SOUTHERN REGION GEOHAZARD ASSESSMENT
ANNUAL ASSESSMENT REPORT
2007

Submitted to:

Alberta Infrastructure and Transportation
Calgary, Alberta

Submitted by:

AMEC Earth & Environmental,
a division of AMEC Americas Limited
Calgary, Alberta

November 2007

CG25263

November 6, 2007
CG25263

Mr. Roger Skirrow, M.Sc., P.Eng.
Alberta Infrastructure and Transportation
2nd Floor, Twin Atria Building
4999 – 98 Avenue
Edmonton, AB T6B 2X3

Dear Roger:

Re: Southern Region Geohazard Assessment
Annual Assessment Report, 2007

Please find enclosed one copy of the 2007 Annual Assessment Report. Also included is an unbound copy of the appendices for inclusion in the appropriate site binders and a CD containing electronic copies of the report files. Copies of these items have also been sent to Ross Dickson of Alberta Infrastructure and Transportation in Calgary.

If you have any questions or require any further information, please do not hesitate to contact the undersigned at (403) 569-6529.

Yours truly,
AMEC Earth & Environmental,
a division of AMEC Americas Limited

Andrew Bidwell, M.Eng., P.Eng.
Associate Geological Engineer

AB

c: Ross Dickson – AIT

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1.0 INTRODUCTION

AMEC Earth & Environmental (AMEC), a division of AMEC Americas Limited (AMEC), has been retained by Alberta Infrastructure and Transportation (AIT) to conduct annual assessments of identified geohazard sites in the Southern Region. This work is being done in conjunction with semi-annual instrumentation monitoring at several of the identified geohazard sites.

This report presents the results of the 2007 annual assessments along with recommendations for continued assessment, monitoring and additional work where required. The enclosed CD contains electronic copies of the report files.

This work has been authorized by AIT under Consulting Services Agreement CE044/2004.

2.0 BACKGROUND

AIT has implemented a Geotechnical Risk Management Plan (GRMP) in order to estimate the risk levels of geohazard events at specific sites and to assist AIT in the prioritization of mitigative works. This work has been conducted in the past by AIT personnel and since 2000 by outside geotechnical consultants with the work being awarded on a regional basis. AMEC has been awarded the assignment of conducting this work for the Southern Region since the spring of 2000.

The GRMP includes the estimation of a Risk Level for each site that is assessed. The estimated Risk Level is expressed as a number ranging from 1 to 200 that is calculated as the product of a Probability Factor and a Consequence Factor assigned to each site on the basis of annual site assessments, geotechnical instrumentation readings, and other information for each specific site. The descriptions for these factors are listed on Tables A1 to A3 in Appendix A. Table A1 lists general descriptions for these factors, as provided by AIT. Tables A2 and A3 list the sets of probability and consequence factors specific to rockfall hazards and debris flows, respectively, as developed by AMEC for AIT during a recent geohazards review of the Highway 40/Highway 541 corridor.

3.0 FIELD PROGRAM

The annual assessments were performed on June 18 to 21, 2007 for the following sites.

<u>June 18, 2007</u>
S2 – Priddis
S7 – Millarville
S10 – Highway 762 S10(C)
S8 – Fisher Creek
S22 – Highway 762 “S” Curve
S10 – Highway 762 S10(A)
S1 – Jumpingpound Creek
S3 – Cochrane

June 19, 2007
S12 – Spray Lakes Road
S17 – Highway 40 – Mount Baldy Rock Cut
S18 – Highway 40 – Galatea Creek Through-Cut
S19 – Highway 40 – King Creek
S20 – Highway 541 – Highwood House Rock Cut
S21 – Highway 541 – Highwood Base Road Creek
S16 – Chain Lakes Site

June 20, 2007
S15 – Crowsnest Lake Rockfall Barrier
S14 – Bellevue Sites
S27 – Highway 3 – Windmill
S28 – Highway 3A At Range Road 2-2A
S23 – Highway 507:02 – East Of Mill Creek
S24 – Highway 507 – Eastbound Lane Site and Westbound Lane Site
S4 – Willow Creek
S25 – Highway 3 – Monarch

June 21, 2007
S5 – Chin Coulee
S26 – Highway 41 – Elkwater
S29 – Highway 1 – Seven Persons Creek

Each site was visited by Andrew Bidwell of AMEC along with Roger Skirrow and Rocky Wang of AIT. Ross Dickson of AIT participated in the site visits on June 19 to 21, 2007.

Each site was assessed visually and measurements and notes of site features were recorded using field reconnaissance level techniques. Digital photographs of site features were also taken.

