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June 16, 2000

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VIA COURIER

Ministry of Transportation and Highways
Cache Creek to the Rockies Program
Suite 200 - 546 Yates Street
Victoria, BC
V8W 1K8

Attention: Alex Izett
Highway Design Coordinator

Dear Mr. Izett:

**RE: CACHE CREEK TO THE ROCKIES PROGRAM
TRANS CANADA HIGHWAY - DONALD TO KICKING HORSE CANYON
FUNCTIONAL PLANNING/PRELIMINARY DESIGN ASSIGNMENT
FINAL FUNCTIONAL PLANNING REPORT - GOLDEN TO ROTH CREEK
(KICKING HORSE CANYON)**

Please find enclosed for your further distribution:

- 1) **Twelve (12)** copies of the final *Golden to Roth Creek (Kicking Horse Canyon) Functional Planning Report* (11" x 17" format), dated June, 2000.
- 2) **Seven (7)** copies of Appendix A - Functional Planning Drawings, dated March, 2000.

NOTE: Five (5) copies were already issued with our April 4, 2000 letter for A. Izett, J. Camilleri, G. Singer, R. Vanlerberg and Angela Buckingham.

NOTE: One (1) CD containing the electronic files for the Functional Planning Drawings was already issued with our April 4, 2000 letter.

- 3) **Seven (7)** copies of Appendix B-K (8-1/2" x 11" format) dated March, 2000.

NOTE: Five (5) copies of Appendix B-K were already issued with our April 4, 2000 letter for A. Izett, J. Camilleri, G. Singer, R. Vanlerberg and A. Buckingham.

- 4) **One (1)** CD containing the electronic files for Appendix L - Detailed Cost Estimates.

If you have any questions, please contact the undersigned at 605-4962 or our Mr. Tim Stevens, P. Eng., Planning and Design Engineer, at 605-4961.

Yours truly,

SNC • LAVALIN INC.

Ron Gratz, P. Eng.
Project Manager

RRG/lv

Enclosures

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Member of the SNC • LAVALIN Group

(2)

**CACHE CREEK TO THE ROCKIES PROGRAM
TRANS CANADA HIGHWAY
GOLDEN TO ROTH CREEK (KICKING HORSE CANYON)**

FUNCTIONAL PLANNING REPORT

**Ministry of Transportation and Highways
Province of British Columbia**

June 2000

013121

**Submitted by
SNC•Lavalin Inc.**

**Prepared by: TS/RG/PG/RF
Reviewed by: RG/TS**

FUNCTIONAL PLANNING REPORT

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EXECUTIVE SUMMARY

FUNCTIONAL PLANNING REPORT

EXECUTIVE SUMMARY

The 7,305 km long Trans Canada Highway (TCH), completed in the early 1960's, is the primary east/west highway route in Canada for interprovincial trade and travel.

Within the principles and framework of the Corridor Management Plan, this Functional Planning Report reviews operations, safety and future requirements along 14 km of the Trans Canada Highway located between the west limit of the Town of Golden and Roth Creek.

Traffic today, which averages from nearly 5,000 vehicles per day on an annual basis to over 9,000 vehicles per day in the summer, is currently accommodated on a generally winding two-lane undivided highway with sharp curves, narrow shoulders and steep gradients. There are sixteen 40 km/h or 60 km/h advisories in less than 8 km of highway. Traffic on the Kicking Horse Canyon section of the TCH is expected to grow to nearly 7,000 vehicles per day in 2021 (up to nearly 13,000 vehicles per day in July and August, 2021) with a truck volume of over 1,200 vehicles per day.

The accident rate on this section of the TCH is more than three times the provincial average. It is reported that there were fifteen fatalities on the TCH in Kicking Horse Canyon between 1987 and 1997, including two girls in July 1990 when a tractor trailer rig lost its load of steel pipes and collided with an oncoming bus. Twenty eight people were injured in that accident, which occurred just east of the Black Wall Bluffs.

Apart from the geometric deficiencies encountered, people and goods travelling through the canyon are at risk from falling rocks, avalanches and mud slides. The Black Wall Bluffs area accounts for approximately one third of all the annual rockfalls on provincial highways in British Columbia. Between 1992 and 1998, 274 avalanches impacted this section of highway, nine of which were large enough to bury a car. Debris flows have also blocked the highway numerous times resulting in one fatality just east of the Black Wall Bluffs area in the 1980's.

The heavy traffic volumes, poor safety record and low travel speeds on the TCH through the Canyon, underscore the fact that the existing canyon route is underbuilt, poorly designed and out of date with respect to current design guidelines and projected traffic volumes. Diversion of trade and travel to the faster and safer U.S. Interstate highway system is a definite probability with corresponding detrimental affects on the economic viability of communities along the TCH.

A new/upgraded 12 km section of four lane divided arterial highway is proposed from the Highway 95 Junction in the Town of Golden to Roth Creek. Within Golden, the proposed design speed is 70 km/h and within the Canyon the proposed design speed is 100 km/h. The preferred route, M5, starts on the north side of the canyon east of Golden, crosses the river and the CPR tracks to the south side at a location approximately 6 km east of Highway 95 and then returns to the north side of the canyon at a location approximately 1.3 km west of the existing Yoho (Five Mile) Bridge. It then crosses the river and the CPR line a third time via a new Yoho (Five Mile) Bridge and follows the existing TCH corridor to Roth Creek. This route, which is estimated to cost \$384 Million, avoids the huge slow moving south landslide, the hazardous Black Wall Bluffs, the South Bluffs and Yoho Landslide areas.

The new route is proposed to be built as soon as possible, subject to further geotechnical and environmental studies, the obtaining of statutory approvals and the securing of adequate funding for an implementation strategy in conjunction with financing partners. For the proposed improvements in the Town of Golden, refer to Figure 9-1. For the proposed new route in the Canyon, M5, refer to Drawing No. 013121-FP-155 in the sleeve at the back of this report.

As a National Highway, with primary goods movement and tourism uses, the quality of the TCH transportation corridor directly affects the economic well-being of the Golden area and the province. Although the existing canyon route was adequate at the time of construction, a higher quality route with improved capacity and safety is now required. The benefits also include improvements in safety, greater stimulus to east/west trade, regional business efficiencies and better transportation for area residents.

SECTION 1

Introduction

FUNCTIONAL PLANNING REPORT

1.0 INTRODUCTION

1.1 Background

The fourteen (14) km section of Trans Canada Highway (TCH), between the Town of Golden's west limit (LKI 54.3, Segment 0985) and the vicinity of Roth Creek near the rest area in the Kicking Horse Canyon (LKI 12.5, Segment 0990), can be conveniently considered as two unique sections for functional planning purposes:

1.1.1 Town of Golden

This section of the highway lies entirely within the municipal limits of the Town of Golden (1996 population of 3969) and is approximately four (4) km long. It is generally built to urban standards and has a posted speed of 60 km/h.

Through the highway commercial strip just west of Highway 95, the TCH, which was reconstructed and widened in 1996, consists of four lanes with a continuous concrete median barrier and concrete curbs. The TCH is flanked here on both sides by two lane two-way paved curbed frontage roads which have an additional parking lane and paved sidewalk. There are traffic signals at both ends of the commercial strip where the frontage roads terminate. Connections are provided across the boulevard between the frontage roads and the TCH through lanes at 11th Street North on the south side of the TCH, at 12th Street North on the north side and at 14th Street North on both sides of TCH. The commercial strip is illuminated and contains two changeable message signs, one for westbound general traffic and the second for eastbound trucks approaching the weigh scale.

Between the signalized intersection at the west end of the frontage roads where the commercial strip ends and the west limit of the Town of Golden, a distance of approximately 0.3 km, the TCH transitions from a 60 km/h four (4) lane urban arterial-divided roadway to a 90 km/h (posted speed) two (2) lane rural arterial - undivided roadway.

ICBC operates the weigh scale on the north side of the TCH at the east terminal of the north frontage road. The scale is located too close to the foot of Golden Hill to enable eastbound trucks that have stopped at the scale to gain a running start for ascending the hill. A changeable message sign for westbound trucks is located at the foot of Golden Hill just east of the weigh scale.

From the signals at the east end of the commercial strip, through the unsignalized Highway 95 junction and on to the east limit of the Town of Golden, a distance of just over two (2) km, the TCH consists of two basic lanes with substandard width paved shoulders. A 1.4 km long eastbound climbing lane is located east of Highway 95, on the 7.9% gradient on Golden Hill, within this two (2) km section. At-grade intersections are located at the junction of TCH with Upper Golden-Donald Road/Golden View Road, Lafontaine Road and at the east end of Golden View Road. Lafontaine Road and Golden View Road parallel the TCH and service a number of highway commercial and residential land uses.

1.1.2 Golden to Roth Creek

This ten (10) km section of the highway is located within the canyon of the Kicking Horse River, and extends from the east limit of the Town of Golden to the vicinity of Roth

FUNCTIONAL PLANNING REPORT

Creek near the rest area. It was built in the 1960's to rural standards and has a posted speed of 80 km/h. Between the Town of Golden and the Yoho (Five Mile) Bridge over the Kicking Horse River and the Canadian Pacific Railway, the TCH is located on the north face of the Canyon. From the bridge to the rest area, the highway follows the south face of the Canyon. Between Golden and Roth Creek, the TCH is an almost continually winding highway with two basic lanes and narrow paved shoulders. The curvature is as sharp as a 50-60 metre radius in places, with a total of sixteen 40 km/h and 60 km/h speed advisories. Steep gradients exist in a number of locations including the 1.5 km long 7-8% westbound up-grade known as Five Mile Hill west of Yoho (Five Mile) Bridge and a shorter 6-7% eastbound up-grade east of Yoho (Five Mile) Bridge. Relatively short truck climbing lanes are provided on both of these gradients. The TCH is four laned in the vicinity of the rest area near Roth Creek with additional turning lanes being provided for traffic accessing the rest area.

Kicking Horse Canyon has very steep side slopes and is very active in a geological sense with numerous natural hazard sites that affect the existing highway. The natural hazards and poor geological environmental result in occasional closures of the TCH and high ongoing maintenance. In 1998, wire nets were installed above the highway at the Black Wall Bluffs to reduce the risk of rockfall onto the TCH.

This section of TCH generally has satisfactory drainage with one exception; the 1800 mm diameter culvert at LKI 7.43, which has insufficient capacity to pass mudslides and debris torrents.

1.2 Objectives

SNC-Lavalin's major objectives for the functional planning review of the four (4) km of TCH through the Town of Golden were to assess the operations and safety of the older and more recently upgraded sections of the highway and make recommendations on measures needed to ensure safe and efficient movement of people and goods through the town over the next 25 years.

The major objectives for the 10 km of TCH in Kicking Horse Canyon were to improve the travel speeds, safety, capacity and reliability of the highway, ensure the improved route can be built with minimum closures and disruption to existing traffic, avoid impacting on the Canadian Pacific Railway and to minimize negative impacts on the natural and social environment.

1.3 Functional Planning Overview

This Functional Planning Report contains four sections dealing with: i) an assessment of the existing highway operations and safety through the Town of Golden and within the Kicking Horse Canyon, ii) a structural assessment of the existing bridge at the Yoho (Five Mile) crossing of the CPR and the Kicking Horse River, together with a description of miscellaneous structures including a retaining wall, a rockfall barrier, drape nets and changeable message signs, iii) an assessment of the existing pavement condition and geotechnical conditions, hazards and constraints in the Kicking Horse Canyon, and iv) an assessment of the natural and social environment within the study area including fisheries, wildlife, archaeological resources, recreation and specific issues related to the Town of Golden. These are followed by a section describing the details of the preferred

FUNCTIONAL PLANNING REPORT

canyon route including geotechnical considerations, its potential impact on the natural and social environment, construction, staging and traffic management issues, the cost estimate and possible short term safety improvements. The Preferred Canyon Route section is followed by another section describing the fourteen route alternatives that were evaluated for the Trans Canada Highway through the Kicking Horse Canyon. All routes are based on a design speed of 100 km/h except as noted. The alternative routes developed are grouped as follows:

- North Side Routes: Three routes, N1 Tunnel, N1 Surface and N2 (90 km/h), are located on the north side of the canyon between Golden and the existing Yoho (Five Mile) Bridge.
- South Side Routes: Three routes, S1, S2 and S3, cross to the south side of the canyon just east of Golden and follow the south side of the canyon between Golden and the existing Yoho (Five Mile) Bridge.
- Canyon Bottom Routes: Two routes, B1 and B2, are located along the bottom of the canyon close to the CPR tracks, between Highway 95 at Golden and the existing Yoho (Five Mile) Bridge.
- Mid Canyon Routes: Six routes, M1 (90 km/h), M2 (variable design speed), M3, M4, M5 and M6, are located on the north side of the canyon east of Golden to a point opposite the South Landslide (on the south side of the canyon) and then cross to the south side of the canyon to avoid the Black Wall Bluffs.

All the routes follow a common location from east of Yoho (Five Mile) Bridge to Roth Creek.

The next section of the report proposes a number of operational and capacity improvements to the existing TCH through the Town of Golden, between the west limit of town and the east limit of town. The proposals for improvement of the TCH between Highway 95 and the east limit of the Town of Golden overlap, to a certain degree, with the proposals for a new canyon route, since the canyon route alternatives commence at the existing junction of the TCH with Highway 95.

The report ends with a series of conclusions and proposals for the TCH within Golden and within the canyon. A number of figures and tables are referenced within the report and at the end of Section 7 there are a series of 1:10,000 Photo Mosaics that illustrate the alternative canyon routes studied.

Appendices A through L (Bound Separately) contain the functional planning drawings, design criteria, alignment information, minutes and correspondence, geotechnical and environmental information and detailed cost estimates.

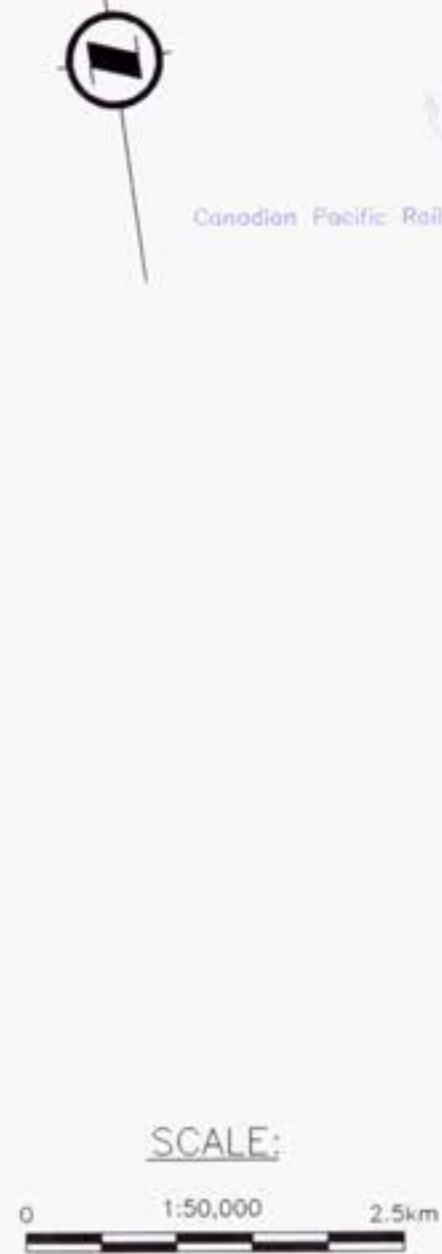
TO REVELSTOKE



LEGEND:

EXISTING

-  TRANS CANADA HIGHWAY
-  CANADIAN PACIFIC RAILWAY



Trans Canada Highway

Canadian Pacific Railway

COLUMBIA RIVER

WEST LIMIT OF TOWN OF GOLDEN LKI 54.7

LKI 56.06 = LKI 0.00

GOLDEN

EAST LIMIT OF TOWN OF GOLDEN LKI 2.3

TO RADIUM HOT SPRINGS & CRANBROOK

Dart Creek

Black Wall Bluffs


Five Mile Hill

Yoho (5 Mile) Bridge LKI 9.5

EAST LIMIT OF SNC-LAVALIN ASSIGNMENT LKI 12.2


TO BANFF

Rest Area LKI 12.6



Province of British Columbia
MINISTRY OF TRANSPORTATION AND HIGHWAYS
CACHE CREEK TO THE ROCKIES PROGRAM

KEY PLAN
Trans Canada Highway No.1
GOLDEN TO ROTH CREEK
FIGURE 1-1



DESIGNED	J. STREUMER	DATE	DEC 76
CHECKED	A. SMITH	DATE	MAR 78
DRAWN	S. PERRY	DATE	MAR 78

SECTION 2

Highway Assessment

FUNCTIONAL PLANNING REPORT

2.0 HIGHWAY ASSESSMENT

2.1 Town of Golden

2.1.1 Existing Highway Classification & Geometrics

Classification

The TCH, through Golden, is generally an urban arterial with a posted speed of 60 km/h. The TCH, through the approximately 1km long highway commercial strip west of Highway 95, consists of a four lane urban arterial-divided (UAD) with continuous parallel frontage roads on both sides of the highway that terminate at signalized intersections with the TCH. West of the commercial strip, the TCH transitions over approximately 0.3 km from a four lane urban arterial to a two lane rural arterial-undivided (RAU) with a posted speed of 90 km/h.

Between the east frontage road intersection and Highway 95, the TCH transitions from the four lane arterial-divided (through the commercial strip) to a basic two lane urban arterial-undivided (UAU) which continues to the east limit of the Town, however, a 1.4 km long eastbound climbing lane is located on Golden Hill. Street lighting is provided through the commercial strip, at the Highway 95 intersection, on Golden Hill, at the Upper Golden-Donald Road intersection and at the Golden View Road intersection.

All intersections along the TCH through Golden are at-grade and two of them, at both ends of the one (1) km long commercial strip, are signalized with advance flashers for approaching traffic - one for eastbound traffic approaching the west signals and one for

westbound traffic approaching the east signals. At-grade driveways also occur at the ICBC weigh scale on the north side of TCH, located at the bottom of Golden Hill, and at the viewpoint and gravel pit on the south and north sides of TCH respectively near the top of Golden Hill.

The TCH can be closed to traffic with a gate located just east of Golden View Road intersection.

Geometrics

The horizontal alignment of TCH through the Town of Golden consists of a series of tangent sections and curves with a minimum radius of 150 metres (on Golden Hill). On Golden Hill there are a series of broken back horizontal curves. The horizontal alignment is adequate for the posted speed of 60 km/h and with marginal improvements could accommodate a design speed of 70 km/h.

From the west limit of the Town of Golden to the Highway 95 junction, the vertical alignment of the TCH generally consists of a gentle 0.5% rise in grade in an easterly direction. At the Highway 95 junction, eastbound traffic on the TCH begins to ascend Golden Hill, a steep hill with a maximum gradient of just under 8%. The steep gradient causes problems for eastbound truck traffic (especially B-trains) which loses traction under winter conditions as well as causing a significant slow down in truck traffic to crawl speed throughout the whole year. The lack of a westbound truck descending lane also reduces general traffic to crawl speed if it is following a heavy truck. From the top of Golden Hill to the east limit of the Town of Golden, the gradient is significantly reduced

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and consists of eastbound up-grades of 1.7%, and then 4.3% followed by a crest vertical curve(K=60) leading to a gentle down grade of 2.4%.

The cross section of TCH through Golden varies from a rural cross section with two 3.6 metre wide lanes and two (2) metre wide paved shoulders at the west limit of Town, to an urban section within the highway commercial strip consisting of four 3.7 metre wide lanes with a 2.6 metre flush median, a continuous concrete median barrier, concrete curb and gutter, grassed boulevards, and two lane frontage roads with additional parking lanes and concrete sidewalks located on both sides of the TCH. The four lane urban section extends for a distance of about 1.1 km and ends opposite the weigh scale which is located just west of Highway 95. Between the weigh scale and Highway 95, TCH transitions from a four lane urban section to a rural section with two basic lanes and paved shoulders that vary in width from one to two metres. From the Highway 95 intersection to the top of Golden Hill in the vicinity of the Upper Golden Donald Road intersection, an eastbound truck climbing lane, approximately 1.4 km long, is provided. Between Upper Golden Donald Road and the east limit of Golden, the TCH consists of a rural section with two 3.7 metre wide lanes and paved shoulders which vary in width from 1.0 to 1.5 metres. Turning lanes are provided on TCH at Upper Golden Donald Road/Golden View Road to accommodate left turning traffic in both directions and decelerating right turning traffic in an easterly direction. At the LaFontaine Road intersection, turning lanes are provided on TCH to accommodate left turning traffic in both directions and decelerating right turning traffic in a westerly direction. At the easterly Golden View Road intersection, an eastbound right turn deceleration lane is provided on TCH.

2.1.2

Existing Operations/Traffic Safety

In 1996, the TCH through Golden carried, west of Highway 95, an annual average daily traffic volume (AADT) of 5,360 vehicles per day and a summer average daily traffic volume (SADT) of 9,940 vehicles per day. East of Highway 95, the volumes were 4,655 (AADT) and 9,175 (SADT) respectively. The 1996 truck volume east and west of Highway 95 was 840 trucks per day on an annual basis, not including local trips. Operational problems are caused by the difficulties eastbound trucks encounter, especially B-trains, in maintaining traction under winter conditions when they are climbing the 7.9% gradient on Golden Hill east of the truck weight station. This difficulty is not effectively relieved by the eastbound truck climbing lane since trucks may end up blocking both eastbound lanes. Furthermore, heavy westbound trucks descend the single westbound lane on Golden Hill at a crawl speed and, in so doing, continue to impede platoons of vehicles that have built up behind them in the Kicking Horse Canyon. Potential problems of a lesser degree occur within the one (1) km commercial strip when large trucks cut through the boulevard openings to get from the frontage roads to the through lanes of TCH.

The signals at the west end of Golden sometimes create platoons of westbound traffic when the signals go to the red phase on TCH. These platoons do not have an opportunity to disperse for approximately ten (10) km until they reach Moberly Marsh, where the first significant overtaking opportunity occurs.

The accident rate on the TCH, through the Town of Golden, based on accidents occurring in the inclusive 5 year period 1991-1995, was 2.2 Accidents per Million Vehicle - Kilometres (A/MVK) which was 60% higher than the provincial average of 1.4

FUNCTIONAL PLANNING REPORT

A/MVK for a typical urban arterial provincial highway. It is important to note that this accident rate is based on data collected before a portion of the TCH through Golden was widened and improved in 1996.

2.1.3 Issues, Constraints and Deficiencies

The section of TCH through Golden has generally satisfactory drainage although the structural condition of the cross culverts is unknown on the older section east of Highway 95. A number of surficial landslides have occurred on the fill slopes beneath the TCH where it climbs up Golden Hill.

In summary, the current transportation problems being experienced by traffic, in the Town of Golden section of the TCH, are related to the short westbound merge distance at the west end of the four lane section through the commercial strip, the steep gradient on Golden Hill, the proximity of the weigh scale to the foot of Golden Hill and uncontrolled truck movements through the boulevard openings along the commercial strip.

2.1.4 Requirements of Other Users

Cycling demand through Golden can be accommodated on the frontage roads adjacent to the four lane portion of TCH through the commercial strip, and also on the paved shoulders of the TCH elsewhere in Golden. East of the Highway 95 junction, where in some sections, the paved shoulder is less than 1.5 metre wide or where it is 1.5 metres wide and adjacent to concrete roadside barrier, the Ministry's policy for cycling is not achieved. Although concrete sidewalks are provided continuously on both sides of the

frontage roads through the commercial strip, it is difficult for pedestrians to cross the TCH because of the continuous concrete median barrier which extends over a distance of approximately 0.7 km. No overhead hydro line is located adjacent to the TCH through Golden.

2.2 Golden to Roth Creek

2.2.1 Existing Highway Classification and Geometrics

Classification

Through the Kicking Horse Canyon, the TCH between Golden and the vicinity of Roth Creek near the rest area in Kicking Horse Canyon, is basically a two-lane undivided rural arterial with a posted speed of 80 km/h, and a small number of at-grade intersections that provide access to Forest Service Roads and the Canadian Pacific Railway. There are also a number of pull-offs along this section of TCH. A total of 16 speed advisories occur in the eastbound and westbound directions (40 km/h and 60 km/h). A 0.45 km long westbound climbing lane exists west of Yoho (Five Mile) Bridge, and a 0.65 km eastbound climbing lane is located east of the bridge. Side by side passing lanes (1.65 km long eastbound and 1.15 km long westbound) with auxiliary turning lanes provide passing and turning opportunities in the vicinity of the rest area.

Geometrics

Between the east limit of the Town of Golden and the vicinity of Roth Creek the horizontal alignment of TCH generally follows the contours of the north and south faces

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of the Kicking Horse Canyon and consists, with a few exceptions, of an almost continuous series of small radius horizontal curves, in many cases reversing, or broken back, with only short or non-existent tangents between them. The curves are as sharp as 50-60 metre radius in places and there are sixteen (16) speed advisories (either 40 km/h or 60 km/h) in both eastbound and westbound directions. There are 160 metre radius curves on the deck at both ends of the Yoho (Five Mile) Bridge. The longest tangent sections on the TCH between Golden and Roth Creek occur on Five Mile Hill west of Yoho (Five Mile) Bridge and on the passing lane section in the vicinity of the rest area. Because the route is generally tortuous and the curves sharp with no lane widening, large truck combinations frequently encroach into the opposing lane of traffic or onto the narrow right shoulders.

The vertical alignment of this section of TCH consists of variable gradients, some of which are as steep as 7-8% and interconnecting crest or sag vertical curves. The sharpest crest curves (total number 3) have a K=40 value which is adequate for a design speed of 80 km/h based on taillight control ($K_{min} = 36$) but not for rock control ($K = 50$). In general terms, as traffic drives east from the east limit of Golden, the highway elevation rises from 920 metres above sea level (130 metres above the Kicking Horse River) to 1010 metres above sea level at LKI 7.4 (170 m above the Kicking Horse River). The maximum uphill gradient in this section is just over 6%. From this high point, the TCH descends to elevation 900 metres at the Yoho (Five Mile) Bridge. The maximum downhill gradient in this section is 7-8%. East of Yoho (Five Mile) Bridge, the TCH ascends a 6-7% upgrade, then goes through one downhill section (maximum downgrade 5%), before rising to an elevation of 935 metres at the rest area.

Although the Ministry's Highway Engineering Design Manual indicates a 7% gradient is acceptable on an 80 km/h rural arterial route in mountainous terrain, it is noted that long grades steeper than 5% necessitate significant speed reductions for heavy trucks.

Between the east limit of the Town of Golden and the vicinity of Roth Creek, the TCH consists of two basic 3.7 metre wide lanes and paved shoulders that are approximately 1.0 to 1.5 metres wide. In many areas, where the Highway abuts the upper lip of the Kicking Horse Canyon down slope, concrete roadside barrier has been installed at the back of the paved shoulder. At Five Mile Hill, an approximately 450 metres long climbing lane has been constructed in the westbound direction. An approximately 650 metres long climbing lane has also been constructed for eastbound traffic on the hill east of Yoho (Five Mile) Bridge. From east of Roth Creek to east of the rest area, the Trans Canada Highway consists of four lanes, which provide passing opportunities in both eastbound and westbound directions. Auxiliary lanes are provided at the rest area for traffic turning left and right off the highway.

There are a limited number of intersections along the TCH between the east limit of Golden and the rest area near Roth Creek. None of these intersections, including the connection to the rest area, are illuminated. Gravel access connections are provided to a small number of forest service roads on the north side of the highway, the most used of which is Dart Creek Forest Service Road located at LKI 6.0. On the south side of the highway there are a small number of gravel access roads that service the Canadian Pacific Railway. A gravel access near Roth Creek at LKI 11.56 provides access to a white water rafting landing area and picnic site. In addition to the above referenced access points, there are also a number of pull-offs located along this section of the TCH.

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2.2.2 Existing Operations/Traffic Safety

In 1996, the TCH through the canyon was experiencing an annual average daily traffic volume (AADT) of 4,655 vehicles per day, a summer average daily traffic volume (SADT) of 9,175 vehicles per day and a truck volume of 840 trucks per day not including local trips. The estimated 1996 Design Hour Volume (DHV), the 30th Highest Hour, is 920 vehicles per hour (two way). This is based on a K factor (DHV÷SADT) of approximately 0.10 (See Page 19, "TCH CMP Community Impact and Development Study - Appendix B - Traffic Forecasts", by Urban Systems, May 1998). Based on the AADT and the terrain, the current Level of Service is E with speeds as low as 40 km/h (20 km/h for heavy trucks in crawl mode). (Refer to Figure 2-1). Passing is prohibited except on the relatively short climbing sections and traffic frequently builds into long slow moving platoons, especially during the summer months. The accident rate, based on accidents occurring in the inclusive 5 year period 1991-1995, is 2.4 Accidents per Million Vehicle-Kilometres (A/MVK), which is more than three times higher than the provincial average of 0.7 A/MVK for arterial highways. The accident severity index for the same five year period is 6.8 which 12% higher than the provincial average of 6.07.

2.2.3 Issues, Constraints and Deficiencies

Kicking Horse Canyon has very steep side slopes and is very active in a geological sense with numerous natural hazard sites that affect the existing highway including: unstable cliff faces, avalanche and rockfall chutes, mudslides and active slide areas. Throughout the ten (10) km section, from Golden to the vicinity of the rest area, there are nineteen (19) rockfall hazard, fourteen (14) erosion fall, four (4) debris torrent,

eleven (11) avalanche, one (1) ice fall and two (2) mass movement areas. These natural hazards and the poor geological environmental result in occasional closures of the TCH and high ongoing maintenance. In 1998, wire nets were installed above the highway at the Black Wall Bluffs to reduce the risk of rockfall onto the TCH.

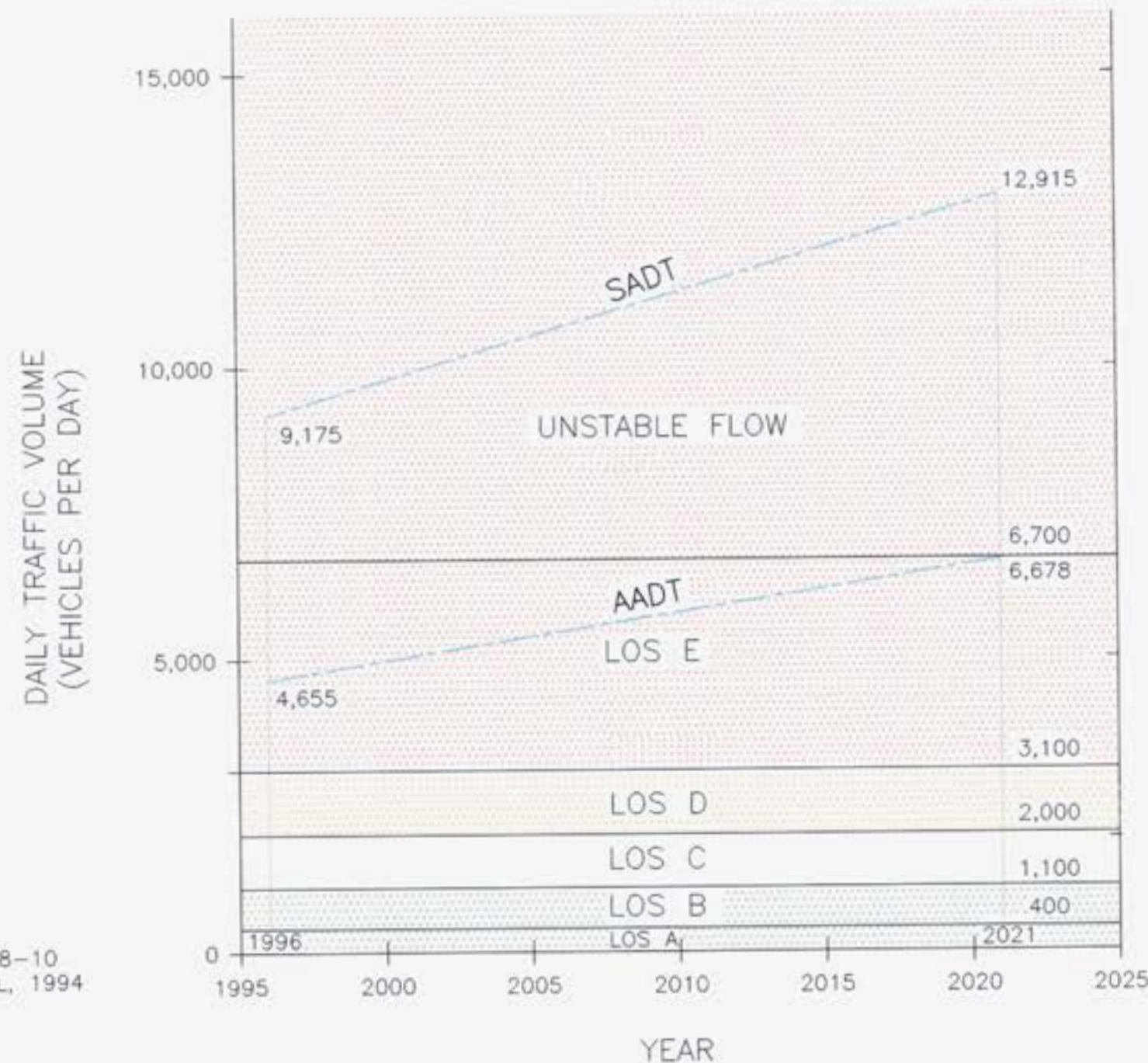
The section of TCH generally has satisfactory drainage with one exception; the 1800 mm diameter culvert at LKI 7.43, which is of insufficient capacity to pass mudslides and debris torrents.

In summary, the current transportation problems being experienced in the canyon section of TCH are poor geometry, travel speeds as low as 20-40 km/h, poor reliability, high ongoing maintenance and operational costs, restricted capacity and an exceptionally high accident rate.

2.2.4 Requirements of Other Users

The TCH between Golden and Roth Creek is used by cyclists. However, the paved shoulder width, in the range 1.0 to 1.5 metres, is generally insufficient to safely accommodate cyclists. This is especially true in areas which are adjacent to extensive sections of concrete roadside barrier and on the inside of the frequent sharp horizontal curves, where the off-tracking of the wheels of long trucks significantly encroaches onto the shoulders.

An overhead hydro power line is located along the TCH through the Kicking Horse Canyon. Owing to the terrain, the line crosses from one side to other side of the highway at various locations.



NOTE: THIS FIGURE IS BASED ON TABLE 8-10
OF THE HIGHWAY CAPACITY MANUAL, 1994

2 LANE HIGHWAY IN MOUNTAINOUS TERRAIN

ASSUMPTIONS: 60/40 DIRECTIONAL SPLIT
14% TRUCKS
4% RECREATIONAL VEHICLES
NO BUSES
PHF=0.92
60% NO PASSING
K FACTOR=0.12 (DHV/AADT)

SECTION 3

Structural Assessment

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3.0	STRUCTURAL ASSESSMENT	3.1.3	Issues/Constraints
3.1	Yoho (Five Mile) Bridge		<u>Capacity</u>
3.1.1	Introduction The Yoho (Five Mile) Bridge was built in 1958/59 and the approach deck was reconfigured in 1962. It is a 200 metre long steel truss bridge with concrete deck that carries the Trans Canada Highway on a flat grade over the Canadian Pacific Railway and over the westward flowing Kicking Horse River, about 10 km upstream of its confluence with the Columbia River. This portion of the Kicking Horse River is popular for white water recreation. The deck carries two lanes of traffic (one lane westbound/one lane eastbound) has no shoulders and is approximately 8 metres wide between the parapet railings. The middle portion of the bridge, approximately 100 metres in length, is on a tangent alignment, however, there are 160 metre radius curves at both ends of the bridge creating a very undesirable "S" configuration for vehicles crossing the bridge. Over the 5 year period, 1991-1995, there were twenty accidents (nine injury and eleven property damage) on and in the immediate vicinity of the bridge.		The bridge was originally designed for an H20-S16 loading which equates to a 36 ton design truck and a 16 ton axle. Current CSA S6 loading would be a CS 600 truck which equates to a 55.6 ton truck with a 16.7 ton axle. A detailed capacity analysis would require evaluation of critical member capacity and demand in their current condition. It is likely that the current truss span of the structure would be found to be sufficient for its original design loading while the approach spans may be found insufficient due to fatigue of critical details. The substructure is likely to be sufficient for the original and current live loadings since seismic load cases will not govern. Based on the foregoing, it is SNC-Lavalin's opinion that components of the main span truss would be overstressed under full CS 600 loading, but would probably be deemed to be sufficient for service conditions with minor upgrades and maintenance. The approach spans would similarly be overstressed and possibly have some fatigue and corrosion related degradation. Again, with some minor upgrades and maintenance, it is probable that the approach spans would be deemed sufficient for the short term. The substructures will most probably be sufficient with regular maintenance.
3.1.2	Existing Structural Integrity Visual assessment of the structure in late 1998 indicated that it is in generally adequate to poor condition. Leakage of expansion joint assemblies, structural steel corrosion and some concrete spalling in the deck and substructure was evident and would require retrofit within the 5 to 10 year term.		<u>Environmental and Geotechnical</u> There is much debris and rock fall at both approaches and it is apparent that the area is subject to a number of geological hazards. It seems that with the apparent condition of the structure and poor roadway geometrics, major slope stabilisation and retaining wall

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retrofit is not warranted. Any proposed replacement structure will have to either avoid or mitigate the geological hazards and should be configured in a more favourable geometric arrangement.

This structure discharges some deck water runoff directly into the Kicking Horse River. This would have to be changed with any new bridge construction by providing a drainage system that can retain contaminants such as salt, heavy metals, oil and fuel prior to storm water running off into the river.

A replacement structure is envisioned to cross the Kicking Horse River at a larger skew and as such would occupy the footprint of the existing bridge and cut and fill slopes. As a result, it is unlikely that any significant habitat would be lost with the new construction. Demolition of the existing structure may include some reinstatement of the river banks and riparian habitat, likely resulting in a net gain of habitat over the current conditions. Demolition and construction work will be subject to approvals from the Canadian Transportation Agency, the Canadian Coast Guard, the Department of Fisheries and Oceans and the provincial Ministry of Environment Lands and Parks.

3.1.4 Upgrading Requirements

- | | |
|-----------------|---|
| 1 to 5 years: | Replacement of the existing structure with a higher level, higher skew crossing, removal of the existing structure and habitat reinstatement. |
| 6 to 15 years: | Normal maintenance. |
| 16 to 25 years: | Normal maintenance. |

3.2 Miscellaneous Structures

3.2.1 Retaining Wall

There is an existing metal bin retaining wall just west of the top of Five Mile Hill on the south side of TCH at LKI 7.43. It is located beneath the TCH pavement level and retains the TCH embankment above the outfall of an 1800 mm corrugated steel pipe culvert. This area is subject to periodic mudslides and debris flows which overtop the highway since the culvert has insufficient capacity to accommodate these flows under peak conditions. A small culvert outfalls over the top of the bin wall. The top of the bin wall is deformed and the entire slope in which it and the culvert are located is eroding and unstable.

A more permanent solution would be to replace the wall and culvert with a bridge that has sufficient hydraulic capacity for the mudslides and debris flows to pass underneath.

3.2.2 Rockfall Barrier on Five Mile Hill

A barrier to retain rockfalls is located on the north side of TCH at LKI 8.73. It consists of chain link fence wedged between layers of precast concrete barrier. The barrier is offset two to three metres from the toe of the cut slope in order to provide storage area for rockfall prior to clean out by highway maintenance crews.

