. This is accomplished using the same procedure as described above (i.e. for climbing lanes) and using the passenger-car equivalents for trucks on downgrades in place of the values for trucks and recreational vehicles on upgrades" AASHTO [22].

There are, however, two examples of auxiliary lanes on two-lane highways that provide a theoretical basis for the location of downgrade passing lanes.

<u>2 + 1 Roadways</u>

A 2 + 1 road design has a continuous three-lane cross-section with alternating passing lanes. A 2 + 1 road can serve as an effective design alternative for higher volume two-lane roads where the provision of a four-lane cross section is not practical due to budget constraints or environmental concerns. It has been found that 2 + 1 roads improve the operational level-of-service for two-lane roads without increasing their capacity [23]. A 2+ 1 road will generally operate at least two levels of service higher than a conventional two-lane highway serving the same traffic volume. A review [24] of 2 + 1 roadway operations in Germany, Finland, and Sweden recommended that 2 + 1 roads can be used for traffic flow rates up to 1,200 veh/h in one direction of travel. The overall finding of the safety analysis is that, were 2 + 1 roads to be used extensively in the United States, they would achieve an overall reduction in collision frequency of 25% within the areas where passing lanes are provided. This reduction, if the passing lanes were nearly continuous except for transition areas, would be equivalent to a reduction in collision frequency over nearly the entire roadway length.

Optimal Location of Climbing Lanes

A microscopic model [20] was developed to determine the optimum length and location of a climbing lane on a specific upgrade. The following are the main findings for a length of grade of 6.4 km, 6.5% gradient, 15% trucks, and a range of volumes of 200 – 400 veh/h in the uphill direction.

- the most cost-effective for the construction of a climbing lane is near the midpoint of the upgrade
- the most cost-effective length of a climbing lane is 460 m (exclusive of entrance and exit tapers).
- it is more efficient to construct one 460 m climbing lane on several upgrades, rather than have more than one 460 m climbing lane on one upgrade.
- the benefit (travel time) which can be obtained from the construction of a climbing lane is most sensitive to the gradient.

5.2 Downgrade/Upgrade Auxiliary Lane Configurations

Studies [16, 17, 25] of long 6 km upgrades with climbing lanes in the Mountain National Parks confirmed that almost all upgrade passing was completed by approximately one-third (2 km) upgrade. This finding suggests that the 2/3 remaining length (approximately 4 km) of the climbing lane was utilized only for a few passing maneuvers. Based on the underutilization of the upper portions of the climbing lane and the extensive platooning on the downgrade the following configurations for combining climbing lanes and downgrade passing lanes are suggested. The overall configuration is in fact a 2 + 1 configuration and both configurations are for a nominal 6 km, 6% downgrade.

Configuration 1: Heavy Platooning Upgrade

- 2 km climbing lane at base of grade
- 2 km downgrade passing lane at mid-point

- 2 km climbing lane at top of grade

Configuration 2: Heavy Platooning Downgrade

- 2 km downgrade passing lane from crest
- 2 km climbing lane at mid-point
- 2 km downgrade at base of grade

The actual length of the climbing and downgrade passing lanes would be less than 2 km as entrance and exit tapers are approximately 200 m. The configuration selected would also depend on upstream and downstream passing zones and assured passing opportunities, terrain, length, and % gradient, constructability, traffic volume and characteristics (% heavy trucks and RVs) and cost. In some jurisdictions, such as the Mountain National Parks, environmental impacts, widening cross-sections may also be a factor in the selection and evaluation of a particular configuration.

6.0 Downgrade Passing Lanes in the Mountain Parks

One of the greatest challenges in managing and maintaining efficient and effective movement of traffic on the TCH within the mountain national parks is the ability to cross over the steep grades of the Kicking Horse Pass in Yoho National Park and the Roger's Pass in Glacier National Park.

