BC Ministry of Forests, Lands and Natural Resource Operations

Thompson Okanagan Region

Investigation of the 2012 Woodlot 1572 Landslide

Prepared for:

Dennis Kelly
Engineering Technician, Okanagan Shuswap District
Ministry of Forests, Lands and Natural Resource Operations

Prepared by:

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1.0 INTRODUCTION

A landslide occurred on Woodlot 1572 early in the morning on April 26th, 2012. On April 27, 2012, Todd Smith, Resource Compliance Technologist, Okanagan Shuswap District, Ministry of Forests, Lands and Natural Resource Operations visited the site with Curt Olson, a representative of Woodlot 1572. On May 8th, 2012, I visited Woodlot 1572 with Dennis Kelly, Engineering Technician with the Okanagan Shuswap District, Ministry of Forests, Lands and Natural Resource Operations and Patrick Martin, P.Eng., Geotechnical Engineer, Southern Engineering Group, Ministry of Forests, Lands and Natural Resource Operations to assess the factors contributing to the initiation of the landslide.

2.0 BACKGROUND

The landslide initiated below Woodlot 1572, Cutting Permit B, block 3 (Block B-3), in the headwaters of Metcalfe Creek which drains southeast off the upland area known as the Larch Hills. Metcalfe Creek is a small tributary of Violet Creek which itself is a tributary to the Shuswap River. The landslide started around 990m elevation as a steep open face failure and moved downslope into a well defined draw.

Woodlot 1572, Block B-3 is accessed off Edgar Road which runs north from Grandview Bench Road (Figure 1). From Edgar Road you turn left onto R10853 1-6 which rises across the slope towards the south. At the time of our visit we were able to drive directly to Block B-3 and review the condition of the roads and drainage structures in the area. There was minimal flow of water anywhere on the slope or in the ditchline, but the trace of the water was still visible. Dennis Kelly visited the site on April 30th and viewed the culverts and debris on Edgar Road. Dennis returned on May 4th and walked the slide upslope from the depositional area to the initiation point and continued on upslope following overland flow in the draw to the woodlot road R10853 1-6.

3.0 FIELD OBSERVATIONS

We commenced our field review on the landing at the southeast corner of Block B-3. At this location we viewed the southern ditchline of the more recently constructed spur road across Block B-3 into Block C-4. This ditchline ran down from the northwest, across the landing and down the hillslope in an easterly direction. We followed the shallow draw into which this ditchline water was directed and walked downslope until we encountered a broad headscarp at an approximate elevation of 990m. We reviewed the initiation point of the slide and the steep slope immediately above. We then walked back upslope to road R10853 1-6 and the landing where we had started. We then followed the ditchline on the spur road upslope through Block B-3 and reviewed the road and drainage structures.

4.0 DISCUSSION

The cause of the landslide appears to be an excess of water in a shallow draw reaching a steep slope below Block B-3 (Figures 1 and 2). As the draw left the Block B-3 it was a small swale, 2-3 m deep, 5-10 m wide and definable as linear watercourse. Downslope, we were able to follow the draw continuously until it reached a steep rock-cored face where it flattened and became more unconfined. The landslide initiated within the shallow

sediments on this steep slope. The steep rock-cored slope then leads down into larger draw which is located to the south. The main channel of Metcalfe Creek starts north of the landslide, and the landslide appears to have entered an upslope tributary of Metcalfe Creek.

The source of the excess water is the spur road ditchline. The ditchline does two things, it:

- concentrates water from several small drainages, and;
- intercepts the groundwater flow and converts it to surface flow.

For approximately 400 metres along the spur road, water from the southwest is intercepted and directed to the southeast through the ditchline. Each shallow draw is capable of handling a small amount of water, mostly during spring freshet or intense thunderstorms. These small drainages all remove water from distinct, small watersheds by groundwater and minor open surface flow, and when dispersed in that manner onto the slopes the small draws remain stable.

The construction of the spur road across Block B-3 allowed interception of several small drainages and increased the size of the watershed draining through the shallow draw. At the same time, the groundwater is being converted to surface flow and also increases the flow through the ditchline. This water is then directed across the landing at the southeast edge of Block B-3 and across road R10853 1-6 and into the shallow draw. The spur road had been waterbarred to remove water from the running surface; these were not deep enough to connect to the ditchline, nor were there ditch blocks to halt ditchline flow.

Removal of forest cover in Block B-3 will also have changed the accumulation of snow and timing of snowmelt; likely increasing the amount of snow accumulated and increasing the rapidity of snowmelt. Typically this results in a larger volume of water flowing downslope over a shorter period of time as snowmelt occurs. Rainfall at the time of snowmelt would also increase the flow volumes.