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The top rail of the chain link fence could be hazardous if an errant vehicle were to run into the barrier. This kind of top rail is no longer considered appropriate next to a road or highway, since there have been accidents where the occupants of vehicles have been speared by the top rail.

Although somewhat unsightly, this barrier appears to be doing its intended job well, and should be retained until the highway is reconstructed or relocated, with however the suggested replacement of the top rail with perhaps a top wire anchored at both ends of the barrier.

3.2.3 Rockfall Nets at Black Wall Bluffs

Drape nets have recently been installed on the north upslope side of TCH along the Black Wall Bluffs. These bluffs extend from LKI 6.4 to 7.2 and are an area of very high rockfall frequency and hazards. The nets have reduced the hazard from smaller rockfall, however there is still a risk from large scale rockfall, which the nets would be unable to retain.

3.2.4 Changeable Message Signs

There are three changeable message signs along the TCH within the Town of Golden. The first sign, at LKI 54.8 (Segment 0985) just east of the west end of the frontage roads, is for westbound traffic and provides road condition information such as "Watch for Wildlife and Fallen Rocks". This sign is operated from the Provincial Communications Centre in Burnaby, B.C. The sign is mounted on a large overhead

cantilever which spans both westbound lanes and has its base, which is protected by concrete roadside barrier, located in the boulevard on the north side of the TCH.

The other two existing changeable message signs are in advance of the ICBC operated weigh scale which is located on the north side of the TCH. They indicate whether the scale is open or closed for truck traffic. The sign for eastbound trucks is located on a light pole standard at LKI 55.3 (Segment 0985) and the sign for westbound trucks is located on its own standard at LKI 0.2 (Segment 0990).

There is no changeable message sign for traffic heading east along the TCH, east of Highway 95.

SECTION 4

Geotechnical Assessment

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4.0 GEOTECHNICAL ASSESSMENT

4.1 Introduction

This geotechnical assessment was prepared by Golder Associates Ltd. and is taken from Sections 1.0, 2.0, 3.0 and 4.0 of their report entitled "Geotechnical Assessment for Functional Planning, Cache Creek to Rockies Program, Trans Canada Highway, Golden to Roth Creek (Kicking Horse Canyon)", dated January 2000.

Golder Associates Ltd. (Golder) has carried out a geotechnical assessment for the purpose of reviewing alternative route options for the Trans Canada Highway (TCH) from Golden and Roth Creek. This work is being undertaken as part of the Cache Creek to Rockies (CCR) Program for the B.C. Ministry of Transportation and Highways (MoTH). The section of highway extends from Landmark Kilometer Inventory (LKI) 54.3 (Segment 0985) to LKI 12.00 (Segment 0990). Unless specifically stated, all further LKI references in this report refer to Segment 0990.

The assessment is comprised of a review of existing information, terrain assessment from airphotos, avalanche assessment by the MoTH Avalanche Section, field reconnaissance by foot and helicopter, development of conceptual cut slope angles and ditch widths and a review of potential requirements and unit costs for excavation, retaining walls, soil nail reinforced slopes and tunnels. The appendices in the Golder "Geotechnical Assessment Report" provide more detailed information on the work carried out, as well as geotechnical conditions and constraints within the canyon. Appendix A of Golder's report provides a photographic overview of the study area, while Appendix B of Golder's report summarizes the observations made during the field

reconnaissance. Figure 1 of Golder's report shows the locations of: i) the existing highway, ii) the LKI markers and iii) twelve of the fourteen route options (N1 Surface Route and M4 Route not shown) considered through the study corridor.

Previous geotechnical assessments for the Kicking Horse Canyon section of the TCH related to Corridor, Route and Functional Design studies were carried out by Thurber Engineering Ltd. (TEL) for SNC Fenco and SNC-Lavalin Inc. between 1986 and 1992. A list of the TEL reports related to these studies, together with other relevant existing information reviewed by Golder for this study are provided in the reference list at the end of Golder's report.

4.2 Existing Pavement and Geotechnical Conditions

The following presents a summary of existing pavement and geotechnical conditions along the TCH between Golden and Roth Creek. More detailed information is provided in the Existing Conditions Report. The geotechnical data contained in the Existing Conditions Report is provided in Appendix C of Golder's report.

4.2.1 Pavement Conditions

Pavement condition is identified in terms of the Pavement Distress Index (PDI) which indicates the surface distress conditions, and the Riding Comfort Index (RCI) which measures the roughness of the road. These have been derived from the MoTH Roadway Pavement Management System (RPMS) and modified where appropriate by Golder based on field observations of pavement conditions.

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The existing pavement conditions along this 13.76 km section of TCH are good with a PDI ranging from 9.0 to 9.5 (good) and a RCI ranging from 7.0 to 7.4 (smooth). A short section of highway in the vicinity of LKI 7.7 has a poor PDI rating of 4.9 because of extensive patching due to previous rockfall/erosion fall activity.

4.2.2 Natural Hazards

The Kicking Horse Canyon section of TCH is exposed to significant geotechnical hazards including rockfall, erosion fall, snow avalanche, debris flow and ice fall. Natural hazards impact the TCH in the Kicking Horse Canyon starting just east of Lafontaine Road at about LKI 2.50 and continue to LKI 10.5. The TCH is not exposed to natural hazards at either end of the study area.

Erosion Fall

Locations of erosion fall and rockfall hazards in the Existing Conditions Report were derived from data in the MoTH Rockfall Hazard Rating System (RHRS). Frequent occurrences of erosion fall, consisting of gravel to boulder sized material that is dislodged from existing highway cuts and natural slopes above the highway as a result of natural weathering processes, land on the highway creating a risk to vehicular traffic. Moderate erosion fall hazard occurs along 1.3 km (or 9.5 %) of the TCH through the study area and high erosion fall hazard occurs on 1.2 km (or 8.4 %). The most significant areas effected by erosion fall occur between LKI 2.50 and 5.50, on 5-Mile Hill between LKI 7.20 and 9.00 and in the Yoho Landslide area between LKI 9.65 to 9.94. In these areas there are high discontinuous cuts in till or blocky colluvium. Other localized areas of low erosion fall hazard occur elsewhere along TCH between Golden

and Roth Creek, in areas of low soil cuts, or from soil mantles at the crest of rock cuts or natural colluvial slopes at higher elevations.

Rockfall

The TCH in the Kicking Horse Canyon is exposed to frequent rockfall activity and has one of the highest incidences of rockfall occurrence along the TCH in British Columbia. The many high cuts in weak, highly fractured or blocky rock present a significant rockfall hazard to highway users. Over the length of the study area, moderate rockfall hazard occurs along 1.2 km (or 8.7 %) and high rockfall hazard occurs along 2.6 km (or 18.6 %) of TCH between Golden and Roth Creek. The areas of highest rockfall frequency and hazard include the Black Wall Bluffs area between LKI 6.41 and 7.18 and Five Mile Hill between LKI 8.47 and 8.95. Rockfall protection in the form of drape nets has been constructed recently on the upslope side of the TCH along the Black Wall Bluffs area. However, coverage is only partial at present and appears limited to areas of highest rockfall incidence. Where rockfall protection has been provided, the rockfall hazard has been reduced but there is still a residual risk to the TCH from large-scale rockfall.

Avalanche

Snow avalanche hazards from twelve avalanche paths affect the TCH between LKI 4.8 and 11.3. Information on each of the avalanche paths including the path locations and the respective size and frequency of avalanche events have been compiled by the MoTH Avalanche Section in Victoria, B.C.

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Eight of the avalanche paths initiate on steep open slopes and generally occur as point releases which only affect a small portion of the highway within the avalanche zone. The remaining four avalanche paths are confined in a gully at the highway. The total length of highway affected by avalanches is approximately 3.2 km. The average number of events/year that affect the highway for the individual paths ranges from 0.1 to 8.4 and the average depth on the highway from these events ranges from about 0.5 to 2.3 metres. The most active avalanche path is at LKI 6.9 (Black Wall Bluffs) and affects 650 metres of highway.

More detailed information on avalanche hazards is provided in Appendix D of Golder's report. In addition to the existing avalanche paths mapped on the north side of the Canyon, MoTH has also carried an assessment of avalanche hazards on the south side of the Canyon. The results of this assessment are also included in Appendix D of Golder's report.

Debris Flow

The gullies located at LKI 7.2, 7.4 and 7.7 have a history of debris flow activity affecting the highway. These gullies are also subject to snow avalanches. The gully at LKI 7.4 has experienced numerous debris flow events that have impacted the highway with an average frequency of one event per year. One fatality has occurred at this location from a debris flow event. Debris flows from the other gullies are less frequent and less severe. A small stream channel at LKI 4.9 has experienced previous small-scale debris flow activity with minor impacts on TCH.

Icefall

Icing of the wet cut slopes at LKI 10.5 occurs annually and presents a low icefall hazard to the TCH in the winter months.

4.3

Geotechnical Issues

This section summarizes the stability and road maintenance issues that may impair the serviceability of the existing highway. The information has generally been obtained from District or Regional MoTH sources, supplemented by field observations by Golder.

Highway Distortion

Significant highway distortion has occurred in the vicinity of the creek at LKI 7.4. This gully is subject to severe debris flow and snow avalanche activity as discussed previously. The approach fills in this area have experienced sloughing and surficial movement, which is causing shoulder settlement and cracks. A bin/crib wall has been constructed at the creek crossing but movements still persist. The toes of the fills that support the wall are being continuously eroded, causing retrogressive movement of the fill slope.

Seepage

Fill erosion and surficial sloughing is occurring on silty cut slopes located between LKI 4.05 and 4.55 and between LKI 5.00 and 5.50. These processes occur primarily during periods of wet weather and snowmelt and result in increased ditch maintenance.

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Mass Movement

Thurber Engineering Ltd. (TEL) identified slide activity below the TCH between LKI 4.05 and 4.15 (TEL, 1986). This area contains high-uncompacted fills, and it is believed that movement of these fills may have caused distortion of the highway in the past. However, there has been no recent movement and there are no signs of instability on the fill slopes at the present time.

An ancient landslide some 200 metres wide extends down to the Kicking Horse River and CPR tracks between LKI 5.00 and 5.20. Apparently, the upper section of the landslide was reactivated in 1969 during construction of the existing cut slopes (TEL, 1986). Subsequent unloading of the upper portion of the landslide above the TCH was undertaken and there have not been any significant problems with highway performance through this section since the work was completed.

A second ancient landslide is located below TCH between LKI 5.20 and 5.50 that extends down to the Kicking Horse River. This slide was reactivated during the construction of the existing highway in 1954, resulting in the west abutment of the CPR bridge at Mile 31.8 of Mountain Subdivision moving 200 mm (8") to the Southeast over a three year period (Fenco, 1959). Drains were subsequently installed at the toe of the landslide and the gradient of the slope flattened in the late 1950's. The slope's surface appears also to have been protected by a shot rock blanket. There have been no subsequent problems with highway performance in this area, although the CPR bridge appears to have been re-located a few metres down stream.

Landslides were also triggered at both the west and east abutments of the Yoho (Five Mile) Bridge, when the existing bridge was being constructed in 1955. The slide on the west side was large enough to block both the existing highway and the CPR (MoTH, 1998). The slide on the east side is referred to as the Yoho Slide (MoTH, 1998). The landslide was subsequently remediated by mass excavation of the slide mass in the 1960's after a bin wall, which was initially constructed at the toe of the landslide, began to over turn.

There are no frost heave or icing problems along this section of the highway.

4.4**Geotechnical Constraints**

This section highlights the geotechnical constraints, which effect route selection for the design and construction of a four lane highway through the Kicking Horse Canyon. These include steep terrain, rockfall, erosion fall, debris flow and avalanche hazards and landslides. The approximate locations and extent of these features have been identified through a comprehensive desk study, air photo interpretation and field reconnaissance. The approximate locations of the features identified as affecting route selection are shown on Figure 1 of Golder's report. (Figure 1 is also included in Appendix A of this report by SNC-Lavalin.)

The majority of the major geotechnical constraints which affect route selection occur within the lower canyon section located between the east edge of the Town of Golden and Yoho (Five Mile) Bridge. To the east of Yoho (Five Mile) Bridge, the canyon floor widens allowing all routes to follow the south shore of the Kicking Horse River, sub-

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parallel to the current highway alignment. Hence, geotechnical issues are less important in this part of the study area in regards to route selection.

4.4.1 Geological Setting

The bedrock and surficial geology of the area is discussed in Appendix E of Golder's report and summarized in Figure 2 of Golder's report. (Figure 2 is also included in Appendix A of this report by SNC-Lavalin). This plan indicates the approximate location of the contacts between each of the geological units and the geological structure mapped by the Geological Survey of Canada (GSC, 1980). There is no evidence of any recent movement along any of the mapped faults, consistent with the low seismic rating for the region. Apart from minor local design and construction issues, the influence of faulting on route selection is considered to be minimal.

The bedrock within the valley comprises units of shales, limy shales, shaly limestones, limestones, dolomites and sandstones which have been folded and faulted, and which, over recent time have been deeply incised by glaciers. The general dip of the bedding planes within each of these units is towards the northeast. This has resulted in the formation of steep slopes and rock bluffs on the northern side of the valley and a more subdued slope profile on the southern side of the valley. This orientation of bedding is a major contributor to the occurrence of landslides on the south side of the valley.

Overburden soils within the valley comprise variable mantles of colluvium, glacial till and glacio-fluvial deposits. Fluvial deposits are rare within the study area and tend to be limited to floodplain areas and active gravel bars at river level. Deep colluvial aprons and cones should be anticipated at the base of the steep rock faces and at the base of

the side gullies in the canyon walls. Ancient landslides have also resulted in large lobes of colluvium being deposited on either side of the valley floor. Previous geotechnical investigations have recorded the thickness of till of up to 7 m and colluvium of up to 28 metres along the existing highway (TEL, 1986).

4.4.2 Geotechnical Constraints - North Side of CanyonGolden Hill

Golden Hill is located at the start of the study area where the TCH leaves Golden and heads east into the canyon (LKI 0.0 to 1.5). The grade of the existing highway here is approximately 8% as it climbs from the weigh scales at LKI 0.0 to the turn off for VSA's highway maintenance yard at LKI 1.4. This section of the existing highway is bound by the Golden Hill Pit to the north and the CPR right-of-way to the south. Oversteepened highway fills, uncontrolled surface water runoff and toe cuts into the natural slope by the CPR has caused the existing slopes below the TCH to slough badly. The poor condition of these slopes is considered to pose a major geotechnical constraint for the canyon bottom routes, which would need to steepen them, while keeping open the existing highway at the crest.

LKI 5 Landslide Area

Three separate landslides have been identified in the vicinity of LKI 5.0 on the existing highway (Figure 1 of Golder's report). They are referred to here as the West, Central and East Landslides and are discussed in more detail below.

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West Landslide

It is uncertain as to whether the feature identified and depicted on Figure 1 of Golder's report is actually an old landslide. It was originally identified in the tunnel feasibility study conducted for a northern tunnel route (TEL, 1986). If it is an area of surficial movement, it is likely an old road fill failure. However, there are no strong geomorphologic indicators, either above or below the highway, of a landslide scarp or a large previous failure. A prominent bench is located below the highway at approximately elevation 860 to 870 metres. This may have been part of the old summer road or an old access road down to the CPR tracks. There does not appear to be any signs of on-going movement, either at this elevation or above the highway. The existing highway fills are thick and are at their angle of repose. It is likely that such fills were end dumped and not compacted. As such, the fills can be expected to be of variable relative density. While any widening of the existing highway through this area should avoid increasing the load on the existing fills, we do not consider this area to pose a significant geotechnical constraint on surface route options.

Central Landslide

This landslide extends from above the existing highway down to the river and was also originally identified in the TEL tunnel feasibility study. The original failure may be related to undercutting of the toe of slope by the Kicking Horse River (the toe of the landslide is located on the outside of a bend in the river). A prominent headscarp up to approximately 6 m high is located above the highway providing evidence of past movement. Two gullied creeks extend down the slope below the highway to the CPR tracks and may represent the lateral boundaries of the landslide.

The upper portion of the landslide appears to have been reactivated, possibly during previous highway upgrading work (TEL, 1986). There is no indication of recent movement and the pavement through this area is in good condition. The landslide appears relatively shallow but the actual depth is unknown. It may have occurred within tills, overlain by a blanket of colluvium. As any northern route would likely unload the crest by cutting into the existing slope, this landslide is currently not considered to pose a significant geotechnical constraint to surface route options.

East Landslide

This landslide appears to be located entirely below the highway and may be related to undercutting of the toe of slope by the Kicking Horse River. It appears to have been reactivated when the fills for the existing highway were placed. It was investigated by Fenco in 1957, shortly after completion of the existing TCH through this area, because of significant movement of the west abutment of the CPR bridge at Mile 31.8, Mountain Subdivision. There was also a concern that any failure could dam the Kicking Horse River and close the CPR tracks.

As a result of the Fenco investigation, a number of drain holes (observed 12, MoTH file information indicates 14) were installed along the toe of slope near river level. In addition, the surface of the slope appears to have been flattened and the central portion of the slope covered with a blanket of shot rock to limit erosion by surface water run off. There is no indication of recent movement and the pavement through this area is in good condition. As all of the proposed surface route options will further unload the crest of the slope, this area is not considered to pose a significant geotechnical constraint to route selection.

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While none of the three landslides are considered to pose a significant constraint to route selection, each should be further investigated at the preliminary design stage, if they are likely to be impacted by the favoured route(s).

Black Wall Bluffs

The Black Wall Bluffs area, located between about LKI 6.4 and 7.2 on the existing highway, poses significant geotechnical challenges for any surface route option through this area. Slopes below the existing highway are steep and covered with variable mantles of loose road fill (at angle of repose) and colluvium overlying bedrock. These slopes terminate at the crest of high, near vertical bedrock cliffs located above the CPR tracks. Construction on these steep slopes, including related hazards to the CPR below and rockfall from the Black Wall Bluffs above, will pose significant geotechnical constraints to the design and construction of a surface route through this area.

There is a rockfall hazard from the cliffs above the highway. Although this hazard has been reduced somewhat by the recent construction of drape nets at the crest of the cuts above the existing highway, additional mitigation (more fences, large ditches etc.) would be required to protect any new four lane highway. Even with extensive fencing it is anticipated the on-going maintenance costs would be high and there would still be a residual risk to the highway from large-scale rockfall which the fences would be unable to contain. During the winter months, this portion of the highway is also regularly impacted by snow avalanches.

Five Mile Hill

The Five Mile Hill section of the existing TCH runs from an elevation of about 1010 metres at LKI 7.2 to elevation 900 metres at Yoho (Five Mile) Bridge (LKI 9.5). The grade of the existing highway over this section averages 8%. At the top of the hill where the highway turns sharply, there are a series of gullies and steep bedrock slopes, which are prone to debris flow and avalanche hazards. Six avalanche paths, ranging in size from small to large (Appendix D of Golder's report) are located here, the largest occurring at LKI 7.2 and 7.62. The gully at LKI 7.4 is also a severe debris flow hazard and was the site of a previous debris flow related highway fatality. A surface route in this area would require bridges with adequate clearance and length to cross these active drainage gullies and possibly snow sheds to cross some of the avalanche paths. Steep colluvial covered slopes also extend below the existing highway in this area. For these reasons, the upper portion of 5 Mile Hill poses a significant geotechnical constraint for any surface route option.

Between about LKI 7.5 and the Yoho (Five Mile) Bridge, the alignment of the existing highway cuts into the base of a large talus slope, which is overlooked by steep bluffs. The talus slope itself appears to be in a state of equilibrium, but deep cuts into the existing talus slope should be avoided. Such cuts could initiate movement that would be difficult to restrain with conventional earth retaining structures. While the talus slope itself appears to be in equilibrium, erosion fall from localized loosening of boulders continues to reach the road. Fences have been erected along the inside of the existing highway to limit erosion fall material from reaching the highway. The poor condition of the fences is an indication of the severity of the erosion fall hazard in this area. Provision of improved erosion fall protection through this area should help mitigate this hazard to

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acceptable levels. Construction of the existing highway has created a large fill slope in the vicinity of LKI 8.0 on the south side of the highway. It appears that the erosion fall/rockfall materials cleaned from the road over the years have been end-dumped on top, and over the edge, of these fills. These fills are likely to be in a state of variable density and should not be overload during the construction of a new highway.

This section of highway is also exposed to moderate avalanche hazards. Overall however, the lower portion of Five Mile Hill is not considered to pose a significant geotechnical constraint for surface route options.

4.4.3 Geotechnical Constraints - South Side of Canyon

South Landslide Area

A 1991 site investigation indicated the presence of a large active landslide on the southern side of the valley about 4.5 km east of Golden. The location of the landslide in plan and section is shown on Figure 3 of Golder's report. Bedrock in the landslide area comprises very weak, fissile McKay Group 3 slates/calcareous slates. This unit contains thin interbeds of stronger micritic limestone and is locally highly folded and sheared. Bedding generally dips out of the slope towards the river. Movement is indicated by surficial features on the slope such as bent tree trunks, irregular topography and local slumping. In addition to these surficial features, large cracks are present in the cliff face that forms the prominent headscarp of the landslide on the upper reaches of the southern valley slopes. Existing cuts in the logging road, upslope of the headscarp area, and to the east of the landslide show many signs of instability and sloughing in the McKay Group 3 slates. These field observations, as well as review of aerial

photographs and inclinometer data taken from two boreholes drilled within the landslide in 1995, confirm the presence of the landslide and indicate movement may be occurring as deep as 120 metres below surface. However, the measured movement rates are in the order of 2 to 3 mm/year and there is no indication from the data that the rates are accelerating. Data from the one inclinometer indicates movement to be predominantly related to slow plastic creep in the upper portion of the landslide, combined with the sliding of blocks on discrete planes, at greater depth. It is difficult to identify the base of the landslide, as the base of both inclinometers, appear to be still within the slide mass. A summary of the inclinometer data, which consists of readings taken over the last four years, is presented in Appendix F of Golder's report. The appendix also contains borehole logs and core photographs for the inclinometer holes.

This landslide poses a significant geotechnical constraint for any surface or sub-surface route option through this area.

Area East of South Landslide

The terrain immediately east of the South Landslide has also experienced instability in the past and there are exposures of landslide debris at river level in this area. This area is also located in McKay Group 3 slates/calcareous slates and contains several active surficial slope failures, particularly on the upper slopes, with debris flow tracks over the western portion.

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South Bluffs and Yoho Landslide Area

The South Bluffs are a steep linear ridge of rock, which forms the south wall of the canyon for approximately 1 km downstream of Yoho (Five Mile) Bridge. The Yoho Landslide area is located at Yoho (Five Mile) Bridge below the bluffs, between LKI 9.5 and LKI 9.7 adjacent to the existing highway.

The Yoho Landslide was initiated during construction of the east abutment and approaches to Yoho (Five Mile) Bridge in the late 1950's, when the toe of the talus slope at the base of the bluffs was cut. A subsequent site investigation revealed silty glaciolacustrine soils beneath the talus material and it was concluded that this weaker material was likely the cause of the instability (Nasmith, 1955). After an initial attempt to support the slope with a toe wall failed, the landslide mass was excavated and removed to ensure the safety of the bridge and eastern highway approaches. Because similar geological conditions could exist further downstream, this area was targeted in the field reconnaissance.

Observations made during the field reconnaissance indicated similar subsurface conditions are likely to exist for a distance of at least 500 metres downstream of the bridge. Indications of movement in the form of fresh tension cracks in the forest floor were actually observed closer to the bridge, approximately 100 metres downstream of the Yoho Landslide area. This area of potential instability poses significant problems for any south side alignments (and possibly to the existing Yoho (Five Mile) Bridge), with the unstable mass likely requiring removal to facilitate highway construction.

In addition to the sub-surface instability, significant avalanche and rock fall hazards exist on these slopes. During the field reconnaissance, tracks of cleared trees three to four metres wide were observed 200 metres and 250 metres west of the Yoho Slide. These tracks are located at the base of gullies in the bluffs and are subjected to chronic small scale rock fall and avalanche activity. At 300 metres west of the Yoho Slide there is a 10 metre wide track, with evidence of recent activity (spring 1999). The majority of the rock fall material in each of the tracks appears to reach the river located 200 metres below the bluffs. The size of potential block falls are highlighted by the presence of large rock pinnacles on the slope (volume > 1000 m³) which appear to have fallen from the cliffs in the past.

This area poses a significant geotechnical constraint for any surface route option.

4.4.4**Canyon Bottom**

The Kicking Horse River follows a meandering path through the base of the canyon as it navigates through rock types of various hardness, as well cutting through debris fans from previous landslides. The narrow canyon bottom and the path of the river pose significant topographic constraints on any surface route chosen. There are numerous small landslides that have occurred along the canyon bottom leaving scars in the valley walls. The cause of these slides appears to be undercutting of the slope's toe by the river. These areas were highlighted by air photo interpretation and confirmed by visual observation during the field reconnaissance. The extent of these areas is shown on plan in Figure 1 of Golder's report. Although much smaller in extent and severity to the landslides previously discussed, these features nonetheless present additional geotechnical constraints to any canyon bottom and canyon crossing routes.

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4.4.5 East of Yoho (Five Mile) Bridge

From LKI 9.7 to LKI 12.0 at the end of the study area, the canyon bottom starts to widen. Here the most significant geotechnical issues become rockfall hazards and minor icefall hazards from the existing cuts. The stability of the existing riverbanks and road fills upon which retaining walls would likely need to be constructed are also geotechnical issues which need to be addressed once a final route has been selected. However, none of these geotechnical issues are considered to be significant enough to pose constraints on route selection.

4.5 Potential Borrow Sources and Disposal Areas

Generally, it is anticipated that widening of cuts will provide all the material required for embankment fill. The native soils and weak bedrock within the construction area are expected to be only suitable as subgrade fill and likely not suitable for use as subbase or base material. Where more competent bedrock (McKay Group 4 and 6 limestones) is encountered, the excavated material could likely be used as structural fill and possibly subbase material following appropriate crushing and sorting.

Potential borrow sources for subbase and base materials are limited. The closest potentially suitable source comprises a series of glaciofluvial terraces (likely kame terraces or kame deltas) located on the north side of the highway, east and west of Hospital Creek in Golden (LKI 55.1, Segment 0985). Several borrow pits have already been developed in these deposits including the privately owned Edelweiss pit located on the west side of Hospital Creek and the MoTH owned Golden Hill pit on the east side of Hospital Creek. The Golden Hill pit is the only active pit on the east side of the creek

and is reserved for winter aggregates. All other pits in this area have been depleted and shut down, and one pit is used as a municipal landfill. There are housing developments on the eastern portions of this deposit. These terraces likely comprise sandy to sandy gravelly materials and aggregate suitability is anticipated to be moderate to good.

No suitable borrow sources were identified in the Kicking Horse Canyon. However, an exposure of hard, quartzite/quartz sandstone (Mount Wilson Formation) was identified on a branch road approximately two to three km along the Dart Creek Forest Service Road. This rock is expected to produce good quality concrete and asphalt aggregate. More investigation is required to define the limits of this deposit and the overall feasibility of the site as a potential quarry.

Potential spoil sites include the abandoned borrow pits on the north side of the highway in the vicinity of Hospital Creek and the extensive areas of gentle terrain (including previously logged areas) in the Dart Creek valley.

Additional geotechnical investigations are required in subsequent design stages to assess the overall suitability of the potential borrow and spoil sites. In addition, environmental and archaeological issues will need to be addressed before using these sites.

A more detailed description of potential aggregate sources and disposal sites is provided in Golder Associates Ltd. report titled *'Preliminary Aggregate Source and Spoil Site Assessment: Proposed Upgrading of Trans Canada Highway from West of Donald to Yoho National Park, B.C.'* dated July 12, 1999.

SECTION 5

Environmental Assessment

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5.0 ENVIRONMENTAL ASSESSMENT

5.1 Introduction

This section includes an overview assessment of environmental issues along the existing Trans Canada Highway (TCH) corridor between the Town of Golden and the vicinity of Roth Creek near the Rest Area. It is divided into the broad categories of i) the Natural Environment; Fisheries and Aquatic Habitat and Wildlife and Terrestrial Habitat addressing both the Canyon and the Town of Golden and ii) the Social Environment; Archaeology and Recreation for the Canyon and other social issues for the Town of Golden. Additional information on the social environment will likely become available when the future public information/consultation program is undertaken that is specifically directed towards this section of TCH.

The program to improve the TCH between Golden and Roth Creek will be contingent on securing approval from a number of government agencies, such as the federal Department of Fisheries and Oceans (DFO), the provincial Ministry of Environment, Lands and Parks (MELP), the Canadian Transportation Agency, and since the Kicking Horse River is a navigable waterway, the Canadian Coast Guard.

This environmental assessment is a first step to securing the required approvals. Specific mitigation measures to protect the environment, during construction and the subsequent period of operations and maintenance, will be addressed in the ensuing stages of preliminary design and detailed design. More detailed environmental assessment information and comments are included in Sections 6 and 7 of this report, in conjunction with the specific preferred canyon route and the alternative canyon routes which were studied.

5.2 Natural Environment - Fisheries & Aquatic Habitat

5.2.1 Summary of Existing Conditions

This section of the TCH is located parallel to the Kicking Horse River from the east junction with Golden View Road on the east side of Golden (LKI 2.2) and extends eastward to just east of a pull-off on the south side of the river near Roth Creek (LKI 12.0). The western portion of the highway of this section is perched above the northern side of the lower Kicking Horse River canyon and is situated on a series of road cuts high above the river. In this section of the TCH, the valley slopes are steep and very rocky with patchy forest cover. Sideslopes north and south of the highway often exceed 75 degrees (i.e. steeper than 0.25H to 1.0V) with rock falls and avalanche zones common along this section.

In terms of fish and aquatic habitat, the features found in this portion of the TCH can be summarized as follows:

- At least 12 culvert crossings (10 - 600 mm CSP's, 1- 900 mm CSP and 1 - 1800 mm CSP) are located under the TCH between LKI 0.00 (located at the Highway 1/Highway 95 Intersection) and LKI 9.45 (Yoho (5 Mile) Bridge).
- At least 9 culvert crossings (7 - 600 mm CSP's, 2 - 900 mm CSP's) are located under the TCH between LKI 9.45 (Yoho Bridge) and LKI 12.0 (Roth Creek area).

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- A variety of second and third order streams cross under the TCH in this section. These stream crossings are documented in the Fisheries Appendix of the "Existing Conditions Report". Five of these larger stream crossings were examined during the functional planning work and are considered to have low fish habitat potential at the highway crossing areas because they contain very steep gradients, have poorly defined stream channels, consist of ephemeral or seasonal flows, and offer very limited, if any, fish habitat potential at the highway crossing other than contribution of clean water, nutrients and food sources to the Kicking Horse River. However, several of these streams, particularly in the area west of Yoho (5 Mile) Bridge, likely provide off-channel high water refuge habitat at their confluence with the Kicking Horse River. Although the amount of refuge habitat may be relatively small in overall area, it is likely very important given the high water velocities and turbid water conditions in the mainstream of the Kicking Horse River during high water flows.
- The Kicking Horse River, a Class A fisheries system, is the primary fish and aquatic habitat feature along this section of the TCH. The Kicking Horse River, a major tributary to the Columbia River, joins the Columbia River at Golden. The Kicking Horse River originates in the Wapta and Waputik Icefields of the Rocky Mountains, which generate very turbid, cold and nutrient poor waters in the river. These water conditions (i.e., low temperature, low nutrient and high seasonal turbidity) result in relatively slow production for fish communities. Previous fish studies indicate that the lower Kicking Horse River and its tributaries are sparsely inhabited with stunted fish populations and that the section of the Kicking Horse River, from about LKI 2.0 to 12.0, is rated as having moderate spawning, rearing and resident adult habitat potential.

Contacts with MELP, results from a previous fisheries study by ENKON Environmental Limited in 1998, and recent field investigations have documented the following fish species in the Kicking Horse River: bull trout, eastern brook trout, kokanee salmon, mountain whitefish, pygmy whitefish, longnose dace, slimy sculpin and torrent sculpin. Given the presence of fish in this system, the Kicking Horse River and the lower reaches of its tributaries are therefore considered to be fish sensitive.

5.2.2**Fish and Aquatic Habitat Constraints**

The highest fisheries habitat values for the corridor between Golden and Roth Creek occur in the Edelweiss/Hospital Creek drainage on the west side of town, and downslope of the TCH. Gradients upstream of the TCH are in excess of 20% and show evidence of lime deposits cemented to the stream bottom. Downstream of the TCH, a series of beaver ponds contain spawning habitat for kokanee salmon, eastern brook trout, and other aquatic life. Year-round flows provide very good salmonid habitat. This series of beaver ponds and associated marsh complex downstream of the TCH should not be encroached upon. Due to its proximity to town, it is popular with Golden residents.

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In terms of fish and aquatic habitat, any activity or project action that has the potential to result in adverse effects would likely constrain highway improvements. Such adverse effects may include, but are not limited to, the following:

- The alteration of existing drainage patterns for streams and drainage systems crossing the TCH, particularly if this results in the loss of food sources for fish and other aquatic species; alteration of clean water and nutrients to downstream fish habitat; or harmful alteration or interference with fish passage in watercourses.
- The loss of a vegetative buffer area alongside the TCH, particularly areas that provide natural biofiltration of drainage from the highway downstream to the Kicking Horse River or into stream crossings of the TCH.
- The loss of riparian vegetation along the Kicking Horse River at major TCH stream crossings due to construction of highway grades or bridge approaches within the riparian zone.
- The encroachment into the floodplain, particularly within the wetted perimeter, of the Kicking Horse River and major stream crossings of the TCH.
- The direct physical loss, displacement or disturbance of fish and aquatic habitat.
- The introduction of deleterious or harmful substances into watercourses as a result of construction activities, changes to slope topography or local drainage, and road runoff.
- An increase in sediment and erosion that results in the discharge of poor quality, silt-laden water into the Kicking Horse River or stream crossings of the TCH resulting in a reduction in the supply of food and nutrients for fish.

- The inadequate stabilization and rehabilitation of disturbed sites or prolonged exposure of construction sites to adverse weather conditions.
- The interference with vessel navigation and/or disturbance of recreational use of Kicking Horse River (*i.e.*, river rafting, fishing).

Most of the stream crossings of the TCH, other than the Kicking Horse River, are considered to have low potential fish habitat value. The steep gradients and lack of suitable habitat in streams, upstream and downstream of the highway, greatly limit the potential for fish presence. The primary fish habitat values for these stream crossings comprise refuge areas at the confluence with the Kicking Horse River. With the adoption of acceptable mitigation measures and environmentally appropriate construction and maintenance practices, the highway upgrade proposed for this section of the TCH should not pose a significant concern in terms of potential impacts on fish and aquatic habitat. In terms of specific concerns, the following activities would likely be of concern to the environmental agencies and require careful planning, design and construction to avoid or minimize adverse effects:

- Installation of retaining walls on steep slopes immediately adjacent to the Kicking Horse River and in areas of larger stream crossings along the TCH.
- Installation of new bridge crossings over the Kicking Horse River, as well as over larger stream crossings along the TCH, particularly in the event that clear span bridge structures are not possible.

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- Construction of staging areas and temporary access roads which may be required to service bridge works and highway earthworks activities.
- Clearing, grubbing, stripping and earthworks for the construction of new sections of highway along the route.
- Construction within an active zone of geotechnical concern (i.e., landslide, avalanche track).
- Construction of the new highway grade in closer proximity to the Kicking Horse River than existing portions of the TCH.

5.2.3 Impacts for Fisheries and Aquatic Habitat

This preliminary assessment of options for highway upgrading in the Kicking Horse Canyon is based on interpretation of aerial photographs, engineering drawings and observations from site visits. Each of the canyon route options studied would likely have some potential concerns regarding impacts to fish habitat. The fisheries concerns with respect to providing effective drainage and erosion control at all stream crossings, the installation of retaining walls adjacent to the Kicking Horse River, the effects on riparian habitat and vegetation and work adjacent to fish-bearing waters may be common to all the proposed route options studied.

North Side Options

All North Side route options studied would require tunnels, new bridges, and long retaining walls. The creation of these tunnels may improve surface water quality conditions somewhat in the local area as well as cause less disturbance to existing

vegetation than other surface route options. However, creation of the tunnels would also generate large volumes of blast rock, which would require suitable disposal sites.

An alignment which shifts the existing highway further away from the Kicking Horse River would likely benefit water quality in the river. Moreover, the installation of tunnels would avoid alteration of some culvert crossings along the TCH. Consequently, this option is preferred from a fish habitat perspective.

An alignment which follows the existing TCH and involves widening of the existing highway would also require tunnelling, new bridges and long retaining walls and would involve highway improvements in areas closer to the Kicking Horse River, resulting in increased concerns regarding sediment and erosion control. However, since these improvements would entail highway widening rather than construction of a completely new grade, some of these additional concerns with sediment and erosion control compared to other options, would be offset.

Fisheries concerns specific to the North Side options include:

- Construction work in close proximity to steep slopes directly above the Kicking Horse River.
- Requirements for disposal of large volumes of waste/spoil material from tunnel excavations.

North Side options would require less work in and around areas of riparian vegetation and fish-bearing waters than other route options, since the only bridge to be built over the Kicking Horse River would be the replacement of the Yoho (Five Mile) Bridge.

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South Side Options

All South Side route options studied have the potential to affect fish habitat. In particular, the development of an entirely new route between Golden and the Yoho (Five Mile) Bridge would likely result in far more disturbance of previously undeveloped land and watercourses than other options for highway improvement. These route options would traverse at least five tributaries of the Kicking Horse River along the south side of the Canyon.

Fisheries concerns specific to the South Side options include:

- Disturbance of previously undeveloped forested areas and streams.
- Construction of a variety of new tunnels, viaducts and retaining walls given the steep terrain and close proximity of these structures to the Kicking Horse River.
- Requirements for disposal of large volumes of waste/spoil material from tunnel excavations.
- Construction within active zones of geotechnical concern.
- Long-term water quality issues.

The South Side options are judged to be less desirable than North Side and Mid Canyon routes in terms of potential fisheries concerns and if a South Side option were to be considered further, a detailed fisheries assessment would be necessary, requiring additional field work.

Canyon Bottom Options

All Canyon Bottom route options studied would involve the construction of an extensive system of structures, including bridges/viaducts and tunnels, as well as numerous retaining walls. The construction of such structures immediately adjacent to and overtop of the Kicking River has a very high potential to affect fish habitat. As several of the structures would encroach into the Kicking Horse River, unavoidable impacts on fish habitat may result. The operation of an extended section of major highway in this environmentally sensitive location will likely create potentially chronic and acute risks for water quality contamination.

Fisheries concerns specific to the Canyon Bottom options include:

- Extended sections of construction immediately adjacent to and directly overtop of the Kicking Horse River.
- Requirements for disposal of large volumes of waste/spoil material from tunnel excavations.
- Long-term water quality issues.

Of all the options considered for highway upgrading in this area, the Canyon Bottom options are judged to be the least desirable in terms of potential impacts on fish habitat. South Side options could result in adverse impacts on water quality, fish habitat, riparian vegetation, water-based recreation, and river vessel navigation. The potential for such impacts would also greatly increase the difficulty in obtaining environmental approvals and permits for the project.