The Kicking Horse Pass is an approximate 8 km long section of the TCH with a grade of between 6.5 % and 4.5 %. The Roger's Pass section is about 6 km long with the longest and steepest section of grade being on the east side of the Summit stretching 4.75 km with a grade of 6 %. Both of these sections of highway are constrained on one side by steep rock cuts and on the other side by CP Rail mainline and a stream or river. Opportunities for widening to accommodate both up hill and downgrade passing lanes were limited. Opportunistically, a widening of sufficient width existed on both sections at about the mid point of each grade but the length available to accommodate the downgrade passing lane varied and was constrained by existing bridge structures and/or limited to avoid large and expensive rock cuts or fills, and to avoid inducing environmental impacts. In the case of the Kicking Horse Pass grade in Yoho, the downgrade passing lane was restricted to a distance of only 600 m while the Roger's Pass downgrade passing lane in Glacier was able accommodated a 1.5 km downgrade passing lane.

Figure 2 illustrates the typical transition zones, dimensions and associated pavement markings and sign placement that Parks Canada uses for laying out its passing lanes.

The general layout for both the Yoho and Glacier downgrades are similar in nature and for the purposes of this paper, only the Yoho downgrade is presented. Figure 3 illustrates the highway vertical and horizontal profiles associated with the section of the TCH where the downgrade passing lane was constructed. Figure 4 and 5 depict the alignment details at start and end points as constructed in 1994. Noteworthy is that centerline was shifted by 1.5 m to maximize the use of existing pavement, thereby reducing the overall impact of the expansion on the park environment while also reducing costs of construction.

The overall effectiveness and safety of both downgrade passing lanes has been monitored over time by Parks Canada. Overall level of service has improved in the down grade direction and no detriment to safety has been documented, although due to the shortness of the Yoho downgrade passing lane, merge issues were observed. Parks Canada remarked and re-signed the Yoho downgrade transitions as per its standard passing lane configuration as illustrated in Figure 6 and 7, thereby providing a wider shoulder area at the merge point. The Glacier downgrade received a similar remarking.

In 2004, milled in centre line rumble strips (CLRS) were installed to address a safety concern during winter months when centerline markings were worn off as a result of plowing and sanding operations or obscured by snow cover.

7.0 Summary

Traffic operations, including level of service; is poorest on long steep downgrades on the trans-mountain highway crossings due to lack of passing opportunities. Most steep upgrades on the primary trans-mountain two-lane highway system have been provided with continuous climbing lanes but no downgrade passing zones or passing lanes. In order to provide a higher level of service on long steep downgrades on the Trans Canada Highway, Parks Canada has constructed two downgrade passing lanes.

The geometry, signing, and marking of the downgrade passing lanes is similar to other passing/climbing lanes that form part of passing lane system in the Mountain National Parks. It is noted that Parks Canada has added some road safety features such as wider shoulders at the merge area.

Parks Canada has not recorded any unusual problems with operations, maintenance or roads safety since the downgrade passing lanes became operational.

Recently, road safety is enhanced on the downgrade passing lanes by means of milled-in centre-line rumble strips (CLRS). It is noted that the CLRS provide enhanced safety on passing/climbing lanes and two-lane sections as it alerts drivers who accidentally drift over the crown line into the oncoming lane. Other benefits of CLRS is that they serve as a supplement to road markings that are worn off part way through winter due to the harsh mountain environment and the action of plows and abrasives. CLRS also eliminated the need for pre-marking prior to line marking each spring.

8.0 Conclusion

The location of the downgrade passing lanes is dependent on topography, upstream and downstream conditions, volume, traffic composition, and % traffic in platoons entering the grade in both directions. The key is to determine the optimal length and location for climbing lanes and downgrade passing lanes as they in effect form part of a 2+1 highway.

Parks Canada has found that the mid-point on the grade location has worked well, but given ability of many trucks and recreational vehicles to maintain their speeds one-third (2 km) of the way up a 6 km, 6% grade, the installation of a downgrade passing lane at the lower third of the grade may be feasible. This compliments the observation that the upper portions of most climbing lanes are underutilized with only a few passing maneuvers. Hence with trucks able to carry their momentum well up the grade, uphill passing opportunities could commence one third the way up the grade and traffic in both directions making better utilization of existing pavement and lanes. Given limited budget and impacts highway widening has on the environment, the feasibility of not constructing additional lanes but simply shifting centerline to create downgrade passing opportunities is being considered by Parks Canada. Potential locations under consideration include other long steep downgrades on the Kootenay and Icefields Parkways and as a means of extending the existing but relatively short TCH Kicking Horse Pass downgrade.