4.18 S21 – HIGHWAY 541 – HIGHWOOD BASE ROAD CREEK

Background

This site is located at a creek crossing approximately 3 km east of the junction between Highways 40, 541 and 940 at Highwood House. Please refer to Figure S21-1 in Appendix S21 for an illustration of the site location.

The creek flows beneath the highway via a single culvert of approximately 1250 mm diameter. The culvert outlet discharges onto a gravel bar along the north bank of the Highwood River.

This site was initially inspected by AMEC in August 2004 when a significant accumulation of debris was noted along the north side of the highway (Photo S21-1 in Appendix S21). It appeared that this debris had overtopped the ditch at some time earlier in 2004 and flowed onto the westbound lane of the highway before being cleared by the maintenance contractor.

An airphoto review of this site along with field inspections in July and August 2005 were performed by AMEC as part of the geohazard review for the Highway 541 corridor. The appearance of the debris along the creek channel was concluded to be the result of multiple debris flow events during previous years with relatively significant events occurring during 2004 and 2005. Specific observations from the previous inspections were summarized in the 2006 report on the corridor geohazard review as follows:

- At the time of the July and August 2005 site inspections, the culvert inlet was approximately two-thirds filled with rock debris.

- The airphotos of this site show that the headwaters of the creek are in a valley on the south side of Holy Cross Mountain, approximately 2 km north of the highway. Topographic maps of the area show that the average gradient of the segment of the creek channel within 1.25 km upstream of the highway is approximately 8°. The average channel gradient increases to around 15° further upstream. Debris flows can travel along channel with these gradients under certain conditions.

- There are levees of cobble to boulder sized debris along the creek channel for approximately 600 m upstream of the highway. There are also many locations where it appeared that the main channel had shifted frequently and recently within the area bounded by the levees.

- The creek channel flows between bedrock controlled slopes between approximately 600 and more than 1200 m upstream of the highway. The creek channel in this area contains large volumes of gravel to boulder-sized debris and numerous fallen trees. A lot of the debris appeared “fresh” and was judged to have been deposited earlier in 2005, however the overall volume and appearance of the debris along the channel suggested that transport and deposition have been ongoing for many years.

- The majority of the debris along the channel and in the fan at the highway crossing consisted of pieces of white limestone. The exposed bedrock in the slopes along the segment of the channel that was traversed upstream of the highway was a dark grey shale. The airphotos of the site show light-colored rock debris originating from rockfall areas and steep colluvium slopes in the upper portion of the watershed and extending downstream along the creek channel to the highway. Therefore, it appeared that the white limestone debris had been transported from the upper portion of the creek's watershed.

The June 2007 site inspection was the first annual site inspection under the Southern Region GRMP and the first site inspection since late 2005. This site was added to the annual site inspection tour because its recommended Risk Level was one of the highest in the geohazards review of the Highway 40 / Highway 541 corridor.

Site Assessment

The site assessment was performed on June 19, 2007. The weather at the time of the site assessment was clear and warm.

The site assessment consisted of a visual inspection of the creek/debris flow channel within the cleared right-of-way upslope of the road as well as the culvert below the road.

Observations

The following points summarize the observations made during the site assessment. Please also refer to Appendix S21 for photographs.

- The overall appearance of the site and the debris along the creek channel had not changed significantly since the 2005 inspections.

- The culvert was still blocked with roughly the same amount of debris as noted in the 2005 inspections. However, it appeared that the normal creek flows could percolate through the debris in the culvert without water impounding along the north side of the highway.

Assessment and Risk Level

The site conditions do not appear to have changed significantly since the initial assessment in 2005 and there remains a risk that future debris flow events along the creek channel could deposit material onto the highway, possibly blocking at least a portion of the road. Therefore, the following recommended Risk Level factors for this site, based on the debris flow frequency-severity matrix (Table A3, in Appendix A), are unchanged from the previous assessment:

- Probability Factor of 11 based on the apparent occurrence of debris flows blocking the ditch in 2004 and possibly 2005 as well as along with the debris accumulation along the

channel upstream of the highway. The Probability Factor may actually be closer to 9 over the long term, but it appears that in recent years a value of 11 is more accurate.

- Consequence Factor of 3 based on observations from August 2004 where it appeared that debris had flowed onto the westbound lane of the road but there was little to no damage to the road surface and closure of the road was not required.

Therefore, the recommended Risk Level for this site is 33.