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Mid Canyon Options

All Mid Canyon route options studied involve the construction of tunnels, new bridges over the Kicking Horse River and major retaining walls. In terms of fish habitat, the Mid Canyon options would likely have fewer concerns than the Canyon Bottom and South Side options.

In comparison to the North Side options, the Mid Canyon options would likely disturb a larger area of riparian vegetation and have a greater potential to affect fish habitat. Since they involve longer bridges over the Kicking Horse River than the North Side options they could also pose greater difficulties in the management of water quality problems arising from deck drainage off the new bridges. These routes would also require land clearing and construction of new grades and structures on the south side of the Canyon in an undeveloped forested area.

Fisheries concerns specific to Mid Canyon options include:

- Disturbance of previously undeveloped forested areas and streams.
- Additional loss of riparian habitat and vegetation at new bridge crossings.
- Long-term water quality issues.

If a Mid Canyon option was to be considered further, detailed fisheries assessment of the south side area would be necessary, requiring additional field work.

In summary, in terms of fisheries concerns, each of the three main options under consideration for further development (See Dwg. No. 013121-FP-131) would likely be acceptable as preferred route options with the development of a suitable design, habitat mitigation and utilizing environmentally sound construction practices.

5.3 Natural Environment - Wildlife & Terrestrial Habitat

5.3.1 Summary of Existing Conditions

Wildlife Movement

The Kicking Horse Canyon is the major movement corridor for wildlife such as ungulates, bears, and carnivores which move seasonally or at other times between the Columbia River Valley (Golden area) and the Beaverfoot River and upper Kicking Horse River Valleys. A recent two year study on animal movements in the Kicking Horse Canyon showed that deer, elk, and sheep move east/west along the canyon mainly on the north side, the same side as the TCH between Golden and Yoho (Five Mile) Bridge. Crossings of the TCH by deer and bighorn sheep occur daily. Crossings by bears, elk, moose, wolves, and other significant wildlife species are much less frequent, occurring mainly east of Yoho (Five Mile) Bridge. Movements by ungulates and bears on the south side of the Kicking Horse Canyon are much more limited than on the north side. Bighorn sheep do not occur there, mountain goats occur infrequently along rock faces and moose occur rarely. Grizzly bears occasionally wander across the south side of the Kicking Horse Canyon and black bears regularly, however the good bear habitat occurs mainly east of Roth Creek.

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Wildlife Road-Kill Mortality

Wildlife-vehicle collisions along the Golden to Kicking Horse Canyon area of LKI Segment 0990 are among the highest along the TCH from Kamloops to Alberta. There were 32 Wildlife Accident Reporting System (WARS) documented road-kills of deer, elk, moose, and bear from 1988 to 1997. Using the standard 5:1 ratio of actual kills to reported kills, translates to an average of 1.6 ungulates, bears, or other large mammals killed/km/year on segment 990 from LKI 0.0 to 10.0.

An analysis of WARS data from 1988-1997, for Golden to Yoho National Park west gate, showed that deer (65%) accounted for most road-killed animals, followed by coyote (11%), elk (8%), moose (7%), bear (5%), and porcupine (4%); however most elk and moose are killed east of the Brake Check (LKI 16.85) which is located 5.7 km east of Roth Creek.

Bighorn sheep were not included in the WARS data analysis as none had been reported killed for the period that data were analyzed. However, in 1998 one road kill sheep was found and one near-collision was witnessed by the wildlife consultant. During field surveys in 1998-1999, bighorn sheep were observed to regularly walk along the shoulder of the TCH and cross at various locations. It is suspected that sheep are killed at relatively low rates on the TCH between Golden and Yoho (Five Mile) Bridge, but at a higher rate than data suggest.

Of the 206 reported accidents between Golden and Roth Creek for the period 1991-1995, fifteen (7%) were caused by collisions with wildlife, resulting in three injury accidents. A hotspot for wildlife-related accidents is between LKI 0.0-4.0. MTH District

staff have observed that sheep movements on slopes above the north side of the TCH frequently cause rock to fall onto the TCH. Such rockfall likely contributes to potential for vehicle accidents.

Between the west town limit of Golden and the intersection with Highway 95, a distance of 1.8 km, collisions with wildlife are more frequent than anywhere else in the corridor. Between 1991 and 1995, an average of 4.4 collisions between wildlife and vehicles per km were recorded in this area.

Wildlife Habitat

The current TCH alignment, which runs along the north side of the Kicking Horse Canyon between Golden and Yoho (Five Mile) Bridge, cuts across seasonally critical habitat for populations of white-tailed deer, mule deer and bighorn sheep. Although these species use the north side of the Kicking Horse Canyon year-round, the south facing slopes between Golden and Dart Creek provide high value winter range for deer and sheep. Immediately adjacent to the TCH the area between LKI 0.0-4.0 is the most important portion for deer.

East of Dart Creek, the terrain is too steep to be of much value for deer. This is important because the quantity and quality of winter range limits populations of ungulates; therefore, impacts of development on winter range should be very carefully assessed. In this case, unmitigated widening of the existing TCH alignment between Golden and Dart Creek would impact on some of the best winter range for populations of deer and sheep.

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Wildlife habitat mapping for areas adjacent to the TCH alignment in the Kicking Horse Canyon area is currently being produced. Habitat ratings for elk, deer, moose, bears and bighorn sheep, which are determined from field plot assessments using provincial standards, are being correlated with current digitized forest cover mapping. Previous wildlife habitat mapping on 1:20,000 TRIM maps showed general areas of use by these species. In contrast, the new mapping will identify specific locations where wildlife habitat values are relatively high and mitigation measures more beneficial.

The south side of the Kicking Horse Canyon area contains less valuable habitat for most wildlife species. On the south side of the Kicking Horse Canyon, little winter range for ungulates exists as the slopes are north facing however small numbers of elk winter from Park (Ten Mile) Bridge (LKI 14.2) approximately 4.7 km east of Yoho (Five Mile) Bridge, west to Golden. However, the bench immediately southeast of Golden is used extensively by wintering deer and is also used as a corridor for deer moving from the Columbia Valley in winter to summer ranges in mountains southeast of Golden.

A mineral lick used by mountain goats is located within 100 metres of the eastern end of the Yoho (5 Mile) Bridge, on the south side of the TCH. The main lick area is situated approximately 75 metres upslope of the TCH. The number of goats that use the lick appear to be small, but licks are, in general, important nutrient resources for local populations of ungulates. Historically, elk have used the Edelweiss wetland area during the winter, however little use has been reported in recent years.

Population Status

A small band of 25-30 bighorn sheep reside along the TCH from Golden to Yoho (Five Mile) Bridge. The band has a high priority for conservation among the local Golden community. Winter feed for these sheep is being augmented by a local conservation group based in Golden. This band of sheep was not given a high priority by wildlife managers earlier in the 1990's because of the potential for winter die-offs. By 1999, the herd's status was reconsidered and raised to be regionally important because of its northerly range and genetic diversity potential. Bighorn sheep do not occur on the south side of the Kicking Horse Canyon.

Deer are relatively numerous, especially from late fall through early spring. Elk and black bears occur in small numbers. Moose occur very infrequently.

5.3.2

Wildlife Constraints

Unmitigated development of the TCH along its existing alignment or along new alignments will add further impediments to seasonal and local movements of ungulates, bears, carnivores and other wildlife. For example, extensive cuts, fills, and retaining walls can preclude movement up/downslope by wildlife. The results can include increased mortality rates, reduced ranges and access to quality habitats, increased disturbance, and fragmentation of habitat; all of which usually lead to smaller population sizes. However, viaduct, tunnel, and bridge construction proposed for any of the north and mid-canyon routes will improve wildlife passage in localized areas over existing conditions. Wildlife passage and reduction of wildlife-vehicle collisions is most effectively accomplished by combining crossing structures with wildlife exclusion fencing, which direct wildlife to cross the TCH at the desired locations.

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Road-kill Mortality

Road-kill mortality of ungulates, bears, and other large mammals is expected to increase if the TCH is widened and the design speed is increased. Wildlife populations impacted by road-kill mortality usually eventually stabilize at significantly lower levels. Impacts of increased mortality rates include smaller animal populations, and increased risk of human injury and property damage.

Wildlife Habitat

Widening of the TCH along its existing alignment will require extensive cuts/fills and walls. Such an approach will bury or destroy valuable winter range. Impediments to wildlife passage are likely more critical than loss of habitat, except between LKI 0.0 and 4.0, where the best quality winter range exists for deer and bighorn sheep between Golden and Roth Creek.

The mineral lick at the east end of Yoho (5 Mile) Bridge, which is used by mountain goats, should not be impacted significantly. Proposed TCH upgrading realignments are shown to be somewhat upslope of the existing alignment, but the main lick area is more than 75 metres above the existing alignment grade.

5.3.3 **Impacts for Wildlife Habitat**

North and Mid Canyon Options

These route options generally present good opportunities to enhance wildlife populations in the Kicking Horse Canyon area. Any one of these options, in combination with wildlife exclusion fencing and reclamation of the existing TCH, would be highly preferable to the existing TCH alignment. Loss of any ungulate winter range on the south-facing slopes on the north side of the TCH could likely be mitigated.

South Canyon Options

South Canyon options are more advantageous for wildlife than unmitigated north or mid canyon options because the south side of Kicking Horse Canyon generally has lower wildlife habitat values and lower wildlife use than the north side. Exceptions include the bench immediately southeast of Golden which is good wintering habitat for elk and deer, and the tie-in point with the existing alignment east of Yoho (Five Mile) Bridge for the south and some mid canyon route options studied which would likely severely disrupt the mineral lick.

Canyon Bottom Options

This route is relatively advantageous for wildlife as the numerous proposed bridges and tunnels provide opportunities to enhance wildlife passage across the Kicking Horse River valley and do not require disturbance or loss of good-quality ungulate winter range, which occurs on the south-facing slopes above the river. However, these routes

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would result in loss and disturbance to relatively rare riparian habitat along the river, through construction of numerous bridge approaches, piers, etc. A canyon bottom alignment may also affect movements up and down the river by wolves, which use the river, especially in winter, as a movement corridor.

Dart Creek Valley

Dart Creek valley has been proposed as a storage site for waste rock. A recent study of wildlife movements found that the Dart Creek drainage area was an important seasonal movement corridor for mule deer as animals move north/south from/to low elevation winter range along the TCH and Columbia Valley and higher elevation summer range to the north of the TCH (Demarchi and Searing 1997). Reconnaissance surveys in 1999 indicated that the Dart Creek valley also includes relatively good seasonal habitat for deer and elk. Impacts of waste rock storage would be mainly related to habitat loss, but disturbance of animals, and disruption of local movement patterns may also occur.

Additional Wildlife Studies

Construction of new or improved TCH alignments in the Kicking Horse Canyon will probably trigger the enforcement of the *Canadian Environmental Assessment Act* (CEAA) and require an increased assessment of environmental impacts. Further studies (1-3 years) on movements of large mammals (ungulates, bears, carnivores) will likely be required, although the provision of wildlife exclusion fencing and crossing structures will likely mitigate impacts on those movements. Such assessments may require additional studies on potential impacts on wildlife that have been poorly studied or not investigated at all in the study area. These include wildlife such as breeding songbirds, bats and

small furbearers. However, impacts to these wildlife are not anticipated to be critical. Sufficient time and resources to complete the required studies will need to be incorporated in the next phases of the design process.

An assessment of the extent of loss of ungulate winter range for any preferred option, including loss of habitat due to development of waste rock disposal sites, should be conducted in order to plan for suitable mitigation.

5.4

Social Environment – Archaeology

This initial assessment of the options suggested for highway upgrading in the Kicking Horse Canyon, for the purposes of the functional planning phase, is based on aerial photograph interpretation and viewing in the field in early June, 1999. Specific route option assessments are included in Section 7 of this Report.

North Canyon and Mid Canyon Options

At the west end, where the North and Mid Canyon options follow the same general route, areas of archaeological potential include the upper heights of Golden Hill where there may be possible benches above and below the existing highway.

North route options which cut through the Black Wall Bluffs area are of major concern because an archaeological site has been recorded above Dart Creek and a trail extends to the east from there which may run along the top of the Bluffs. North route options may also cross a possible upper bench about one km east of Black Wall Bluffs.

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Review of Mid Canyon route options has identified possible high points of land, a lower point of land (where a possible bridge support may be located) and additional lower benches which could be impacted as a result of bridge pier locations. These points and benches may provide archaeological potential.

East of Yoho (Five Mile) Bridge, on the south side of the Kicking Horse River there are a few possible benches or terrace remnants. In general, the proposed straightening of the TCH alignment east of Yoho (Five Mile) Bridge is crossing either steep slope or disturbed fill.

In summary, with regard to the primary North and Mid Canyon route options under consideration for further development, no major archaeological concerns are expected, with the possible exception of the vicinity of Dart Creek and Black Wall Bluffs, if disturbance is anticipated at the upper heights. Given that exception, there is little to choose between these options with respect to archaeological issues, although the north canyon routes have a few more areas of archaeological potential. All will require some field investigations, not necessarily limited to the above noted landscape features; intensive field examination may reveal other areas of archaeological potential. Plans for geotechnical testing with respect to these canyon options will need to be reviewed in order to assess requirements for archaeological field reconnaissance prior to ground disturbance.

South Canyon Options

Much of the south side of the canyon is characterized by steep slope, particularly the eastern two-thirds of the section between Golden and Yoho (Five Mile) Bridge. Although there may be some minor levelling of terrain further along the route, of primary

concern would be the point just east of Golden where the south route options cross the river to the south side. Other areas of potential archaeological interest include a small drainage area and an elevated promontory.

The southern extents of the South Side options were assessed using the 1992 base plan contour mapping. This assessment suggests that several approximately level areas may be crossed which could require further review if these routes were developed in future phases of design.

Canyon Bottom Options

Aerial photograph interpretation suggests that there is little level land in the bottom of the canyon that is not already occupied by the railway. In general, the potential for archaeological resources in the canyon bottom is considered low. Only three locations are judged to exhibit some archaeological potential and these are detailed in Section 7.

5.5

Social Environment - Recreation

The Kicking Horse River offers the most popular and exciting river adventure in the Canadian Rockies and is extensively used for whitewater rafting and kayaking on both a private and commercial basis. Owing to the extreme conditions in the vicinity of the Yoho (Five Mile) Bridge, the commercial rafting companies do not ride the river between the Glenogle takeout, upstream of the bridge, and the Lower Canyon put-in, downstream from the bridge.

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The TCH between Golden and Roth Creek is part of a fairly popular cycle route, the golden triangle, which includes Golden, Lake Louise and Radium Hot Springs.

Golden View Road, also at the east end of town, would be impacted by any realignment of TCH or noise generated by increased traffic.

5.6 Town of Golden

The Town of Golden is an important service centre for truckers and for tourists travelling through the Rocky Mountains. It is also a popular base for summer recreation activities in addition to whitewater rafting, such as fishing, mountain hiking, rock climbing, hiking and golf. Furthermore, it is close to the Whitetooth Ski (Golden Peaks) area, snowmobiling trails, heli-skiing, ice climbing areas and other winter recreation facilities. Golden has many motels and restaurants, gas stations, food stores and vehicle servicing centres. It also has a backpackers hostel, two recreational vehicle parks, an airport and a hospital. Many of these facilities are located within or close to the TCH corridor and there would clearly be business concerns if the highway was relocated. Most of the residential development in Golden is located across the Kicking Horse River from the TCH and would not be directly affected by highway improvements, other than the Canyon Bottom options.

The location of the ICBC weigh station on the north side of TCH at the bottom of Golden Hill is considered important for the local economy, because once truckers have stopped for the scale they may also stop over for food, accommodation, fuel and any necessary vehicle repairs.

The Gareb residential subdivision, located on the north side of TCH at the east end of Town, together with the trailer park and RV park/campground which is located off

The school, recreation complex, pool, arena and RV park on the south side of the Kicking Horse River at the east end of town, together with the CPR mainline, sidings and yards below Golden Hill, would be negatively impacted by any new routes along the bottom of the Canyon.

Natural environmental issues within the Town of Golden have been discussed in the previous sections under Natural Environment – Fisheries and Wildlife. With regard to archaeological issues, a historic site is recorded close to the highway corridor, and there is good potential for additional historic or archaeological remains, if any undisturbed land is proposed for highway improvements. Agricultural land use extends only as far east as Anderson Road and is unlikely to be affected by highway improvements in this area.

5.7 First Nations

There are no Indian Reserves in the vicinity of the TCH between Golden and Roth Creek. The study area was traditionally utilized by the Ktunaxa, Kutenai and Kinbasket Shuswap peoples, whose descendants are members within the Ktunaxa-Kinbasket Tribal Council. Protocols for archaeological field work and reporting include involvement of local First Nations groups.

SECTION 6

Preferred Canyon Route

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6.0 PREFERRED CANYON ROUTE

6.1 Introduction

SNC-Lavalin's major objectives for the functional planning assignment of the 10 km section of the Trans Canada Highway (TCH) located in Kicking Horse Canyon (from the Town of Golden east limit to the vicinity of Roth Creek) were to:

- Improve the travel speeds, safety and capacity of the highway by developing a divided four lane route through the canyon which can be safely and comfortably driven at a speed of at least 90 km/h, preferably at a speed of 100 km/h, located in areas with minimum exposure to natural hazards such as rockfall, erosion, debris torrents, avalanches, ice falls and mass movements (landslides).
- Ensure the improved TCH route can be built for the least possible cost with minimum closures and disruption to existing traffic and avoiding negative impacts on the Canadian Pacific Railway.
- Minimize negative impacts of the improved route on the natural and social environment i.e. fisheries, wildlife, archaeology and other corridor users.

Existing traffic volumes, the high accident rate and the high operational and maintenance costs on the TCH within Kicking Horse Canyon indicate a need for significant improvements to the highway. In 1992, SNC-Fenco carried out a Corridor and Route Study for the Ministry's Kootenays Regional Office based on criteria for developing a new four-lane freeway for the TCH with a design speed of 110 km/h.

Using, as a starting point, the preferred north side and south side route alternatives that were evaluated in the 1992 study, SNC-Lavalin has now developed and evaluated an additional fourteen route alternatives for the TCH.

The fourteen alternatives can conveniently be considered in four groupings. The first group includes Routes N1 (with tunnel or surface route options in the Black Wall Bluffs area) and N2 and are located on the north side of the Kicking Horse Canyon, the same side as the existing TCH, between Golden and the existing Yoho (Five Mile) Bridge. The second group, Routes S1, S2 and S3, cross to the south side of the Canyon immediately east of Golden, connecting back to the existing TCH east of the Yoho Bridge. The third group, Routes B1 and B2, are located along the Canyon bottom, starting at the existing TCH in the vicinity of the Highway 95 junction, then follow the Kicking Horse River and the CPR as far east as the Yoho Bridge. The fourth group of alternatives, Routes M1, M2, M3, M4, M5 and M6, follow the existing TCH east from Golden then cross to the south side of the Canyon in an area roughly midway between Golden and the Yoho Bridge. The design speed of all of the above alternatives is 100 km/h, except for Routes N2 and M1 which were developed using a design speed of 90 km/h.

Route N1 is located along the existing TCH corridor. However because it is based on a design speed of 100 km/h, this route allows very little use of the existing highway and as a consequence is very costly to construct. This led to the development of alternative Route N2 based on 90 km/h design speed in order to utilize as much of the existing highway as possible. An evaluation of all the route alternatives has involved a review of horizontal and vertical alignments, the structure requirements, geotechnical feasibility and impacts, environmental impacts, constructability and cost. Alternative Route M5 is

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the preferred alternative of all the routes evaluated. (For a plan of this route see Drawing No. 013121-FP-155, in sleeve at back of this report. This drawing is also included in Appendix A along with the profile of Route M5, Drawing No. 013121-FP-165). It is mainly located through friendly geological strata, does not pose excessive constructability challenges and can be built at lower cost than any of the other 100 km/h alternatives. Furthermore, Route M5 has an excellent horizontal alignment and a vertical alignment with a maximum gradient of less than 4% and does not, at this stage, appear to have adverse impacts on the natural environment.

6.2 Highway Classification, Design Criteria and Geometrics

Classification

Based on the projected needs over the next 25 years, it is proposed that the section of TCH between the east limit of the Town of Golden and Roth Creek be classified as a rural arterial-divided, with a design speed of 100 km/h (RAD 100).

Design Criteria

The design criteria is based on RAD 100. Adoption of the M5 route will enable the Ministry to achieve the desirable design standards for all of the normal criteria listed in the Ministry's Standard Design Criteria Sheet.

Geometrics

The proposed horizontal alignment for the Route M5 rural section of TCH between Golden and Roth Creek consists of a series of tangents and gentle horizontal curves, the sharpest radius of which is 900 metres. There are two curves with a radius of 900 metres. This radius, rather than the minimum radius of 440 metres, is employed because in both instances the curves have fairly lengthy tangent approaches and employing a sharper curve would likely reduce safety. Furthermore, there is no significant cost penalty associated with employing the flatter curves. The route includes one major 600 metre long tunnel and four major bridges, three of which span the Kicking Horse River. The first bridge is approximately 145 metres long, the second is approximately 850 metres long, the third is approximately 700 metres long and the fourth is approximately 350 metres long. The rationale for having three crossings over the Kicking Horse River and the Canadian Pacific Railway is as follows:

- The provision of the first two of the long bridges east of Golden (850 metres long and 700 metres long) across the Kicking Horse River and the CPR avoids the construction challenges associated with either a surface route across the front of the Black Wall Bluffs or the provision of two long tunnel sections north of and behind Black Wall Bluffs. The maximum gradient on the M5 route, which avoids both the Black Wall Bluffs and a significant portion of Five Mile Hill, is less than 4%. Furthermore, the maximum elevation of the M5 route is just over 950 metres above sea level, about 60 metres below the maximum elevation of the existing TCH at the top of Five Mile Hill (about 1010 metres above sea level).

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- The third long bridge (350 metres long) is located over and replaces the existing Yoho (Five Mile) Bridge which carries the TCH over the Kicking Horse River and the Canadian Pacific Railway.

The alignment of the Trans Canada through the 600 metre long tunnel consists of a gentle horizontal curve of 2950 metres radius and a tangent. The alignment of the TCH on the first of the long bridges east of Golden across the Kicking Horse River consists of a tangent section in order to facilitate design and construction and to minimize risks associated with bridge icing under winter conditions. The second long bridge east of Golden has a spiral at the east end. The functional plan shows a tangent alignment on the new Yoho Bridge.

Starting at the east limit of the Town of Golden, the proposed profile of alternative Route M5 consists of a gentle crest curve leading to a down grade (in a eastbound direction) of just over 1%. This is followed by a long gentle sag curve (K=245) leading to a 3.7% upgrade through the first part of the tunnel. A gentle crest curve (K=167) starts within the tunnel prior to the east portal and leads into an 0.5% upgrade just east of the east portal of the tunnel. This 0.5% upgrade extends across the first major bridge over the Kicking Horse River and the Canadian Pacific Railway. The 0.5% upgrade leads into a long gentle crest curve (K=179) across the second major bridge over the Kicking Horse River and the railway. At the east end of this second bridge, a down grade of just over 3% leads to the start of the third major bridge over the Kicking Horse River and the railway. The profile across this third bridge consists of a gentle sag curve (K=103) which in turn connects to an upgrade of 1.9%. A series of gently undulating vertical curves which follow the existing highway profile as closely as possible extend from this last point to the existing Trans Canada in the vicinity of Roth Creek near the rest area.

Apart from the portions of the TCH located in tunnel or on long bridges, the proposed cross section of Trans Canada consists of two 3.7 metre wide travel lanes in each direction, 3 metre wide paved shoulders on the outside and a 2.6 metre flush median with concrete median barrier. In areas where concrete road side barrier is required for safety reasons, it should be located on the outside of the 3 metre paved shoulder. The rationale for the 3.0 metre right shoulder is that the proposed ultimate reconstructed four lane TCH will require concrete roadside barrier (CRB) on the outside of the shoulders in most areas in order to prevent errant vehicles and their occupants from either falling down the steep fill slopes or running into a steep cut slope. Ministry design guidelines recommend provision of a 3.0 metre wide paved shoulder on high volume multilane rural arterials adjacent to CRBs so that the doors can be opened on a stopped vehicle without putting the occupants at risk. For functional planning purposes, a 5.0 metre wide ditch has been suggested as a means of containing erosion falls and catching rocks and other falling debris and was used throughout in order to develop templated cross-sections, quantity takeoffs and comparative canyon option cost estimates.

In areas where the horizontal alignment of the highway is on a curve with a radius of less than 1600 metres (100 km/h design speed) the median of the Trans Canada should be widened to 4 metres to provide increased sight distance and minimize the effect of shy distance. On major bridges, *i.e.* greater than 50 metres long, it is proposed that the right hand (outside) shoulder be reduced in width to 2 metres and that the left hand (inside) shoulder be 2 metres wide. Alternatively, the right hand shoulder could be 2.5 metres and the left hand shoulder 1.5 metres resulting in the same overall width. Within tunnels, a 2 metre shoulder is proposed on both the right hand (outside) and left hand (inside) shoulders within the vehicular clearance envelope.

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6.3 Intersections and Access Treatment

Along the existing TCH, between the east limit of the Town of Golden and Roth Creek, there are several intersections; a few forest access roads that connect to the TCH, including the Dart Creek Forest Service Road, which is likely to continue to be in use for the foreseeable future, and two access roads which are used by the Canadian Pacific Railway. Just east of Roth Creek, there is an access to a landing area for rafts and kayaks. An access is provided to the rest area on the north side of the TCH east of Roth Creek and there are also a number of pull-offs dispersed along the length of the highway between Golden and the rest area. In the next phase of design, an access management plan should be prepared which will address the previously noted existing intersections, with a view to closing or maintaining some, relocating others and in some cases providing new intersections.

6.4. Structures

6.4.1 Bridges

Four bridge crossings are required on the M5 alignment through the Kicking Horse Canyon. Conceptual general arrangements for Bridges 2, 3, and 4, the bridges over the Kicking Horse River and the Canadian Pacific Railway, have been developed. Bridge 1, spanning a gully on the north side of the Canyon just east of Golden, will be a conventional structure.

Providing for future lighting or other electrical safety or information systems should be installed on these structures.

Bridge #1:

- Span Arrangement: Total span of 145 metres configured into a three span continuous structure with span arrangement of 45/55/45 metres. The west abutment is at station 402+355, Pier #1 at station 402+400, Pier #2 at station 402+455 and the east abutment at 402+500.
- Abutment and Pier Loads: Abutment total loads in the order of 25 MN and pier loads in the order of 45 to 50 MN.
- Constructability: Abutments are easily accessed for construction and will be of conventional concrete construction. Piers will be in the order of 30 to 35 metres high likely also of conventional concrete construction. Owing to the steepness of the terrain and height of the piers the superstructure will probably be structural steel launched or possibly conventionally erected. The feasibility and economy of using a concrete super structure will also need to be assessed. The deck will be conventional concrete either cast-in-place, precast or a combination.

- Cost: Assume \$2,000.00 per m² at this stage for a total budget of \$7,000,000.

Bridge #2:

- Span Arrangement 2a: Total span of 850 metres configured into a four span cable stayed structure with span arrangement of 120/305/305/120 metres. The west abutment is at station 405+400, Pier #1 at station 405+520, Pier #2 at station 405+825, Pier #3 at station 406+130 and the east abutment is at 406+250.

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- Span Arrangement 2b: Total span of 800 metres configured into a twin arch structure with arch arrangement of 270 and 230 metres. The west abutment is at station 405+400, Arch 1 West Pier at station 405+550, Arch 2 East Pier at station 405+820, Arch 2 West Pier at station 405+870, Arch 2 East Pier at station 406+100 and the East Abutment is at 406+200. The approaches to arches can be trestle type framing or conventional medium span and pier framing depending on geology and economics.
 - Abutment and Pier Loads - Option 2a: Abutment total loads in the order of 100 MN and pier loads in the order of 300 to 350 MN.
 - Abutment and Pier Loads - Option 2b: Abutment total loads in the order of 20 MN and arch pier thrusts in the order of 300 to 350 MN.
 - Constructability -Option 2a: Abutments are easily accessed for construction and will be of conventional concrete construction. Piers will be in the order of 60 to 65 metres high and will likely be conventional concrete construction with hollow core pier legs of variable cross section. The superstructure will probably be structural steel with concrete deck.
 - Constructability -Option 2b: Abutments are easily accessed for construction and will be of conventional concrete construction. Piers for the arches will be a maximum of 60 m high. Approaches will likely consist of short to medium span arrangements on piers. Due to the local geology and the use of arch spans it is thought that this bridge will be constructed with structural steel. The deck will be conventional concrete either cast-in-place, precast or a combination.
 - Cost: Assume at this time the cable stayed structure would be preferred in the conceptual/preliminary design. However the feasibility and economy of using arches will also need to be assessed in subsequent stages of design. On the assumption of a cable stayed structure use \$3,500.00 per m² at this stage for a total budget of \$72,000,000.
- Bridge #3:
- Span Arrangement: Total span of 700 metres configured into a single 250 metre arch structure with approaches. The West Abutment is at station 407+000, the Arch West Pier is at station 407+150 and the Arch East Pier is at station 407+100 and the East Abutment is at 407+700. The approach to the arch can be trestle type framing or conventional medium span and pier framing depending on geology and economics.
 - Abutment and Pier Loads: Abutment total loads in the order of 20 MN and arch pier thrusts in the order of 300 to 350 MN.
 - Constructability: Abutments are easily accessed for construction and will be of conventional concrete construction. Piers for the arches will be a maximum of 60 metres high. Approaches will likely consist of short to medium span arrangements on piers. Due to the local geology and the use of an arch span it is thought that this bridge will be constructed with structural steel. The deck will be conventional concrete either cast-in-place, precast or a combination.
 - Cost: Assume \$3,300.00 per m² at this stage for a total budget of \$56,000,000.
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Bridge #4:

- Span Arrangement: Total span of 350 metres configured into a five span continuous structure with span arrangement of 60/80/90/70/50 metres. The West Abutment is at station 408+500, Pier #1 at station 400+560, Pier #2 at station 408+645, Pier #3 at station 408+730, Pier #4 at station 408+800 and the East Abutment at 402+500. The unbalanced span arrangement is needed to avoid conflicts with the existing bridge, the Kicking Horse River and the Railway.
- Abutment and Pier Loads: Abutment total loads in the order of 35 MN and Pier loads in the order of 75 to 80 MN.
- Constructability: Abutments are easily accessed for construction and will be of conventional concrete construction. The abutments will likely need to be staged to allow completion of wing walls after closure of the existing bridge. Piers will be a maximum of 35 m high and will most likely be of conventional concrete construction. The superstructure will probably be structural steel launched or possibly conventionally erected. The deck will be conventional concrete either cast-in-place, precast or a combination.
- Cost: Assume \$2,000.00 per m² at this stage for a total budget of \$17,000,000.

6.4.2 Tunnels

The proposed tunnels would be twin tube, two-lane highway tunnels (see Figures 6-1 and 6-2) with an approximate excavated cross-sectional area of 107 m². For fire

safety, cross passages with an approximate excavated cross sectional area of 13 m² would be required every 250 metres between the individual tubes.

The minimum pillar width between tubes should be assumed to be one excavated tunnel diameter at the portals. Where possible, the pillar width should then be increased to at least two tunnel diameters over the remaining length of the bores. Where the highway alignment is oblique to the strike of the natural slope profile, it should be assumed that staggered portals will be required to minimize portal excavation volumes.

For the purposes of functional planning, the following assumptions regarding design and construction of the 2 lane tubes have been made:

Excavation:

- Running tunnel: 12.95 m wide; 9.23 m high; D-shape profile
- Cross passages: 3.2 m wide; 3.2 m high; D-shape profile
- Drill and blast excavation with faces advanced from each portal
- Excavation sequence would be 2 top headings trailed by a single bench
- Cross passages would be excavated during excavation of main running tunnels to facilitate equipment and muck handling

Rock Bolt Support:

- Eleven, 4.0 m long fully grouted tensioned bolts on a 1.5 m x 1.5 m pattern in crown
- Six, 2.5 m long fully grouted tensioned bolts on a 1.5 m x 1.5 m pattern in side walls

Shotcrete Lining:

- Crown and sides walls: 150 mm thick steel fibre reinforced silica fume shotcrete
- Rebar spiders used to integrate rock bolts into shotcrete

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- Reinforced Concrete Lining
- Drainage fabric used over crown and side walls
- Fabric connected to slotted 100 mm diameter PVC drains at base of side walls
- 300 mm thick cast in place lining in crown and side walls
- 500 mm thick cast in place base slab

Mechanical:

- Longitudinal ventilation assisted by twin jet fans
- Basic fire suppression systems

Electrical:

- Basic traffic management systems
- Basic CCTV monitoring systems
- Emergency telephones
- Carbon monoxide monitoring systems
- Full length lighting with multiple daytime and a single night time level
- Emergency lighting and power generation
- Approach lighting at portals

The average lengths of cut and cover (C & C) and bored tunnel construction is estimated to be as follows:

M5 Tunnel	Station	Length
West Portal (C & C)	404+100 to 404+160	60 metres
Bored Tunnel Length	404+160 to 404+700	540 metres
East Portal	404+700	110 metres

For tunnel costs a unit cost of \$46,000/linear metre has been assumed for two lane tunnel construction (includes cost of excavation, lining, ventilation, services, control systems etc.). The unit rate has been developed as follows:

Item	Unit Rate	Quantity	Sub-total
Excavation	\$70/m ³	107 m ³	\$7,490/m
Rock Bolts	\$200/m	40 m	\$8,000/m
Shotcrete	\$2,025/m ³	5 m ³	\$10,125/m
Grouting, pumping etc.	\$2500/m	-	\$2,500/m
Drainage	\$500/m	-	\$500/m
Lining	\$900/m ³	14 m ³	\$12,600/m
Lighting	\$800/m	-	\$800/m
Mechanical	\$2,000/m	-	\$2,000/m
Miscellaneous	\$1,000/m	-	\$1,000/m
Crosspassages	\$750/m	-	\$750/m
Sub-Total			\$45,765/m

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This rate is also supported by the historical tunnel cost data, which suggests tunnel costs will likely range from \$40,000 to \$60,000/linear metre for a two-lane structure depending on the ground conditions encountered.

Where cut and cover tunnel portals are required, i.e. for the M5 Tunnel, West Portal, a cost of \$68,000/m/tube is assumed.

The high unit rates are largely due to the extent of excavation and shoring required to construct the excavations for the cut and cover boxes and the large amount of backfill that the boxes will have to support in order to restore the natural slopes for rockfall and avalanche protection. It may be more cost effective to tunnel through the colluvium, rather than try and attempt cut and cover construction, because of the steep topography of the site. These are details which will need to be resolved during preliminary and detailed design.

For the other tunnel portals on M5, where the portal face can be developed directly in rock, a lump sum cost of \$3,000,000 for the twin tubes has been estimated. This cost covers excavation, rock support and rockfall/avalanche protection measures.

6.4.3 Retaining Walls

The following table shows where retaining walls are required for Route M5, their length, average height and wall area:

Station		Length (m)	Average Height (m)	Wall Area (m ²)
From	To			
400+475	400+625	150	5.3	800
401+025	401+125	100	1.5	150
402+325	402+355	30	6.3	190
402+500	403+075	575	9.4	5400
405+075	405+400	325	11.5	3730
406+250	406+675	425	14.7	6250
406+950	407+000	50	15.3	763
407+700	408+500	800	11.1	8850
408+850	409+075	225	10.5	2363
409+275	410+625	1350	7.2	9770
411+150	411+350	200	0.6	125
Total		4230		38391

It is assumed that the majority of the retaining walls constructed will be Mechanical Stabilized Earth (MSE) designs. Suggested unit costs for these walls are \$600/m² for walls less than 20 metres high and \$800/m² for walls higher than 20 metres. A suggested unit cost for reinforced cantilever concrete walls, which may be required below some of the tunnel portals and bridge abutments is \$1000/m².

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6.4.4 Wildlife Crossings

Several wildlife crossing structures between Golden and Roth Creek are recommended to mitigate impacts of highway development on wildlife movements. Existing and/or planned new bridges, viaducts and tunnels will act as crossing structures in combination with wildlife exclusion fencing. See Appendix K for details on types of crossing structures. Figure 6-3 shows the proposed wildlife exclusion system and preferred locations for potential crossing structure sites.

6.5 Drainage and Utilities

Where Route M5 is located along the existing TCH, it will be necessary to relocate some of the existing hydro poles and maintain existing drainage patterns where possible. Direct outfalls into the Kicking Horse River or onto the CPR should be avoided where Route M5 crosses the canyon. Where the route follows a new location on the south side of the canyon it will be necessary to establish new ditches and areas which can retain deleterious materials before they are transported into the Kicking Horse River.

6.6 Geotechnical Considerations

Route M5 is located on the north side of the canyon to a point close to LKI 5, and then crosses the canyon obliquely to the south side. The alignment remains on the south side for a distance of about 1.2 km and then crosses back to the north side to link up with the N1 alignment about 900 m west of the Yoho (Five Mile) Bridge. This alignment includes provision of a 600 metre long tunnel on the north side at approximately the same location as the western tunnel along Route N1, as well as construction of two

major bridges with lengths of about 850 and 700 metres. There is one other smaller bridge approximately 145 m long at about LKI 3.

Tunnel (Stations 404+100 to 404+700)

The tunnel will be developed in weak McKay Group 3 slates/calcareous slates in the western portion and more competent McKay Group 4 limestones in the eastern portion. Tunneling conditions are anticipated to be poor to fair in the McKay Group 3 rock and fair to good in the McKay Group 4 rock.

The approaches to the west portal will be in a combination of soil and rock. Soils comprise a blanket (approx. 1 to 6 metres thick) of colluvium overlying fissile, weak McKay Group 3 slates/calcareous slates. The west portal will be difficult since the proposed alignment is oriented obliquely to the slope of the terrain. Staggered portals with high approach cuts will be required, as well as sheds for rockfall and avalanche protection.

The east portal is located in a steep rock face (McKay Group 4 limestone) and appears to be good portal location; however, scaling, bolting, meshing and fences will likely be required to protect the portal from rockfalls and avalanches.

Bridges

The west major bridge for this alignment will span from the current highway location just west of Dart Creek to a central support pier located on a spur extending out into the river, and then across the river to the south slopes of the canyon. The central pier will

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be founded just north of an existing CPR tunnel through the spur, but at an elevation about 50 metres above the river.

The west abutment of the bridge is proposed to be located on steep bedrock slopes mantled with colluvium just below the current road alignment. The rock in this area comprises thinly bedded limestone that dips gently back into the slope. Vertical stress fractures are common in this rock, which form loose pillars of rock on the surface of the steep natural rock slopes above and below the existing highway. Adequate setbacks from the edge of any bench excavated into rock for the bridge abutment will be required to avoid placing it on loose blocks and some support of the rock below the foundation will likely be required. Space is very limited at this location and additional excavation into the existing highway cut will be required to increase the staging/construction area and maintain traffic flow during construction. Both temporary and permanent rockfall protection will also be necessary at this location. Maintaining traffic flow and construction sequencing at this location will present a challenge. Although the physical and technical constraints at this location are significant, there appears to be a sufficient degree of flexibility in the alignment and abutment design requirements to permit resolution of the issues.