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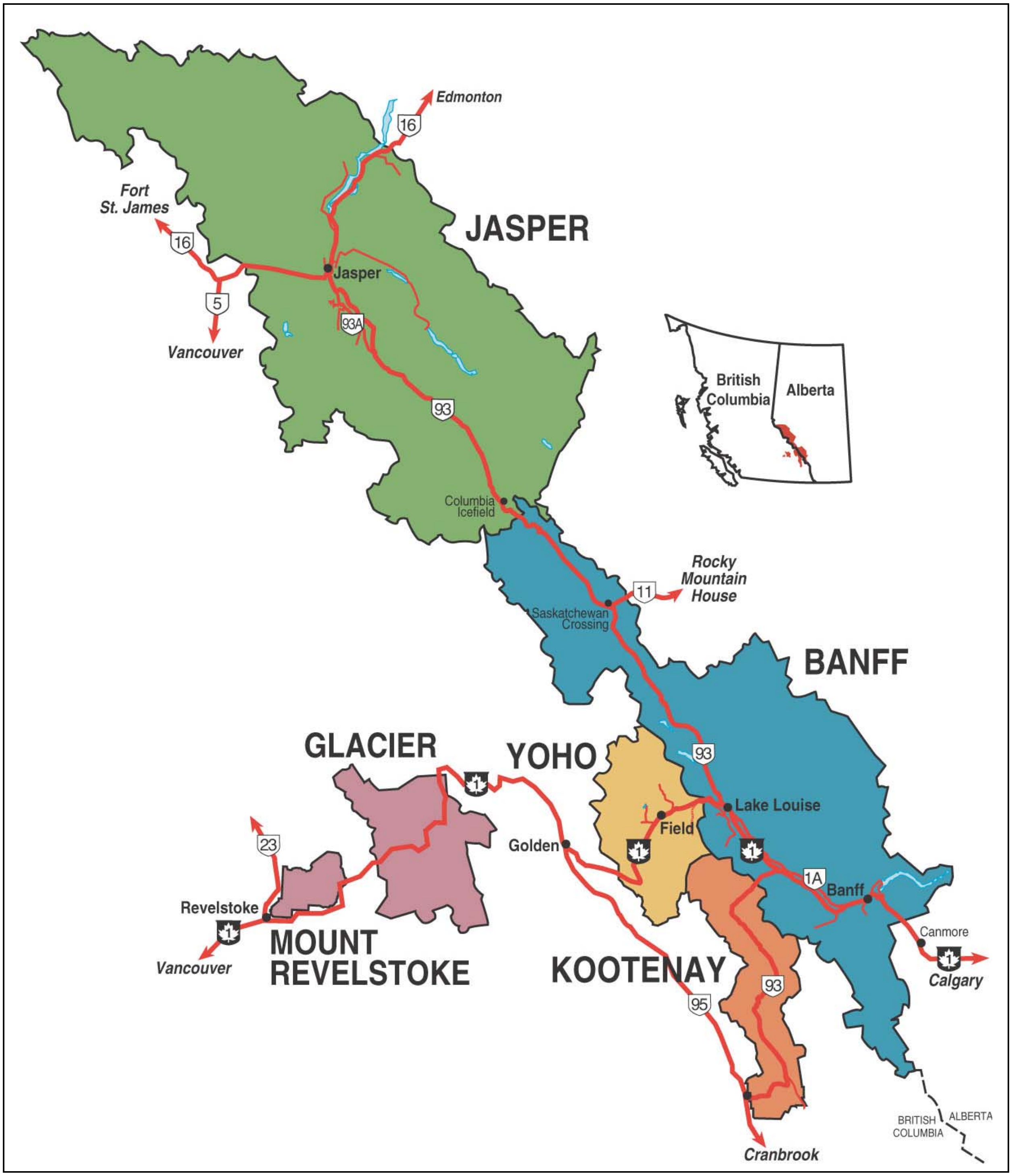
Table 1