Recommendations

AMEC recommends the following work for this site:

1. Further excavation of the accumulated debris along the creek channel upstream of the culvert inlet in order to increase the available volume of debris storage upstream of the culvert during future debris flow events. This will provide additional "buffer" capacity before future debris accumulations encroach onto the highway and therefore reduce the Consequence Factor for this site. This will also help to reduce the chance of future channel shifting away from the existing culvert due to a build-up of debris along the existing channel. The excavated debris could possibly be hauled away and dumped in the cleared area along the north side of the highway approximately 100 m westbound from the creek channel. One to two days of work by a track-mounted excavator and two trucks would likely be sufficient to complete this work.

2. The debris within the culvert itself should also be cleaned out in order to restore the culvert's flow capacity. It may be more practical to install a second culvert adjacent to the existing culvert in order to increase the drainage capacity at the creek channel.

The previous recommendation to install a "trash rack" grate across or slightly upstream of the inlet of the existing culvert (as well as the second culvert, if installed) in order to reduce the amount of debris that enters the culvert in the future could still be considered. However, the debris excavation recommended in point 1 above is likely a more practical way to manage the risk of debris flow deposition onto the highway.

5.0 SUMMARY

A list of the sites, ranked by current recommended Risk Level, is presented in Table A4 in Appendix A for reference. This table also shows:

- Which sites have been recommended for further assessment (e.g. site investigation).
- Which sites have been recommended for repair work, and whether or not the recommended repair work is pending.

6.0 CLOSURE

This report has been prepared for the exclusive use of Alberta Infrastructure and Transportation for the specific project described herein. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it are the responsibility of such third parties. AMEC Earth & Environmental, a division of AMEC Americas Limited cannot accept responsibility for such damages, if any, suffered by any third party as a result of decisions made or actions based on this report. This report has been prepared in accordance with accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

We trust that this meets your needs at this time. Please contact the undersigned if you have any questions or require any further information.

Respectfully Submitted,

AMEC Earth & Environmental,
a division of AMEC Americas Limited

Andrew Bidwell, M.Eng., P.Eng.
Associate Geological Engineer

APEGGA Permit To Practice No. P-04546

Reviewed by:

Pete Barlow, M.Sc., P.Eng.
Principal Geotechnical Engineer

APPENDIX A

Tables

Table A1 – Geohazard Risk Level Factors

Risk Level = (Probability Factor, PF) x (Consequence Factor, CF)	
Probability Factor (ranked on a scale of 1 to 20)	
1	Inactive, very low probability of slide occurrence.
3	Inactive, low probability of remobilization.
5	Inactive, moderate probability of remobilization, uncertainty level moderate, or active but very slow rate of movement or indeterminate movement pattern.
7	Inactive, high probability of remobilization or additional hazards, uncertainty level high, or active with perceptible movement rate and defined zone(s) of movement.
9	Active with moderate steady, or decreasing, rate of ongoing movement.
11	Active with moderate but increasing rate of movement.
13	Active with high rate of movement, steady or increasing.
15	Active with high rate of movement with additional hazards.
20	Catastrophic slide is occurring.
Consequence Factor (ranked on a scale of 1 to 10)	
1	Shallow cut slope where slide may spill into ditches or fills where slide does not impact pavement, minor consequence of failure, no immediate impact to driver safety, maintenance issue.
2	Moderate fills and cuts, not including bridge approach fill or headslopes, loss of portion of the roadway or slide onto road possible, small volume. Shallow fills where private land, waterbodies or structures may be impacted. Slides affecting use of roadways and safety of motorists, but not requiring closure of the roadway. Potential rock fall hazard sites.
4	Fills and cuts associated with bridges, intersectional treatments, culverts and other structures, high fills, deep cuts, historic rock fall hazards areas. Sites where partial closure of the road or significant detours would be a direct and unavoidable result of a slide occurrence.
6	Sites where closure of the road would be a direct and unavoidable result of a slide occurrence.
10	Sites where the safety of public and significant loss of infrastructure facilities or privately owned structures will occur if a slide occurs. Sites where rapid mobilization of large scale slide is possible.

Table A2 – Rock Fall Risk Level Factors

Probability Factor – Rock Falls
(For Each Rock Cut or Rock Slope)

Weight	Description
1	Inactive, very low probability of fall occurrence.
3	Inactive, low probability of fall occurrence.
5	Inactive, moderate probability of fall occurrence.
7	Inactive, high probability of fall occurrence (e.g. seasonal, following freeze/thaw cycles) and/or a fall has occurred in the historic past.
9	Active, falls occur after exceptional weather (e.g. the melting of greater than average snow accumulations or exceptionally intense precipitation), fall frequency is in the order of once a decade.
11	Active, one or two falls occur each year triggered by annually recurring weather conditions.
13	Active, several falls occur each year and/or the frequency of falls is increasing in comparison to equivalent time periods in previous years.
15	Active, many falls occur each year and/or the area producing rock falls is expanding. Ongoing or persistent rock falls during specific times of the year.
20	Active, a large volume of rock is surrounded by open cracks. Toppling or sliding of the displacing mass is accelerating. Sites where rapid movement of a large fall is possible.