The proposed mid-span pier site is located on a prominent ridge of McKay Group 6 limestone. A CPR tunnel is located near river level at the south end of the ridge. This site appears suitable for the proposed mid-span pier location for either a twin arch or cable stay bridge. The elevation of the top of the ridge where the proposed bridge footing would be located is about 50 metres above the arch of the CPR tunnel. Although remote from the existing road there appears to be ample staging room at this location. However, access for construction traffic would need to be developed.

The east abutment of the crossing structure would likely be founded on a bench in the terrain of the south slopes of the canyon. Despite the presence of some shallow superficial sloughing failures on the steep slopes below the bench, it is not anticipated that these features will unduly influence the design of the proposed bridge footing, provided of course that adequate setbacks from these features can be achieved. More detailed ground survey of the site for preliminary design purposes would be required. Access to the site may be possible from a logging road located further upslope and to the west.

The abutment locations for the second major bridge site have not been reviewed in detail in the field as this alignment was developed after the field reconnaissance was completed. However, based on our previous work in the area, the abutment and pier sites appear reasonable from a geotechnical perspective. Appropriate setbacks will be required from any surficial instability on the south side slopes. On the north side, a bench in the terrain just upslope of the CPR tracks should provide a good location for the east abutment. Some protection from erosion fall/rockfall originating on the high slopes of Five Mile Hill may be required for the bridge abutment/piers on the north side.

6.7**Environmental Mitigation/Protection**

The mitigation measures prescribed in this section are generic in nature due to the preliminary stage of highway planning for the proposed project. Detailed mitigation requirements are to be developed in subsequent planning and design stages as additional details regarding the project become available. Further field studies may be required to refine and finalize mitigation details. Development of such requirements will be done in consultation with the environmental agencies.

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6.7.1 Fish and Aquatic Resources

The following general protection and mitigation measures would likely be required for the proposed M5 route for upgrading this portion of the TCH:

Water Quality Protection and Mitigation Measures

- Incorporate best management practices (BMPs) into all work occurring at environmentally sensitive sites, such as at or near fish-bearing watercourses such as the Kicking Horse River. Such BMPs may include construction practices that isolate the work site from active stream flows or divert smaller stream flows around the work area.
- Provide effective drainage and erosion control at all stream crossings and other environmentally sensitive sites to prevent the discharge of sediment or other harmful substances. Drainage and erosion control structures may include: check dams, rock riprap, gabions, straw bales or rolls, bioengineering features, seeding and mulching, erosion control blankets, energy dissipators, and vegetated waterways.
- Ensure adequate stabilization and rehabilitation of disturbed work sites as soon as practicable after completion of construction. In the event permanent rehabilitation measures are not feasible within a reasonable period, implement temporary measures immediately after construction is completed in an area. Minimize the period that disturbed soils are exposed without some form of erosion protection and/or slope stabilization.

- Develop and implement detailed drainage and sediment control plans, as required, for the project. These plans will require prior approval by the fisheries agencies and are to be consistent with the DFO/MELP Land Development Guidelines.
- Create suitable sediment control features, such as permanent biofiltration systems, to replace disturbed or displaced vegetation buffer areas alongside the TCH. Such features are critical in areas that provide natural biofiltration of drainage from the highway downstream into the Kicking Horse River or into other major stream crossings of the TCH.

Instream Fish Habitat Protection and Mitigation Measures

- Avoid adverse alterations to existing drainage patterns for streams crossing the TCH. Ensure reasonable water quality and stream flow levels are maintained in watercourses to provide food sources, clean water, and nutrients to fish habitat.
- Wherever possible, avoid modifications to stream channels, particularly in fish-bearing streams. On such systems, bridges should be used to span the stream. For small fish-bearing streams, where a clear-span bridge is not practical, consider the use of open bottom culverts to avoid limiting fish passage or altering the streambed.
- Avoid encroachments into active floodplains, particularly within the wetted perimeter of the Kicking Horse River and other major stream crossings of the TCH. Any crossings of the Kicking Horse River should involve a clear span bridge, with piers set back from the high water mark. Furthermore, any proposed retaining walls should be designed and constructed in a manner that avoids direct encroachment within the wetted perimeter of the Kicking Horse River.

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- Devise suitable mitigation/enhancement measures to offset the direct physical loss, displacement or disturbance of fish habitat. Instream sediment control measures may include cofferdams, instream silt barriers, and isolation of sensitive areas.

Riparian Habitat Protection and Mitigation Measures

- Replace any riparian vegetation that is disturbed or displaced from the construction of highway grades or bridge approaches/piers.
- Design and implement a revegetation plan to mitigate the disturbance or loss of any riparian vegetation within 15 metres of the high water marks of all fish-bearing waters. Such revegetation plans will be subject to approval by the fisheries agencies, and will follow criteria provided by those agencies.
- Where possible, provide a leave strip or buffer of undisturbed vegetation at least 30 m along streams, particularly fish-bearing watercourses. If removal of trees and large shrubs is required within a fisheries sensitive zone or on adjacent steep slopes, consider the use of close-cut clearing methods to retain stability on slopes.

Planning and Scheduling

- Conduct activities within or adjacent to the wetted perimeter of any fish-bearing streams, particularly the Kicking Horse River, during periods when fish species are least sensitive to disturbance and when weather conditions are favorable (e.g., during relatively dry periods). Any activities that could adversely affect fish or fish habitat will likely be subject to construction timing windows.

- Avoid conducting construction activities at environmentally sensitive sites during periods of inclement weather.

Environmental Monitoring

- Ensure that the Contractor(s) comply with the MoTH Standard Specifications for Highway Construction: Section 195 – Protection of the Environment, as well as all other applicable regulatory requirements.
- Ensure that a suitably qualified environmental monitor is on-site during the course of the project to ensure proper implementation of the drainage and sediment control plans, as well as other applicable environmental regulatory requirements. Typical activities for which the monitor should be present may include: clearing and grubbing activities, grading operations within or adjacent to riparian or fisheries sensitive zones, installation of stream crossings, construction of bridges or other highway structures over or near watercourses, or any other activity that has the potential to directly or indirectly affect fish or fish habitat.

6.7.2

Wildlife

General principles for mitigation or conservation of wildlife and wildlife habitat include:

Alignment Location

The most advantageous alignment for wildlife is along the southern side of the canyon, because of generally lower wildlife values, assuming that the existing north side

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alignment was decommissioned and reclaimed as wildlife habitat. The worse-case scenario for wildlife is if a southern route is constructed, and the existing alignment is retained. Wildlife movements would then be impacted by two highways and a railway in order to cross the valley.

Viaducts, Bridges and Tunnels as Wildlife Crossing Structures

Options for TCH upgrades that include tunnels, viaducts, or bridges are positive for wildlife because of the reduced impacts on movements or habitat.

All three structures can be used as effective wildlife crossing structures, and can be relatively easily incorporated within a system of wildlife exclusion fencing. Tunnels take the highway underground, allow for the retention of existing habitat, act as land-bridges to connect or reconnect habitat, and remove the potential for road-kill mortality. Viaducts and bridges can allow effective passage of most wildlife underneath the highways. Height above ground of viaducts and bridges is critical however, and a 5 metre minimum height is suggested.

Wildlife Exclusion Fencing

Wildlife exclusion fencing, with tie-ins to crossing structures, is recommended for the TCH between Golden and Yoho (Five Mile) Bridge, regardless of the alignment option. Route M5 presents opportunities for crossing structures in the form of bridges, viaducts and tunnels which can be effectively tied into a fencing system. Fencing will keep large species of wildlife off of the TCH, thereby greatly reducing mortality for the animals and risk of human injury and property damage associated with collisions or interactions between vehicles and wildlife.

Wildlife Habitat

Assuming that wildlife exclusion fencing is used in the Kicking Horse Canyon to direct wildlife to crossing structures, the construction of retaining walls (which usually impede wildlife passage) would be better on the down-slope. This will reduce the footprint of the TCH and reduce the loss of critical ungulate winter range. The existing TCH alignment should be decommissioned and reclaimed as wildlife habitat where feasible. Assuming that exclusion fencing is erected, then all disturbed areas accessible to wildlife should be reclaimed using plant species palatable to ungulates.

Relative Amounts of Mitigation Required

All new alignment options require wildlife crossing structures and wildlife exclusion fencing to mitigate against the impact of the TCH on movements and mortality of wildlife. Mitigation of loss of important wildlife habitat such as ungulate winter range and riparian vegetation can likely be achieved through reclamation of disturbed lands or enhancement of adjacent lands.

Route M5, with one tunnel and three major bridges, is a favourable route for wildlife. These structures would provide about 2.4 km of crossing structure opportunity at four locations (0.63 km of tunnel and 1.8 km of bridges). Additional small crossing structures (underpassing the TCH) may be needed. This rating assumes that the redundant portion of the existing TCH alignment will be decommissioned so there will not be highway on both sides of the Kicking Horse River.

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Route M5 includes a bridge just east of Golden at Lafontaine Road, in an area with very high densities of wildlife. In conjunction with fencing, this structure would provide high quality wildlife passage opportunities.

Dart Creek as a Rock Waste Site

Impacts on use of the Dart Creek valley for wildlife passage could be minimized by minimizing the area required for waste. Loss of wildlife habitat, however, would need to be assessed after the extent of the waste site and access roads was established. Such loss would need to be considered in addition to habitat loss from highway construction, when developing mitigation for wildlife habitat loss throughout the canyon area.

6.7.3 Archaeology

For Route M5 , possible high points of land occur at Sta. 404+100 to 404+200 and at Sta. 404+400 to 404+500. A lower point of land (where a possible bridge support is proposed) occurs at Sta. 405+800 to 405+900.

The following areas associated with bridge approaches, piers and abutments appear to represent somewhat level benches suggestive of some archaeological potential:

Bridge #2	Sta. 405+800 to 405+900
	Sta. 406+200 to 406+300
Bridge #3	Sta. 407+500 to 407+600
Bridge #4	Sta. 408+400 to 408+600

6.8

Right-of-Way

Mitigation and/or protective measures cannot be determined until detailed field reconnaissance has been completed, because selection of such measures depends on the nature of the specific archaeological site and associated landscape conditions.

From east of the east limit of the Town of Golden to Roth Creek, Route M5 is generally located on crown land and will require a nominal minimum right-of-way width of approximately 80 metres. The route crosses the CPR right-of-way on bridges at three locations and it will be necessary to obtain construction or permanent easements from CPR for any temporary works or bridge foundations located within the CPR right-of-way.

6.9

Aesthetics

The M5 route provides significant scenic and aesthetic opportunities.

The existing TCH route, because of its restricted alignment and frequent sharp horizontal curves, does not allow drivers or passengers many opportunities to appreciate the grandeur of the scenery in the Kicking Horse Canyon. Furthermore, there are few vantage points from which an observer can view the road or the manner in which it has been fitted to the landscape.

In contrast, the gentle alignment of the M5 route, its long bridges and its location, which encompasses both sides of the canyon between Golden and Yoho (Five Mile) Bridge, afford many opportunities for travellers to view the canyon and the mountain peaks beyond. Although, outside the scope of this current study, it is proposed the services of

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a landscape architect be engaged in subsequent stages of design, to suggest ways of harmoniously integrating the various design elements of the route such as the bridges, retaining walls, tunnels and tunnel portals, cut slopes, wildlife fencing, tree plantings and miscellaneous landscaping features.

6.10 Construction, Staging and Traffic Management

Owing to the very high cost of Route M5, albeit considerably less than the other 100 km/h design speed alternatives, it will likely be necessary to stage the construction in a series of segments over a period of years starting however as soon as possible. As well as each segment needing to be affordable within the Ministry's multi-year capital program, ideally each segment should be self-contained *i.e.* it can be constructed and opened to traffic immediately upon completion of construction. Furthermore, the multi-year staging of the project should address sections of highway which are a high priority for improvement from the point of view of the accident rate (and potential), the age of the infrastructure or geometric deficiencies.

The preferred Route M5 lends itself to a practical, long term construction staging/package program if it is implemented in the following proposed six segments:

- i) TCH/Highway 95 Intersection to Golden East Town Limit
- ii) TCH-Golden East Town Limit to Tunnel
- iii) Tunnel
- iv) Two Mid Canyon Crossing Structures and Approaches (from east end of tunnel to Five Mile Hill)
- v) Yoho (Five Mile) Bridge Replacement and Approaches

- vi) TCH-East of Yoho (Five Mile) Bridge to Roth Creek

The six segments are shown in order from west to east, from Highway 95 in Golden to Roth Creek. When considering the accident rate, age of infrastructure, geometric deficiencies and construction costs, the following may be an appropriate construction sequence:

- i) Yoho (Five Mile) Bridge and Approaches
- ii) Golden to Tunnel
- iii) Tunnel
- iv) Yoho (Five Mile) Bridge to Roth Creek
- v) Highway 95 to East Town Limit
- vi) Mid Canyon Crossing Structures and Approaches

In order to implement each segment, the following steps and estimated timeframes are envisaged:

- | | |
|---|-----------------|
| • Preliminary Design, including obtaining larger scale topographical mapping and definition of right-of-way | 12 Months |
| • Detailed Design, including preparation of tender ready contract documents | 12 to 18 Months |
| • Additional geotechnical & environmental investigation and monitoring | 12 to 18 Months |

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● Stakeholder Consultation/Information Sessions	6 Months
● Statutory Approvals	12 Months
● Acquisition of Right-of-Way	12 Months
● Construction	12 to 30 Months

Since some of the design steps can proceed in parallel with others, the estimated total time to undertake design, monitoring, consultation, statutory approvals and construction will likely be in the range of three to four years for each segment. The total three year period would likely apply where the construction only involves grading, roadway construction, including retaining walls; the four year period where major bridges and tunnels are required. These overall periods could possibly be reduced by combining preliminary and detailed design and considering alternative delivery mechanisms for the major structures, such as a Design-Build Process.

If a new four lane route between Golden and Roth Creek is not initially affordable, it could be built over a number of years as either a new two-lane two-way route in its entirety, or as a new two-lane two-way route with some more affordable segments being built to four lanes to provide assured passing opportunities. However, it is noted that the ultimate cost of achieving a four lane route will be significantly higher if it is not initially constructed to four lanes, since the cost of a new two lane facility may be 60-70% of the cost of a new four lane facility.

The constructability challenges of Route M5 are less than those of other routes, particularly with respect to maintaining traffic flow during construction because of its generally greater distance away from the existing highway. This is an important advantage of this route since it has been reported that a twenty minute closure of the TCH in the Kicking Horse Canyon has taken four to five hours to clear.

Owing to the strategic importance of the TCH and the lack of any alternative routes within convenient driving time, it is proposed that two lanes of traffic be continuously open during the construction period, apart from brief closures during critical operations such as blasting and removal of rockfall. "Rolling" slow downs of traffic using scout vehicles may be an appropriate measure for certain construction operations. Temporary detours should desirably have a design speed of no less than 50 km/h.

6.11 Possible Short Term Safety Improvements

Inspection of the accident data along the existing TCH between the east limit of the Town of Golden and Roth Creek shows that a large number of accidents are occurring where sharp curves are encountered. This includes the ends and approaches to the existing Yoho (Five Mile) Bridge which are on curves.

If the proposed permanent upgrading of the TCH is delayed, there would be considerable merit in undertaking a number of short term relatively low-cost safety improvements, consisting of the following:

- Install improved pavement markings, signing and lighting on the approaches to and through critically sharp curves where there are currently speed advisories.

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- Remove small rock bluffs where they are blocking vision and reducing decision sight distance.
- Locally improve the alignment on the approaches to the Yoho (Five Mile) Bridge.

6.12 Drawings

The Plan of Route M5 is shown on Drawing No. 013121-FP-155 (in sleeve at back of this report) and the Profile on Drawing No. 013121-FP-165. Both of these drawings are in Appendix A.

6.13 Cost Estimate

The cost estimate for the preferred Route M5 is as follows (in Millions of Dollars, current costs):

Engineering		\$17.3
Land		\$0.7
Construction:		\$312.6
Road Construction	\$75.3	
Structure Construction	\$217.1	
Operational	\$2.3	
Utility	\$0.1	
Other	\$0.9	
Resident Engineering	\$16.9	
Tender Contingency		\$53.3
Total Cost		\$383.9

It is noted that, because of the extreme terrain in the canyon, the provision of full 3.0 metre wide shoulders and continuous 5.0 metre wide ditches in cut sections are very costly. Due to the varying rock cut heights, ditches wider than 5.0 metres may ultimately be recommended as the preliminary and detailed design phases progress. Acknowledging that the Program may not be able to afford provision of full 3.0 metre wide shoulders and that, in some areas CRBs may not be needed, a 2.5 metre wide shoulder would be effective. Subsequent field investigation and design efforts may also determine minimal risk from rockfall in certain areas, thereby allowing for a reduced ditch width.

The following table shows potential cost reductions associated with various combinations of narrower shoulders and ditches.

Shoulder Width (m)	Ditch Width (m)	Savings (\$ Million)
3.0	5.0	—
2.5		3 (0.8%)
2.0		6 (1.6%)
3.0	5.0	—
	4.0	5 (1.3%)
	3.0	11 (2.9%)

The most appropriate widths for the shoulders and ditches will be established during subsequent stages of preliminary and detailed design.

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6.14 Next Steps

Some of the key steps required to carry this important project forward are as follows:

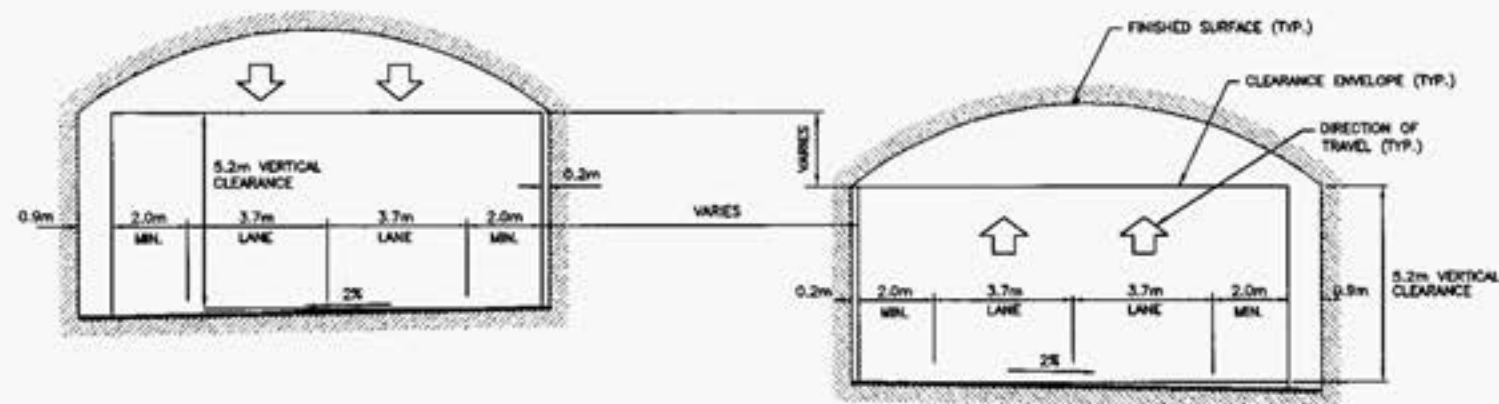
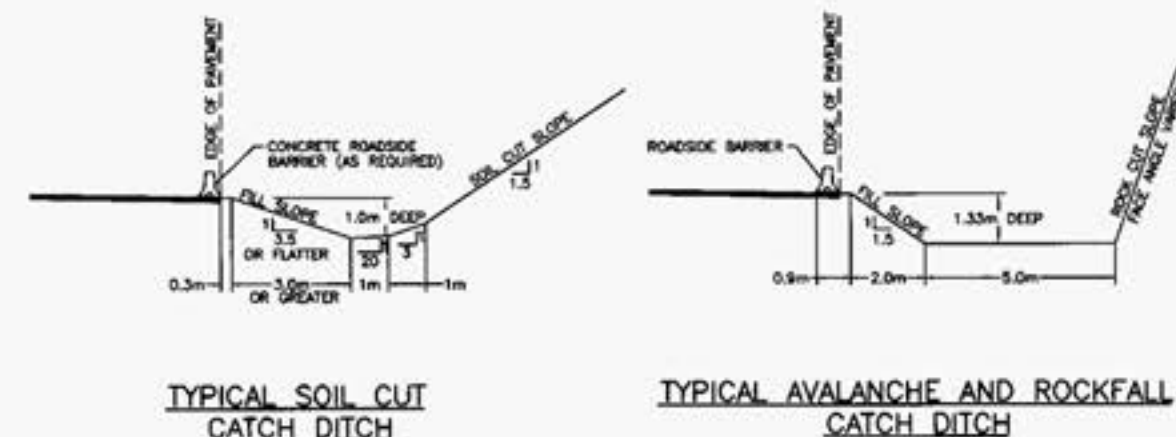
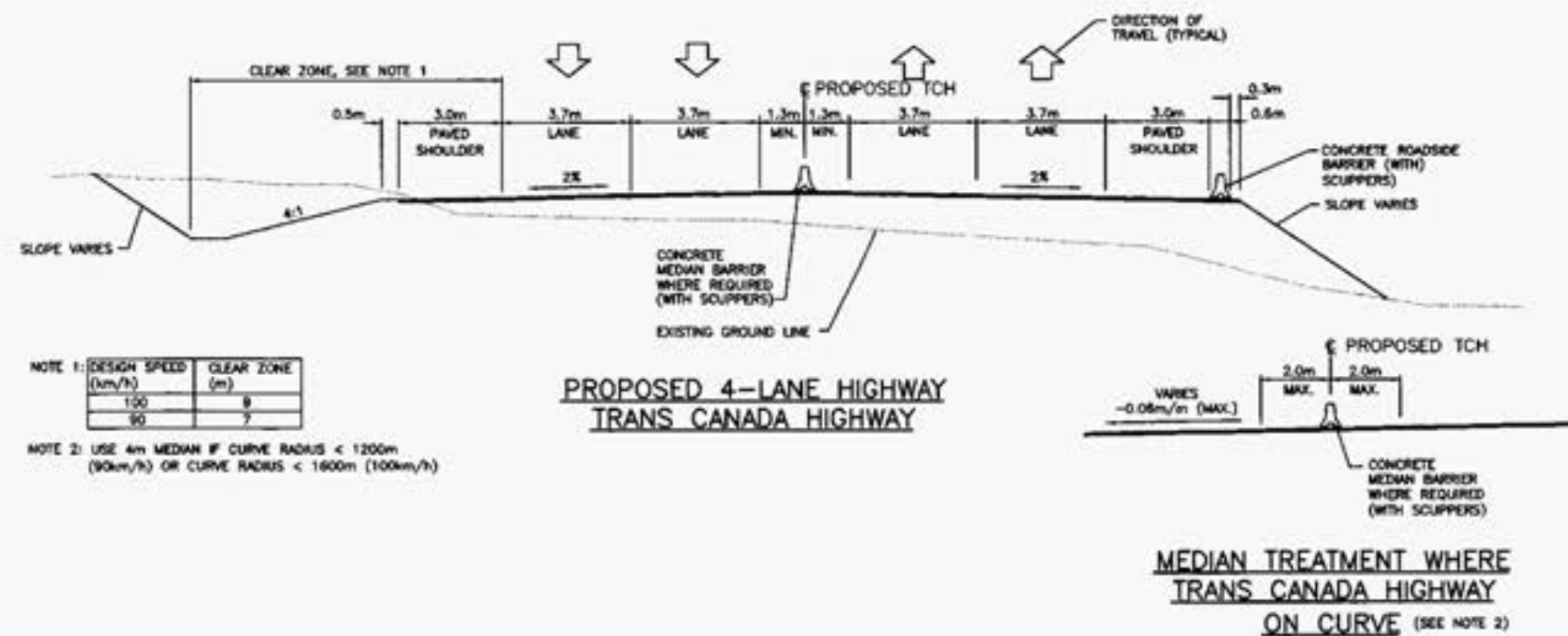
- Obtain larger scale mapping and carry out further ground surveys to provide the necessary basis for preliminary design.
- Undertake preliminary design including required geotechnical investigation and monitoring.

Note 1: The horizontal and vertical alignments of the proposed Yoho (Five Mile) Bridge and approaches have been developed to a preliminary design stage and are now in detailed design stage. In the preliminary design, the sag vertical curve shown on the functional plans on the proposed Yoho (Five Mile) Bridge has been moved off the structure. The cost estimate in Section 6.13 is based on the original M5 horizontal and vertical alignments at the proposed Yoho (Five Mile) Bridge and approaches, as developed for the functional planning route comparisons and evaluations (as shown on Drawing Nos. 013121-FP-155 and 165), and does not include costs developed for the Yoho (Five Mile) Bridge approaches preliminary design work.

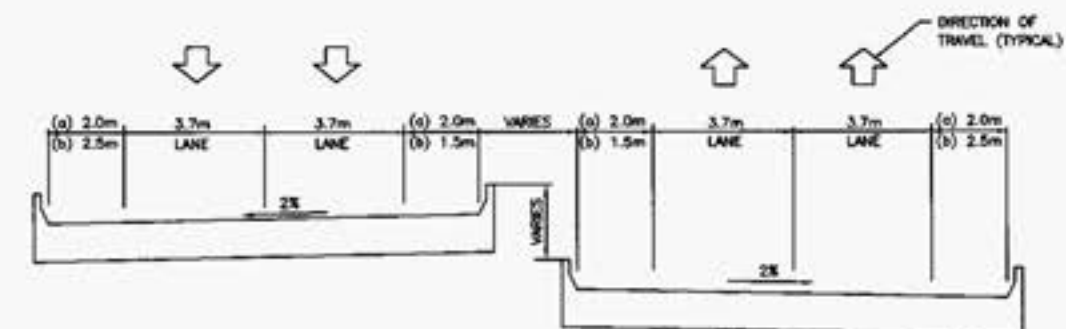
Note 2: Subsequent to the initial assessment and evaluation process for determining the preferred M5 route alignment, a more refined horizontal and vertical alignment was prepared for Route M5 between Yoho (Five Mile) Bridge and Roth Creek. These alignments are shown on Drawing Nos 013121-FP-157 and 167. This study was undertaken in order to optimize the initial functional planning horizontal and vertical alignment, minimize earthworks, reduce the height of retaining walls and facilitate

staging and traffic management by more closely following the existing alignment of the TCH. The cost estimate in Section 6.13 is based on the original M5 horizontal and vertical alignments at the proposed Yoho (Five Mile) Bridge and approaches, as developed for the functional planning route comparisons and evaluations (as shown on Drawing Nos. 013121-FP-155 and 165), and does not include costs developed for the Yoho (Five Mile) Bridge approaches preliminary design work.

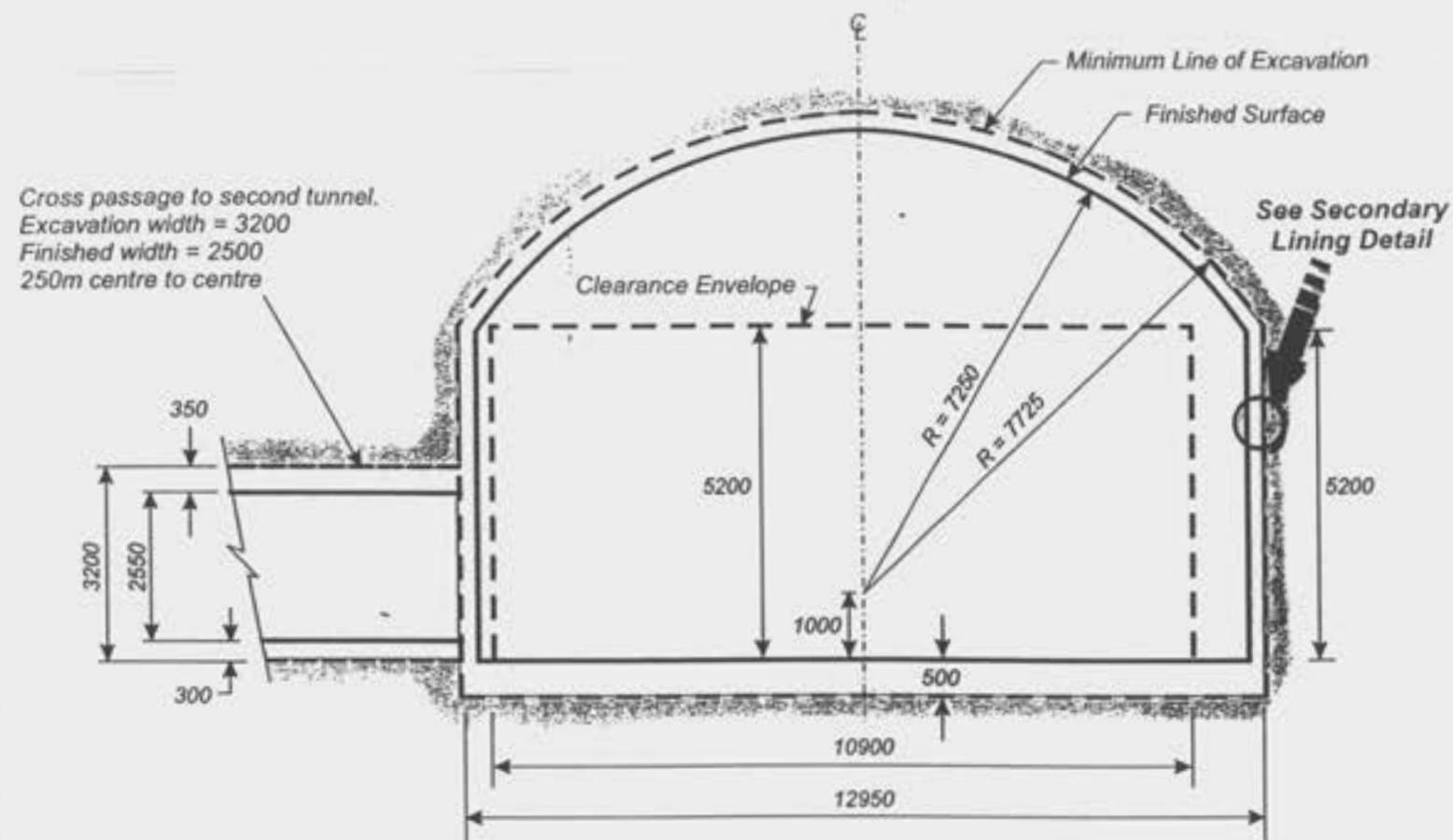
- Conduct further required environmental studies and investigation - fisheries, wildlife and archaeology.
- Initiate stakeholder information and consultation including the Insurance Corporation of British Columbia (ICBC), the Town of Golden, Canadian Pacific Railway, utilities and regulatory agencies such as the Department of Fisheries and Oceans, the Ministry of Environment Lands and Parks, the Canadian Coast Guard and the Canadian Transportation Agency.
- Securing funding partners for the project.



- NOTES:
1. OFFSET BETWEEN TUNNELS IS APPROXIMATELY 2x TUNNEL DIAMETER
 2. FOR PROPOSED TUNNEL DETAILS, SEE SNC-LAVALIN FIGURE 6-2 (GOLDER FIGURE 4)



SCALE 0 1:200 5m 	Province of British Columbia MINISTRY OF TRANSPORTATION AND HIGHWAYS CACHE CREEK TO THE ROCKIES PROGRAM
	TYPICAL CROSS SECTIONS Trans Canada Highway No.1 GOLDEN TO ROTH CREEK FIGURE 6-1
DESIGNED: J. B. B. DATE: MAY '78 CHECKED: J. B. B. DATE: MAY '78 DRAWN: J. B. B. DATE: MAY '78	



CONCEPTUAL TUNNEL GEOMETRY AND CLEARANCE ENVELOPE

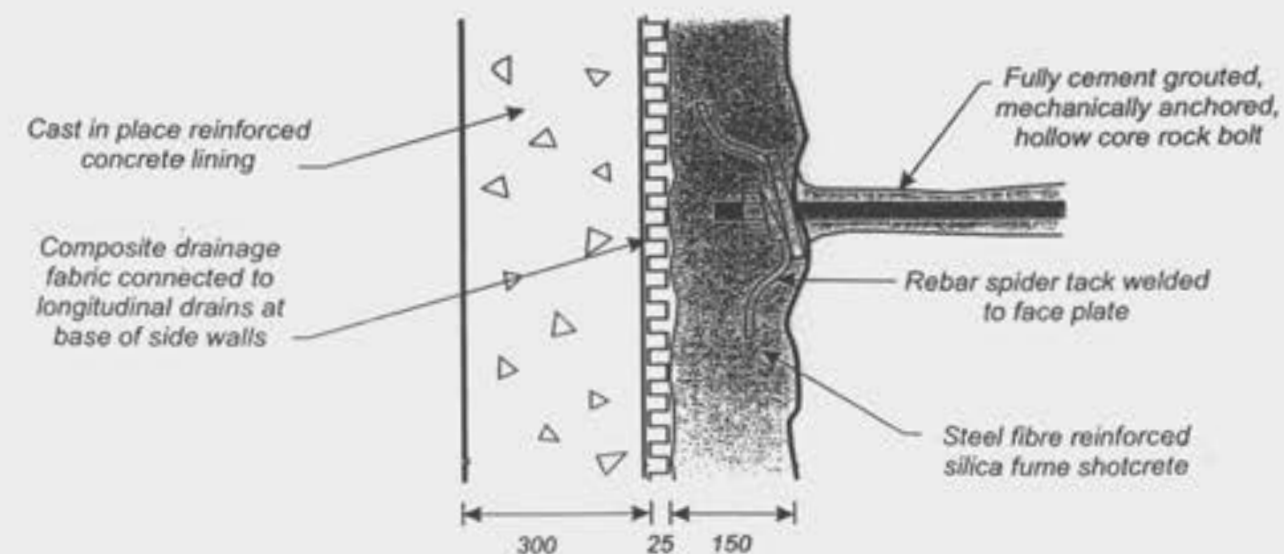
Not to Scale

NOTE : All dimensions in millimeters unless otherwise stated.



TYPICAL PRIMARY SUPPORT REQUIREMENTS FOR EXCAVATION THROUGH POOR QUALITY ROCK

Not to Scale



SECONDARY LINING DETAIL

Not to Scale



ROUTE N1 ALTERNATIVE



ROUTE M5 ALTERNATIVE

LEGEND:

- MODIFIED TCH BRIDGE (WILDLIFE UNDERPASS)
- MODIFIED TCH TUNNEL (WILDLIFE OVERPASS)
- WILDLIFE EXCLUSION FENCING

SCALE:



Province of British Columbia
MINISTRY OF TRANSPORTATION AND HIGHWAYS
CACHE CREEK TO THE ROCKIES PROGRAM

POTENTIAL SITES FOR WILDLIFE CROSSING STRUCTURES
Trans Canada Highway No.1
GOLDEN TO YOHO (5 MILE) BRIDGE
FIGURE 6-3

DESIGNED: J. COOPER DATE: NOV '98
CHECKED: S. BAKER DATE: MAR '99
DRAWN: S. PECO DATE: MAR '99



Alternative Canyon Routes Studied

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7.0 ALTERNATIVE CANYON ROUTES STUDIED

7.1 Introduction

As described in Section 6 of this report, SNC-Lavalin's major objectives for the functional planning of the 10 km of the TCH through Kicking Horse Canyon were to i) improve the travel speeds and capacity of the highway; ii) improve the safety, comfort and reliability of the highway; iii) ensure the improved TCH can be built at the least possible cost with minimum closures and interruption to existing traffic and iv) minimize negative impacts on the environment.

Starting from the preferred north side and south side route alternatives evaluated in the 1992 SNC-Fenco Corridor and Route Studies, SNC-Lavalin assessed a total of fourteen route alternatives for the TCH through the canyon, most of which were developed to a desirable design speed of 100 km/h and some others to a minimum of 90 km/h. (See Drawing No. 018121-FP-130 in Appendix A).

This section of the report briefly describes the rationale for the route alternatives, their geometrics, structures, associated transportation engineering, geotechnical and environmental issues together with constructability. Figures 7-1 and 7-2 are matrices containing a two stage tabular comparison of key groupings of the alternative canyon routes.

In the first stage, the south side route options (S1, S2 and S3), the canyon bottom route options (B1 and B2), the north side route options (N1 and N2) and the initially developed mid canyon crossing route option (M1) were compared on the basis of geometrics,

structures, transportation engineering, geotechnical issues, environmental issues, constructability and relative costs.

In the second stage, the north side route options (N1 and N2) and the preferred mid canyon route option (M5) were compared using the same factors.

Figures 7-3 and 7-4 are matrices containing a two stage empirical evaluation of additional key groupings of alternative canyon routes. The first stage evaluates routes S1, B1 and N1 and the second stage evaluates routes N1, M5 and N2. Tables 7-1, 7-2, and 7-3 contain, for the key groupings of the alternative canyon routes, the estimates of excavation quantities, the required structures and the estimated costs.

Limited 1:2000 mapping, based on a one hundred metre band width centred about the existing Trans Canada Highway, was made available upon which to develop the alignments for the route alternatives. However, because of the geographical range spanned by the various options and design delays that would have been incurred while larger scale mapping was developed, options were developed using on-hand 1:5,000 mapping with coverage that spanned the breadth of the Canyon. Concerns were expressed that the 1:5,000 mapping may not be as accurate as 1:2,000 scale mapping, however, through spot checks between the two mapping scales, it was concluded that elevations on the smaller-scale, 1:5,000 mapping were reasonably accurate compared to the 1:2,000 mapping.

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7.2 North Side Routes

Background

Three alternative routes for upgrading the Trans Canada on the north side of the Kicking Horse Canyon were developed, N1 (100 km/h), N1 Surface (100 km/h), and N2 (90 km/h). The general location of this family of north side routes follows the north side preferred route from the 1992 SNC-Fenco Route Study. However, the reduction in the design speed from 110 km/h (1992) to 100 km/h or to 90 km/h creates greater opportunity to match the existing TCH grade, thus facilitating management of existing traffic and segmental construction staging. These routes tie to the existing TCH at the top of Golden Hill in the west and in the vicinity of the rest area east of Yoho (Five Mile) Bridge in the east and have the flexibility to connect to the possible future Golden North Bypass.

Route N1

This route is located completely on the north side of the river and roughly parallels to the existing TCH alignment. The route incorporates three tunnels to provide a 100 km/hr design speed and avoid the geotechnical constraints associated with a surface route at the Black Wall Bluffs. Apart from the geotechnical issues associated with the proposed tunnels and portals as discussed later, other significant geotechnical constraints for this alignment will be the rockfall and erosion fall hazards on Five Mile Hill, the debris flow and avalanche hazard just east of the Black Wall Bluffs, and the widening of the fill slopes at the western end of the alignment approaching the first tunnel.