PASSING / CLIMBING LANE SYSTEM
TRANS-CANADA HIGHWAY
MOUNTAIN PARKS

PARK	ROAD	PASSING LANE WESTBOUND	LENGTH (KM) (exclude tapers)	PASSING LANE EASTBOUND	LENGTH (KM) (exclude tapers)
BANFF	TCH	Reference: Km 0.0 at Alberta / BC Boundary Length 2 lane section: 32.09 km (km 0.0 to 8.48 & km 10.61 to 34.22)			
		km 7.90 - 8.48	0.58	km 10.61 - 11.27	0.34
		km 18.57 - 20.33	1.76	km 20.61 - 22.71	2.10
		km 28.02 - 29.42	1.40		
		TOTAL WESTBOUND	3.74		
		TOTAL EASTBOUND			2.44
YOHO	TCH	Reference: Km 0.0 at Yoho west boundary Length 2 lane section: 45.63 km (km 0.0 to 45.63)			
		km 2.65 - 4.48	1.83	km 0.07 - 0.63	0.56
		km 10.14 - 11.18	1.04	km 8.24 - 9.29	1.05
		km 25.51 - 27.71	2.20	km 15.87 - 18.34	2.47
		km 35.51 - 36.11(downhill)	0.60	km 21.02 - 25.05	4.03
		km 44.27 - 46.67	2.40	km 33.05 - 40.83	7.78
		TOTAL WESTBOUND	8.07		
		TOTAL EASTBOUND			15.89
GLACIER	TCH	Reference: Km 0.0 at Glacier west boundary Length 2 lane section: 43.84 km (km 0.0 to 43.84)			
		km 4.37 - 6.15	1.78	km 1.51 - 2.97	1.46
		km 16.76 - 17.77	1.01	km 6.36 - 7.44	1.08
		km 24.30 - 24.76	0.46	km 16.76 - 19.21	2.45
		km 27.26 - 32.01	4.75	km 27.28 - 28.78 (downhill)	1.50
		km 35.94 - 37.45	1.51	km 32.64 - 33.80	1.16
				km 41.05 - 43.84*	2.79
		TOTAL WESTBOUND	9.51		
		TOTAL EASTBOUND			10.44
		* passing lane extend 1.75 km into the province			
REVELSTOKE	TCH	Reference: Km 18.28 at Revelstoke west boundary Length 2 lane section: 11.69 km (km 18.82 to 30.51)			
		km 21.33 - 22.11	0.78	km 18.28 - 19.89*	1.61
		TOTAL WESTBOUND	0.78		
		TOTAL EASTBOUND			1.61
		* passing lane extend into the province			

Map 1: Banff National Park in relation to the Provinces and other mountain national parks