The climate station at Salmon Arm (Table 1; elevation of 527m and located under 10 km west) indicates that daily maximum temperatures were in the range of 17 to 22 ^{o}C for the days of April 20th to 25th. Of possible significance are the higher night time temperatures observed on April 22nd to 25th; temperatures did not drop below freezing overnight remaining over 5 ^{o}C for four nights. Precipitation was observed on April 25th and 26th with 7.4 and 9.4 mm of rain falling, respectively.

Table 1: Climate data from the Salmon Arm A climate station (April 20th to 26th, 2012).

Date	Max Temp (^{o}C)	Min Temp (^{o}C)	Mean Temp (^{o}C)	Rainfall (mm)
April 20	19.0	4.8	11.9	1.3
April 21	16.9	-0.6	8.2	0.0
April 22	19.5	7.4	13.5	0.0
April 23	22.5	5.5	14.0	0.0
April 24	17.0	9.5	13.3	0.6
April 25	21.0	8.5	14.8	7.4
April 26	9.0	8.0	8.5	9.4

Historical radar images from Silver Star Mountain indicate steady rainfall occurred on the highlands during the day on April 24th. Subsequently on April 25th, heavy rainfall occurred from 9 pm through to 4 am on April 26th. These climate data suggest that warm daytime temperatures initiated melting in the 1000-1100 m elevation band which covers the south end of Larch Hills and overnight temperatures remained above zero and melt continued through the night. The steady rain on the 24th and the heavy rainfall on the night of April 25th-26th, following these four days of warm temperatures increased water flow (both surface flow and groundwater) off the plateau surface and concentrated it onto the steeper slopes below.

5.0 CONCLUSIONS

The cause of the landslide is an excess of water in a shallow draw reaching the steep slope below Block B-3. It is suggested that elevated daytime temperatures and continued above 0^{0}C night-time temperatures caused synchronous and uninterrupted melting of the snowpack on the plateau surface. This was supplemented by the heavy rainfall starting on the night of April 25th and continuing through the early hours of April 26th. The source of the water is the spur road which intercepts the dispersed surface flow and groundwater across the plateau and concentrates it into a ditchline. This water is then directed down the ditchline and into the shallow draw. The runoff from this was significant and once directed into the shallow draw saturated the shallow sediments on the steep slope and initiated a landslide. The landslide then propagated into a larger draw and appears to have transitioned into a more fluid debris flow and moved downslope into Metcalfe Creek.

It is recommended that rehabilitation of the spur road across Block B-3 be completed to disperse the ditchline flow. The existing waterbars serve only to disperse road surface water flow, but not to intercept and disperse the ditchline flows. This will require several cross-ditches be constructed to move water across the road and into existing shallow draws. Location of the cross-ditches should be checked to ensure a continuous drainage path into an established draw on the steeper slopes below. The ditchline should be blocked on the downhill side of the cross-ditches to prevent future flow. There will still be some flow in the lower segment of the ditchline which will continue to flow into the existing shallow draw, but this flow should be much reduced and the draw should be capable of handling the flow.

Questions on the foregoing can be directed to the undersigned at 250-828-4168 or via e-mail to: tim.giles@gov.bc.ca

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Thompson Okanagan Region
Ministry of Forests, Lands and Natural Resource Operations