East of the east limit of the Town of Golden, Route N1 has a minimum horizontal radius of 900 metres. (West of the east limit of the Town of Golden, Route N1 follows the existing TCH as described in Section 8, Town of Golden). Route N1 has a maximum gradient of 5% over a distance of about 1 km on Five Mile Hill and a maximum gradient of 4% in tunnel over a distance of about 1.3 km. The first tunnel required on this route going east from Golden, is 450 m long (on 1600 m radius curve), the second is 600 m long (on tangent) and the third is 700 m long (on 1000 m radius curve) which is located behind the Black Wall Bluffs. The vertical alignment through the tunnel consists of a long crest curve (K=199) transitioning from an eastbound upgrade of 4% to an eastbound downgrade of 5%. In order to slightly reduce the very high cost of construction, SNC-Lavalin is recommending provision of 2.0 metre wide shoulders on the left (inside) and right (outside) shoulders of the TCH through the tunnels. This 2.0 metre shoulder width, combined with the 1000 m horizontal radius through the tunnel, means that the stopping sight distance for traffic travelling at 100 km/h cannot be fully obtained through the tunnel. In fact, a theoretical design speed of only 91 km/h is obtainable through this tunnel for eastbound traffic in the slow, right hand lane and for the westbound traffic in the fast, left hand lane. Three bridges are required, the first east of Golden is 165 m long (on tangent), the second is 124 m long (on 950 m radius curve) across the mudslide and debris chute in the vicinity of LKI 7.43, and the third, a new bridge over the Kicking Horse River and the Canadian Pacific Railway at the Yoho (Five Mile) Bridge, is 250 m long. Ten major retaining walls are required, 3.5 km long in total as shown in Table 7-2.

This route encounters two slide areas, one in the vicinity of the west entrance to the first tunnel east of Golden, and the second in the vicinity of the west entrance of the second tunnel east of Golden. Maintenance of existing traffic and construction of portals pose

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considerable challenges at the ends of all three tunnels, and in particular at the west end of the first tunnel east of Golden, and at the east end of the third tunnel east of Golden.

Geotechnical Considerations

With regard to tunnel design, the following presents the major geotechnical issues to be considered at the functional planning level.

West Tunnel (Stations 104+130 to 104+700)

This tunnel will be developed in weak McKay Group 3 slates/calcareous slates in the western portion and more competent McKay Group 4 limestones in the eastern portion. Tunneling conditions are anticipated to be poor to fair in the McKay Group 3 rock and fair to good in the McKay Group 4 rock.

The approaches to the west portal will be in a combination of soil and rock. Soils comprise a blanket (approx. 1 to 6 m thick) of colluvium overlying fissile, weak McKay Group 3 slates/calcareous slates. The west portal will be difficult since the proposed alignment is oriented obliquely to the slope of the terrain. Staggered portals with high approach cuts will be required, as well as sheds for rockfall and avalanche protection.

The east portal is located in a steep rock face (McKay Group 4 limestone) and appears to be a good portal location; however, scaling, bolting, meshing and fences will likely be required to protect the portal from rockfalls and avalanches.

Mid Tunnel (Stations 105+025 to 105+750)

This tunnel will be developed in weak McKay Group 5 slates/calcareous slates in the western portion and more competent McKay Group 6 limestones in the eastern portion. Tunneling conditions are anticipated to be poor to fair in the McKay Group 5 rock and fair to good in the McKay Group 6 rock.

The approaches to the west portal will be in a combination of soil and rock. Soils comprise a thick blanket of colluvium (and possibly till) overlying weak fissile McKay Group 5 slate/calcareous slate. Portal construction will be difficult since the alignment is oriented obliquely to the slope of the terrain. A staggered portal will likely be required as well as covered approaches due to avalanche and rockfall hazards. In addition, the alignment is located within the upper portion of the 'central landslide' discussed in Section 4. However, excavation of much of the upper portion of the landslide will be required which should help to increase overall stability of the slide mass.

No significant problems are anticipated with respect to construction of the east portal, however, protection for rockfall/avalanche hazards will be required.

East Tunnel (Stations 106+150 to 107+000)

The tunnel and portals will be developed in weak, black shales of the lower Glenogle formation. Tunneling conditions are anticipated to be poor to fair.

Terrain at the west portal of the tunnel comprises a blanket of colluvium overlying rock and the ground surface rises gradually along the approaches to the portal. There will

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likely be a need for wide ditches for rockfall/avalanche protection on the approach cuts to the portal. Pushing the alignment further into the slope (northwards) may be beneficial by achieving adequate depth of cover for the tunnel more quickly. A staggered portal is not likely to be required. There are no significant geotechnical concerns for this portal.

The east portal is a difficult site. The proposed road grade is some 20 m below the elevation of the existing highway and is located in plan below or immediately south/southeast of the existing highway. The east approaches to the portal will involve cut and cover construction to provide protection to the new highway from future avalanche and rockfall hazards. Careful planning and staging of construction will be required to maintain traffic flow along the existing alignment, but portal development appears feasible from a geotechnical perspective.

Based on site observations, the existing highway appears to be containing most, if not all, of the avalanche material associated with the avalanche path at LKI 7.2. As such, the highway is protecting the CPR tracks located downslope from avalanche hazard. If the natural slope profile is reestablished over top of the new highway alignment (which would be in tunnel or cut and cover at this location), it could put the CPR again at risk from snow avalanches. This will require consideration during preliminary design.

In general, tunnel portal design will be constrained by rock type and the thickness of overburden, as well as the angle of approach of the proposed road alignment to the rock face. For functional planning, one tunnel diameter is proposed as the separation distance between tunnel tubes at portal locations as well as the edge pillar width. Within the main body of the tunnels, separation between tubes should be one diameter or

greater, and maximized to the extent practical. Ultimately, separation widths between tubes and edge pillar widths will likely be greater for tunnels in the weaker rock types. However, these widths will be refined at the preliminary design stage following additional geotechnical site investigations and numerical modeling. In addition, tunneling costs are likely to be higher and production/excavation rates slower in the weaker rock types.

Route N1 Surface

In order to fully achieve 100 km/h design speed and reduce the high costs associated with tunnel construction, SNC-Lavalin developed a version of alternative Route N1 which is located on the surface of the north side of the Kicking Horse Canyon beneath the Black Wall Bluffs. This surface route alternative is shown on Drawing Nos. 013121-FP-130 and 131. It has a horizontal alignment across Black Wall Bluffs consisting of reversing curves with a minimum radius of 440 metres. Management of traffic during construction will be extremely challenging because the profile of the Trans Canada Highway needs to be lowered about 15 metres while existing traffic is maintained. Since the Canadian Pacific Railway is located immediately below this section of highway, sheds or other protective measures would be needed, in consultation with CPR, to protect the railway from the risk of falling rock and other debris. The existing TCH route across Black Wall Bluffs experiences high rock falls and wire nets have been recently installed to reduce the problems associated with falling rock. The N1 surface route alternative would require long term continuing measures to minimize the rock fall problem and, even with rock fall protection, would still require extraordinary ongoing maintenance.

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Route N2

Route N2 was proposed as a potentially more economic surface alternative to N1. In proposing the alignment however, the design speed was downgraded to 90 km/hr. This option essentially follows the existing alignment, but does require one tunnel. The major constraints on this route are exposure to rockfall, avalanche and debris flow hazards and constructing on the steep slopes below the existing highway through the Black Wall Bluffs area.

The general location of Alternative Route N2 follows that of Route N1. The reduction in design speed from 100 km/h to 90 km/h and an increase of maximum gradient from 5% to 5.5% creates greater opportunity to match the existing TCH alignment and grade. The minimum radius of this alternative is 350 metres. The tunnel required is 910 metres long (mainly on tangent) at approximately the same location as the second tunnel east of Golden on Alternative Route N1. Four bridges are required on this route; the first, east of Golden, is 145 metres long (on tangent), the second is 75 metres long (on spiral/curve) in the vicinity of LKI 5.0 and the third is 345 metres long (on a 480 m radius curve) across the mudslide and debris flow chute in the vicinity of LKI 7.43. The fourth bridge is 350 metres long (on tangent) and is the new bridge required over the Kicking Horse River at Yoho (Five Mile) Bridge. As with Route N1 Surface, rockfall protection will be required for Route N2 at Black Wall Bluffs in order to protect TCH traffic over the long term and to protect the Canadian Pacific Railway during construction. The gradients on the vertical alignment of Route N2 are generally similar to that of Route N1 between the east limit of the Town of Golden and Black Wall Bluffs, except that it undulates a little more at the Golden end and has a maximum gradient of just over 5% for a short distance. Between a point east of Black Wall Bluffs and the Yoho (Five Mile)

Bridge, Route N2 has a gradient of 5.5% over a distance of over 800 metres on Five Mile Hill compared with the maximum gradient on Route N1 of 5%. This will have a significant impact on the operation of heavy trucks travelling in either an uphill or downhill direction. Route N2 also goes through the same two slide areas as Route N1. Route N2 requires twelve major retaining walls, 4.2 km long in total, as shown in Table 7-2.

During construction across Black Wall Bluffs, significant temporary earth support works would also be required to minimize the risk of failure/collapse of the existing highway. Construction staging and traffic management issues would be significant and the overall construction risk would be high. While drape nets similar to those already in place could protect the highway from small-scale rockfall, there would still be a residual risk of large-scale rockfalls. These could only be mitigated by placing the highway in tunnel through this area.

As such, adopting a two lane tunnel for westbound traffic combined with a two lane surface route for eastbound traffic for the Blackwall Bluffs area could be a preferable alternative to avoid the risks associated with constructing a four lane surface route across this area. Construction of a surface route through the Black Wall Bluffs area would also require protection of the CPR tracks below. This would likely require full time flag men and equipment to clean the tracks during the construction works. Alternatively, a rockfall shed could be constructed over the tracks; however this would cost approximately \$5,000,000 (based on \$25,000/linear metre).

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Construction of the N2 alignment east of the Blackwall Bluffs is similar to that for N1, hence the constraints in this area are similar. Elsewhere along the alignment, designers would have to consider the impacts of widening onto the existing fill slopes, as well as the size of cuts on the uphill side.

Route N2 will have slightly greater impacts on the natural environment than Route N1 since more of it is constructed on the surface and less of it in tunnel. Route N2 also poses more constructability problems related to maintaining existing traffic than N1, simply because it follows the existing route of the TCH over a greater length.

Environmental Mitigation/Protection

Two North Side options were brought forward for evaluation purposes. Route N1 would require three tunnels, three new bridges and three long retaining walls. The creation of these three tunnels may improve surface water quality conditions somewhat in the local area, as well as cause less disturbance to existing vegetation than other surface route options, such as the other North Side Route N2 and the Mid Canyon Route M5. However, creation of the tunnels would also generate large volumes of blast rock, which would require suitable disposal sites.

Portions of the N1 alignment would result in shifting the existing highway further away from the Kicking Horse River, which would likely benefit water quality in the river. Moreover, the installation of tunnels between LKI 5 to 7 would avoid alteration of five culvert crossings along the TCH. Consequently, this option is preferred from a fish habitat perspective.

Fisheries concerns specific to the N1 option include construction work in close proximity to steep slopes directly above the Kicking Horse River, and requirements for disposal of large volumes of waste/spoil material from tunnel excavations.

The majority of Route N2 follows the existing TCH and involves widening of the existing highway. Route N2 would require one tunnel, two new bridges and three long retaining walls. This route would involve highway improvements in areas closer to the Kicking Horse River than alternative Route N1, which would increase concerns regarding sediment and erosion control. However, these improvements would entail highway widening rather than construction of a completely new grade, which would offset some of these additional concerns with sediment and erosion control.

Fisheries concerns specific to the N2 option include construction work in close proximity to steep slopes directly above the Kicking Horse River.

Both North Side options would require less work in and around areas of riparian vegetation and fish-bearing waters than other options, since the only bridge to build overtop of the Kicking Horse River would be the upgrade of Yoho (Five Mile) Bridge.

N1 and N2 options present good opportunities to enhance wildlife populations in the Kicking Horse Canyon area. Any one of these options, in combination with wildlife exclusion fencing and reclamation of the existing TCH, would be highly preferable to the existing TCH alignment. Loss of any ungulate winter range on the south-facing slopes on the north side of TCH could likely be mitigated.

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From an archaeological perspective, N1 and N2, with a few minor exceptions, generally impact the same landforms.

At the west end, where both options follow the same general route, areas of archaeological potential include the upper heights of Golden Hill.

For Routes N1 and N2, possible benches below the existing highway occur in the vicinity of Sta. 102+700 to 103+300, Sta. 103+600 to 104+000, Sta. 104+100 to 104+300.

At upper elevations above the proposed north options, possible benches occur at Sta. 102+200 to 102+600, Sta. 103+200 to 103+400, Sta. 103+700 to 103+800. The section of the N1 Route which skirts to the north to cut through the Black Wall Bluffs (from Sta. 106+000 to 106+900) is of major concern because an archaeological site has been recorded above Dart Creek and a trail extends to the east from there which may run along the top of the Bluffs. A possible upper bench is crossed by option N1 in the vicinity of Sta. 107+200 to 107+400.

East of Yoho (Five Mile) Bridge, on the south side of the Kicking Horse River, are a few possible benches or terrace remnants associated with Route N2: Sta. 110+000 to 110+100, Sta. 110+300 to 110+500 and Sta. 111+100 to 111+400. In general, the proposed straightening of the alignment east of Yoho (Five Mile) Bridge is crossing either steep slope or disturbed fill.

Conclusions

The two 100 km/h design speed North Side Routes (N1 and N1 surface) were carried forward for evaluation with M5, the most viable 100 km/h design speed route which used the south side of the Canyon. Route N2, the 90 km/h design speed alternative, was also carried forward as a non-preferred fallback option. (Not preferred because it does not meet the desirable 100 km/h design criteria, and despite considerable expenditure, would only increase the nominal posted speed of TCH by 10 km/h, from 80 km/h to 90 km/h).

7.3

South Side Routes

Background

Three south side route alternatives, S1, S2, and S3 were developed. These routes essentially eliminate most of the traffic management problems that are encountered with the north side route alternatives during the construction period.

Route S1

Route S1 is a surface route on the south side of the canyon. This route traverses the main South Landslide, as well as the South Bluffs and Yoho Landslide area just west and south of the Yoho (Five Mile) Bridge. The route also crosses a medium sized avalanche path located in steep terrain where avalanche mitigation measures would be required.

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Alternative Route S1 generally follows the preferred south side route alternative identified in the 1992 Route Study by SNC-Fenco. The alignment of route S1 is shifted at the point where it departs from the existing TCH just inside the east limit of the Town of Golden, compared with the 1992 alignment, in order to avoid the Gareb subdivision. This route has the flexibility to connect to the future Golden North Bypass. The geometry of this route has a minimum horizontal curve radius of 700 metres and a maximum gradient of 5%. The structures required are a 450 metres long bridge (on tangent) over the Kicking Horse River and the Canadian Pacific Railway at the west end of the canyon, a 350 metres long tunnel (partly on 2600 metre radius curve) on the south side of the canyon followed by two viaducts also on the south side of the canyon, one 450 metres long (partly on 2600 metre radius curve) and the second 400 metres long (on tangent). Eighteen major retaining walls are required, 3.5 km long in total. One of the major concerns with this route is that over 800 metres of it is located across the main South Landslide, a large slow moving landslide on the south side of the canyon. The route also crosses a slide area just west of the Yoho (Five Mile) Bridge, where it is also exposed to rockfalls from the cliffs (South Bluffs) on the south side of the canyon. As noted above, it also crosses the old Yoho Slide Area immediately south of the Yoho (Five Mile) Bridge.

Geotechnical Considerations

A surface route across the South Landslide would require very high cuts in weak landslide material and/or extensive retaining structures. Given the strong evidence of the South Landslide being active and observations of terrain conditions in and around the landslide, construction of a roadway surface route across the landslide area is unlikely to be feasible within normally accepted cost and risk constraints. There is

currently insufficient geotechnical information on the size of the landslide and failure mechanism(s) to determine if it would be possible to construct a tunnel through or under the landslide mass. In order to develop a better understanding of the failure mechanism(s), dimensions and overall stability of the landslide, a significant geotechnical investigation including drilling and instrumentation of the landslide would be required. Such an investigation would likely be in the order of several hundred thousand dollars. In addition, subsequent monitoring of the landslide, likely over a period of several years would be required. This work, would by necessity, extend over a period of many years and involve considerable expense with little guarantee of a positive outcome. As a consequence it is proposed that this area be avoided by all potential routes.

Development of a surface route through the South Bluffs area would be extremely difficult. The steep unstable slopes in these areas will not support standard fill construction or high retaining walls. Cuts into the colluvial/silty soils could initiate additional instabilities similar to the Yoho Landslide. In addition, the unfavorable bedrock structure (dipping towards river) could cause potential instabilities in cuts developed in rock. An alignment through this section would also be subject to high rockfall and snow avalanche hazards.

Given the uncertainty surrounding the magnitude and stability of the South Landslide and the significant geotechnical constraints for a route across the steep unstable slopes in the South Bluffs area, the S1 Route is not favoured. Crossing of these areas is not considered feasible within the normal fiscal and risk constraints associated with this type of project. As such, it is proposed that there should be no further consideration of this route.

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Environmental concerns with this route include loss of tree cover, erosion, sedimentation and potential requirements for wildlife fencing and crossings.

Routes S2 and S3

Alternative Routes S2 and S3 were developed and assessed as a means of avoiding the large active slide area on the south side of the canyon. Alternatives S2 and S3 retained the same crossing location at the west end of the canyon and the same alignment east of the South Landslide area as Route S1. Route S2 was based on a tunnel alignment option developed during an earlier canyon study and involves 1.5 km of tunnel (on tangent) including approximately 800 metres of tunnel through the slide area. Route S3 involves a realignment of Route S1 further south to completely avoid the South Landslide area. This latter alternative involves 3.15 km of tunnel on 1500 metres radius curve. Since both Routes S2 and S3 involve considerably more tunnel than Alternative S1, their impacts on the natural environment will be accordingly less. However considerably more spoil materials will be produced from the longer tunnels which will need to be deposited in areas which would not damage the natural environment.

Geotechnical Considerations

Route S2 is similar to that of S1 with the exception that a tunnel is proposed through the South Landslide area. The vertical and horizontal alignment for this route were proposed prior to receiving information on the depth of drill holes and the inclinometer within the landslide. This alignment appears to position the tunnel through the landslide mass. Given that movement is on-going and that the landslide materials are highly

variable, such an alignment is not considered feasible without a detailed geotechnical investigation of the landslide as previously described for the S1 route.

In light of the information received regarding the probable extent of the landslide mass, the alternative Route S3 was formulated which would completely avoid the landslide through provision of a deep tunnel on a horizontal alignment to the south of the known landslide boundaries. This alignment returned to the original S1 alignment about 1.5 km east of the landslide. Apart from the high cost associated with the length of this tunnel, the alignment would still have to cross the unstable South Bluffs area just west of Yoho (Five Mile) Bridge. As with route S1, this is not considered feasible within the normal financial and risk constraints; hence it is proposed that this option be discarded.

Environmental Mitigation/Protection

Route S1 would require a variety of new bridges, tunnels, viaducts and retaining walls. From a fish habitat perspective, the construction of such structures would be of concern given the steep terrain and close proximity of these structures to the Kicking Horse River. Moreover, the geotechnical issues related to construction of this route may also pose fisheries concerns.

Routes S2 and S3 are situated somewhat further away from the Kicking Horse River than Route S1. Route S2 traverses the South Landslide area on the south side of the Canyon, while Route S3 involves a long tunnel presenting concerns related to the disposal of a very large volume of spoil material.

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South canyon options are more advantageous for wildlife than unmitigated north or mid-canyon options because the south side of Kicking Horse Canyon generally has lower wildlife habitat values and lower wildlife use than the north side. Exceptions include: i) the bench immediately southeast of Golden which is good wintering habitat for elk and deer, ii) tie-in with the existing alignment east of Yoho (Five Mile) Bridge for S1, S2, S3, M1, M2, and M3 would likely severely disrupt the mineral lick there.

Much of the south side of the canyon is characterized by steep slope, particularly the eastern two-thirds of the section between Golden and Yoho (Five Mile) Bridge. Although there may be some minor levelling of terrain further along the route, of primary concern would be the joint just east of Golden where the routes cross the river to the south side, that is on Route S1, between Sta. 302+100 to 302+200 and Sta. 302+500 to 302+800. Other areas of potential archaeological interest on route S1 occur at Sta. 304+100 to 304+200 (as small drainage) and Sta. 306+100 to 306+400 (elevated promontory).

The southern extents of options S2 and S3, which have large curves to the south, may cross several approximately level areas which could require further assessment if these routes were developed in future phases of design.

Conclusions

The very high costs for tunnelling associated with Routes S2 and S3 and the fact that S2 does not avoid the south side area, results in these two alternatives being dropped from further consideration. When SNC-Fenco stated a preference for the south side route alternative in 1992, it was just prior to evidence emerging of the large active landslide on

the south side of the canyon. Since there are alternatives to the routes that go through the South Landslide which have comparable performance in terms of TCH operations and safety, in terms of ease of constructability and cost and in terms of the impact on the natural environment, it is proposed to drop Route S1 from consideration. If it had stayed in consideration for further development, lengthy and fairly costly monitoring of the large landslide would have been necessary in order to more accurately assess the risks and problems associated with constructing a new highway across the South Landslide.

7.4

Canyon Bottom RoutesBackground

Although the Kicking Horse River is fast flowing and contains five rapids, it does not have deep, abrupt changes in gradient between Golden and the rest area near Roth Creek. This means that a highway route following the bottom of the Canyon can achieve a fairly gentle gradient as long as it allows for navigation clearance over the Kicking Horse River (for kayaking and other white water craft), and for sufficient railway clearance over the Canadian Pacific Railway. The challenge with this location is to superimpose an acceptable horizontal highway alignment within the serpentine curves of the river, and to minimize impacts on the railway, which moves from side to side in the Canyon, and crosses over and through four bridges and three tunnels. Two routes were developed and assessed, Alternative Route B1 and Alternative Route B2, and both were based on a design speed of 100 km/h. Reducing the design speed to 90 km/h would not achieve any significant cost savings. In order to parallel the alignment of the CPR the

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design speed would need to be reduced in some areas to 60-70 km/h, which is clearly unacceptable for a new segment of the TCH.

Route B1

This route is located at the base of the canyon just above the river. The alignment involves the construction of numerous tunnels and bridges as well as considerable cuts at the base of the existing slopes. In addition, the proposed alignment is situated just above the CPR tracks in several areas. This will restrict CPR's opportunities to twin their tracks in the future should this be necessary.

Route B1 starts on the existing TCH in Golden at the east end of the commercial strip, a short distance west of the junction with Highway 95. From here the route swings to the right of the existing TCH, going in an easterly direction, and follows the north side of the existing CPR tracks at the base of Golden Hill. At the entrance of the Kicking Horse Canyon, the route crosses the CPR and enters a series of tunnels and bridges located on both sides of Kicking Horse Canyon until it reaches a point on the north side of the river beneath Five Mile Hill. From here east the route follows the north side of the Canadian Pacific Railway tracks to Yoho (Five Mile) Bridge where it crosses the Kicking Horse River and the railway and rejoins the alignment of the north side routes (N1, N2) until it reaches the existing TCH in the vicinity of Roth Creek near the rest area.

Through the first portion of Kicking Horse Canyon, from the east limit of the Town of Golden to approximately LKI 7.5, the B1 route alternative is generally located on the opposite side of the river to the Canadian Pacific Railway. This is because the Canadian Pacific Railway is already occupying an existing bench at the base of the canyon and

there is essentially no room left for a new highway. East of approximately LKI 7.5, the route crosses to the north side of the river and follows the CPR in order to avoid some low level landslides on the south side of the river. Along this section, there is more room available on the side of the canyon above the railway. The horizontal alignment of Alternative Route B1 is fairly gentle with a minimum radius curve of 500 metres. The maximum gradient of the route is 4% and the profile is essentially determined by the requirement of minimum vertical clearances over the railway and the Kicking Horse River. This route requires the construction of nine bridges/viaducts and four tunnels, together with extensive retaining walls. One major retaining wall of length 1.6 km is needed within the CPR right-of-way below Five Mile Hill. More than 600 metres of this route is located across the base of the south landslide on the south side of Kicking Horse Canyon. The first CPR tunnel east of Golden may need to be reconstructed because of its proximity to Alternative Route B1. This route has several structures which would encroach into the Kicking Horse River.

Geotechnical Considerations

Apart from the obvious environmental issues of constructing numerous bridge piers and retaining walls in or at the edge of the river, this route requires completion of large cuts at the toe of the South Landslide. Extensive cuts into the toe of unstable, raveling and sloughing slopes adjacent to the CPR siding at the east end of Golden below TCH at about LKI 1.0 would also be required, as would cuts into presently stable road fills along the Five Mile Hill. The alignment would be subject to two small avalanche paths that will require some mitigation.

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Based on Golder's preliminary assessment of the South Landslide, large cuts into the toe of the landslide are not recommended and completion of the route as indicated does not appear feasible.

The encroachment and the proximity of the route to the river at many locations would generate serious risks of erosion and sedimentation during and after construction. Furthermore, the proximity of the highway to the river would generate future risks of river contamination from highway runoff. Since this route is located in a very inaccessible portion of the canyon, it would probably have to be built from end to end, which would stretch out the construction period and generate significant increase in construction costs.

Route B2

As a consequence of the geotechnical concerns noted above in the discussion of alternative Route B1 another canyon bottom alternative was developed, alternative Route B2. Route B2 follows Route B1, except it switches to the north side of the Canyon to avoid the South Landslide. A short distance east of Golden, Route B2 swings north of Route B1 and crosses to the same side of the river as the CPR. It then swings back to cross the Kicking Horse River at the same location as the third railway bridge east of Golden. From here, it approximately follows Route B1 in an easterly direction before crossing the river again and running over the top of the CPR tracks for a short distance before shifting back onto to Route B1 on the north side of the CPR below Five Mile Hill. Route B2 was generated to avoid the base of the South Landslide on the south side of the canyon and also the smaller slides on the north side of the canyon

opposite Five Mile Hill. However, it should be noted that although it avoids the South Landslide, Route B2 still encounters small slide areas on the north side of the canyon.

Geotechnical Considerations

Like the B1 Route, the B2 Route involves the construction of numerous tunnels and bridges, considerable cuts at the base of the existing slopes and the environmental issues of constructing numerous bridge piers and retaining walls in, or at the edge of the river. Extensive cuts into the toe of unstable, raveling and sloughing slopes adjacent to the CPR siding at the east end of Golden below the TCH at about LKI 1.0 would also be required, as would cuts into presently stable road fills along the Five Mile Hill. Where the proposed alignment is situated just above the CPR tracks in several areas construction risks would be high. This alignment will also be affected by two low elevation avalanche paths that will require mitigation.

Environmental Mitigation/Protection

Route B1 would involve the construction of an extensive system of structures, including nine bridges/viaducts and four tunnels, as well as numerous retaining walls. The construction of such structures immediately adjacent to and overtop of the Kicking Horse River has a very high potential to affect fish habitat. As several of the structures would encroach into the Kicking Horse River, unavoidable impacts on fish habitat may result. The operation of an extended section of major highway in this environmentally sensitive location will likely create potentially chronic and acute risks with water quality contamination.

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Route B2 would likely result in similar fisheries concerns and impacts to that of Route B1. Routes B1 and B2 are relatively advantageous for wildlife as numerous bridges and tunnels proposed provide opportunities to enhance wildlife passage across the Kicking Horse River Valley. Routes B1 and B2 also do not require disturbance or loss of good-quality ungulate winter range, which occurs on the south-facing slopes above the river. However, these routes would result in loss and disturbance to relatively rare riparian habitat along the river, through construction of numerous bridge approaches, piers, etc. A canyon bottom alignment may also affect movements up and down the river by wolves, which use the river, especially in winter, as a movement corridor.

Aerial photograph interpretation suggests that there is little level land in the bottom of the canyon that is not already occupied by the railway. In general, the potential for archaeological resources in the canyon bottom is considered low. Only three locations are judged to exhibit some archaeological potential:

- On Routes B1 and B2: small benches/promontories may be present between Sta. 202+700 to 203+000, Sta. 203+400 to 203+500 and Sta. 207+600 to 208+800.
- Routes B1 and B2 also affect areas on the upper plateau noted for the south canyon options judged to have good archaeological potential, between Sta. 202+200 to 202+600.

Conclusions

It is concluded that further consideration of the bottom of the canyon alternatives, Routes B1 and B2 be dropped. The main rationale for not pursuing the development of

these routes is that they are very expensive to build, could cause serious detrimental impacts on water quality and fisheries habitat in the Kicking Horse River and downstream, would require rebuilding of CPR structures and construction of structures over the top of CPR for fairly lengthy distances, could interfere with any plans CPR may have for future twinning of their track and they are in a very inaccessible site that would result in lengthy construction periods. Furthermore, with Route B1, if constructed across the base of the South Landslide on the south side of the canyon, it could in fact trigger more rapid downhill movement of this mass. Although not an overriding concern, it should be noted that the alignment of the bottom of the canyon routes where they tie into the existing TCH in Golden would sever an area south of TCH and west of Highway 95 that is prime land for further highway commercial development.

7.5

Mid Canyon Crossing RoutesBackground

As a result of the traffic management and constructability problems associated with north side routes, particularly in the vicinity of Black Wall Bluffs, and in order to avoid construction of routes across the South Landslide, SNC-Lavalin developed a family of route alternatives that follow the north side of the canyon immediately east of Golden to a point east of the South Landslide area. At a point east of the South Landslide and west of the Black Wall Bluffs, these route options cross to the south side of the canyon and follow the south side to a point east of the Black Wall Bluffs. This series of route alternatives is described as Mid Canyon Crossing Routes of which six were developed and assessed.

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Routes M1 and M2

The first Mid Canyon Crossing Route developed by SNC-Lavalin, M1, was based on a conceptual location, Route M2, generated by Kootenays Region staff. Alternative Route M1, after crossing the Kicking Horse River just east of the South Landslide, follows the south side of the canyon to a point east of Yoho (Five Mile) Bridge. The design speed of M1 is 90 km/h and the maximum gradient is in the range of 5 to 6%. Alternative M1 would require a 1 km long bridge (on tangent and curve) across the Kicking Horse River and curved tunnels at both ends of the bridge.

Geotechnical Considerations

Route M1 was formulated following initial assessment of the South Landslide, but prior to discovery of the instabilities on the south side of the canyon in the South Bluffs area just west of Yoho (Five Mile) Bridge. For the reasons discussed above under the South Side Routes, traversing the South Bluffs area is not considered a viable option, from a geotechnical viewpoint.

Route M2, (variable design speed), the conceptual location generated by Kootenays Region, is similar in many respects to Route M1 except that the canyon crossing is further west and places the eastern abutment for the bridge crossing at the boundary of the South Landslide where the surficial soils are not likely to be stable. This combined with the lack of geotechnical viability of completing a southern route to Five Mile Bridge implies that this option warrants no further consideration.

Conclusions

Because of the requirement of a curving bridge and curving tunnels with a gradient over 4%, alternative Route M1 was not pursued further; however the concept of crossing the canyon from the north side to the south side between the South Landslide and the Black Wall Bluffs was pursued further and led to the generation and assessment of three more Mid Canyon Crossing Routes, known as M3, M4 and M5. Each of these three subsequent Mid Canyon Routes were based on a design speed of 100 km/h and a maximum gradient of 5%.

Routes M3 and M4

Route M3 is based on 100 km/h design speed and is essentially common with the north side route alternative N1 to a point just under 2 km east of the east limit of the Town of Golden. East of this point, M3 swings to the north of Route N1 and is located in a 600 metre long tunnel. It emerges from this tunnel in the vicinity of LKI 5.0 and follows the location of the existing TCH for another 700 metres before swinging south to cross the Kicking Horse River on an 850 metre long bridge (on tangent). From the touch down point on the south side of the canyon, Route M3 then runs along the side of the canyon until it connects to the existing TCH in the vicinity of Roth Creek rest area. In addition to the long bridge across the Kicking Horse River and the tunnel on the north side of the canyon, this route has three viaducts. The first viaduct just east of Golden is 145 metres long, and the second viaduct, on the south side of the canyon, is 250 metres long, followed by another viaduct 100 metres long. Fourteen major retaining walls are required with a total length of 3.4 km.

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Geotechnical Considerations

This route crosses the canyon to the east of Route M1, but adopts the M1 alignment to Yoho (Five Mile) Bridge. For the same reasons as stated for M1 with respect to the South Bluffs area, this option warrants no further consideration.

Conclusions

The geology along Route M3 is generally satisfactory based on known geological information, except for the portion of the route on the south side of the canyon opposite Five Mile Hill where there are a number of surficial landslides on the south side of the canyon above the Kicking Horse River. In order to avoid these landslides, SNC-Lavalin developed another alternative, Route M4 (not shown on drawing, Figure 7-1), which is similar to Route M3, except it avoids the surficial landslides on the south side of the canyon as noted above. During a field trip to the canyon made by SNC-Lavalin and Golder Associates between May 5th and May 7th 1999, evidence of a fresh potentially deep slide area was discovered on the south side of Kicking Horse Canyon just west of Yoho (Five Mile) Bridge and just west of the old Yoho Slide area. As well as very steep slopes down to the river, this area has a number of rock chutes, which showed evidence of recent activity with rocks falling from cliffs above the slopes down the chutes into the river. It was therefore concluded that any routes such as M3, M4 and S1 through this area were not viable because of the risk of major slippage and the rock fall hazards from above.

Route M5

Route M5 follows a similar alignment to Route N1 to a point close to LKI 5, and then crosses the canyon obliquely to the south side. The alignment remains on the south side for a distance of about 1.2 km and then crosses back to the north side to link up with the N1 alignment about 900 m west of the Yoho (Five Mile) Bridge. This alignment includes provision of a 600 m long tunnel on the north side at approximately the same location as the western tunnel along Route N1, as well as construction of three major bridges and one smaller bridge.

Route M5 was developed (based on a design speed of 100 km/h) to avoid the problems associated with Routes M3 and M4 on the south side of the canyon just west of Yoho (Five Mile) Bridge. Route M5 follows the same basic route of Route M3 for about 5 km east of Golden and crosses the Kicking Horse River and the CPR on an 850 metres long bridge. However, after touching down on the south side, the route swings back to the north side of the canyon on another bridge over the river and CPR which is 700 metres long (on tangent). From here east, the route approximately follows the location of the existing TCH on Five Mile Hill, however it is considerably lower than the existing road. Another bridge is provided across the Kicking Horse River and the CPR at Yoho (Five Mile) Bridge. This bridge is 350 metres long and has essentially the same horizontal and vertical alignment as the new Yoho (Five Mile) Bridge required for alternative Route N1. This means that if there is a need for early replacement of the existing Yoho (Five Mile) Bridge, which was built in 1958/59, the decision to rebuild does not require determination of the preferred route for the new TCH west of here towards Golden. Route M5 requires eleven major retaining walls totalling 4.2 km in length. Route M5 has a minimum curvature of 900 metre radius and a maximum gradient of less than 4%.

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The route is generally located over sound geological strata, however the west abutment of the first bridge over the Kicking Horse River and the CPR does pose a number of challenges because of the unknown depth to bedrock under the overlying colluvium and the need to maintain existing Trans Canada traffic during construction of the abutment. The elevation of the top of the proposed abutment is similar to that of the existing TCH at this location. The depth and quality of the bedrock can be ascertained by exploratory drilling. Furthermore, the design of the bridge and the abutment can be tailored to accommodate the conditions encountered. TCH traffic can be maintained on a temporary detour cut into the rock face on the north side of the proposed abutment. This route is common with Route N1 east of Yoho (Five Mile) Bridge and does encroach somewhat into the river as a result of complying with the 100 km/h design. Generally the route does not appear to have serious impact on the natural environment since the piers for the bridges across the Kicking Horse Canyon can be set back from the wetted perimeter of the river.

Geotechnical Considerations

Conditions for the Route M5 tunnel will be similar to those discussed for the western tunnel on Route N1 but with slightly more favourable conditions at the west portal.

The west major bridge for this alignment will span from the current highway location just west of Dart Creek to a central support pier located on a spur extending out into the river, and then across the river to the south slopes of the canyon. The central pier will be founded just north of an existing CPR tunnel through the spur, but at an elevation about 50 metres above the river.

The west abutment of the bridge is proposed to be located on steep bedrock slopes mantled with colluvium just below the current road alignment. The rock in this area comprises thinly bedded limestone that dips gently back into the slope. Vertical stress fractures are common in this rock, which form loose pillars of rock on the surface of the steep natural rock slopes above and below the existing highway. Adequate setbacks from the edge of any bench excavated into rock for the bridge abutment will be required to avoid placing it on loose blocks and some support of the rock below the foundation will likely be required. Space is very limited at this location and additional excavation into the existing highway cut will be required to increase the staging/construction area and maintain traffic flow during construction. Both temporary and permanent rockfall protection will also be necessary at this location. Maintaining traffic flow and construction sequencing at this location will present a challenge. Although the physical and technical constraints at this location are significant, there appears to be a sufficient degree of flexibility in the alignment and abutment design requirements to permit resolution of the issues.

The proposed mid-span pier site is located on a prominent ridge of McKay Group 6 limestone. A CPR tunnel is located near river level at the south end of the ridge. This site appears suitable for the proposed mid-span pier location for either a twin arch or cable stayed bridge. The elevation of the top of the ridge where the proposed bridge footing would be located is about 50 m above the arch of the CPR tunnel. Although remote from the existing road there appears to be ample staging room at this location. However, access for construction traffic would need to be developed.

The east abutment of the crossing structure would likely be founded on a bench in the terrain of the south slopes of the canyon. Despite the presence of some shallow

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superficial sloughing failures on the steep slopes below the bench, it is not anticipated that these features will unduly influence the design of the proposed bridge footing, provided of course that adequate setbacks from these features can be achieved. More detailed ground survey of the site for preliminary design purposes would be required. Access to the site may be possible from a logging road located further upslope and to the west.

The abutment locations for the second major bridge site have not been reviewed in detail in the field as this alignment was only considered after the field reconnaissance was completed. However, based on previous work in the area the abutment and pier sites appear reasonable from a geotechnical perspective. Appropriate setbacks will be required from any surficial instability on the south side slopes. On the north side a bench in the terrain just upslope of the CPR tracks should provide a good location for the east abutment. Some protection from erosion fall/rockfall originating on the high slopes of Five Mile Hill may be required for the bridge abutment/piers on the north side.

Environmental Mitigation / Protection

Route Options M1, M2, M3 and M4 were previously dropped from further evaluation due to engineering and geotechnical constraints. As an alternative, Route M5 was developed to avoid major geotechnical concerns on the south side of the Canyon. Provisions have already been made to minimize encroachment by this route into the Kicking Horse River. Route M5 would involve the construction of one tunnel, four bridges (including two new bridges over the Kicking Horse River), and major retaining walls.

In terms of fish habitat, Option M5 would likely have fewer concerns than the Canyon Bottom option and South side options. However, the requirement for construction of two additional bridge crossings over the Kicking Horse River would likely pose greater fisheries concerns than the two main North Side options (N1 and N2).

In comparison to the North Side options, the Mid Canyon Option M5 would likely disturb a larger area of riparian vegetation and have a greater potential to affect fish habitat. It would also pose greater difficulties in the management of water quality problems arising from deck drainage off the new bridges. This route would also require land clearing and construction of new grades and structures on the south side of the Canyon in an undeveloped forested area.

Fisheries concerns specific to Option M5 include disturbance to previously undeveloped forested areas and streams, additional loss of riparian habitat and vegetation at new bridge crossings, and long-term water quality issues.

If the Mid Canyon option was to be considered further, detailed fisheries assessment of the south side area would be necessary, requiring additional field work.

The M5 option presents good opportunities to enhance wildlife populations in the Kicking Horse Canyon area. This option, in combination with wildlife exclusion fencing and reclamation of the existing TCH, would be highly preferable to the existing TCH alignment. Loss of any ungulate winter range on the south-facing slopes on the north side of the TCH could likely be mitigated.