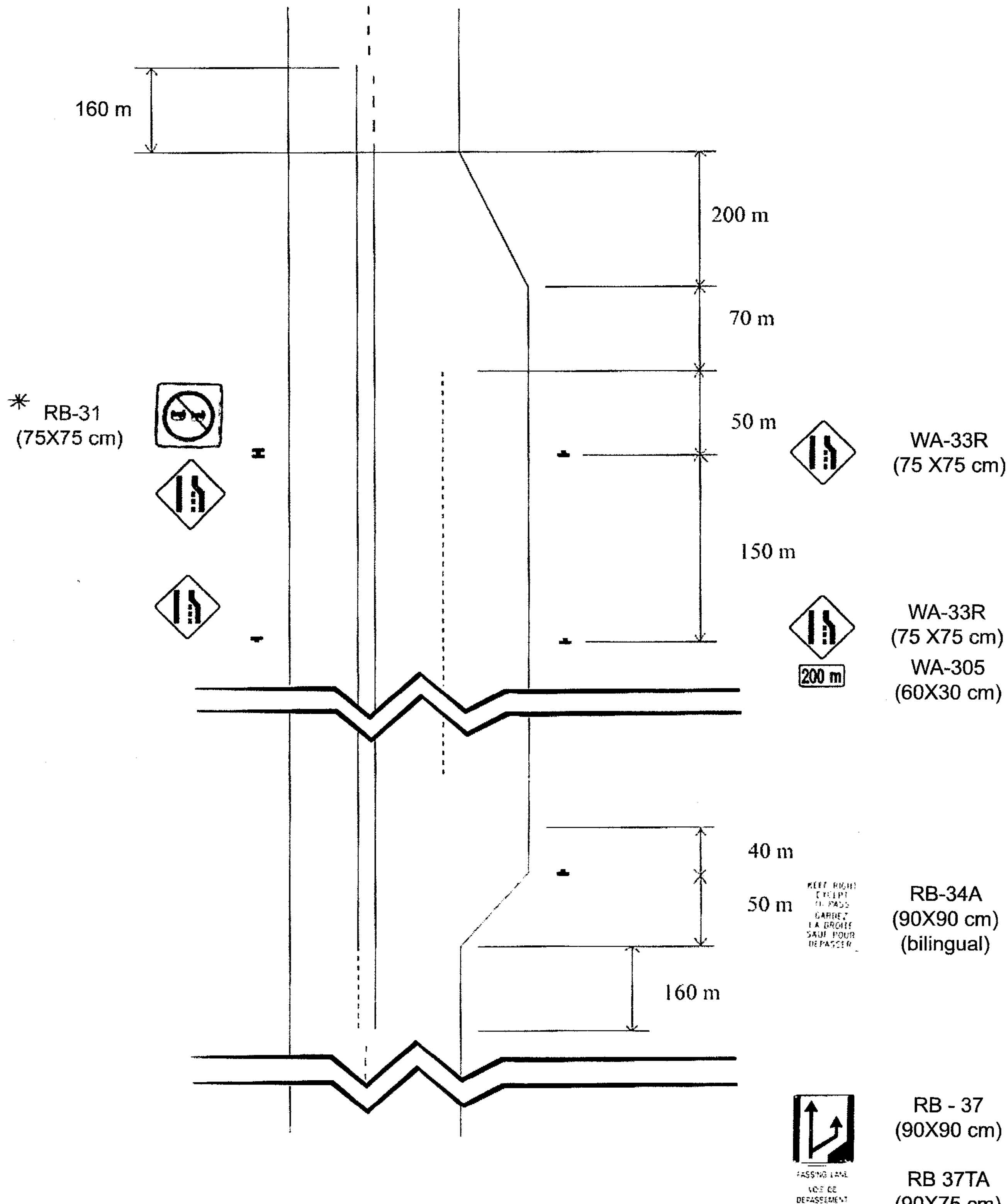


Courtesy of Parks Canada

Figure 2

Parks Canada

Passing / Climbing Lane Markings
& Sign Placement



* RB-31 Approximately every kilometer