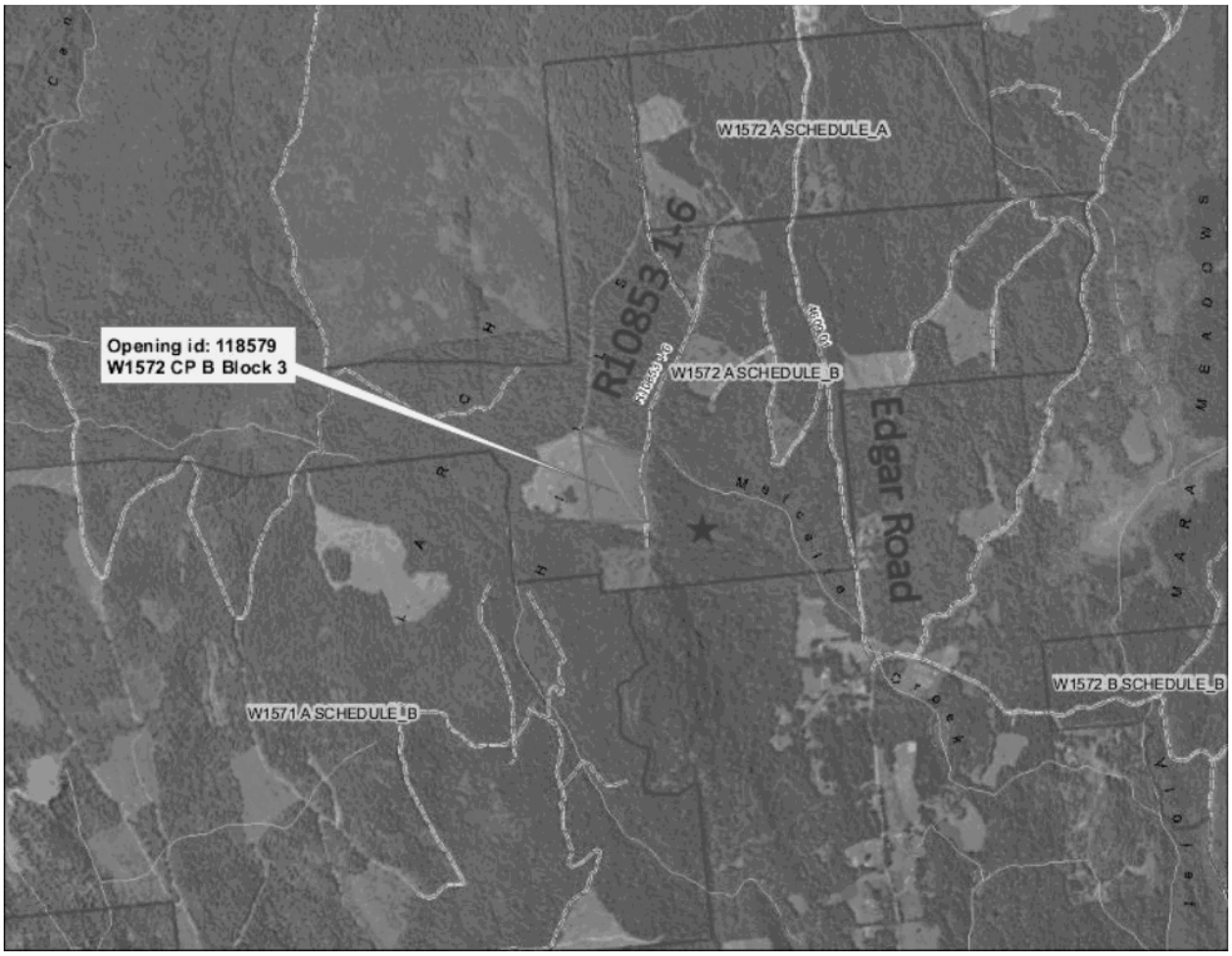

Figure 1: Location map of the Woodlot 1572 showing road access across the woodlot on R10853 1-6 into block B-3. The spur road is visible crossing block B-3 from southeast to northwest. The landslide initiation location is marked with a star.