Consequence Factor – Rock Falls
(For Each Rock Cut or Rock Slope)

Weight	Description
1	Rock fall contained by ditch if cleaned as required to maintain capacity.
2	Rock fall onto roadway removable by maintenance crews by hand or with shovels. Road closure not required. Minor damage to the road surface that can be repaired during annual patching and sealing of the road. Minor to no damage to vehicles being struck by falling rocks or striking rocks deposited onto road.
3	Rock fall onto road that could damage a vehicle (e.g. flat tire, dent body of vehicle). Rocks bounce or roll onto the road surface but likely not with a trajectory that would pass through the windows or windshield of a passing vehicle.
4	Individual rocks or the total volume of rocks deposited on the road large enough to: Damage vehicles or cause accidents if struck by traffic or damage vehicles and injure occupants if they strike a moving vehicle. o Cause partial closure of the road or require a detour lane prior to cleanup. Damage to the road surface may require temporary repair in order to re-open road.
6	Individual rocks or the total volume of rocks deposited on the road large enough to: o Damage/destroy vehicles and severely injure occupants if struck by traffic or damage/destroy vehicles and severely injure/kill occupants if they strike a moving vehicle. o Cause complete closure of the road, with a rough detour/diversion possible within hours to days. o Require days to weeks required to restore the road to normal service. Possibly significant damage to the road surface that requires immediate repair.
8	Same as weighting of 6, but with several days required to develop a rough detour/diversion around the rockfall site.
10	Individual rocks or the total volume of rocks deposited on the road large enough to: o Damage/destroy vehicles and severely injure occupants if struck by traffic. o Bury vehicles if they strike a moving vehicle. o Cause complete closure of the road, with a temporary, rough detour or diversion possible in days to weeks. o Require complete reconstruction or rerouting of the road after the rockfall.

Table A3 – Debris Flow Risk Level Factors

Probability Factor – Debris Flows
(For Each Fan)