Downhill Passing Lane WB - TCH Yoho
Alignment Details
As built 1968

Figure 3

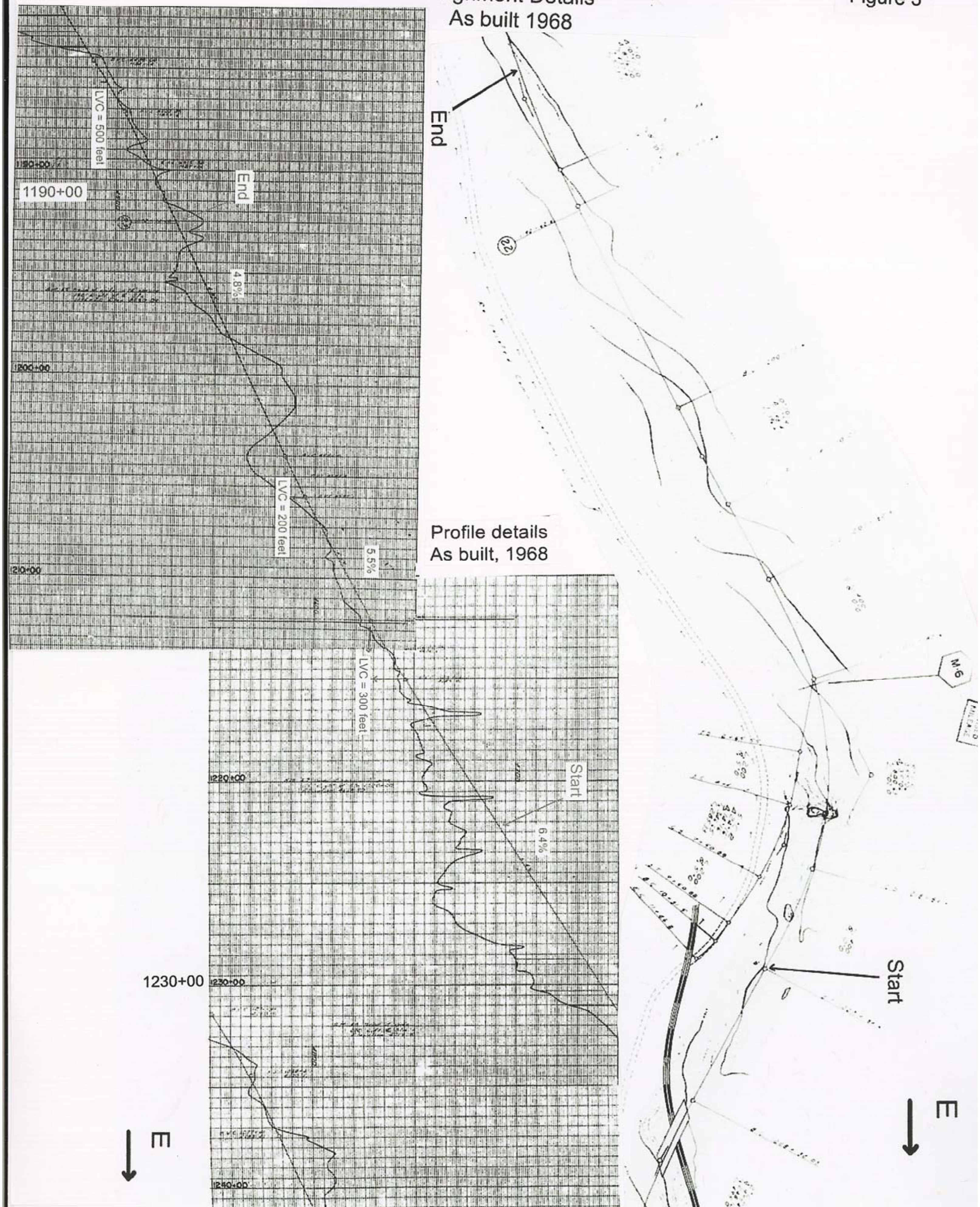


Figure 4

Downhill Passing Lane - TCH Yoho
Alignment details - Start Passing Lane
As built 1994