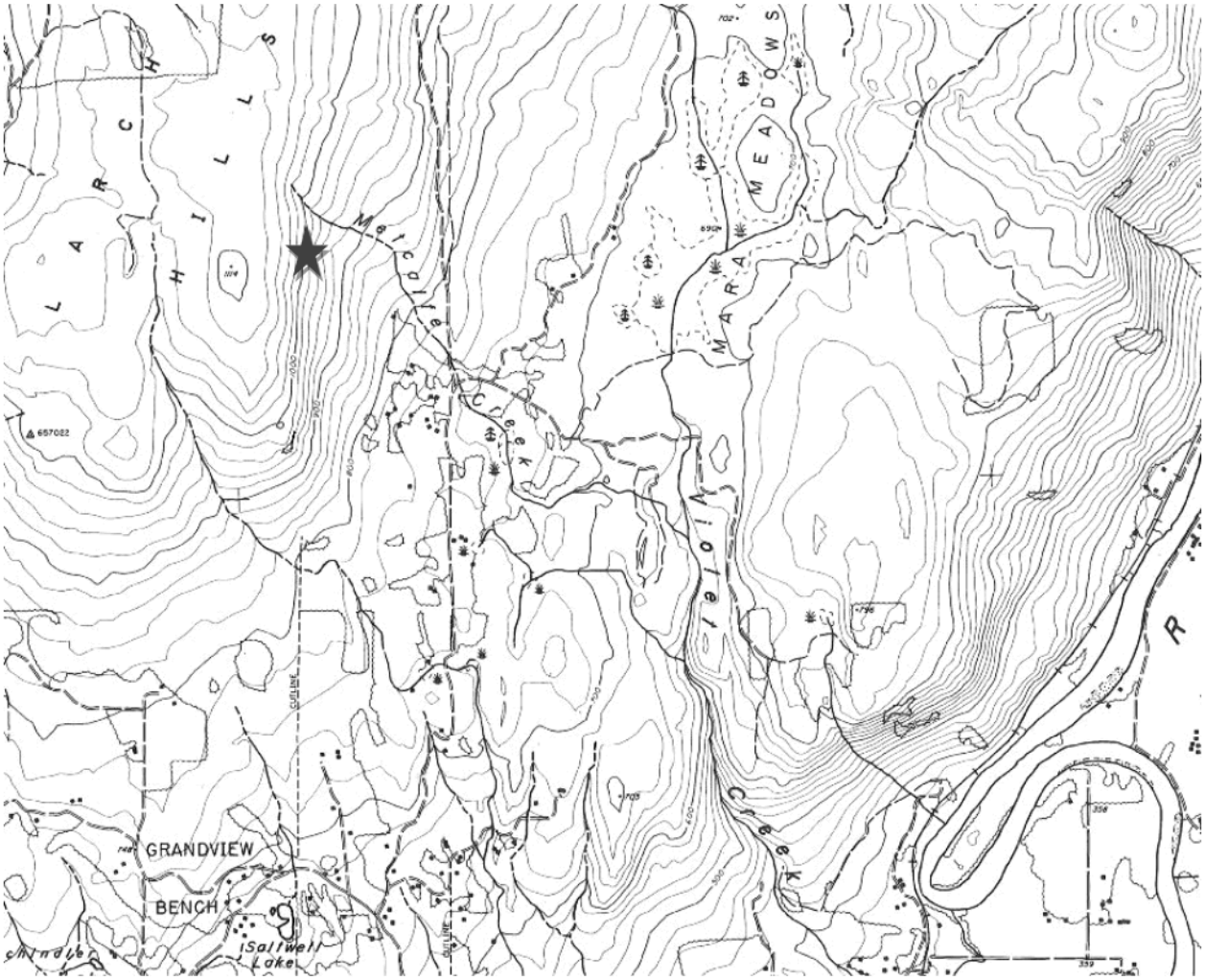

Figure 2: Approximate location of initiation point of landslide. Block B-3 located upslope to the west on the top of the upland plateau (see Figure 1).

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Thompson Okanagan Region

Investigation of the 2014 Woodlot 1572 Landslide

Prepared for:

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Ministry of Forests, Lands and Natural Resource Operations

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1.0 INTRODUCTION

A landslide occurred on Woodlot 1572 on April 22nd, 2014. Woodlot 1572 is accessed off Edgar Road which runs north from Grandview Bench Road (Figure 1) near Salmon Arm, British Columbia. On April 23rd, 2014, residents in the area contacted Brett Barnard, RPF who recently purchased Woodlot 1572, and he visited the site on April 24th, 2014. I attended the site on May 2nd, 2014 with Bob Annand, Tenures Forester with the Okanagan Shuswap Resource District and Brett Barnard to assess the factors contributing to the initiation of the landslide.

Brett Barnard indicated that steady rainfall at the end of the previous week (April 16-18th) had resulted in elevated flows being observed in the ditch-lines along Edgar Road from the junction with Larch Hills Forest Service Road upslope for a couple of kilometres. This ditch-line flow was not associated with the debris flow event which was observed and reported on April 22nd. This report addresses the drainage and landslide issues on the woodlot, but does not deal with the drainage issues around Edgar Road. A review of old air photos supplemented by fieldwork is required to address the Edgar Road problems.

2.0 BACKGROUND

The 2014 landslide initiated below Woodlot 1572, Cutting Permit B, block 3 (Block B-3), in the headwaters of Metcalfe Creek which drains southeast off the upland area known as the Larch Hills. Metcalfe Creek is a small tributary of Violet Creek which itself is a tributary to the Shuswap River. The landslide started around 1050m elevation as a steep open face failure and moved downslope into a well-defined draw. This draw eventually joined Metcalfe Creek just above Edgar Road on a broad, mid-slope alluvial fan and deposition of slide debris occurred on the fan surface. This is the second landslide to occur in this area; in the spring of 2012 another drainage-related landslide occurred on this slope.