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At the west end areas of archaeological potential include the upper heights of Golden Hill. For the M5 Route, possible high points of land occur at Sta. 404+100 to 404+200, Sta. 404+400 to 404+500; a lower point of land (where a possible bridge support is proposed) occurs at Sta. 405+800 to 405+900. A further assessment of preliminary bridge designs proposed for the M5 option resulted in the identification of additional lower benches which could be impacted and may provide archaeological potential at Sta. 406+200 to 406+300, Sta. 407+500 to 407+600 and Sta. 408+400 to 408+600.

Conclusions

Route M5 was considered to have sufficient merit to be carried forward and evaluated alongside the most viable 100 km/h design speed North Side Route.

Route M6

This was the last route alternative to be generated and evaluated. Route M6 follows a similar alignment to Route M1 to a point close to LKI 4.8 and then crosses the canyon obliquely to the south side. The alignment remains on the south side for a distance of about 2 km and then crosses back to the north side, similar to Route M5 to link up with the N1 alignment about 900 m west of the Yoho (Five Mile) Bridge. The M6 alignment includes provision of a 1 km long tunnel on the north side at approximately the same location as the western tunnel along Route M1, a 380 m long tunnel on the south side, and three major bridge structures with lengths of about 630 m, 700 m and 350 m. There are two other smaller bridges, one approximately 145 m long located at about LKI 2.5 and one approximately 190 m long located on the south side of the river. The first crossing of the Canyon east of Golden consists essentially of almost 2.6 km of

continuous, generally curving structures - 1 km long tunnel, the 630 m long bridge, the 380 m long tunnel and the 190 m long bridge. Both tunnels are on 1,000 metre radius curves. The eastbound and westbound roadways in the tunnels are proposed to be separated by at least twice the diameter of the tunnels resulting in the need for the proposed roadways, which emerge from the first tunnel east of Golden and cross the Kicking Horse River, to be on two separate bridges. Eleven major retaining walls are required totalling 3.9 km in length. The design speed is 100 km/h and the minimum horizontal radius is 900 metres. The maximum gradient is 3.5% with a maximum gradient in the tunnels of 2%.

Geotechnical Considerations

Rock conditions for the long west tunnel on Route M6 will be similar to those discussed for the west tunnel on Route N1. The west portal for the M6 tunnel will require high soil nail walls at the approaches and there is likely no need for avalanche/rockfall protection. The east portal will be difficult to construct since it is coincident with the existing highway location and leads directly onto the first long bridge crossing the canyon. The east portal will also require approximately 30 metres of cut and cover construction for rockfall and avalanche protection.

The first long bridge on the M6 alignment, the west bridge, will be curved and span from the current highway location at approximately LKI 4.8 across the river to the south slopes of the canyon. The second major bridge, the central bridge, will be on tangent and cross from the south side of the river to the north side below the Five Mile Hill.

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The abutment locations for these bridges have not been reviewed in detail in the field as the M6 alignment was only considered after the field reconnaissance was completed. However, based on previous work in the area, the abutment and pier sites appear reasonable from a geotechnical perspective, but do present a number of challenges as discussed below.

On the north side of the river, the west abutment of the west bridge will be located at the east portal of the long west tunnel. Space is very limited at this location and additional excavation into the existing highway cut will be required to increase the staging/construction area and maintain traffic flow during construction. Both temporary and permanent rockfall protection will likely be necessary at this location. Maintaining traffic flow and construction sequencing at this location will present a challenge.

The east abutment of the long west bridge and the west abutment of the long central bridge would be founded on the south slopes of the canyon. Despite the presence of some shallow superficial sloughing failures on the steep slopes below these abutment locations, it is not anticipated that these features will unduly influence the design of the proposed bridge footing, provided of course that adequate setbacks from these features can be achieved. More detailed ground survey of these sites would be required for preliminary design purposes.

On the north side of the river, a bench in the terrain just upslope of the CPR tracks should provide a good location for the east abutment of the long central bridge. Some protection from erosion fall/rockfall originating on the high slopes of Five Mile Hill may be required for the east abutment and piers.

For each of the route options, rock socketed piers may be required at the bridge sites, especially in cases where there is limited space for spread footings and/or where the quality of the surficial materials is poor.

Conclusions

Route M6 has a generally favourable horizontal and vertical alignment with a minimum radius horizontal curvature of 900 metres and a maximum gradient of less than 4%. The total bridge length is comparable to Route M5. However, because of its considerably greater length of tunnel compared to Route M5 and greater length of bridge on curve, M6 results a much greater cost than M5 such that M6 was not carried forward for further evaluation.

7.6

Evaluation of Canyon Route Alternatives

With considerable geotechnical input, environmental input covering archaeology, fisheries and wildlife, and with participation from the Program Management Team, SNC-Lavalin carried out their evaluation of the Canyon route alternatives in a number of stages.

Geotechnical Considerations

Only four of the routes evaluated (N1, N2, M5 and M6) are considered to be feasible options from a geotechnical perspective. Of these, Route M5 is considered to be the preferred geotechnical option. Route N1 poses more geotechnical challenges than Route M5 because of the two extra tunnels whose portals would be technically

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challenging to construct. Route M6 includes an extra tunnel and an extra bridge and has more challenges with respect to traffic management and constructability. Route N2 presents more geotechnical challenges than the M5, M6 and N1 routes and hence is rated as the least preferred of the four.

Route N2 is also considered to be the least safe for future highway users, because of the ongoing danger of large rockfalls and avalanche events which would still affect the highway. Because of the steep terrain at the site, these hazards would be difficult to mitigate with conventional protection measures. Consequently, this route would require frequent on-going maintenance.

Environmental Considerations

In summary, each of the three main options currently under consideration for further development (i.e., Options N1, N2 and M5) presents potential fisheries concerns. With respect to these concerns, Option N1 would be preferred, followed by Option N2 (Surface route upgrade). M5 (Mid Canyon option) would be somewhat less desirable in terms of fisheries concerns. However, with suitable design, habitat mitigation, and environmentally sound construction practices, all three would likely be acceptable as route options.

In summary, with regard to the three major primary options (N1, N2, M5) under consideration for further development, no major archaeological concerns are expected, with the possible exception of the vicinity of Dart Creek and Black Wall Bluffs, if disturbance is anticipated at the upper heights. Given that exception, there is little to choose between these three options with respect to archaeological issues, although the north canyon routes have a few more areas of archeological potential. All will require

field investigations, not necessarily limited to the above noted landscape features; intensive field examination may reveal other areas of archaeological potential. Plans for geotechnical testing with respect to these canyon options will need to be reviewed in order to assess requirements for archaeological field reconnaissance prior to ground disturbance.

A route options comparison matrix (Figure 7-1) was initially prepared in March/April 1999 that compared Routes S1, B1, N1 and M1. These four route options were compared in terms of their geometrics, structures, transportation engineering, geotechnical engineering, environmental impacts, constructability and preliminary costs. Following this initial comparison, two routes were carried forward for further study, namely the North Side Route N1 and the Mid-Canyon Crossing Route M1.

In May 1999, a second options/alternatives comparison matrix was prepared (Figure 7-2). In this second phase comparison, Routes N1, M5 and N2 were compared, again in terms of their geometrics, structures, transportation engineering, geotechnical engineering, environmental impacts, constructability and preliminary costs.

The two routes, N1 and M5, were considered to be the two front running candidates after the May 1999 comparative study. Route N2 (90 km/h design speed) was also, as previously noted, carried forward as a non-preferred fallback option.

Route M6 was compared with Route M5, the front running Mid Canyon crossing candidate, resulting from earlier studies. Although Route M6 requires slightly less total length of bridges than Route M5 (2015 m versus 2045 m), it requires considerably greater length of tunnel (1400 m versus 600 m). Furthermore for Route M6 the 630

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metre long bridge at the first crossing of the Canyon east of Golden requires approximately 400 metres of curving structure. The first crossing of the Canyon east of Golden required for Route M5 is entirely on tangent. Route M6 is estimated to cost \$74.5 Million more than Route M5.

SNC-Lavalin considers that the Mid Canyon Crossing Route M5 to be the preferred route for a new four-lane TCH in Kicking Horse Canyon. This route allows for the development of excellent horizontal and vertical alignment geometrics (minimum horizontal curvature is 900 metres and the maximum gradient within the Canyon is less than 4%) resulting in improved safety and considerable savings in operating costs, particularly for heavy truck combinations. Subject to further site investigations, this route takes advantage of generally favourable ground geology and it appears that impacts on the natural environment can be mitigated. Furthermore, it will be simpler to manage existing traffic and stage construction for this route than for routes studied that stay on the north side of the canyon. Route M5 has considerably less length of tunnels than its closest competitor, the north side 100 km/h design speed route alternative (N1). This results in less unknowns associated with building long, deep tunnels, a greater perception of comfort and safety for the travelling public and considerably lower construction costs.

It is noted that the location of the proposed Yoho (Five Mile) Bridge horizontal and vertical alignments are essentially common to both the short listed route alternatives (N1 and M5) which were studied. Therefore, if an early decision is needed to replace the Yoho Bridge, over the Kicking Horse River and the Canadian Pacific Railway, the decision can be made without necessarily committing to either Route M5 or Route N1.

Comparative cost estimates of Routes N1, N1Surface, N2, S1, B1, M3, M5 and M6 are shown in Table 7-3. Two Canyon Route Evaluation Matrices are included (Figure 7-3 and Figure 7-4), covering the initial and secondary evaluation of the alternative canyon routes. A brief inspection of the matrices will demonstrate that the Mid-Canyon Crossing Route, M5, does not score poorly in any of the decision criteria. The North Side Route, N1, scores poorly in two areas i) facilitate constructability and ii) minimize accident rate during construction. The non-preferred North Side Route, N2, scores poorly in i) facilitate constructability ii) minimize accident rate during construction iii) minimize geotechnical risk iv) minimize risk of closure v) minimize CPR risk and vi) maintenance costs. The constructability challenges of Routes N1 and N2 are considerably greater than those of Route M5 with respect to maintaining the flow of traffic during construction, because of their greater proximity to the existing highway. It has been reported that on a recent occasion a twenty minute closure of the TCH in the Kicking Horse Canyon took four to five hours to clear.

Table 7-1 shows the "Excavation Quantities" (in millions of m³) for the alternative canyon routes for which cost estimates are included in Table 7-3 and Figure 7-4.

Route Alternative	N1		N2	S1	B1	M3	M5	M6
	Tunnel	Surface						
Road Excavation (Million m ³)	2.25	2.36	2.32	4.22	4.73	3.39	2.73	2.47
Tunnel Excavation (Million m ³)	0.49	0.32	0.18	0.07	0.38	0.13	0.13	0.28
Total Excavation (Million m ³)	2.74	2.68	2.50	4.29	5.11	3.52	2.86	2.75

Table 7-2 (on the following page), shows a "Summary of the Structures" (Bridges, Tunnels and Retaining Walls) that are required for alternative canyon routes N1, N2, B1, S1, M3, M5 and M6.

7.7

Drawings

Plans and profiles of the alternative canyon routes studied are in Appendix A.

**CACHE CREEK TO THE ROCKIES PROGRAM - FUNCTIONAL PLANNING
TRANS CANADA HIGHWAY - GOLDEN TO ROTH CREEK
SUMMARY OF MAJOR STRUCTURES**

Table 7-2

ROUTE OPTION	BRIDGE			TUNNEL			RETAINING WALL					
	Chainage from to		Length (m)	Chainage from to		Length (m)	Chainage from to		Length (m)	Avg. Height (m)	Wall Area (m2)	
N1	102+370	102+495	125	104+130	104+700	570	100+475	100+625	150	5.0	750	
	107+095	107+220	125	105+025	105+750	725	102+495	103+075	580	12.7	7385	
	108+950	109+300	350	106+150	107+000	850	103+925	104+075	150	5.0	750	
							107+000	107+095	95	18.0	1710	
							107+375	107+525	150	5.8	875	
							107+725	108+950	1225	7.0	8540	
							109+300	109+475	175	10.1	1775	
							109+825	110+275	450	6.3	2825	
							110+375	110+675	300	10.1	3020	
							110+775	111+025	250	11.3	2825	
TOTAL N1			600			2145			3525			30455
N2	102+385	102+510	145	105+025	105+750	725	100+475	100+625	150	5.3	800	
	104+830	104+905	75				102+510	102+825	315	9.9	3125	
	106+960	107+305	345				103+375	103+525	150	1.5	225	
	109+030	109+380	350				104+025	104+225	200	1.5	300	
							104+475	104+575	100	14.0	1400	
							104+905	104+950	45	7.2	328	
							106+075	106+960	885	10.5	9250	
							107+475	107+575	100	9.3	925	
							107+825	109+030	1205	5.8	7010	
							109+380	109+575	195	11.0	2150	
							110+025	110+725	700	7.0	4875	
						110+875	111+075	200	4.6	925		
TOTAL N2			915			725			4245			31311
B1	201+970	202+175	205	202+225	202+605	380	207+205	208+630	1625	8.0	13000	
	202+655	202+750	95	204+750	205+090	340						
	202+985	203+075	90	205+520	205+885	365						
	203+340	203+420	80	206+125	206+530	405						
	203+495	203+635	140									
	203+835	203+920	85									
	204+105	204+290	185									
	207+090	207+210	120									
	208+830	209+240	410									
TOTAL B1			1410			1490			1625			13000

Notes:

- 1) Only the major walls are shown on the drawings
- 2) • Not required for Route Option N1 Surface
- 3) ** Required for Route Option N1 Surface

ROUTE OPTION	BRIDGE			TUNNEL			RETAINING WALL				
	Chainage from	to	Length (m)	Chainage from	to	Length (m)	Chainage from	to	Length (m)	Avg. Height (m)	Wall Area (m2)
S1	302+170	302+655	485	305+255	305+590	335	300+225	300+375	150	2.3	350
	305+645	306+020	375				300+475	300+675	200	8.3	1650
	306+450	306+710	260				300+675	300+925	50	2.0	100
	308+145	308+195	50				301+025	301+125	100	3.0	300
	308+460	308+555	95				302+655	302+675	20	15.8	315
	309+040	309+075	35				304+175	304+225	50	5.0	250
	309+420	309+660	240				304+825	304+925	100	2.0	200
							305+125	305+175	50	8.0	400
							307+075	307+225	150	7.0	1050
							308+100	309+145	1045	0.4	425
							308+425	308+460	35	6.0	210
							308+555	308+725	170	6.9	1175
							309+025	309+040	15	25.3	380
							309+075	309+420	345	21.2	7330
							309+675	309+925	250	12.3	3075
							310+150	310+325	175	2.6	450
							310+625	310+925	300	9.2	2750
							310+975	311+275	300	9.7	2900
TOTAL S1			1540	335			3505			23310	
M3	402+355	402+500	145	404+100	404+700	600	400+475	400+625	150	5.3	800
	405+400	406+250	850				401+025	401+125	100	1.5	150
	407+200	407+450	250				402+325	402+355	30	6.3	190
	407+550	407+650	100				402+500	403+075	575	9.3	5350
	407+900	408+040	140				405+070	405+400	330	11.4	3765
	408+495	408+520	25				406+250	406+675	425	14.9	6325
							406+975	407+200	225	15.9	3575
							407+450	407+550	100	27.4	2735
							407+650	407+900	250	12.4	3100
							408+040	408+175	135	14.9	2015
							408+425	408+495	70	5.2	361
							408+520	409+175	655	19.1	12510
							410+475	410+625	150	12.3	1850
							411+175	411+375	200	5.9	1175
TOTAL M3			1510	600			3395			43901	
M5	402+355	402+500	145	404+100	404+700	600	400+475	400+625	150	5.3	800
	405+400	406+250	850				401+025	401+125	100	1.5	150
	407+000	407+700	700				402+325	402+355	30	6.3	190
	408+500	408+850	350				402+500	403+075	575	9.4	5400
							405+075	405+400	325	11.5	3730
							406+250	406+675	425	14.7	6250
							406+950	407+000	50	15.3	763
							407+700	408+500	800	11.1	8850
							408+850	409+075	225	10.5	2363
							409+275	410+625	1350	7.2	9770
							411+150	411+350	200	0.6	125
TOTAL M5			2045	600			4230			38391	
M6	402+355	402+500	145	403+640	404+660	1020	400+475	400+625	150	5.3	800
	404+670	405+300	630				401+025	401+125	100	1.5	150
	406+060	406+250	190				402+500	403+075	575	13.4	7715
	407+186	407+886	700				405+300	405+500	200	10.3	2050
	408+686	409+036	350				406+575	406+900	325	13.5	4375
							406+000	406+060	60	5.0	300
							406+250	406+325	75	7.0	525
							407+886	408+686	800	12.8	10260
							409+035	409+260	225	10.6	2385
							409+560	410+860	1300	7.5	9800
							411+325	411+425	100	1.0	100
TOTAL M6			2015	1400			3910			38460	

**CACHE CREEK TO THE ROCKIES PROGRAM - FUNCTIONAL PLANNING
TRANS CANADA HIGHWAY - GOLDEN TO ROTH CREEK
CANYON ROUTE ALTERNATIVES - COST ESTIMATES**

TABLE 7-3

	N1		N2	S1*	B1*	M3*	M5	M6
	N1 Tunnel	N1 Surface	(90 km/h)					
ENGINEERING	21.8	18.6	14.1	15.8	22.7	15.7	17.3	20.7
LAND	0.9	0.9	0.9	0.7	0.5	0.7	0.7	0.7
CONSTRUCTION	355.9	303.7	244.6	301.2	407.5	289.6	312.6	374.1
Road Construction	68.1	80.2	84.5	146.1	128.1	92.8	75.3	69.1
Structure Construction	265.7	203.5	142.7	134.3	252.5	177.8	217.1	282.1
Operational	2.4	2.6	2.7	2.6	2.3	2.2	2.3	2.2
Utility	0.2	0.2	0.2	0.1	0	0.1	0.1	0.1
Other	0.6	0.7	0.8	0.6	2.1	0.7	0.9	0.8
Resident Engineering	18.9	16.5	13.7	17.5	22.5	16.0	16.9	19.8
TENDER CONTINGENCY	61.0	52.1	41.8	51.2	69.5	49.4	53.3	63.8
TOTAL COST	439.6	375.3	301.4	368.9	500.2	355.4	383.9	459.3
TOTAL COST (ROUNDED)	440	375	305	370	500	355	385	460

NOTES:

- 1) All costs in Millions of Dollars (1999 Dollars).
- 2) Estimates are for the area of the TCH from the Highway 95 Intersection (LKI 0.00) to the vicinity of the Rest Area (LKI 12.2)
- 3) * There is an unknown cost associated with the risk of routing the TCH through/near the south side Landslide Area.

Options Comparison Matrix (No. 1)

	ROUTE OPTION			
	<i>SOUTH SIDE ROUTE (S1) (100km/h)</i>	<i>CANYON BOTTOM ROUTE (B1) (100km/h)</i>	<i>NORTH SIDE ROUTE (N1) (100km/h)</i>	<i>MID CANYON CROSSING ROUTE (M1) (90km/h)</i>
RATIONALE:	<ul style="list-style-type: none"> General location follows 1992 route study (110km/h) Eliminates most traffic management problems during construction period Alignment at west end of Canyon shifted to avoid Gareb Subdivision Ties to existing TCH at top of Golden Hill and in vicinity of Rest Area east of Yoho (5 Mile) Bridge Flexibility to connect to future Golden North Bypass 	<ul style="list-style-type: none"> Follows Kicking Horse River Canyon bottom and parallels CPR as closely as possible, resulting in a gentle rolling vertical alignment Ties to existing TCH just west of TCH/Highway 95 Intersection and in vicinity of Rest Area east of Yoho (5 Mile) Bridge Generally located on opposite side of river from CPR within Canyon except where it crosses to avoid some low level landslides west of Yoho (5 Mile) Bridge 	<ul style="list-style-type: none"> General location follows 1992 route study; however reduction in design speed from 110km/h (1992) to 100km/h, creates greater opportunity to match existing TCH grade, thus facilitating management of existing traffic and segmental construction staging Ties to existing TCH at top of Golden Hill and in vicinity of Rest Area east of Yoho (5 Mile) Bridge Flexibility to connect to future Golden North Bypass 	<ul style="list-style-type: none"> Conceptual location based on Option 2 generated by Region 3 staff (received by SNC-L January 12, 1999) Location of Kicking Horse River crossing has been shifted to avoid large landslide on south side of Canyon Route avoids Black Wall Bluffs, mud slide (at Sta. 107+150 approx.), and existing 7-8% gradient on TCH west of Yoho (5 Mile) Bridge New location for TCH follows North Side Route from Golden to Sta. 103+200. It then continues east, north of the North Side Route, before swinging south to cross the Kicking Horse River and connect to the South Side Route at Sta. 309+300.
GEOMETRICS:	<ul style="list-style-type: none"> Design speed 90km/h on west approach to new bridge at west end of Canyon Design speed 100km/h on and east of new bridge at west end of Canyon Maximum gradient 5% (4% in tunnels) 	<ul style="list-style-type: none"> Design speed 100km/h Maximum gradient 4% Profile set by minimum vertical clearances over railway (7.01m min. between underside of structure and top of rail) and Kicking Horse River (Navigable Waterway) 	<ul style="list-style-type: none"> Design speed 100km/h Maximum gradient 5% (4% in tunnels) 	<ul style="list-style-type: none"> Design speed 90km/h Maximum gradient (5-6%) subject to further study (4% in tunnels)
STRUCTURES:	<ul style="list-style-type: none"> 485m long bridge (on tangent) over Kicking Horse River at west end of Canyon 335m long tunnel (partly on 2600m R curve) on south side of Canyon One 375m long viaduct (partly on 2600m R curve) and one 260m long viaduct (on tangent) on south side of Canyon Retaining walls required - 3.5km long in total 	<ul style="list-style-type: none"> Series of bridges (8) and tunnels (4) between Sta. 201+800 and Sta. 207+300 (5.5km) Retaining walls needed within CPR ROW between Sta. 207+300 and Sta. 208+750 (1.45km long) New 410m long bridge (on tangent) over river at Yoho (5 Mile) Bridge Retaining walls required - 1.6km long in total 	<ul style="list-style-type: none"> 3 tunnels required - 570m long (on 1600m R curve), 725m long (on tangent) and 850m long (on 1000m R curve) 3 bridges required - 125m long (on tangent), 125m long (on 1000m R curve) and 350m long (on tangent - new bridge over river at Yoho (5 Mile) Bridge) Retaining walls required - 3.5km long in total 	<ul style="list-style-type: none"> Length of bridge over Kicking Horse River subject to further study Length of tunnels (2) and viaducts (2) subject to further study
ALTERNATIVE ALIGNMENTS:	<ul style="list-style-type: none"> Southerly realignment through 1.5km long tunnel (on tangent) from Sta. 303+00 to Sta. 306+800 (S2) Southerly realignment through 3.15km long tunnel (on 1500m R curve) from Sta. 303+000 to 306+800 (S3) 	<ul style="list-style-type: none"> Northerly realignment (Golder) from Sta. 202+600 to Sta. 205+900 (3.3km) to avoid large landslide and from Sta. 206+100 to Sta. 207+400 (1.3km) to avoid smaller slides (B2) These realignments will necessitate building viaducts above and along the CPR tracks 	<ul style="list-style-type: none"> Realignment making more use of existing TCH between Sta. 102+700 and Sta. 105+100 (2.4km) and between Sta. 105+900 and Sta. 108+200 (2.3km). Maximum gradient 5.5% (N2) (90km/h) Realignment making even greater use of existing TCH than N2 between Sta. 106+800 and Sta. 107+400 (600m). Maximum gradient 6% (N3) (90km/h) 	<ul style="list-style-type: none"> Evaluate feasibility of a 100km/h alignment alternative with maximum 5% gradient

Options Comparison Matrix (No. 1)

	ROUTE OPTION			
	SOUTH SIDE ROUTE (S1) (100km/h)	CANYON BOTTOM ROUTE (B1) (100km/h)	NORTH SIDE ROUTE (N1) (100km/h)	MID CANYON CROSSING ROUTE (M1) (90km/h)
TRANSPORTATION ENGINEERING ISSUES:	<ul style="list-style-type: none"> Review of bridge options at Kicking Horse River crossing Refinement of alignment, profile and cross section (including split alignments) Assessment of costs and risks associated with crossing large landslide between Sta. 304+400 and Sta. 305+700 (1.3km) or realigning route around slide area Assess need for future truck lanes (climbing or descending) 	<ul style="list-style-type: none"> Review of bridge options at Kicking Horse River crossings (7 bridges) Refinement of alignment, profile and cross section (including split alignments) Assessment of costs and risks associated with crossing large landslide between Sta. 203+900 and Sta. 205+200 (1.1km) or realigning route around it (B2) Constructability and environmental protection (see below) 	<ul style="list-style-type: none"> Review of bridge options at Kicking Horse River crossing (Yoho (5 Mile) Bridge) Refinement of alignment, profile and cross section (including split alignments) Assessment of management of existing traffic and constructability at tunnel portals (6) and where existing 7-8% gradient on TCH needs to be lowered between Sta. 107+300 and Sta. 108+000 (0.7km) west of Yoho (5 Mile) Bridge Assess need for future truck lanes (climbing or descending) Access to Dart Creek Forest Service Road 	<ul style="list-style-type: none"> Refinement of alignment, profile and cross section (including split alignments) Review of bridge options at Kicking Horse River crossing at mid canyon Assessment of traffic management and constructability of tie-ins with existing TCH at east and west limits of project (as per North Side and South Side Route Options), also where route crosses TCH at west end of new mid canyon crossing of Kicking Horse River Assess need for future truck lanes (climbing or descending)
GEOTECHNICAL ISSUES & COMMENTS:	<ul style="list-style-type: none"> High 400m long bridge over Kicking Horse River at Sta. 302+400 Large landslide between Sta. 304+500 and Sta. 305+100. Extent, depth and stability unknown. Existing information suggests it was moving in 1995/1996 to at least a depth of 128m Tunnelling through landslide anticipated to be very slow and difficult due to ground conditions (slide debris) Tunnelling option behind slide also through weak rock. Feasibility of this tunnel option unlikely due to length If South Side Route (S1) costs are comparable or lower than other route options, detailed geotechnical assessment of the landslide and design of remedial works (eg. drainage adits, excavation/unloading of top of slide, monitoring, etc.) would be required. Time related to such studies could have a significant impact on highway construction scheduling with no assurance of favourable results. The geotechnical investigation of the landslide could potentially be in the order of \$1M Existing inclinometers in landslide should be read regardless of route chosen, and results forwarded to appropriate stakeholders East of landslide have a 300m rock tunnel (Sta. 305+300 to Sta. 305+600) in fair tunnelling 	<ul style="list-style-type: none"> Alignment is frequently in tunnel (4 tunnels) or on structure Split tunnels will require split bridges due to frequency of tunnels and alignment constraints Extensive work within CPR right-of-way; will present construction constraints and natural hazard to CPR Numerous encroachments into the navigable waters of Kicking Horse River Location of tunnels relative to CPR tunnels requires careful review and may necessitate upgrade of CPR tunnels Recommend avoidance of south side through large old landslide area Careful construction through slides on north side required Canyon Bottom alignment will have to follow CPR into Golden and can't tie into north bypass route Significant constructability issues. Access for construction requires starting construction from each end of canyon. Bridges need to be constructed to remove excavated materials; some bridges lead directly into tunnels. There is a lack of suitable staging sites. This will likely increase the unit cost of bridges and tunnels. Constructability issues will likely mean increased difficulty and cost for implementing mitigation measures. 	<ul style="list-style-type: none"> Localized marginally stable fills along existing alignment, potential downslope hazard to CPR Two previous landslides along existing highway (between Sta. 104+100 and Sta. 104+300 and between Sta. 104+800 and Sta. 105+100) Proposed viaducts for surface route on potentially unstable fills Black Wall Bluffs area presents a major rockfall and avalanche hazard; feasibility of 4-lane surface route questionable due to extreme cut heights likely required and steep bedrock slopes extending down to CPR below existing highway Tunnelling will be required on North Side Route for all 90-100km/h alignment options. Due to anticipated high costs for tunnels, lengths should be minimized where possible. Tunnels through variable quality rock will require variable tunnel support and separation requirements and careful checking of edge pillar distances Development of tunnel portals will require careful study (i.e. stepped portals or split grades to take advantage of local conditions, rockfall/avalanche mitigation, divergence of alignments at portals, possible cut and cover sections, etc.) 5% grade constraint on 5-Mile Hill forces alignment below existing highway at Black Wall Bluffs and will require significant retaining walls along the 5-Mile Hill section 	<ul style="list-style-type: none"> Positive components of this option include avoidance of major landslide area and major tunnels Potential long bridge crossing immediately after coming out of short tunnel on north side of canyon Avoids construction of new Yoho (5 Mile) Bridge Rockfall/avalanche hazards to west of Yoho (5 Mile) Bridge between Sta. 308+700 and Sta. 309+400 (same as on South Side Route) Pier location on north side of mid canyon crossing may present potential hazards to CPR during construction Limit of large scale landslide on south side of canyon needs to be assessed relative to south abutment/pier locations; requires additional surface and possibly subsurface investigations

Options Comparison Matrix (No. 1)

	ROUTE OPTION			
	SOUTH SIDE ROUTE (S1) (100km/h)	CANYON BOTTOM ROUTE (B1) (100km/h)	NORTH SIDE ROUTE (N1) (100km/h)	MID CANYON CROSSING ROUTE (M1) (90km/h)
GEOTECHNICAL ISSUES & COMMENTS (Con't):	<ul style="list-style-type: none"> conditions for most of its length Construction of highway over natural terrain from Sta. 305+800 to Sta. 309+400 with several bridges required Rock structure is unfavourable on south side due to structure typically dipping towards Kicking Horse River; may dictate maximum allowable cut slope angles Significant geotechnical hazards (rockfall, avalanche and debris flow) particularly to the west of the Yoho (5 Mile) Bridge below dolomite bluffs (Sta. 308+700 to Sta. 309+400) and locally on steep slopes along the valley bottom Old landslide at east abutment of Yoho (5 Mile) Bridge was activated during construction of cut for bridge abutment Large cuts required in dolomite slopes from Sta. 309+400 to Sta. 309+900 with heavy seepage in cuts East of Yoho (5 Mile) Bridge, will have reconstruction of existing highway in the base of the canyon above south river bank. Retaining structures will likely be founded near river level Generally require additional airphoto interpretation, field reconnaissance, natural hazard assessment and preliminary mapping of observed outcrop exposures along route for functional planning 		<ul style="list-style-type: none"> Significant rockfall/avalanche and debris flow hazards at east end of Black Wall Bluffs and down Five-Mile Hill Constructability issues for new highway at east end of Black Wall Bluffs need serious consideration Encroachment on Kicking Horse River close to Yoho (5 Mile) Bridge Poor ground conditions at approaches to Yoho (5 Mile) Bridge where previous landslides occurred on both sides of bridge during construction of existing highway 	
ENVIRONMENTAL ISSUES:	<ul style="list-style-type: none"> Loss of vegetation & habitat; erosion; sedimentation Need for archaeological reconnaissance River encroachment east of Yoho (5 Mile) Bridge Fisheries impacts at river (clear span) and stream crossings; loss of riparian habitat Wildlife fencing, crossing structures, and increased human access New crossing of Kicking Horse River Impact on mountain goat mineral lick at east end of Yoho (5 Mile) Bridge Rock waste sites and borrow sites Disturbance of extensive section of natural terrain on steep slopes leading down to river (i.e., 	<ul style="list-style-type: none"> Need for archaeological reconnaissance Encroachment of structures into Kicking Horse River (Navigable Waters and fisheries impacts) Risks of erosion and sedimentation during and after construction Loss of vegetation and habitat Long-term water quality issues Need for fisheries reconnaissance Extended sections of construction immediately adjacent to and overtop of Kicking Horse River (major fisheries concerns) Wildlife fencing and crossing structures Minimize impacts to riparian wildlife habitat 	<ul style="list-style-type: none"> Need for archaeological reconnaissance especially in vicinity of Dart Creek River encroachment east of Yoho (5 Mile) Bridge Fisheries impacts at river and stream crossings Construction work in close proximity to steep slopes above River (sediment and erosion concerns) Rock waste sites Loss of vegetation & habitat; erosion; sedimentation Wildlife fencing and crossing structures Impacts to ungulate winter range on south-facing slopes 	<ul style="list-style-type: none"> Need for archaeological reconnaissance Fisheries impacts at river and stream crossings Loss of vegetation & habitat; erosion; sedimentation New stream crossings on south side of canyon Need for fisheries reconnaissance Wildlife fencing, crossing structures, and increased human access Impacts to ungulate winter range on south-facing slopes

Options Comparison Matrix (No. 1)

	ROUTE OPTION			
	<i>SOUTH SIDE ROUTE (S1) (100km/h)</i>	<i>CANYON BOTTOM ROUTE (B1) (100km/h)</i>	<i>NORTH SIDE ROUTE (N1) (100km/h)</i>	<i>MID CANYON CROSSING ROUTE (M1) (90km/h)</i>
ENVIRONMENTAL ISSUES (con't):	<ul style="list-style-type: none"> drainage, erosion and sediment control) Long-term water quality issues Need for fisheries reconnaissance Numerous new stream crossings on south side of canyon 			
CONSTRUCTABILITY:	<ul style="list-style-type: none"> Assess feasibility of crossing large slide Ensure constructability and management of existing traffic at tie in at top of Golden Hill and east of Yoho (5 Mile) Bridge 	<ul style="list-style-type: none"> Assess feasibility of locating within CPR ROW between Sta. 207+200 to Sta. 208+800 (1.6km) Identify potential construction access points and staging areas along route for importing construction equipment and materials and for removal of excavated materials Assess feasibility of crossing large slide Ensure constructability and management of existing traffic at tie in within Golden and across/east of Yoho (5 Mile) Bridge 	<ul style="list-style-type: none"> Assess feasibility of crossing slide areas Ensure constructability and management of existing traffic at terminals and along entire route (route follows or crosses existing TCH at more than a dozen locations) 	<ul style="list-style-type: none"> Assess feasibility of constructing high long span bridge over Kicking Horse River
PRELIMINARY CONSTRUCTION COST ESTIMATE: (For comparison purposes only*)	\$476 Million (Oct. 13, 1999) \$335 Million (April 1, 1999)	\$666 Million (Oct. 13, 1999) \$405 Million (April 1, 1999)	\$617 Million (Oct. 13, 1999) \$337 Million (April 1, 1999)	Not available pending further study
SCHEDULE OF PRE-CONSTRUCTION ACTIVITIES:	<ul style="list-style-type: none"> Geotechnical investigation and monitoring 1999-2001(including South Landslide, South Bluffs & Yoho Landslide) Environmental investigation and monitoring 1999-2000 Permitting and design 2000-2001 	<ul style="list-style-type: none"> Geotechnical investigation and monitoring 1999-2001 (including South Landslide) Environmental investigation and monitoring 1999-2000 Permitting and design 2000-2001 	<ul style="list-style-type: none"> Geotechnical investigation and monitoring 1999 Environmental investigation and monitoring 1999 Permitting and design 1999-2000 	<ul style="list-style-type: none"> Geotechnical investigation and monitoring 1999-2000 (including South Bluffs & Yoho Landslide) Environmental investigation and monitoring 1999-2000 Permitting and design 1999-2001

- i) Does not include Property Acquisition, Planning, Design and Administration Fees, Traffic Management, Environmental Mitigation, Signing, Lighting, Utilities, Drainage, Landscaping, Clearing, Special Geotechnical Treatment
- ii) See Detailed Cost Estimates for breakdown of costs for Route Options S1, B1 and N1

Options/Alternatives Comparison Matrix (No. 2)

	ROUTE OPTION		
	NORTH SIDE ROUTE (N1) (100km/h)	MID CANYON CROSSING ROUTE (M5) (100km/h)	NORTH SIDE ROUTE (N2) (90km/h)
RATIONALE:	<ul style="list-style-type: none"> General location follows 1992 route study; however reduction in design speed from 110km/h (1992) to 100km/h, creates greater opportunity to match existing TCH grade, thus facilitating management of existing traffic and segmental construction staging Ties to existing TCH at top of Golden Hill and in vicinity of Rest Area east of Yoho (5 Mile) Bridge Flexibility to connect to possible future Golden North Bypass 	<ul style="list-style-type: none"> Conceptual location developed from Option 2 generated by Region 3 staff (received by SNC-L January 12, 1999) (M2) and comments received from PMT on April 22, 1999 Location of Kicking Horse River crossing has been shifted east to avoid large landslide on south side of Canyon Route avoids Black Wall Bluffs and mud slide (at Sta. 107+150 approx.); it eliminates the existing 7-8% gradient on TCH west of 5 Mile Bridge New location for TCH follows North Side Route (N1) from Golden to approximate Sta. 103+500. It then continues east, north of the North Side Route, before swinging south to cross the Kicking Horse River at Sta. 406+000. In order to avoid a fresh slide area on the south side of the Canyon just west of Yoho (5 Mile) Bridge the route re-crosses the Kicking Horse River and reconnects to the North Side Route (N1) just west of the west end of the proposed new Yoho (5 Mile) Bridge. Both the proposed horizontal alignment and the profile of M5 and N1 can be common over the new Yoho (5 Mile) Bridge 	<ul style="list-style-type: none"> General location follows N1 (100km/h); however reduction in design speed from 100km/h to 90km/h and increase in maximum gradient from 5% to 5.5%, creates greater opportunity to match existing TCH alignment and grade
GEOMETRICS:	<ul style="list-style-type: none"> Design speed 100km/h Maximum gradient 5% (4% in tunnels) 	<ul style="list-style-type: none"> Design speed 100km/h Maximum gradient just under 4% 	<ul style="list-style-type: none"> Design speed 90km/h Maximum gradient 5.5%
STRUCTURES:	<ul style="list-style-type: none"> 3 tunnels required – 570m long (on 1600m R curve), 725m long (on tangent) and 850m long (on 1000m R curve). (Tunnels listed in order proceeding east from Golden) 3 bridges required - 125m long (on tangent), 125m long (on 1000m R curve) and 350m long (on tangent - new bridge over river at Yoho (5 Mile) Bridge). (Bridges listed in order proceeding east from Golden). Need to ensure bridge abutments and piers have secure foundations Retaining walls required - 3.5km in total 	<ul style="list-style-type: none"> 1 tunnel required - 600m long (mainly on tangent) 3 bridges required over Kicking Horse River approximately 850m long (on tangent), 700m long (on tangent) and 350m long (on tangent). (Bridges listed in order proceeding east from Golden). Length, types and arrangements of bridges (3) over Kicking Horse River subject to further study Need to ensure bridge abutments and piers have secure foundations Retaining walls required - 4.2km long in total 	<ul style="list-style-type: none"> 1 tunnel required - 725m long (mainly on tangent) Bridges required 145m long (on tangent), 75m long, (partly on spiral, partly on 900m R curve), 345m long (partly on 480m R curve, partly on spiral) and 350m long (on tangent - new bridge over river at Yoho (5 Mile) Bridge) Need to ensure bridge abutments and piers have secure foundations Retaining walls required - 4.2km long in total Rockfall protection required at Black Wall Bluffs (nets?)
ALTERNATIVE ALIGNMENTS:	<ul style="list-style-type: none"> At Black Wall Bluffs between approximate Sta. 105+900 and approximate Sta. 107+500 provide a 4 lane surface alternative (100km/h) Split alignment at Black Wall Bluffs (2 westbound lanes in tunnel, 2 eastbound lanes on surface) 		
TRANSPORTATION ENGINEERING ISSUES:	<ul style="list-style-type: none"> Review of bridge options at Kicking Horse River crossing, Yoho (5 Mile) Bridge Refinement of alignment, profile and cross section (including split alignments) 	<ul style="list-style-type: none"> Review of bridge options at Kicking Horse River crossings (two at mid-canyon and one at Yoho (5 Mile) Bridge) Refinement of alignment, profile @ cross section (including split alignments) 	<ul style="list-style-type: none"> Review of bridge options at Kicking Horse River crossing, Yoho (5 Mile) Bridge Refinement of alignment, profile and cross-section Assess need for future truck lanes (climbing, descending or runaway) Accommodation of cyclists and pedestrians in the TCH corridor Road access to Dart Creek (water supply), Dart Creek Forest Service Road, CPR and Kicking Horse River (whitewater rafting)