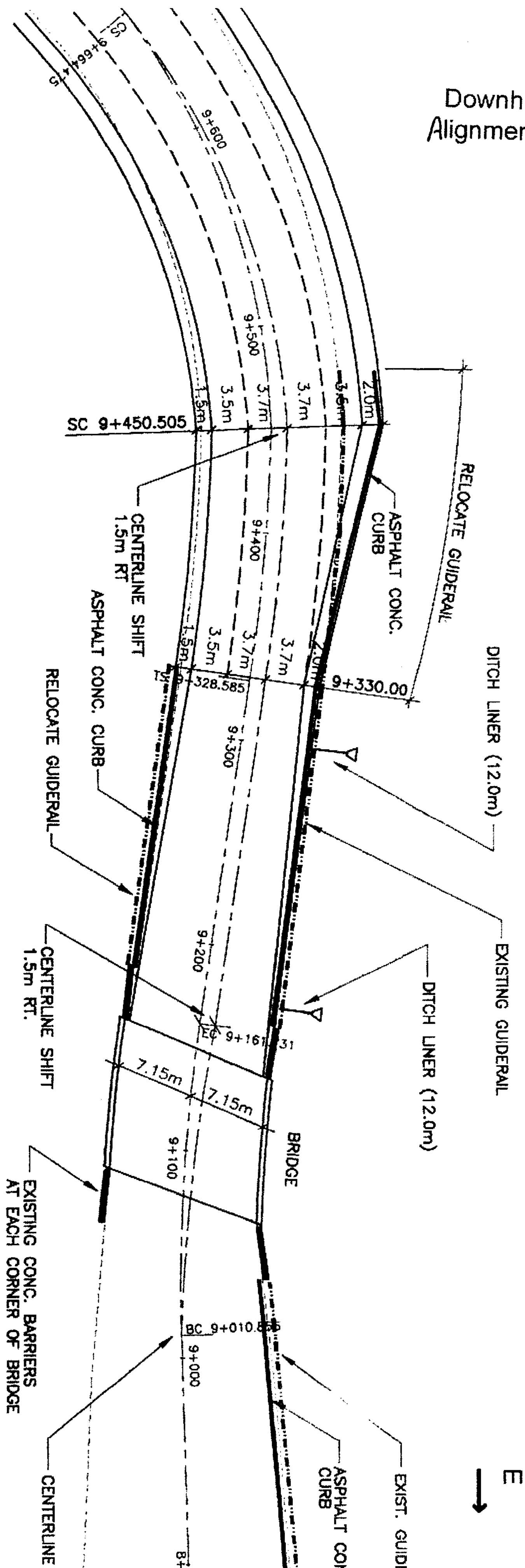


Figure 5

Downhill Passing Lane - T

Alignment details - End Pa

As built 1994

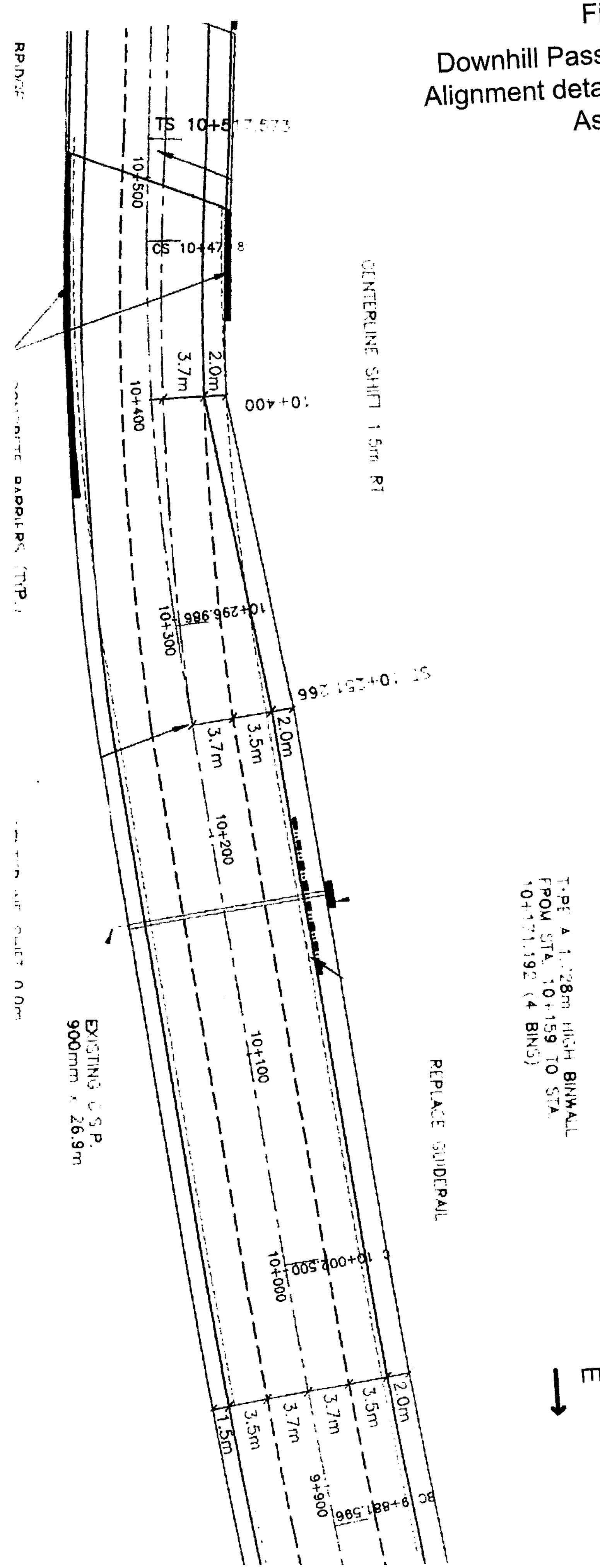


Figure 6

Downhill Passing Lane WB - TCH Yoho
Pavement Marking - Start Passing Lane
Modified 2000