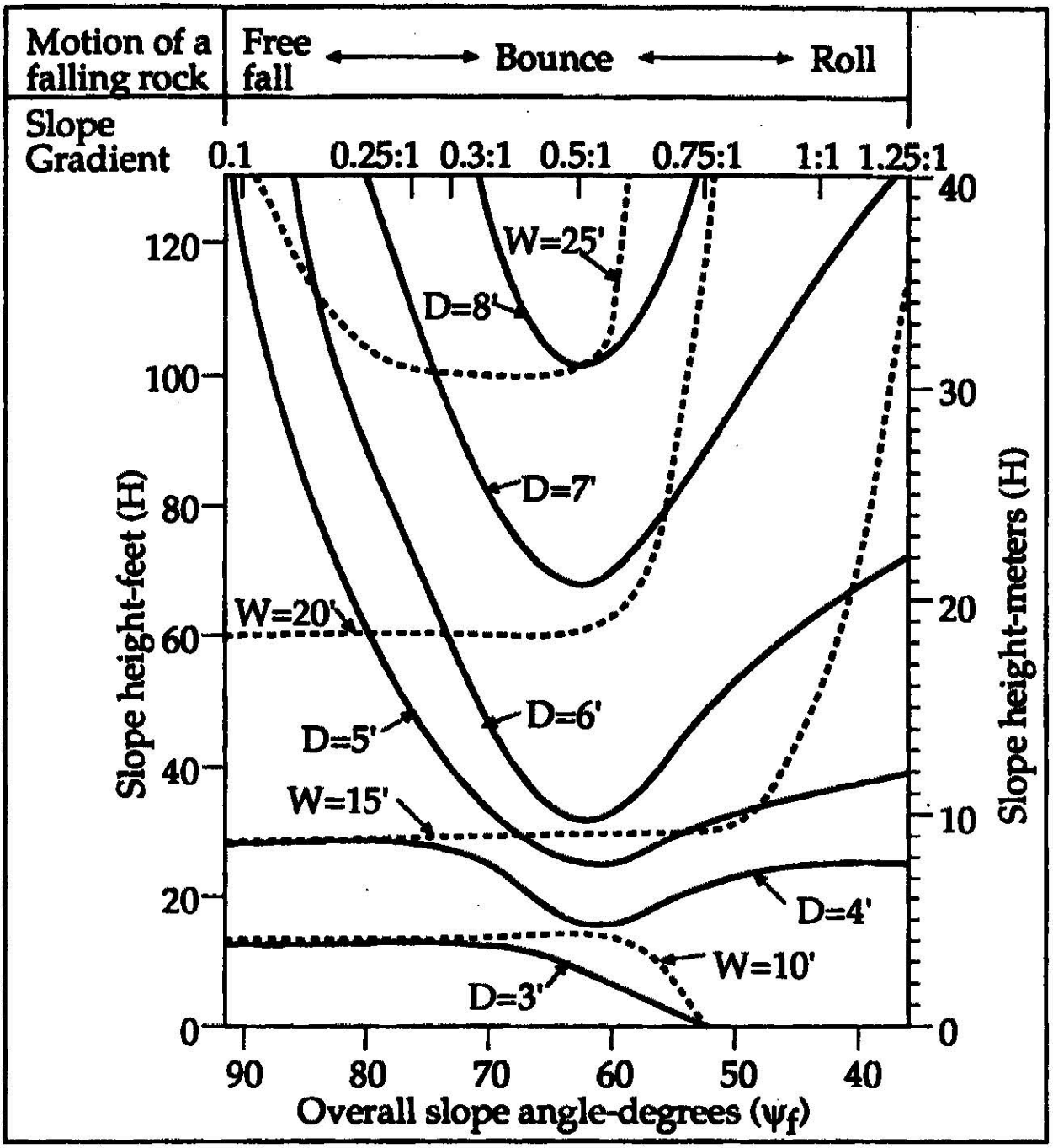
Weight	Description
1	Inactive, very low probability of a flow. No historical or current visual evidence of debris flow activity.
3	Inactive, low probability of a flow.
5	Inactive, moderate probability of a flow based on channel morphology and presence of debris in the potential source zone.
7	Inactive, high probability of a flow; a flow has occurred in the historic past and/or debris buildup in the channel/source area is considered to be ongoing.
9	Debris accumulation normally present in the source area. Fan is considered to be active, with flows occurring after the melting of an exceptional snow accumulation or an exceptionally intense rainfall.
11	Active, one or two flows per year triggered by annually recurring weather conditions.
13	Active, several flows each year.
15	Active, many flows each year, the area producing flows is expanding.
20	Active, a large volume of debris is impounding a large and rising reservoir of water upstream. Overtopping and dam-break is expected.

Consequence Factor – Debris Flows
(For Each Fan)

Weight	Description
1	Debris flow contained by the ditch or able to be conveyed past the road alignment via a sufficiently sized culvert or clear span bridge.
2	Debris flow onto roadway easily removable by maintenance crews. No damage to the road surface. Road closure not required and/or road still passable without damage to vehicles provided reduced speed limit established.
4	Partial closure of the road or significant detours would result from a debris flow. Debris flow onto roadway that requires partial closure of the road or significant detours while maintenance crew uses heavy equipment to clear debris and restore road surface. Damage to the road surface possible.
6	Complete closure of the road would result from debris flow while maintenance crew uses heavy equipment to clear the roadway and/or remove debris flow deposits plugging culvert or ditch. Geotechnical inspection required to assess post-event stability of road fills. Damage to the road surface likely.
10	Sites where the safety of the public is threatened by a debris flow, where there will be significant loss of infrastructural facilities or privately-owned structures if a flow occurs.