Options/Alternatives Comparison Matrix (No. 2)

	ROUTE OPTION		
	NORTH SIDE ROUTE (N1) (100km/h)	MID CANYON CROSSING ROUTE (M5) (100km/h)	NORTH SIDE ROUTE (N2) (90km/h)
TRANSPORTATION ENGINEERING ISSUES (con't):	<ul style="list-style-type: none"> Assessment of management of existing traffic and constructability at tunnel portals (6) and where existing 7-8% gradient on TCH needs to be lowered between Sta. 107+300 and Sta. 108+000 (0.7km) west of Yoho (5 Mile) Bridge Assess need for future truck lanes (climbing, descending or runaway) Accommodation of cyclists and pedestrians in the TCH corridor Road access to Dart Creek (water supply), Dart Creek Forest Service Road, CPR and Kicking Horse River (whitewater rafting) 	<ul style="list-style-type: none"> Assessment of traffic management and constructability at tie-ins with existing TCH at east and west limits of project (as per North Side Route Options); also where route crosses existing TCH at west end of first new crossing of Kicking Horse River (east of Golden) Assess need for future truck lanes (climbing, descending or runaway) Accommodation of cyclists and pedestrians in the TCH corridor Road access to Dart Creek (water supply), Dart Creek Forest Service Road, CPR and Kicking Horse River (whitewater rafting) 	
GEOTECHNICAL ISSUES:	<ul style="list-style-type: none"> Drilling required at Kicking Horse River crossing, Yoho (5 Mile) Bridge and along route Additional drilling and monitoring of all slide areas e.g. between Sta. 104+100 and Sta. 104+300 (200m) and between Sta. 104+800 and Sta. 105+050 (250m) to assess depth, nature, extent and rate of movement Construction options for TCH through or across slide areas; also in areas where tunnels, bridge abutments, footings and anchors, extensive cuts, fills or retaining structures are required 	<ul style="list-style-type: none"> Site reconnaissance of route along south side of Canyon Drilling at Kicking Horse River Crossings and along balance of route Ensure bridge foundations are secure and not in slide risk areas Additional drilling and monitoring of all slide areas e.g. between Sta. 404+100 and Sta. 404+300 (200m) and between Sta. 404+800 and Sta. 405+300 (500m) to assess depth, nature, extent and rate of movement Construction options for TCH through or across slide areas; also in areas where tunnel, bridge abutments, footings and anchors, extensive cuts, fills or retaining structures are required Rockfall and avalanche protection 	<ul style="list-style-type: none"> Drilling required at Kicking Horse River crossing, Yoho (Five Mile) Bridge and along route Additional drilling and monitoring of all slide areas e.g. between Sta. 104+100 and Sta. 104+300 (200m), between Sta. 104+800 and Sta. 105+050 (250m) to assess depth, nature, extent and rate of movement Construction options for TCH through or across slide areas; also in areas where tunnel, bridge abutments, footings and anchors, extensive cuts, fills or retaining structures are required Rockfall and avalanche protection
ENVIRONMENTAL ISSUES:	<ul style="list-style-type: none"> Rock waste and borrow sites Need for archaeological reconnaissance especially in vicinity of Dart Creek and Black Wall Bluffs River encroachment east of Yoho (5 Mile) Bridge Fisheries impacts at river and stream crossings Wildlife fencing and crossing structures Impacts to ungulate winter range on south-facing slopes Loss of vegetation & habitat; erosion; sedimentation Construction work in close proximity to steep slopes above River (sediment and erosion concerns) N1 provides the most options for mitigating impacts on wildlife movement, compared to M5 and N2 	<ul style="list-style-type: none"> Rock waste and borrow sites Need for archaeological reconnaissance River encroachment east of Yoho (5 Mile) Bridge Fisheries impacts at river and stream crossings Wildlife fencing and crossing structures Impacts to ungulate winter range on south-facing slopes Loss of vegetation & habitat; erosion; sedimentation Long-term water quality issues (additional crossings of river) Construction work in close proximity to steep slopes above river (sediment and erosion concerns) Some new stream crossings on south side of canyon Need for fisheries reconnaissance 	<ul style="list-style-type: none"> Rock waste and borrow site Need for archeological reconnaissance especially in vicinity of Dart Creek and Black Wall Bluffs River encroachment east of Yoho (5 Mile) Bridge Fisheries impacts at river and stream crossings Wildlife fencing and crossing structures Impacts to ungulate winter range on south-facing slopes Loss of vegetation & habitat; erosion; sedimentation Construction work in close proximity to steep slopes above river (sediment and erosion concerns)
CONSTRUCTABILITY	<ul style="list-style-type: none"> Assess feasibility of crossing slide areas (2) Ensure constructability and management of existing traffic at terminals and along entire route (route follows or crosses existing TCH at more than a dozen locations) 	<ul style="list-style-type: none"> Assess feasibility of constructing high long span bridges over Kicking Horse River Assess feasibility of crossing slide areas Ensure constructability and management of traffic where route is common with Route N1 and where it crosses existing TCH @ Sta. 405+050 Construction access required to south side of Canyon 	<ul style="list-style-type: none"> Assess feasibility of crossing slide areas (2) Ensure constructability and management of existing traffic at terminals and along entire route (route approximates existing TCH throughout)

Options/Alternatives Comparison Matrix (No. 2)

	ROUTE OPTION		
	NORTH SIDE ROUTE (N1) (100km/h)	MID CANYON CROSSING ROUTE (M5) (100km/h)	NORTH SIDE ROUTE (N2) (90km/h)
PRELIMINARY COST: (For comparison purposes only)	439.6	383.9	301.4
SCHEDULE OF PRE-CONSTRUCTION ACTIVITIES:	<ul style="list-style-type: none">• Geotechnical investigation and monitoring 1999• Environmental investigation and monitoring 1999• Permitting (e.g. NWPA and CPR) and design 1999-2000	<ul style="list-style-type: none">• Geotechnical investigation and monitoring 1999-2000• Environmental investigation and monitoring 1999-2000• Permitting (e.g. NWPA and CPR) and design 1999-2001	<ul style="list-style-type: none">• Geotechnical investigation and monitoring 1999• Environmental investigation and monitoring 1999-2000• Permitting (e.g. NWPA and CPR) and design 1999-2000

CACHE CREEK TO THE ROCKIES PROGRAM
TRANS CANADA HIGHWAY - GOLDEN TO ROTH CREEK

CANYON ROUTE EVALUATION MATRIX- Phase I

Figure 7-3

LEGEND	
○	GOOD
◐	FAIR
●	POOR

DECISION CRITERIA		SOUTH SIDE ROUTE (S1) (100 km/h)		CANYON BOTTOM ROUTE (B1) (100 km/h)		NORTH SIDE ROUTE (N1) (100 km/h)	
SOCIAL/COMMUNITY ISSUES		Eval.	Comments	Eval.	Comments	Eval.	Comments
1. Minimize Urban Land Use Conflicts		◐	Impacts campground & trailer park off Golden View Road	●	Loss of prime commercial land in Golden	○	None
2. Minimize Recreational Land/River Use Conflicts		◐	Bridge over canyon visible from Town Park	●	Highly visible from Town Park & Kicking Horse River, major river encroachments	○	None
3. Minimize Resource Land Use Conflicts		●	Severs forested land on south side of canyon	◐	Less impact than South Side Route	○	
4. Residences Indirectly Impacted (noise, visual, air pollution)		◐	Increased traffic past Gareb Subdivision	●	Closer to residential area of town & school	◐	Increased traffic past Gareb Subdivision
5. Residential Takings (#)		○	None	●	Homes on Station Ave	○	None
6. Business/Institutions Indirectly Impacted (noise, visual, air pollution)		◐	Motels & church along LaFontaine & Golden View Roads	●	CPR sidings/buildings/operations & Town Park	◐	Motels & church along LaFontaine & Golden View Roads
7. Business/Institutional Takings		○	None	●	CPR sidings/buildings/operations	○	None
ENVIRONMENTAL ISSUES							
1. Archaeological Sites Impacted (#)			Unknown, no archaeological survey has been conducted		Unknown, no archaeological survey has been conducted		Unknown, no archaeological survey has been conducted
2. Fish Habitat Impacted		◐	Numerous new stream crossings, sediment & erosion concerns	●	Major encroachments into river, serious water quality issues, considerable potential fisheries impacts. Numerous encroachments on fisheries habitat.	○	Portion of TCH shifted further away from river
3. Wildlife Habitat Impacted (ha)		◐	Fragments forested land on south side of canyon, but wildlife values are lower than on north side of canyon. Good opportunities to improve wildlife passage and mitigate habitat loss.	○	Good opportunities to improve wildlife passage. Impacts on rare riparian habitat.	◐	Increased traffic through, and impact on, bighorn sheep and deer range, but good opportunities for improving wildlife passage and mitigating habitat loss
AESTHETICS							
1. View of Highway		◐	Bridge over canyon visible from town	●	Route visible from town & river rafting	○	Route hidden in three tunnels
2. View from Highway		○	Superior to existing TCH	●	Poor since route in bottom of canyon, frequent tunnels	◐	View constrained in three tunnels; otherwise similar to existing TCH
CUSTOMER SERVICE - TRAFFIC MANAGEMENT							
1. Improve Level of Service for Local Users		◐	Frees up existing TCH east of Golden	○	Frees up existing TCH east of Highway 95	◐	Generally occupies existing TCH route east of Highway 95 to Five Mile Bridge
2. Improve Level of Service for Regional Users		○	Improved & safer operations on TCH	○	Improved & safer operations on TCH	○	Improved & safer operations on TCH
CONSTRUCTION CONSTRAINTS - MINIMIZE							
3. Facilitate Constructability		○	Generally remote from existing TCH & CPR Accessible from Ceeg Road	●	Poor construction access	●	New construction along existing TCH route
4. Vehicle Operating Costs		◐	5% maximum gradient outside Golden	○	Gentle gradients including in Golden	◐	5% maximum gradient outside of Golden
CUSTOMER SERVICE - SAFETY & RELIABILITY							
1. Minimize Accident Rate Due to Weather Conditions		◐	South side of canyon has lack of direct sunlight	◐	Low elevation - lack of direct sunlight	○	North side of canyon has abundance of direct sunlight
2. Minimize Accident Rate Due to Road Conditions		○	High standard horiz. & vert. alignment	○	High standard horiz. & vert. alignment	○	High standard horiz. & vert. alignment
3. Minimize Accidents at Access Points		○	Very little access	○	Very little access	◐	Existing forest & CPR access to be maintained
4. Minimize Accident Rate During Construction		○	Remote from existing TCH except at W & E tie-ins	○	Remote from existing TCH except at W & E tie-ins	●	New construction along existing TCH route
GEOTECHNICAL CONSIDERATIONS - FAVOURABLE?							
5. Minimize Geotechnical Risk		●	May activate big slide & others on south side of canyon	●	Frequent bridges, tunnels, cuts & fills - high risk from slides during and after construction	◐	Unknown geology in tunnels. One tunnel thru an old slide. Avoids active slides.
6. Minimize Risk of Closure		●	Risk from slides & rock chutes	●	Located in high risk slide	○	New design reduces existing exposure to geotechnical hazards
7. Minimize CPR Risk		○	Generally remote from CPR	●	Crosses CPR at 5 locations, parallels CPR for 4 km	◐	New construction on slopes above CPR in several locations
FINANCIAL							
1. Construction Costs (including Utility Relocations)		◐		●	Frequent bridges & tunnels	◐	
2. Property Acquisition Costs		◐	Impacts campground off Golden View Road	●	Commercial land in Golden	○	
3. Environmental Mitigation Costs		◐	Wildlife fencing required	●	Route close to river	◐	Wildlife fencing required
4. Maintenance Costs		●		●		○	

CANYON ROUTE EVALUATION MATRIX- Phase 2

Figure 7-4

LEGEND	
○	GOOD
◐	FAIR
●	POOR

DECISION CRITERIA		NORTH SIDE ROUTE (N1) (100 km/h)		MID CANYON CROSSING ROUTE (M5) (100 km/h)		NORTH SIDE ROUTE (N2) (90km/h)	
SOCIAL/COMMUNITY ISSUES		Eval.	Comments	Eval.	Comments	Eval.	Comments
1.	Minimize Urban Land Use Conflicts	○	None	○	None	○	None
2.	Minimize Recreational Land/River Use Conflicts	○	None	◐	Three bridges over canyon visible from river rafters	○	None
3.	Minimize Resource Land Use Conflicts	○		◐	Severs small area of forested land on south side of canyon	○	
4.	Residences Indirectly Impacted (noise, visual, air pollution)	◐	Increased traffic past Gareb Subdivision	◐	Increased traffic past Gareb Subdivision	◐	Increased traffic past Gareb Subdivision
5.	Residential Takings (#)	○	None	○	None	○	None
6.	Business/Institutions Indirectly Impacted (noise, visual, air pollution)	◐	Motels & church along LaFontaine & Golden View Roads	◐	Motels & church along LaFontaine & Golden View Roads	◐	Motels & church along LaFontaine & Golden View Roads
7.	Business/Institutional Takings	○	None	○	None	○	None
ENVIRONMENTAL ISSUES							
1.	Archaeological Sites Impacted (#)		Unknown, no archaeological survey has been completed		Unknown, no archaeological survey has been completed		Unknown, no archaeological survey has been completed
2.	Fish Habitat Impacted	○	Portion of TCH shifted further away from river	◐	Additional bridge crossings over River: increased water quality issues, greater effect on riparian vegetation & fish habitat		
3.	Wildlife Habitat Impacted (ha)	◐	Increased traffic through, and impact on, bighorn sheep and deer range, but good opportunities for improving wildlife passage and mitigating habitat loss	◐	Increased traffic through, and impact on, bighorn sheep and deer range, but good opportunities for improving wildlife passage and mitigating habitat loss	◐	Increased traffic through, and impact on, bighorn sheep and deer range, but good opportunities for improving wildlife passage and mitigating habitat loss
AESTHETICS							
1.	View of Highway	○	Route hidden in three tunnels	◐	Three bridges over canyon visible from river rafters	○	One tunnel
2.	View from Highway	◐	View constrained in three tunnels; otherwise similar to existing TCH	○	Superior to existing TCH	◐	One tunnel; otherwise similar to existing TCH
CUSTOMER SERVICE - TRAFFIC MANAGEMENT							
1.	Improve Level of Service for Local Users	◐	Generally occupies existing TCH route east of Highway 95 to Five Mile Bridge	◐	Generally occupies existing TCH route from east of Highway 95 to Dart Creek	◐	Generally occupies existing TCH route east of Highway 95 to Five Mile Bridge
2.	Improve Level of Service for Regional Users	○	Improved & safer operations on TCH	○	Improved & safer operations on TCH	○	Improved & safer operations on TCH
CONSTRUCTION CONSTRAINTS - MINIMIZE							
3.	Facilitate Constructability	●	New construction along existing TCH route	◐	Remote from existing TCH between Dart Creek and Five Mile Hill	●	New construction along existing TCH route
4.	Vehicle Operating Costs	◐	5% maximum gradient outside of Golden	○	Less than 4% maximum gradient outside of Golden	◐	5% maximum gradient outside Golden
CUSTOMER SERVICE - SAFETY & RELIABILITY							
1.	Minimize Accident Rate Due to Weather Conditions	○	North side of canyon has abundance of direct sunlight	○	Route has considerable direct sunlight. Straight bridges over river (3) reduce impact of icing	○	North side of canyon has abundance of direct sunlight
2.	Minimize Accident Rate Due to Road Conditions	○	High standard horiz. & vert. alignment	○	High standard horiz. & vert. alignment	◐	Medium standard horiz. & vert. alignment
3.	Minimize Accidents at Access Points	◐	Existing forest & CPR access to be maintained	◐	Existing forest & CPR access to be maintained	◐	Existing forest & CPR access to be maintained
4.	Minimize Accident Rate During Construction	●	New construction along existing TCH route	◐	Remote from existing TCH between Dart Creek and Five Mile Hill	●	New construction along existing TCH route
GEOTECHNICAL CONSIDERATIONS - FAVOURABLE?							
5.	Minimize Geotechnical Risk	◐	Unknown geology in tunnels. One tunnel thru an old slide. Avoids active slides.	○	Follows existing TCH across an old slide. Avoids active slides	●	Tunnel thru an old slide. Existing geotechnical hazards will continue especially at Black Wall Bluffs
6.	Minimize Risk of Closure	○	New design reduces existing exposure to geotechnical hazards	○	New design reduces exposure to geotechnical hazards	●	Slightly better than existing TCH
7.	Minimize CPR Risk	◐	New construction on slopes above CPR in several locations	○	Minimal new construction on slopes above CPR	●	CPR exposure between Black Wall Bluffs and Five Mile Hill
FINANCIAL							
1.	Construction Costs (including Utility Relocations)	◐		◐		○	
2.	Property Acquisition Costs	○		○		○	
3.	Environmental Mitigation Costs	◐	Wildlife fencing required	◐	Wildlife fencing required. Additional mitigation for bridge work over river.	◐	Wildlife fencing required
4.	Maintenance Costs	○		○		●	

LONG TERM IMPROVEMENTS

OVERPASS
UNDERPASS
DIRECTION OF TRAFFIC
ROAD CLOSED
CLOSE TCH MEDIAN



LEGEND:

EXISTING:

LKI 54.0
LANDMARK KILOMETRE MARK

AGRICULTURAL LAND RESERVE (ALR)

GEOTECHNICAL: (EXISTING)

DEBRIS FLOW SLIDE /
LANDSLIDE AREA

POTENTIAL SLIDE AREA

POTENTIAL ROCKFALL
HAZARD

DEBRIS FLOW SLIDE /
LANDSLIDE AREA

POTENTIAL SLIDE AREA

POTENTIAL ROCKFALL
HAZARD

DEBRIS FLOW SLIDE /
LANDSLIDE AREA

POTENTIAL SLIDE AREA

POTENTIAL ROCKFALL
HAZARD



STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)

PROPOSED:

T.C.H. ROUTE ALTERNATIVES:

N1 NORTH SIDE ROUTE 100m/h

N2 NORTH SIDE ROUTE 80m/h

S1 SOUTH SIDE ROUTE

S2 SOUTH SIDE ROUTE

S3 SOUTH SIDE ROUTE

B1 CANYON BOTTOM ROUTE

B2 CANYON BOTTOM ROUTE

M1 MID CANYON CROSSING ROUTE

M2 MID CANYON CROSSING ROUTE

M3 MID CANYON CROSSING ROUTE

M4 MID CANYON CROSSING ROUTE

M5 MID CANYON CROSSING ROUTE

M6 MID CANYON CROSSING ROUTE

BRIDGE

TUNNEL

APPROVED: R. GRIFFIN DATE: 08/01/01
DESIGNED: P. GRIFFIN DATE: 07/01/01
CHECKED: T. GRIFFIN DATE: 08/01/01
DRAWN: S. GRIFFIN DATE: 07/01/01



TRANS CANADA HIGHWAY
ALTERNATIVE CANYON ROUTES
GOLDEN TO ROTH CREEK
SHEET 1B OF 5

LONG TERM IMPROVEMENTS

- OVERPASS
- ROAD CLOSED
- CLOSE TCH MEDIAN
- DIRECTION OF TRAFFIC



LEGEND:

EXISTING:

- LKI 54.0
- LINEAR KILOMETRE INVENTORY
- AGRICULTURAL LAND RESERVE (ALR)

GEOTECHNICAL (EXISTING)

- OPEN RIGHT-OF-WAY
- POTENTIAL ROCKFALL HAZARD
- DEBRIS FLOW SLUE / ANCHOR CHUTE POTENTIAL SLIDE AREA
- LANDSLIDE AREA
- SURFICIAL SLOUGHING
- ANCHOR CHUTE



ANCHOR CHUTE IDENTIFIED BY BOTH IN FUNCTIONAL PLANNING ASSESSMENT

STRIKE-SLIP FAULT
ANTICLINE (OVERTURNED)



THRUST FAULT
THRUST FAULT (OVERTURNED)

PROPOSED:

T.C.H. ROUTE ALTERNATIVES:

- N1 NORTH SIDE ROUTE 100km/h
- N2 NORTH SIDE ROUTE 90km/h
- S1 SOUTH SIDE ROUTE
- S2 SOUTH SIDE ROUTE
- S3 SOUTH SIDE ROUTE
- B1 CANYON BOTTOM ROUTE

- B2 CANYON BOTTOM ROUTE
- M1 MID CANYON CROSSING ROUTE
- M2 MID CANYON CROSSING ROUTE
- M3 MID CANYON CROSSING ROUTE
- M4 MID CANYON CROSSING ROUTE
- M5 MID CANYON CROSSING ROUTE
- M6 MID CANYON CROSSING ROUTE
- BRIDGE
- TUNNEL

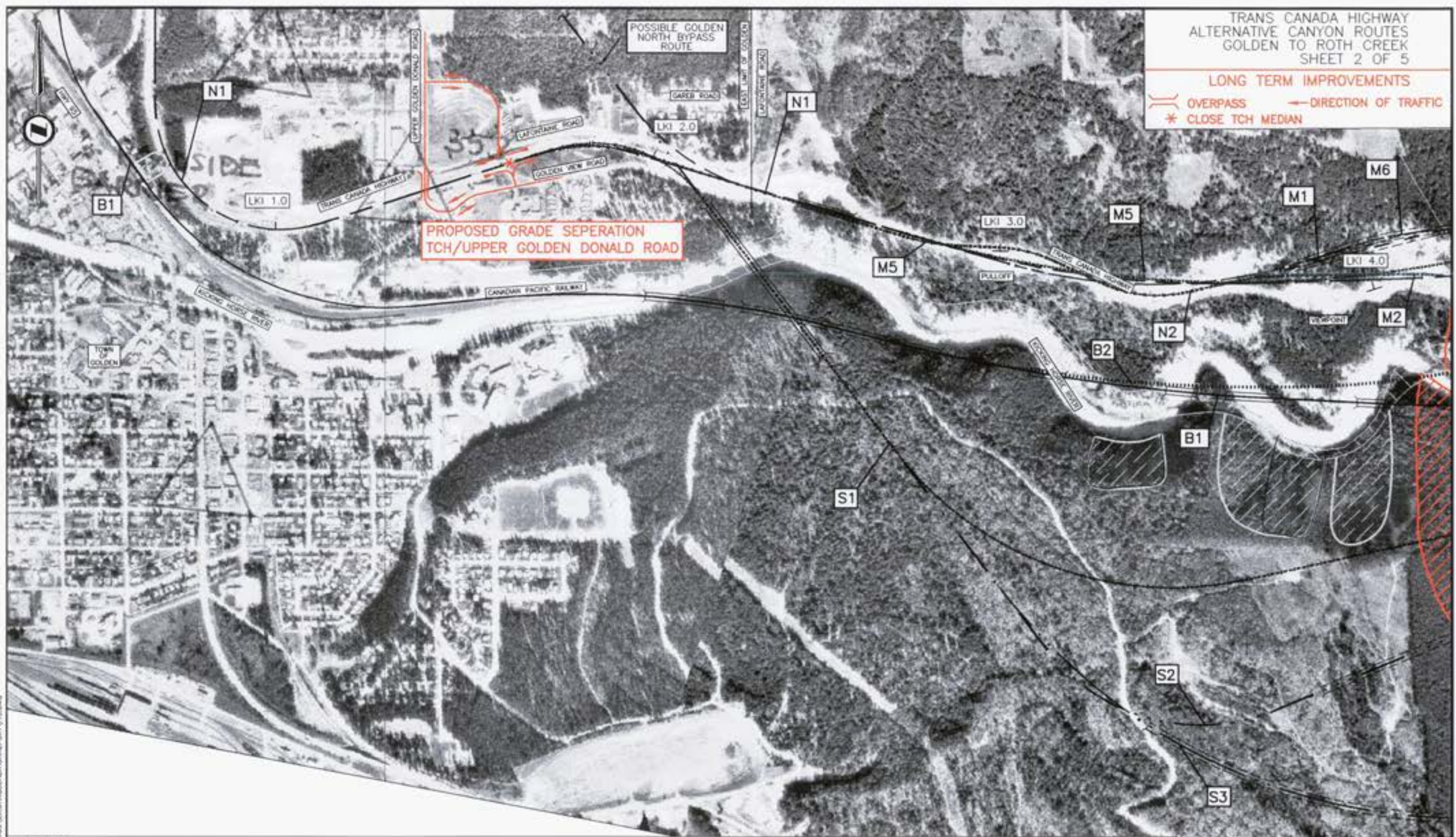
APPROVED: J. SMITH DATE: JAN 10, 2010
DESIGNED: J. SMITH DATE: OCT 09, 2009
CHECKED: J. SMITH DATE: JAN 10, 2010
DRAWN: J. SMITH DATE: OCT 09, 2009



TRANS CANADA HIGHWAY
ALTERNATIVE CANYON ROUTES
GOLDEN TO ROTH CREEK
SHEET 2 OF 5

LONG TERM IMPROVEMENTS

OVERPASS
DIRECTION OF TRAFFIC
CLOSE TCH MEDIAN



LEGEND:

EXISTING:

LKI 54.0 LINEAR KILOMETRE INDICATOR

AGRICULTURAL LAND RESERVE DATA

GEOTECHNICAL: (EXISTING)

CRP RIGHT-OF-WAY

POTENTIAL FLOODING

DEBRIS FLOW SLIDE / AVALANCHE CHUTE

POTENTIAL SLEW AREA

LANDSLIDE AREA

SURFICIAL SLOUGHING

AVALANCHE CHUTE

STRIKE-SLIP FAULT

WYCLINE (OVERTURNED)

THRUST FAULT

THRUST FAULT (OVERTURNED)

PROPOSED:

T.C.H. ROUTE ALTERNATIVES:

N1 NORTH SIDE ROUTE 100km/h

N2 NORTH SIDE ROUTE 80km/h

S1 SOUTH SIDE ROUTE

S2 SOUTH SIDE ROUTE

S3 SOUTH SIDE ROUTE

B1 CANYON BOTTOM ROUTE

B2 CANYON BOTTOM ROUTE

M1 WID CANYON CROSSING ROUTE

M2 WID CANYON CROSSING ROUTE

M3 WID CANYON CROSSING ROUTE

M4 WID CANYON CROSSING ROUTE

M5 WID CANYON CROSSING ROUTE

M6 WID CANYON CROSSING ROUTE

BRIDGE

TUNNEL

APPROVED: J. P. [Signature] DATE: APR. 06

DESIGNED: P. [Signature] DATE: DEC. 05

CHECKED: J. [Signature] DATE: APR. 06

DRAWN: S. [Signature] DATE: DEC. 05

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TRANS CANADA HIGHWAY
ALTERNATIVE CANYON ROUTES
GOLDEN TO ROTH CREEK
SHEET 3 OF 5

LEGEND:

EXISTING:

LK 54.0 LK 54.0 LK 54.0

AGRICULTURAL LAND RESERVE (ALR)

GEOTECHNICAL (NOTING)

SPRINT-OF-WAY

POTENTIAL AVALANCHE

PROPOSED:

T.C.H. ROUTE ALTERNATIVES:

M1 NORTH SIDE ROUTE 100m/h

M2 NORTH SIDE ROUTE 80m/h

S1 SOUTH SIDE ROUTE

S2 SOUTH SIDE ROUTE

S3 SOUTH SIDE ROUTE

B1 CANYON BOTTOM ROUTE

B2 CANYON BOTTOM ROUTE

M1 MID CANYON CROSSING ROUTE

M2 MID CANYON CROSSING ROUTE

M3 MID CANYON CROSSING ROUTE

M5 MID CANYON CROSSING ROUTE

M6 MID CANYON CROSSING ROUTE

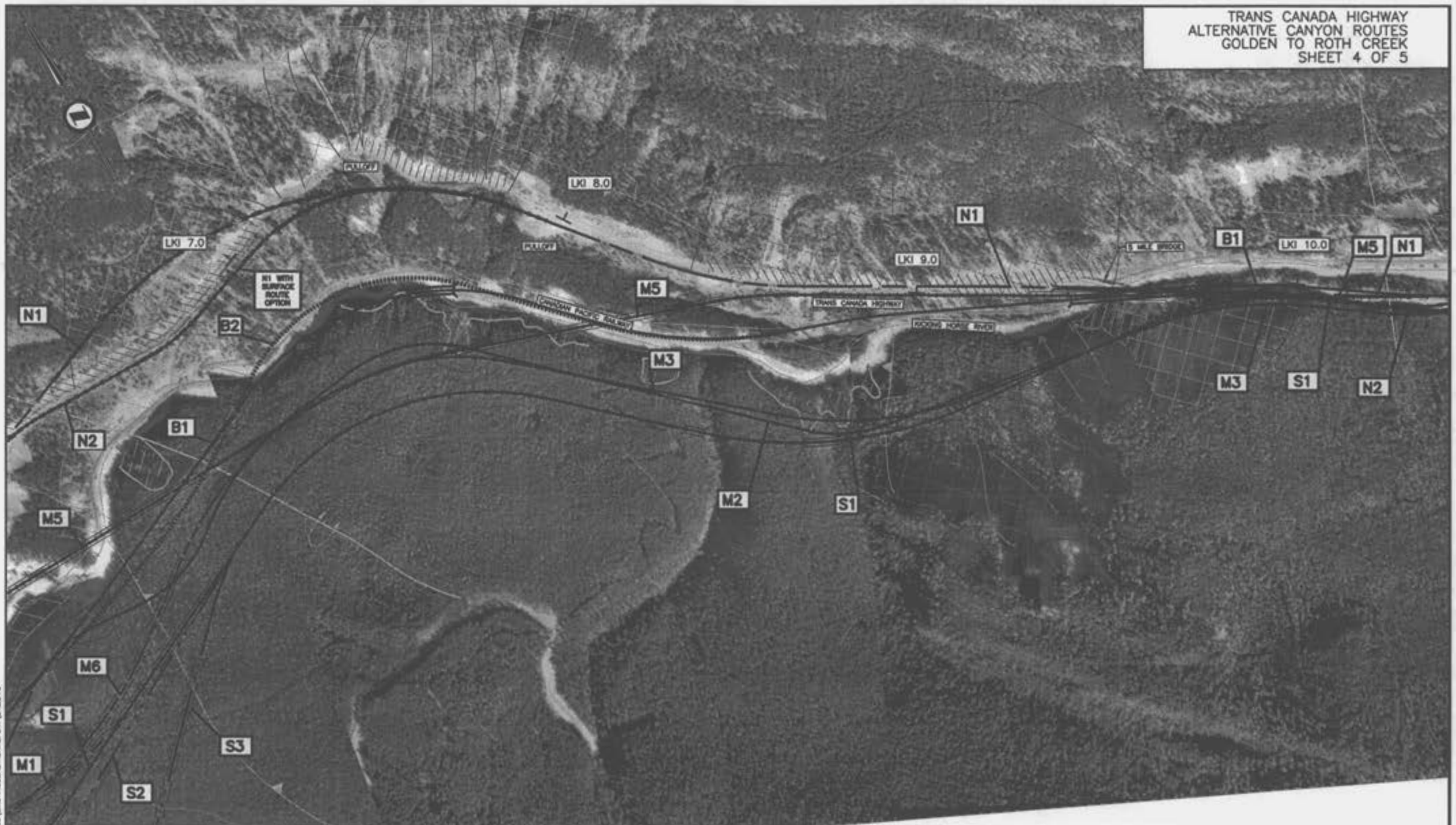
BRIDGE

TUNNEL

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LEGEND:

EXISTING:

- LANDMARK KILOMETRE MILEPOST
- ADULTERATED LAND RESERVE (ALR)
- ONE-WAY-OF-WAY
- POTENTIAL ROADWAY

- DRAINAGE DRAINAGE / ANTI-SLIP DRAINAGE
- POTENTIAL SLIDE AREA
- LANDSLIDE AREA
- SURFICIAL SLIDING
- AVALANCHE DRAINAGE

PROPOSED:

- STRIKE-SLIP FAULT
- ANTI-SLIP (OVERLAP)
- THRUST FAULT
- THRUST FAULT (OVERLAP)

PROPOSED:

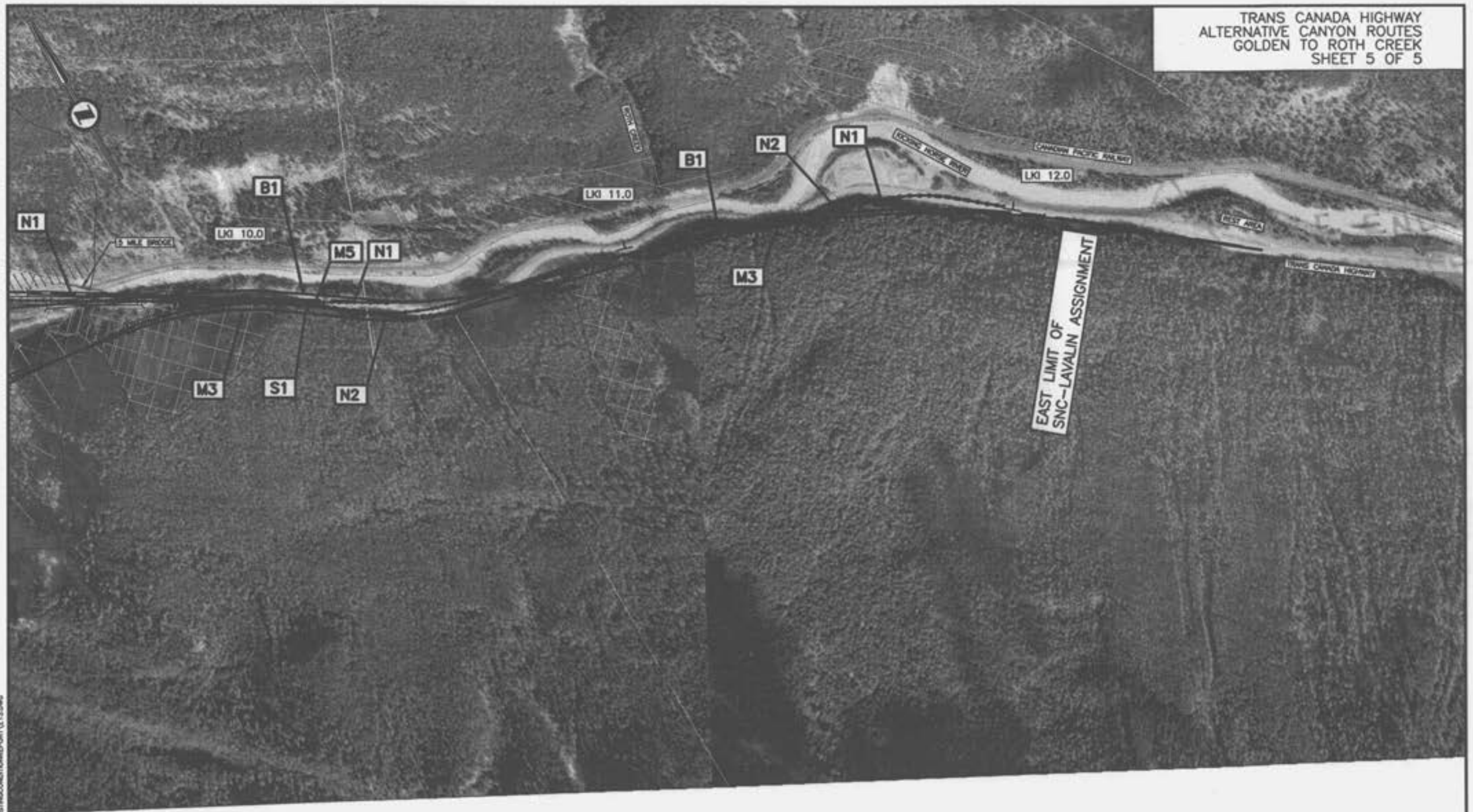
T.C.H. ROUTE ALTERNATIVES:

- N1 NORTH SIDE ROUTE 100km/h
- N2 NORTH SIDE ROUTE 80km/h
- S1 SOUTH SIDE ROUTE
- S2 SOUTH SIDE ROUTE
- S3 SOUTH SIDE ROUTE
- B1 CANYON BOTTOM ROUTE

- B2 CANYON BOTTOM ROUTE
- M1 MID CANYON CROSSING ROUTE
- M2 MID CANYON CROSSING ROUTE
- M3 MID CANYON CROSSING ROUTE
- M5 MID CANYON CROSSING ROUTE
- M6 MID CANYON CROSSING ROUTE
- BRIDGE
- TUNNEL

APPROVED: 5/20/01 DATE: 5/20/01
DESIGNED: 7/20/01 DATE: 7/20/01
CHECKED: 1/27/02 DATE: 1/27/02
DRAWN: 5/20/01 DATE: 5/20/01





LEGEND:

EXISTING:

- LKI 54.0
- AGRICULTURAL LAND RESERVE (ALR)
- OPR RIGHT-OF-WAY
- POTENTIAL ROADFALL HAZARD

- SLOPE FLOW SLIDE / AVALANCHE CHUTE POTENTIAL SLIDE AREA
- LANDSLIDE AREA
- SURFACE SLIDING
- AVALANCHE CHUTE

- STRIKE-SLIP FAULT
- ARCuate (OVERTURNED)
- THRUST FAULT
- THRUST FAULT (OVERTURNED)

PROPOSED:

T.C.H. ROUTE ALTERNATIVES:

- N1 NORTH SIDE ROUTE 100m/h
- N2 NORTH SIDE ROUTE 90m/h
- S1 SOUTH SIDE ROUTE
- S2 SOUTH SIDE ROUTE
- S3 SOUTH SIDE ROUTE
- B1 CANYON BOTTOM ROUTE

- B2 CANYON BOTTOM ROUTE
- M1 HS CANYON CROSSING ROUTE
- M2 HS CANYON CROSSING ROUTE
- M3 HS CANYON CROSSING ROUTE
- M4 HS CANYON CROSSING ROUTE
- M5 HS CANYON CROSSING ROUTE
- BRIDGE
- TUNNEL

APPROVED: S. PRICE DATE: JAN. 98.
DESIGNED: P. GORDON DATE: DEC. 96.
CHECKED: T. KITCHEN DATE: JAN. 98.
DRAWN: S. PRICE DATE: DEC. 96.