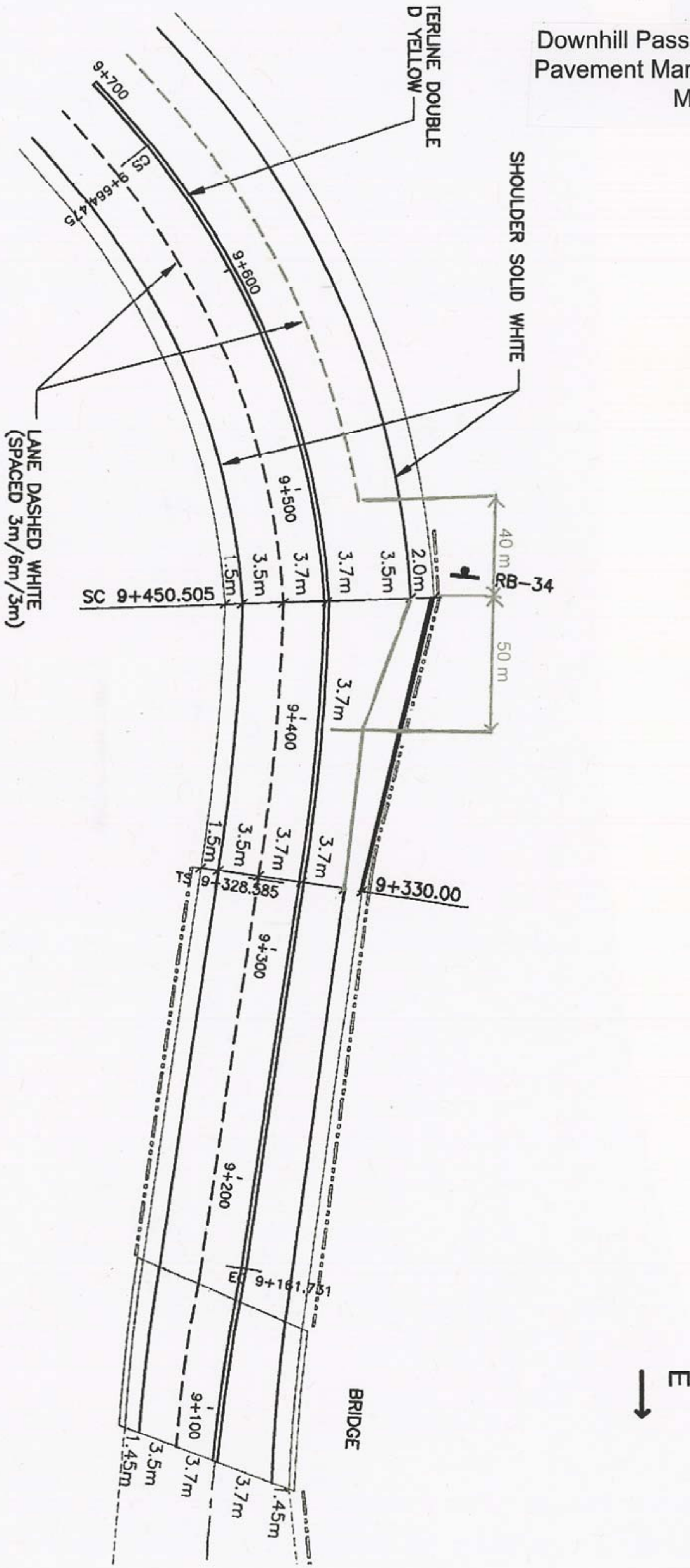


Figure 7

Downhill Passing Lane WB - TC

Pavement Marking - End Passin

Modified 2000