Table A4 – Summary of Recommended Risk Levels for Southern Region Sites

Site	Recommended Risk Level Value		Recommendations		
	Current	2006	Annual Inspection In 2008	Further Assessment	Design and Repair or Maintenance Work, With Notes On Schedule Where Applicable
S15 – Crowsnest Lake Rockfall Barrier	90	15	Yes	No	Repairs to net required ASAP.
S14 – Bellevue Sites (Potential sinkhole site)	72	72	No	Borehole drilling to follow-up and supplement 2004 GPR survey.	Nothing planned. To be confirmed once borehole information available.
S12 – Spray Lakes Road	54	63	Yes	No	Develop list of repair options for AIT review and decision.
S26 – Highway 41 - Elkwater	52	n/a	Yes	Boreholes to assess applicability of horizontal drains to reduce landslide movement.	Horizontal drain design, pending information from boreholes. Boreholes not scheduled yet. Ongoing road maintenance as required.
S19 – Highway 40 – King Creek (worst case scenario)	50	50	Yes	No	Design/cost estimate for secondary culvert, for AIT review and decision.
S2 – Priddis	45	45	Yes	New piezometers.	Maintenance of road surface as required.
S17 – Highway 40 – Mount Baldy Rock Cut - East Cut Slope	45	45	Yes	No	Scaling – as soon as practical. Ditch cleaning – ongoing.
S18 – Highway 40 – Galatea Creek Through-Cut - East Cut Slope	45	45	Yes	No	Ditch cleaning – ongoing. Increase capacity of East Ditch (if possible while maintaining clear width requirements).
S20 – Highway 541 – Highwood House Rock Cut	45	45	Yes	Track and assess required effort for ditch cleaning to verify if it is cost-effective vs. other measures.	Ditch cleaning – ongoing.
S10 – Highway 762 S10(A)	44	44	Yes	No	Develop list of repair options for AIT review and decision.
S21 – Highway 541 – Highwood Base Road Creek	33	33	Yes	No	Excavate and haul away debris from upslope side of road. Clean out debris from existing culvert or install second culvert.
S1 – Jumpingpound Creek	30	40	Yes	No	Surface drainage improvements and apply creek bank erosion protection measures.
S23 – Highway 507:02 – East Of Mill Creek	30	30	Yes	No	Excavation to maintain south ditch capacity – if required. Maintenance work if/when required.
S7 – Millarville	30	24	Yes	Install SI's and piezometer in new cracking area. Locate and mark shear key drain outlet for future visual monitoring.	Nothing planned. To be confirmed once new instrument data available.
S3 – Cochrane	27	27	Yes	No	Repairs to ditch berm. Develop list of repair options for AIT review and decision.
S24 – Highway 507 – Westbound Lane Site	27	27	No (unless recommended further assessment work performed)	Boreholes to check subsurface conditions and investigate causes of damage to road surface.	Depends on findings from boreholes, otherwise continue with road surface maintenance as required.
S10 – Highway 762 S10(C)	27	n/a	Yes	Overexcavate existing sinkhole in west embankment slope to further assess its cause.	Nothing planned. To be confirmed once further assessment completed.
S8 – Fisher Creek	24	32	Yes	No	Shear key design previously completed. Defer repair work until if/when more significant damage occurs.
S28 – Highway 3A At Range Road 2-2A	24	n/a	Yes	Airphoto review, site survey, and borehole drilling/instrumentation to characterize slope instability.	Design work based on further assessment data. In the meantime, road surface maintenance as required.
S5 – Chin Coulee	20	25	Yes	No	Install soil nails to stabilize downslope shoulder of road.
S22 – Highway 762 "S" Curve	20	10	Yes	No	Maintain road surface as necessary. Develop list of repair options for AIT review and decision.
S19 – Highway 40 – King Creek ('typical' year)	10	n/a	Yes	No	Design/cost estimate for secondary culvert, for AIT review and decision.
S4 – Willow Creek	18	18	Yes	No	Repair work to be tendered, late 2007. Planned to be completed in spring 2008.
S24 – Highway 507 – Eastbound Lane Site	18	18	No	No	Road surface maintenance as required.
S14 – Bellevue Sites (Rock cut site)	15	15	No	No	n/a
S18 – Highway 40 – Galatea Creek Through-Cut - West Cut Slope	12	12	Yes	No	Ditch cleaning in conjunction with east ditch at this site.
S27 – Highway 3 – Windmill	7.5	n/a	Yes	No	Nothing planned.
S16 – Chain Lakes Site	5	n/a	Yes	Instrument readings in 2008.	n/a
S25 – Highway 3 – Monarch	5	n/a	Yes	Not recommended.	Road surface maintenance as required.
S29 – Highway 1 – Seven Persons Creek	5	n/a	Yes	No	n/a



NOTES:

1. AFTER RITCHIE (1963), AS SHOWN IN TRANSPORTATION RESEARCH BOARD SPECIAL REPORT 247 (1996).

amec Earth & Environmental

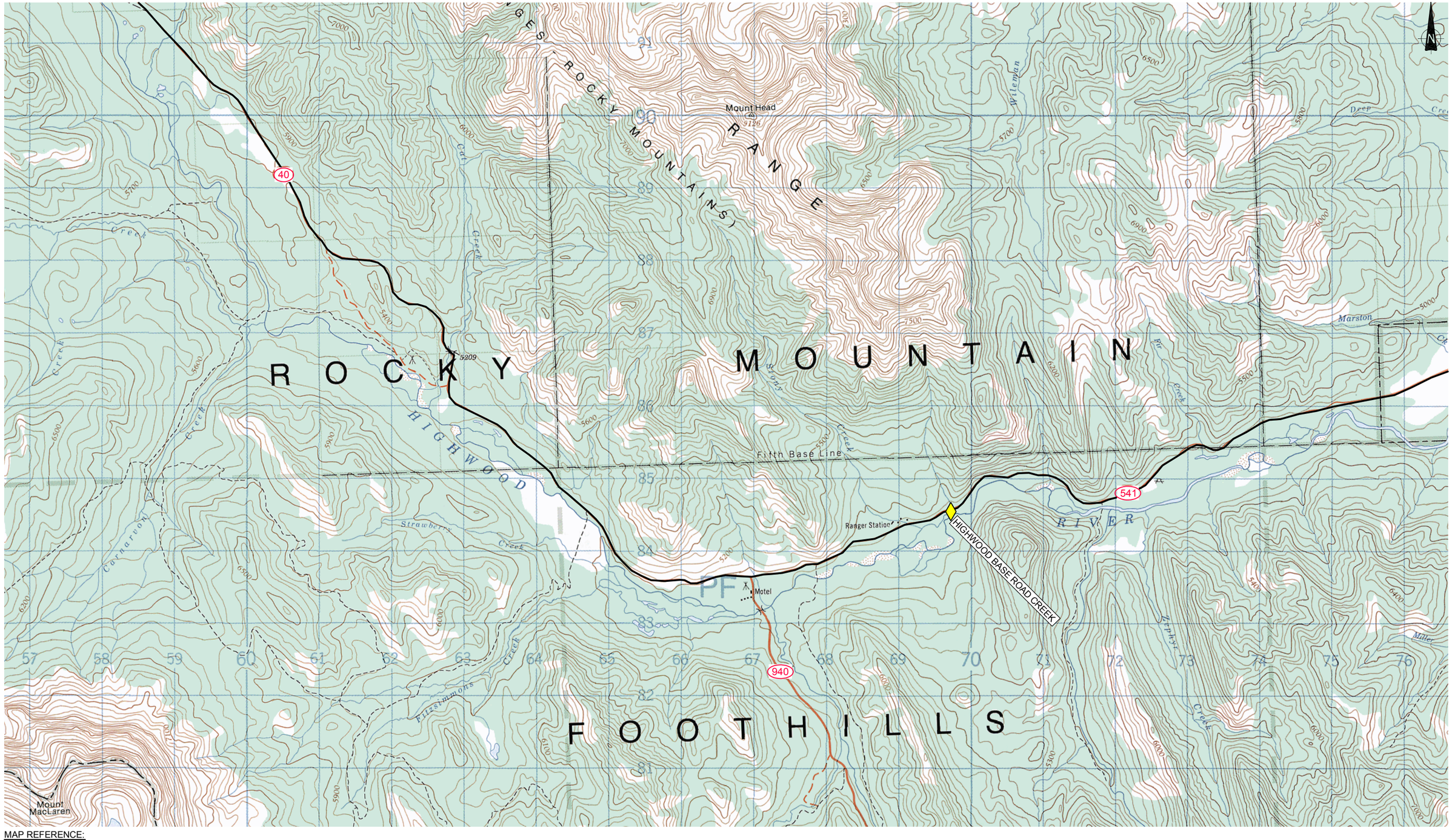
CLIENT: Alberta Infrastructure and Transportation

PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT

TITLE: ROCKFALL CATCHMENT DITCH SIZING CHART

DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
AUGUST 2007	CG25263	25263X04.dwg	FIGURE A1	A

APPENDIX S21
Highway 541 – Highwood Base Road Creek



MAP REFERENCE:
1:50 000, 82-J/7,8,9,10,11,14, 82-O/2,3 (ETOPO)

SCALE
1:50 000
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amec Earth & Environmental