CACHE CREEK TO THE ROCKIES EXPLANATION OF TERMS

INTERSECTIONS/ACCESSES:	SEE LEGEND FOR TYPE AND INDICATION OF PERMITTED TURNING MOVEMENTS
SEGMENT/LKI:	LKI = M.O.T.H. LANDMARK KILOMETRE INVENTORY
CUT/FILL:	C = CUT, F = FILL
CLEAR ZONE:	<ul style="list-style-type: none"> - 0 = NON-TRAVERSIBLE SIDE SLOPE WITH OPEN SHOULDER LESS THAN REQUIRED DISTANCE - 7+ = CLEAR ZONE EXCEEDS REQUIRED STANDARD - N/A = URBAN SECTION WITH CURB & GUTTER - CRB = CONCRETE ROADSIDE BARRIER - CLB = CONCRETE LOW BARRIER
SHOULDER WIDTH:	WIDTH TO NEAREST 0.5 METRE (PAVED)
RIGHT TURN LANE/LENGTH:	<ul style="list-style-type: none"> - X.X/L WIDTH(m)/LENGTH OF PARALLEL RIGHT TURN LANE(m) - X.X MAXIMUM WIDTH OF RIGHT TURN TAPER(m)
LANE WIDTH (NUMBER):	WIDTH(m)/(NUMBER OF LANES)
LEFT TURN LANE/LENGTH:	<ul style="list-style-type: none"> - X.X/L WIDTH(m)/LENGTH OF PARALLEL LEFT TURN LANE(m) (FOR CLARIFICATION OF TURN LANE LENGTHS IN URBAN SECTIONS REFER TO APPENDIX 1)
MEDIAN WIDTH/TYPE:	WIDTH(m), MEDIAN TYPE DENOTED BY: <ul style="list-style-type: none"> - P = PAINTED MEDIAN - RI = RAISED MEDIAN/ISLAND - CMB = CONCRETE MEDIAN BARRIER - D = DEPRESSED MEDIAN
HORIZONTAL (e):	<ul style="list-style-type: none"> - RADIUS(m), LEFT(L) OR RIGHT(R) AND TANGENT(T) - SUPERELEVATION(e) HAS BEEN RECORDED WHERE FIELD VERIFIED
VERTICAL (%):	GRADE(+/-) AND "K" VALUE WHERE KNOWN
POSTED SPEED: (ADVISORY)	<ul style="list-style-type: none"> - POSTED SPEED IN km/h - ADVISORY SPEED ZONES SHOWN IN BRACKETS
AADT(SADT):	TRAFFIC VOLUMES DERIVED FROM M.O.T.H. 1996 DATA
ACCIDENTS:	ACCIDENT DATA FOR PERIOD JAN.1,1991 TO DEC.31,1995 (NUMBER FOLLOWING SYMBOL INDICATES INCIDENTS OF ACCIDENT TYPE SHOWN AT THIS LOCATION). SEE LEGEND FOR TYPE

ELECTRICAL:	<ul style="list-style-type: none"> - I = ILLUMINATED AREA - AWF = ADVANCED WARNING FLASHER - CMS = CHANGABLE MESSAGE SIGN - TS = TRAFFIC SIGNAL
DRAINAGE:	CULVERTS, GREATER THAN OR EQUAL TO 600mm, CARRYING NATURAL WATERCOURSES, FROM M.O.T.H. ROAD FEATURES INVENTORY OR AS FIELD SURVEYED <ul style="list-style-type: none"> - CSP = CORRUGATED STEEL PIPE - Conc = CONCRETE PIPE OR BOX - REFER TO LEGEND FOR CULVERT SYMBOLS - REFER TO LEGEND FOR CURB SYMBOLS
STRUCTURES (BCI):	<ul style="list-style-type: none"> - REFER TO LEGEND FOR SYMBOLS - BCI = M.O.T.H. BRIDGE CONDITION INDEX
R/W (TOTAL):	<ul style="list-style-type: none"> - APPROXIMATE RANGE IN RIGHT OF WAY WIDTH IN METRES - FOR INDIAN RESERVES, AGRICULTURAL LAND RESERVES, NATIONAL PARKS AND FORESTRY LAND RESERVES. REFER TO LEGEND.
PDI/RCI:	PAVEMENT DISTRESS INDEX/RIDE COMFORT INDEX FROM M.O.T.H. ROADWAY PAVEMENT MANAGEMENT SYSTEM (RPMS) DATA FOR 1996, (* INDICATES A QUANTITATIVE OR QUALITATIVE VALUE CONTRARY TO RPMS DATA)
NATURAL HAZARDS:	<ul style="list-style-type: none"> - A = AVALANCHE - D = DEBRIS TORRENT - E = EROSION FALL - I = ICEFALL - R = ROCKFALL
GEOTECHNICAL ISSUES:	<ul style="list-style-type: none"> - D = HIGHWAY DISTORTION (LATERAL OR VERTICAL MOVEMENT OF HIGHWAY) - F = FROST HEAVE - I = ICING OF HIGHWAY - M = MASS MOVEMENT (SOIL OR ROCK SLIDE ONTO HIGHWAY) - S = SEEPAGE (EROSION OR FLOODING) - * = QUALITATIVE VALUE CONTRARY TO M.O.T.H. INFORMATION
ENVIRONMENTAL CONDITIONS:	SENSITIVITY INDICATED BY NIL(N), LOW(L), MODERATE(M) OR HIGH(H)
AGRICULTURE:	<input type="checkbox"/> OR <input type="checkbox"/> INDICATES FARM ACCESS LOCATION
WILDLIFE/WARS:	M.O.T.H. WILDLIFE ACCIDENT REPORTING SYSTEM (WARS) DATA FOR PERIOD JAN.1, 1988 TO DEC. 31, 1997

CACHE CREEK TO THE ROCKIES LEGEND

SIGNALIZED 4 WAY INTERSECTION		ASPHALT CURB (LEFT SIDE)		DISTRICT/MUNICIPAL BOUNDARY	
SIGNALIZED 3 WAY INTERSECTION		CONCRETE CURB (RIGHT SIDE)		AGRICULTURAL LAND RESERVE CROSSING HIGHWAY	
4 WAY INTERSECTION UNSIGNALIZED		CULVERTS CROSSING TCH TYPE & SIZE WHERE KNOWN	600 CSP	APPROXIMATE ALR BOUNDARY AS SHOWN ON PLAN	
3 WAY INTERSECTION UNSIGNALIZED		CULVERTS UNDER CROSS STREETS, TYPE & SIZE WHERE KNOWN		NATIONAL PARK BOUNDARY	
ENTRANCE/EXIT RAMP		- LEFT SIDE	600 CSP	FORESTRY LAND RESERVE	
INTERSECTION RIGHT IN & RIGHT OUT		- RIGHT SIDE	600 CSP	INDIAN LAND RESERVE	
INTERSECTION RIGHT IN ONLY		BRIDGE TCH OVER		INDIAN RESERVE	
INTERSECTION RIGHT OUT ONLY		BRIDGE TCH UNDER		AGRICULTURAL LAND RESERVE	
INTERSECTION RIGHT IN & RIGHT OUT & LEFT IN		TUNNEL OR SNOWSHED		NATIONAL PARK	
INTERSECTION RIGHT IN & RIGHT OUT & LEFT OUT		PEDESTRIAN STRUCTURE TCH OVER		FORESTRY LAND RESERVE	
PRIVATE PROPERTY ACCESS ALL MOVEMENTS		PEDESTRIAN STRUCTURE TCH UNDER		HIGH GEOTECHNICAL SEVERITY	
PRIVATE PROPERTY ACCESS RIGHT IN & RIGHT OUT		CATTLE UNDERPASS TCH OVER		MEDIUM GEOTECHNICAL SEVERITY	
PRIVATE PROPERTY ACCESS RIGHT IN ONLY				LOW GEOTECHNICAL SEVERITY	
PRIVATE PROPERTY ACCESS RIGHT OUT ONLY				HIGH ENVIRONMENTAL SENSITIVITY POINT FEATURE	
DATA NOT APPLICABLE	N/A			MEDIUM ENVIRONMENTAL SENSITIVITY POINT FEATURE	
THROUGH MOVEMENT				LOW ENVIRONMENTAL SENSITIVITY POINT FEATURE	
TURNING MOVEMENT				WILDLIFE ACCIDENT REPORTS (KILLS/KM/YEAR)	(x,x)
ACCIDENT PROPERTY DAMAGE ONLY					
ACCIDENT INJURY					
ACCIDENT FATALITY					

SECTION 8

Town of Golden

FUNCTIONAL PLANNING REPORT

8.0 TOWN OF GOLDEN

8.1 Introduction and Background

The Trans Canada Highway, from the west limit to the east limit of the town, is part of SNC-Lavalin's Functional Planning assignment. Much effort with respect to the Town of Golden, during the Functional Planning assignment, was devoted to the study of the tie-ins to the existing highway at the east end of Golden for the alternative routes developed through the Kicking Horse Canyon.

With the exception of the Canyon Bottom Routes, all of the alternatives developed through the Canyon tie into the existing highway just west of the east town limit. The Canyon Bottom Route alternatives tie into the existing highway at the east end of the commercial strip through Golden, just west of the Highway 95 intersection.

In conjunction with the development of the canyon route alternatives, and in order to provide a common starting point for comparison of Canyon route alternatives, SNC-Lavalin looked at geometric improvements on the section of TCH from Highway 95 to the east limit of town in order to bring the horizontal alignment of the road up to a safe operating speed of 70 km/h. The existing gradient on Golden Hill is just under 8% which theoretically meets the design criteria in the Ministry's Highway Engineering Design Manual for an arterial in mountainous terrain with a design speed of 70 km/h, however, a problem for heavy trucks, in particular B-trains operating on this hill under winter conditions has been identified by various stakeholders.

Following the assessment of route alternatives in the Canyon and their tie-ins to the existing Trans Canada east of Golden, SNC-Lavalin carried out an assessment of the existing operations of Trans Canada within the Town of Golden. A brief assessment has been made of i) operational improvements from the west limit of Golden to Highway 95, ii) four laning from Highway 95 to west of Golden View Road, iii) elimination of traffic signals through Golden, and iv) a grade reduction on Golden Hill.

The conclusions of this assessment and the costs associated with the proposed improvements are summarized in Section 9 and illustrated on Figure 9-1. In the long term future, if improvements to the existing TCH through Golden cannot meet future capacity and safety requirements, it may be necessary to provide a bypass of Golden. The preferred location for this possible future bypass is on the north side of Golden and, this location which was studied in 1992, is described in Section 8.5.

8.2 Operational Improvements, West Limit of Golden to Highway 95

There are a number of deficiencies and operational problems along this section of TCH:

- The traffic signals located at the west junction (LKI 54.6) of the north and south frontage roads and at the east junction (LKI 55.7) of the north and south frontage roads are not interlinked and not coordinated.
- The westbound merge from 2 lanes to one lane, west of west signals, is only 200 metres long, which is insufficient to break up platoons created at the west signals.

FUNCTIONAL PLANNING REPORT

- The existing uphill gradient, from the east signals to the foot of Golden Hill, is approximately 0.7% over the distance of about 550 metres. A truck with a mass/power ratio of 180g/W(300 lb/hp) should be able to accelerate to about 54 km/h in this distance.
- Eastbound trucks stopped at the east signals can accelerate for only 550 metres ± before they reach the bottom of Golden Hill (8%).
- Eastbound and westbound trucks may have to stop at the ICBC weigh scale/truck inspection station on the north side of TCH at LKI 55.75. The distance from the east entrance of the weigh scale to the bottom of Golden Hill (8%) is only 400 metres ±.
- There are two unsignalized at-grade connections on the north side of TCH (right turns only) at LKI 54.9 and 55.2; two unsignalized at-grade connections on the south side of TCH (right turns only) at LKI 54.9 and 55.35. Long trucks using these at-grade connections encroach on both lanes of the TCH when they turn.
- The posted speed on this section of TCH is 60 km/h, less than the desirable minimum speed of 70 km/h along urban sections of TCH.

These deficiencies and problems can be relieved by a number of short term improvements:

- Interlink and coordinate the signals on TCH at the west and east ends of the north and south frontage roads.

- Close the ICBC weigh scale/truck inspection station to EB traffic only.
- Closure of the ICBC weigh scale/truck inspection station to EB traffic, together with the above referenced signal coordination, will enable many EB trucks to have a much improved running start for climbing Golden Hill.
- Close the four at-grade connections to the TCH between the signals at west and east ends of the north and south frontage roads. Improve the existing signalized intersections at the west and east ends of the north and south frontage roads, if required, to accommodate additional turning traffic.
- Increase the posted speed to 70 km/h between the west limit of Golden (LKI 54.3) and the east signals (LKI 55.7), located at the east end of the north and south frontage roads.
- Provide advance flasher units at all the approaches to both sets of signals (at LKI 54.6 and 55.7). (Currently there is a flasher for eastbound traffic approaching the west signals and a flasher for westbound traffic approaching the east signals).

The expected benefits of the improvements are:

- Reduction in creation of platoons at existing downstream traffic signals.
- Interlinking and coordinating the signals could ensure that WB platoons created at the east signals would not be stopped again at the west signals, thus enabling the platoon

FUNCTIONAL PLANNING REPORT

dispersal achieved on the four lane section to be maintained. A similar situation could be ensured in the EB direction.

- Increasing the running speed of many EB trucks as they start up Golden Hill (8%).
- Closure of the ICBC weigh scale/truck inspection station to EB traffic, together with the above referenced signal coordination, will enable many EB trucks to have a much improved running start for climbing Golden Hill.
- Reduction in accident rate as a result of reducing the number of intersections by four (not including weigh scale east access) and consolidating access at the two existing signalized intersections
- Increase in operating speed of TCH traffic.

8.3 Four Laning, Highway 95 to West of Golden View Road

There are a number of deficiencies and operational problems along this section of TCH:

- The TCH WB has a single lane (3.7-3.8 metres wide) and narrow paved shoulder (1-1.5 metres wide) on the 8% downgrade of Golden Hill between Highway 95 junction and Golden View Road Intersection. The single WB lane does not allow for the dissipation of platoons which have built up in Kicking Horse Canyon.
- EB B-trains have problems maintaining traction under winter conditions when they are climbing the 8% up-grade on Golden Hill.

- The existing horizontal alignment on Golden Hill includes 3 broken back curves, one of which has a radius of 150 metres. This curve is satisfactory for 60 km/h, the existing posted speed, but would not be adequate for a design speed of 70 km/h (min. radius 190 metres).
- There are several surficial failures in the fill slope below TCH on Golden Hill. CPR tracks below the TCH on Golden Hill are at risk if there is a slope failure.
- The TCH is only two lanes wide between Upper Golden-Donald Road and the east limit of Golden (LKI 2.2), just west of Golden View Road Intersection (East Junction).
- Six accidents have occurred in 5 years (1991-95) in vicinity of Golden View Road Intersection (East Junction) including one fatal, one injury, four property damage and two wild animal/vehicle collisions (property damage).

These deficiencies and problems can be relieved by a number of interim term improvements:

- Improve the TCH alignment and provide an additional WB lane on TCH between Highway 95 and Upper Golden-Donald Road.
- Operational improvements west of this section (signal coordination & closure of weigh scale to EB traffic) will benefit truck operations on this section of TCH.
- Four lane TCH between Upper Golden-Donald Road and Golden View Road (East Junction).

FUNCTIONAL PLANNING REPORT

- Realign TCH on Golden Hill to achieve a minimum design speed of 70 km/h.
- Improve the Upper Golden-Donald Road intersection as required to accommodate the additional WB lane and any other needed improvements such as provision of a westbound right turn lane.
- Ducting should be provided at the Highway 95 and Upper Golden-Donald Road Intersections to allow for future signals prior to the long term provision of grade separations.
- Stabilize the fill slopes below TCH.
- Eliminate left turns at Golden View Road Intersection (East Junction).

The expected benefits of the improvements are:

- Provision of an additional downhill lane WB on Golden Hill will enable general traffic to pass heavy trucks in crawl mode and dissipate platoons built up in Canyon.
- Realignment of the TCH will reduce steering effort, driver workload and potential for off road accidents on Golden Hill.
- Operational improvements, west of this section, will provide EB heavy trucks and B-trains with an improved running start in ascending Golden Hill.
- Stabilization of fill slopes below TCH will reduce risk of larger slope failures.

- Reduced accident potential at Golden View Road (East Junction).
- Increased WB passing opportunities.
- Capacity sufficient for long term and beyond 2021.

8.4

Elimination of Traffic Signals through Golden and Grade Reduction on Golden Hill

There are a number of deficiencies and operational problems through Golden that will require resolution in the long term are noted below. Long term resolution is proposed because the cost of most of the improvements is high or because the deficiencies and operational problems they address will only likely become severe at some future date depending on traffic growth and accidents.

- Signals at LKI 54.6 and at LKI 55.7 (at west and east ends of north and south frontage roads) disrupt flow of through traffic on TCH.
- The existing unsignalized at-grade intersections at Highway 95 and Upper Golden-Donald Road create delays for long distance and local traffic turning left onto TCH.
- Posted speed on the TCH of 60 km/h between the east signals at LKI 55.7 and the east limit of Golden is less than the desirable minimum of 70 km/h.
- Existing steep gradient (maximum 8%) on Golden Hill between LKI 0.2 and LKI 1.4.

FUNCTIONAL PLANNING REPORT

These deficiencies and problems can be relieved by a number of long term improvements as follows:

- Provide a grade separation at the west end of the north and south frontage roads (LKI 54.6) in order to provide free flow operation on the TCH. A single line sketch of a possible grade separation scheme is shown on both Sheets 1A and 1B of 5 of the 1:10,000 photomosaics located at the end of Section 7.
- Provide a grade separated interchange at Highway 95 (LKI 56.1) in order to safely increase the free flow operating speed on the TCH and to improve the safety and operations of turning traffic on the TCH and on Highway 95. A single line sketch of a possible grade separation scheme, "Option A", is shown on Sheet 1A of 5 of the 1:10,000 photomosaics located at the end of Section 7.

Note: Kootenays Region has developed a number of options for an interchange. However, these options may need to be revisited in light of potential developments in the south west quadrant of the TCH/Highway 95 intersection. One of the Region's options for an improved at-grade intersection scheme is shown as "Option B" on the single line sketch on Sheet 1B of 5 of the 1:10 000 photomosaics at the end of Section 7.

- Realign and reprofile TCH on Golden Hill to achieve a maximum gradient of 5-6%.

- Provide a grade separation at Upper Golden-Donald Road to enable the latter to overpass the TCH. It will need to be located in a deep cut as a result of reducing its gradient from 8% to a maximum of 5-6%. A single line sketch of this grade separation is shown on Sheet 2 of 5 of the 1:10,000 photomosaics located at the end of Section 7.
- The grade reduction on Golden Hill will likely require realignment of TCH across the existing weigh scale/truck inspection station.
- Close the ICBC weigh scale/truck inspection station and relocate if necessary.
- Increase the speed limit to 70 km/h from LKI 55.7 (existing east signals) to the east limit of Golden (LKI 2.3), over a total distance of 2.7 km.

The expected benefits of the improvements are:

- Significant improvement in average travel speed on TCH.
- Significant improvement in operations and safety for truck traffic.
- Capacity sufficient for long term and beyond 2021

FUNCTIONAL PLANNING REPORT

8.5 Possible Golden North Bypass

A new eight (8) km route from the TCH, at the top of Golden Hill, to the TCH just west of Edelweiss Creek was studied in 1992. The route would have a maximum gradient of just under 6% and avoids the existing 8% grade on Golden Hill. A future north bypass of Golden would be of concern to the Town since it would bypass the existing commercial strip which is used extensively by the travelling public for food, accommodation, fuel and related highway services. The commercial strip is also an important source of business revenue for the Town of Golden.

Fish and Aquatic Habitat Issues

To be addressed with future developments, if any, of this proposed route.

Wildlife Issues

This proposed alignment traverses an area of rural residential areas, small farms and wild land which is good year-round range for white-tailed deer and reasonably good winter range for mule deer. Wildlife exclusion fencing and crossing structures would be advisable. This route would also generate some wildlife habitat compensation issues.

Archaeological Issues

It is noted that, without the development of detailed functional planning plans for assessment, archaeological potential is expected to be high on any elevated benches as well as at the point that the alignment would reach the heights of the plateau level. Of particular interest, would be crossings of Edelweiss and Hospital Creeks and the upper

levels of Golden Hill. Furthermore, it is expected that there would be good potential for historic remains.

8.6 Next Steps

- Undertake preliminary design of the proposed short and interim term improvements.
- Further develop the functional planning of the long term improvements.
- Conduct further required environmental studies and investigation.
- Initiate stakeholder information and consultation.

SECTION 9

Conclusions

FUNCTIONAL PLANNING REPORT

9.0 CONCLUSIONS

Towards the end of the next twenty five years, a number of long term improvements are proposed for this section of TCH, (See Figure 9-1):

9.1 Town of Golden

9.1.1 West Limit of Golden to Highway 95

This section of TCH was widened and improved in 1996 and, with some relatively low cost additional improvements coupled with a sound access management policy, can be expected to perform satisfactorily for most of the next twenty five years.

The proposed short term operational improvements are, (See Figure 9-1):

- Interlink and coordinate the signals at the west and east ends of the north and south frontage roads.
- Close the ICBC weigh scale/truck inspection station to eastbound trucks (except in extraordinary circumstances).
- Close the four at-grade connections to the TCH between the signals at the west and east ends of the north and south frontage roads.
- Increase the posted speed to 70 km/h from the west limit of Golden to west of the east signals (i.e. the signals just west of Highway 95).
- Install new advance flasher units on all the approaches to both sets of signals.

The short term improvements and their expected benefits are summarized in Table 9-1.

The estimated cost of the proposed short term improvements is \$205,000.

Application of access management principles along this section of TCH should be directed to ensuring that there are no increase in access points.

9.1.2 Highway 95 to East Limit of Golden

This existing section of TCH has two basic lanes together with an eastbound truck climbing lane on the 8% upgrade on Golden Hill. Some improvements have been made to the Upper Golden-Donald Road Intersection to improve operations and safety i.e. provision of a raised median and separated left turn lanes.

In the interim term, it is proposed to four lane this entire section, realign TCH on Golden Hill to achieve a minimum design speed of 70 km/h and stabilise the fill slopes below the TCH.

The estimated cost of the proposed interim improvements is \$10.0 Million.

In the long term, towards the end of the twenty five year planning period, the following improvements are proposed:

FUNCTIONAL PLANNING REPORT

- Provide a grade separated interchange at Highway 95.
- Provide grade separation at Upper Golden-Donald Road.
- Realign and reprofile TCH on Golden Hill to reduce the gradient to a maximum of 5 to 6%.
- Increase the speed limit to 70 km/h from west of Highway 95 to the east limit of Golden.

The estimated cost of the proposed long term improvements is \$28.0 Million.

The interim and long term improvements and their expected benefits are summarized in Table 9-1.

Application of access management along this section of TCH should aim to avoid any increase in access points and to remove any private access as opportunities present themselves.

9.2 Golden to Roth Creek

Subject to further environmental and geotechnical investigation, Route M5 is the preferred Canyon Route Option location for a 100 km/h design speed, four lane divided Trans Canada Highway from Golden to Roth Creek through the Kicking Horse Canyon. (For a plan of this route, see Drawing No. 013121-FP-155 in the sleeve at back of this report. This drawing is also included in Appendix A along with the profile of Route M5, Drawing No. 013121-FP-165).

The route generally follows the existing TCH corridor, on the surface and then in a tunnel on the north side of the canyon from the east limit of Golden to LKI 5.6. This is a location east of the unstable South Landslide (on the south side of the canyon) and west

of the hazardous Black Wall Bluffs (on the north side of the canyon). From here, the route crosses by a long bridge to the south side of the canyon. About 0.75 km of the new route is located on the south side of the canyon to a point west of the hazardous South Bluffs area (on the south side of the canyon). In order to avoid the South Bluffs, the route then returns, by another long bridge, to the existing TCH corridor on the north side of the canyon along Five Mile Hill at LKI 8.5. From here east, Route M5 generally follows the existing TCH corridor to Roth Creek. A new structure is required at the Yoho (Five Mile) Bridge.

The estimated cost of Route M5 is \$384 Million. (This cost includes the four laning of TCH from Highway 95 to the east limit of Golden which is described previously under the proposed interim improvements in Section 9.1.2)

The rationale for proposing Route M5 as the preferred route is as follows:

- Achieves desirable design speed of 100 km/h.
- Has excellent horizontal and vertical alignments (max. grade $\pm 4\%$) and will provide optimum efficiency and safety for the movement of people and goods.
- Flatter gradient than all other feasible routes (N1, N1 Surface and N2).
- Comparable or lower capital cost than other 100 km/h alternatives, N1 and N1 Surface.
- Significantly less constructability and long term geotechnical maintenance challenges than surface options at Black Wall Bluffs (N1 Surface and N2).
- Significantly less construction along existing TCH, resulting in simpler traffic management and less risk to public safety during construction.
- Shorter length of tunnel (600 metres) than any other feasible option.
- Avoidance of major known geological hazards.
- Minimal risk to fisheries, wildlife and known archaeological sites.
- Route lends itself to a practical long term construction staging/packaging program.

SEGMENT: THROUGH GOLDEN

FUNCTIONAL PLANNING - IMPROVEMENT CONCLUSION SUMMARY TABLE

1 PROJECT/WK PKG DESCRIPTION	2 LKI REFERENCE LOCATION	3 PROBLEM DEFINITION ELEMENTS	4 IMPROVEMENT ELEMENTS	5 ESTIMATED COST \$ MILLION	6 EXPECTED BENEFITS	7 CMP OPTION REFERENCE (IF APPLICABLE)	8 COMMENTS
<p>i. Short Term Improvement Projects</p> <p>i. Operational Improvements, West Limit of Golden to Highway 95</p>	LKI 0985, km 54.4 to 56.1	<ul style="list-style-type: none"> Traffic signals at west junction (LKI 54.6) of north and south frontage roads and at east junction (LKI 55.7) of north and south frontage roads, are not interlinked and coordinated (distance between signals just under 1.1 km). Westbound merge from 2 lanes to one lane, west of west signals is only 200 m long, which is insufficient to break up platoons created at the west signals. Eastbound trucks stopped at east signals can accelerate for only 550 m ± before they reach the bottom of Golden Hill (8%). Eastbound and westbound trucks may have to stop at the ICBC weigh scale/truck inspection station on the north side of TCH at LKI 55.75. The distance from the east entrance of the weigh scale to the bottom of Golden Hill (8%) is only 400 m ±. There are 2 unsignalized at-grade connections on the north side of TCH (right turns only) at LKI 54.9 and 55.2; also 2 unsignalized at-grade connections on the south side of TCH (right turns only) at LKI 54.9 and 55.35. Long trucks using these at-grade connections encroach on both lanes of TCH when they turn. The posted speed on this section of TCH is 60 km/h, less than the desirable minimum speed of 70 km/h along urban sections of TCH. 	<ul style="list-style-type: none"> Interlink and coordinate the signals on TCH at the west and east ends of the north and south frontage roads. Close the ICBC weigh scale/truck inspection station to EB traffic. Close 4 at-grade connections to TCH between signals at west and east ends of north and south frontage roads. Improve existing signalized intersections at west and east ends of north and south frontage roads if required to accommodate additional turning traffic. Increase the posted speed to 70 km/h between the west limit of Golden (LKI 54.3) and the east signals (LKI 55.7), located at the east end of the north and south frontage roads. Install advance flasher units at all the approaches to both sets of signals (at LKI 54.6 and 55.7). 	<p>0.05</p> <p>—</p> <p>0.10</p> <p>0.005</p> <p>0.05</p> <p>Total \$ 0.205</p>	<ul style="list-style-type: none"> Reduction in creation of platoons at existing downstream traffic signals. Increase in running speed of many EB trucks as they start up Golden Hill (8%). Reduction in accident rate as a result of reducing the number of intersections by four (not including weigh scale east access) and consolidating access at the two existing signalized intersections. Increase in operating speed of TCH traffic. 	<p>G.1 Eliminate Unsignalized Intersections</p> <p>\$0.107 Million</p>	<ul style="list-style-type: none"> Interlinking and coordinating the signals could ensure that WB platoons created at the east signals would not be stopped again at the west signals, thus enabling the platoon dispersal achieved on the 4 lane section to be maintained. A similar situation could be ensured in the EB direction. The existing uphill gradient from the east signals to the foot of Golden Hill is approximately 0.7%, over the distance of about 550 m. A truck with a mass/power ratio of 180g/W(300 lb/hp) should be able to accelerate to about 54 km/h in this distance. Closure of the ICBC weigh scale/truck inspection station to EB traffic together with the above referenced signal coordination will enable many EB trucks to have a much improved running start for climbing Golden Hill. Closure of the ICBC weigh scale to EB traffic can be achieved with an appropriate message on the changeable message sign for EB traffic

SEGMENT: THROUGH GOLDEN

FUNCTIONAL PLANNING - IMPROVEMENT CONCLUSION SUMMARY TABLE

1 PROJECT/WK PKG DESCRIPTION	2 LKI REFERENCE LOCATION	3 PROBLEM DEFINITION ELEMENTS	4 IMPROVEMENT ELEMENTS	5 ESTIMATED COST \$ MILLION	6 EXPECTED BENEFITS	7 CMP OPTION REFERENCE (IF APPLICABLE)	8 COMMENTS
2. Interim Term Improvement Projects							
ii. Four laning, Highway 95 to West of Golden View Road	LKI 0990, km 0.0 to 2.3	<ul style="list-style-type: none"> TCH WB has a single lane (3.7-3.8 m wide) and narrow paved shoulder (1-1.5 m wide) on the 8% downgrade of Golden Hill between Highway 95 junction and Golden View Road Intersection. The single WB lane does not allow for the dissipation of platoons which have built up in Kicking Horse Canyon. The existing horizontal alignment on Golden Hill includes 3 broken back curves, one of which has a radius of 150m. This curve is satisfactory for 60 km/h, the existing posted speed, but would not be adequate for a design speed of 70 km/h (min. radius 190 m). Six accidents in 5 years (1991-95) in the vicinity of Upper Golden-Donald Road Intersection including two injury, four property damage and one wild animal/vehicle collision (injury). There are several surficial failures in the fill slope below TCH on Golden Hill. EB B-trains have problems maintaining traction under winter conditions when they are climbing the 8% up-grade on Golden Hill. The TCH is only 2 lanes wide between Upper Golden-Donald Road and the east limit of Golden (LKI 2.2) just west of Golden View Road Intersection (East Junction). Six accidents in 5 years (1991-95) in vicinity of Golden View Road Intersection (East Junction) including one fatal, one injury, four property damage and two wild animal/vehicle collisions (property damage). 	<ul style="list-style-type: none"> Provide an additional WB lane on TCH between Highway 95 and Upper Golden-Donald Road. Four lane TCH between Upper Golden-Donald Road and Golden View Road (East Junction). Realign TCH on Golden Hill to achieve a minimum design speed of 70 km/h. Improve the Upper Golden-Donald Road intersection as required to accommodate the additional WB lane and any other needed improvements. Stabilize the fill slopes below TCH Operational improvements under project i. (signal coordination & closure of weigh scale to EB traffic) will benefit this section of TCH. Eliminate left turns at Golden View Road Intersection (East Junction). 	\$10.0	<ul style="list-style-type: none"> Provision of additional downhill lane WB on Golden Hill will enable general traffic to pass heavy trucks in crawl mode and dissipate platoons built up in Canyon. Realignment of the TCH will reduce steering effort, driver workload and potential for off road accidents on Golden Hill Stabilization of fill slopes below TCH will reduce risk of larger slope failures. Operational improvements under project i. will provide EB heavy trucks and B-trains with an improved running start in ascending Golden Hill Reduced accident potential at Golden View Road (East Junction). Increased WB passing opportunities. Capacity sufficient for long term and beyond 2021. 	<p>G.8 Four Lane Upgrade \$11.8 Million</p> <p>G.7-1 Upper Golden-Donald Road Intersection Improvements \$0.053 Million</p> <p>G.7-2 Signalize Upper Golden-Donald Road/TCH Intersection \$0.3 Million</p>	<ul style="list-style-type: none"> Four laning TCH through Kicking Horse Canyon will not eliminate the need for four laning from Highway 95 to east limit of Golden since WB platoons could build up prior to and within the hill section. Ducting should be provided at Upper Golden-Donald Road Intersection to allow for future signals. CPR tracks below TCH on Golden Hill at risk if there was a slope failure. Weigh scale/truck inspection station retained in interim term for WB traffic only
				Total \$10.0			

SEGMENT: THROUGH GOLDEN

FUNCTIONAL PLANNING - IMPROVEMENT CONCLUSION SUMMARY TABLE

1 PROJECT/WK PKG DESCRIPTION	2 LKI REFERENCE LOCATION	3 PROBLEM DEFINITION ELEMENTS	4 IMPROVEMENT ELEMENTS	5 ESTIMATED COST \$ MILLION	6 EXPECTED BENEFITS	7 CMP OPTION REFERENCE (IF APPLICABLE)	8 COMMENTS
3. Long Term Improvement Projects							
iii. Elimination of signals through Golden; Grade Reduction on Golden Hill	LKI 0985, km 54.4 to 56.06 LKI 0990, km 0.0 to 2.2	<ul style="list-style-type: none"> Signals at LKI 54.6 and at LKI 55.7 (at west and east ends of north and south frontage roads) disrupt flow of through traffic on TCH. At grade intersections at Highway 95 and Upper Golden-Donald Road create difficulties and delays for long distance and local traffic turning left onto TCH. Posted speed on TCH 60 km/h between east signals at LKI 55.7 and east limit of Golden, less than the desirable minimum of 70 km/h. Existing steep gradient (maximum 8%) on Golden Hill between LKI 0.2 and LKI 1.4 (1.2 km). 	<ul style="list-style-type: none"> Provide grade separation at west end of north and south frontage roads (LKI 54.6) Provide grade separated interchange at Highway 95 (LKI 56.1) Provide grade separation at Upper Golden-Donald Road. Realign TCH on Golden Hill to achieve maximum gradient of 5-6% Close the ICBC weigh scale/truck inspection station and relocate if necessary. Increase speed limit to 70 km/h from LKI 55.7 (existing east signals) to east limit of Golden (LKI 2.3), over a total distance of 2.7 km. 	<p>\$6.0 Million</p> <p>\$10.0 Million</p> <p>\$8.0 Million</p> <p>\$10.0 Million</p> <p>\$3.0 Million</p> <p>Total \$ 37.0</p>	<ul style="list-style-type: none"> Significant improvement in average travel speed on TCH. Capacity sufficient for long term and beyond 2021. 	<p>G.6 Interchange at West End of Frontage Roads \$6 Million</p> <p>G.5 Interchange at Highway 95 \$9.6 Million</p> <p>G.7-3 Grade Separate Upper Golden-Donald Road \$8.0 Million</p>	<ul style="list-style-type: none"> Grade reduction on Golden Hill will likely require realignment of TCH across the existing weigh scale/truck inspection station. Cost of closing and relocating (if necessary) weigh scale/truck inspection station to be cost shared with ICBC.



LEGEND:

- PROPOSED SHORT TERM IMPROVEMENT
- PROPOSED INTERIM TERM IMPROVEMENT
- PROPOSED LONG TERM IMPROVEMENT

0 1:10,000 500m
SCALE

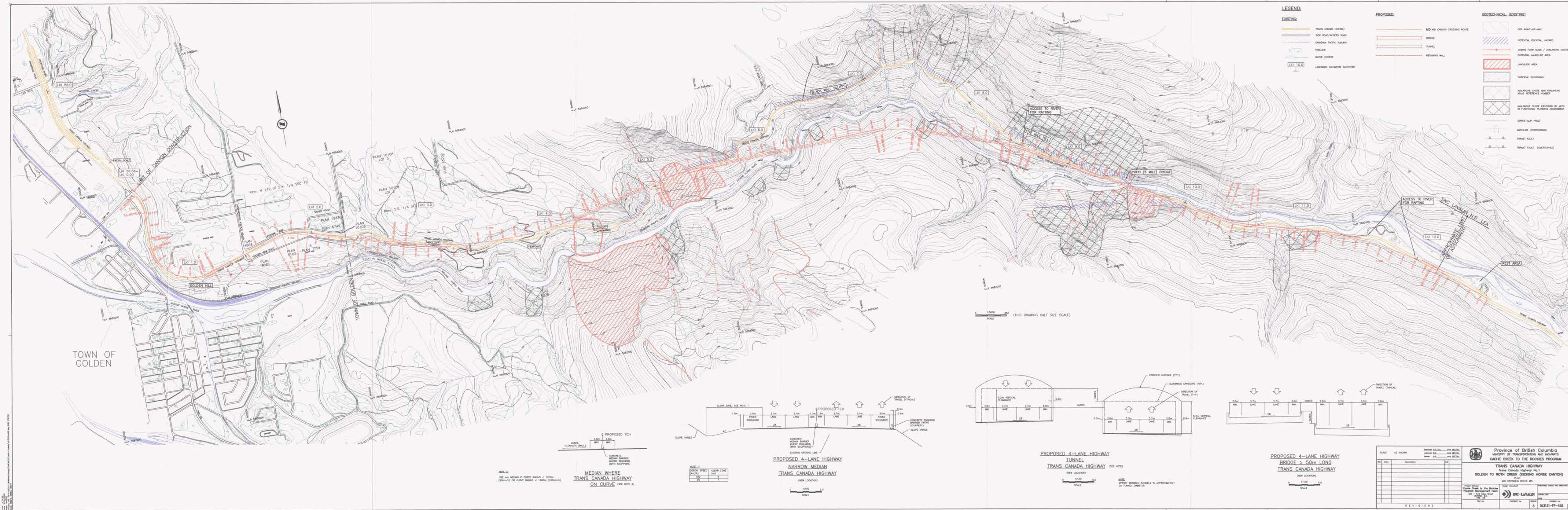
DESIGNED: T. S. 10/00 DATE: FEB. 00
CHECKED: S. 10/00 DATE: JAN. 00
DRAWN: S. 10/00 DATE: FEB. 00



Province of British Columbia
MINISTRY OF TRANSPORTATION AND HIGHWAYS
CACHE CREEK TO THE ROCKIES PROGRAM

PROPOSED IMPROVEMENTS & FOUR LANING
Trans Canada Highway No. 1
TOWN OF GOLDEN
FIGURE 9-1





NOTE 2:
USE 4m MEDIAN IF CURVE RADII < 1200m
(2000m) OR CURVE RADII < 1800m (1000m/A)

MEDIAN WHERE
TRANS CANADA HIGHWAY
ON CURVE (SEE NOTE 2)

NOTE 1:
DESIGN SPEED CLEAR ZONE
(m/s) (ft)

PROPOSED 4-LANE HIGHWAY
NARROW MEDIAN
TRANS CANADA HIGHWAY
(NEW LOCATION)

PROPOSED 4-LANE HIGHWAY
TUNNEL
TRANS CANADA HIGHWAY (SEE NOTE)

PROPOSED 4-LANE HIGHWAY
BRIDGE > 50m LONG
TRANS CANADA HIGHWAY
(NEW LOCATION)

REVISIONS	
No.	Description

Province of British Columbia
MINISTRY OF TRANSPORTATION AND HIGHWAYS
CACHE CREEK TO THE ROCKIES PROGRAM

TRANS CANADA HIGHWAY
Trans Canada Highway No. 1
GOLDEN TO ROTH CREEK (YODUNG HORSE CANYON)
PLAN
MID CROSSING ROUTE 401

3 013121-PP-155