CLIENT: Alberta Infrastructure and Transportation

PROJECT: SOUTHERN REGION GEOHAZARD ASSESSMENT

TITLE:
LOCATION PLAN
S21- HIGHWAY 541- HIGHWOOD BASE ROAD CREEK

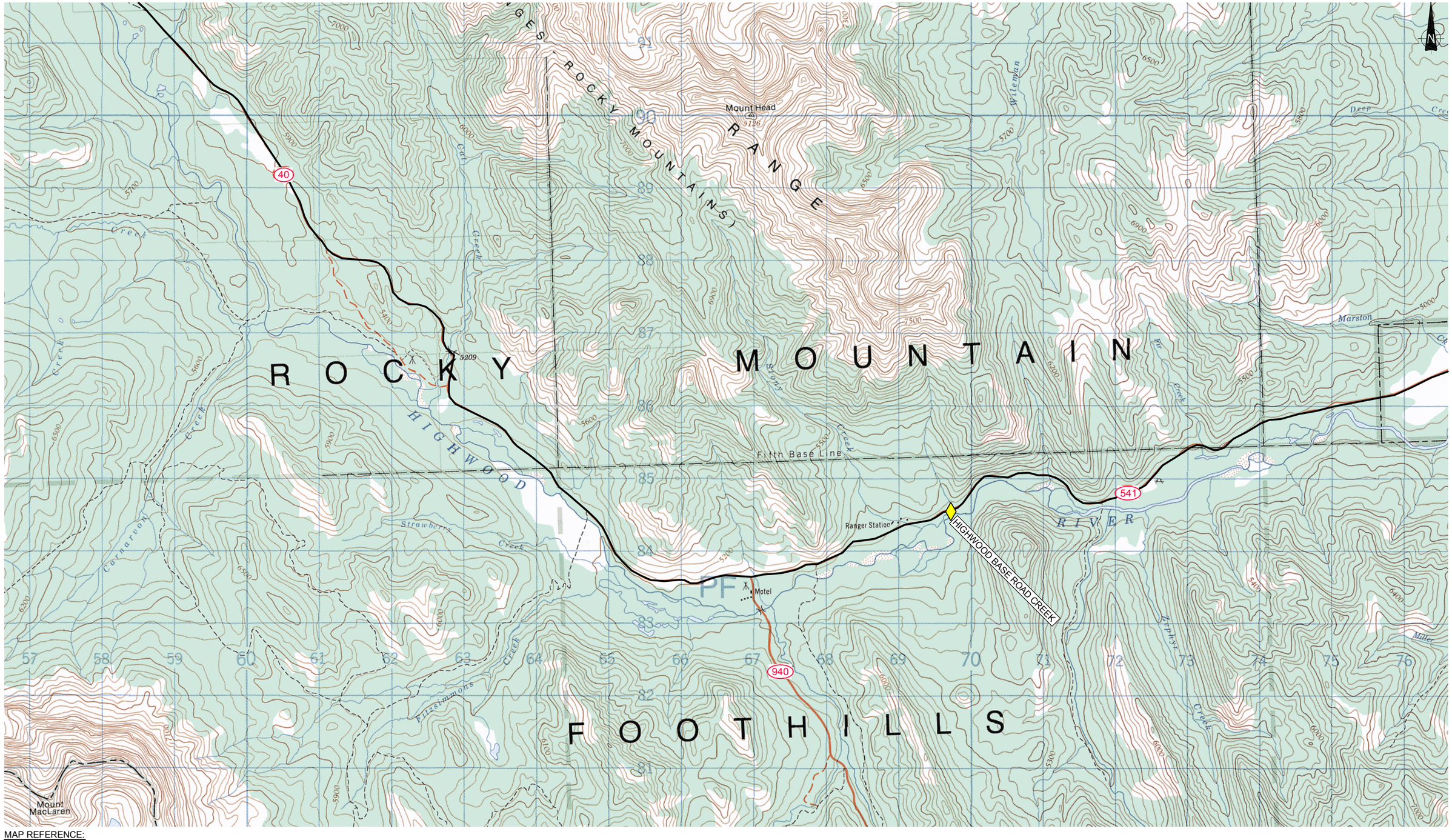
DATE:	JOB No.:	CAD FILE:	FIGURE No.:	REV.
AUGUST 2007	CG25263	25263X02.dwg	S21–1	A

Photo S21-1 – August 2004 (upper left)
Facing west across debris filling the north ditch and burying the culvert inlet. It appears that the debris had previously buried the culvert inlet and also extended onto the westbound lane of the highway before being cleared by the maintenance contractor.

Photo S21-2 – June 2007 (upper left)
Facing westbound along the highway with the 2004 debris flow deposit visible on the upslope side of the road.

Photo S21-3 – June 2007 (upper right)
Facing downstream towards the inlet of the 1250 mm diameter culvert below the highway. The culvert inlet is in roughly the same condition as noted in the August 2005 inspection and is approximately 2/3 full of debris.

Photo S21-4 – August 2005 (lower left)
This photo from the August 2005 site inspection shows the outlet of the culvert approximately ¼ full of debris. The culvert outlet was in essentially the same condition at the time of the June 2007 inspection.



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Facing downstream towards the inlet of the 1250 mm diameter culvert below the highway. The culvert inlet is in roughly the same condition as noted in the August 2005 inspection and is approximately 2/3 full of debris.

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This photo from the August 2005 site inspection shows the outlet of the culvert approximately ¼ full of debris. The culvert outlet was in essentially the same condition at the time of the June 2007 inspection.