3.0 FIELD OBSERVATIONS

We reviewed the runout zone of the 2014 landslide along the lower slope and then hiked up the slope to review the upper part of the landslide, the initiation point, the main access road and the plateau surface beyond. On the plateau we viewed the southern ditch-line of the more recently constructed spur road across Block B-3 into Block C-4. This ditch-line ran down from the northwest, across the landing and down the hillslope in an easterly direction. We then located cross-ditches on this spur road which directed water eastwards onto the open plateau surface and followed the trace of water down to the east to the main access road which runs north-south along the break in slope.

The debris flow began to deposit on the more gentle slopes of the alluvial fan, some deposited in the standing timber, some continued down the channel of Metcalfe Creek and some diverted onto and flowed down the Kunzler access road toward the Edgar Road junction. The majority of the woody debris and coarse sediment was deposited on the fan upslope of Edgar Road, but dirty streamflow continued down the Edgar Road ditch-line. This water partially made it through culverts under and beside Edgar Road but much of it ran on the surface of the road leaving it heavily disturbed upslope of the intersection with the Larch Hills Forest Service Road.

4.0 DISCUSSION

The cause of the landslide appears to be saturation of the slope due to an excess of water reaching the steep slope below Block B-3 (Figures 1 and 2). Removal of forest cover in Block B-3 changed the accumulation of snow and timing of snowmelt; increasing the amount of snow accumulated and increasing the rapidity of snowmelt. Typically this results in a larger volume of water flowing downslope over a shorter period of time as snowmelt occurs. Rainfall at the time of snowmelt would also increase the flow volumes. From a spur road cross-ditch, water could be traced to the main access road, into a ditch-line and then through either a culvert or cross-ditch onto the moderate 20-30% slopes immediately below the road. The road drainage structures (culverts or cross-ditches) have taken the widespread flow of groundwater (sub-surface flow) on the plateau and concentrated it on the downslope side of the road. Despite this, there was no clearly traceable watercourse on the slope between the culvert or cross-ditch and the headwall of the landslide. The water running through the culvert or through the cross-ditch disappears into the ground below the main access road but a steady flow reappears in the headwall of the failure approximately 75 m downslope. Likely the concentrated flow is beginning to disperse across the slope, but the plume of this sub-surface flow is still more concentrated than natural groundwater flow. Also, due to the increased volume the water is likely moving faster and saturating areas much more rapidly.

The initial failure was a shallow plane of weakness in the till or colluvial material which overlie bedrock. The slope at the headwall of the landslide is up to 70%. Downslope of the initiation point the slope is continuously over 60% for 100 metres and starts to form a draw into which the landslide entered and followed downslope. The plume of water from the culvert and cross-ditch saturated this slope and failure occurred as a shallow translational slide. This moved downslope en masse with trees, sediment and water essentially sliding as one. The sliding mass entered the draw and once it became more confined it transitioned into a debris flow. This debris flow was much more mobile and followed the confined draw downslope through a series of turns until it reached the alluvial fan approximately 800 m distance below. At this point the flow was substantial in size but the channel was infilled with standing timber which slowed and deflected the flow. Some of the debris continued moving through the channel, some deflected onto the Kunzler's access road, and some of it spread out and deposited amongst the standing timber.

The climate stations at the Salmon Arm, Silver Creek and Vernon North (Table 1) indicates that moderate to steady rain fell in the north Okanagan on April 16-18 and again April 22. Imagery from the Silver Star radar shows a similar pattern with steady rainfall on April 16-18, but the imagery for April 21 is unavailable. The radar imagery also shows increased rainfall occurs at higher elevations, thus it is reasonable to expect that the rainfall recorded at the three low elevation stations would be minimum values and much more rain could be expected to have fallen on the plateau surface and slopes below within Woodlot 1521.

Climate records from the three stations also show that moderate daily temperatures in the range of 11 to 18^{0}C were the norm through April. Of possible significance are the higher night time temperatures observed from April 15 onwards. Valley temperatures did not drop below freezing overnight remaining with a maximum of around 8^{0}C on April 15 and continuing above zero through the end of April.

Table 1: Rainfall data from the North Okanagan Valley (April 16 to 23, 2014).

Date	Salmon Arm	Silver Creek	Vernon North
April 16	0.0 mm	8.1 mm	4.6 mm
April 17	7.6 mm	No data	17.0 mm
April 18	10.8 mm	1.1 mm	No data
April 19	0.2 mm	0.4 mm	0.6 mm
April 20	0.0 mm	No data	No data
April 21	0.0 mm	1.5 mm	1.6 mm
April 22	8.2 mm	2.1 mm	13.8 mm
April 23	1.5 mm	3.4 mm	4.0 mm

These climate data suggest that moderate daytime temperatures initiated melting in the 1000-1100 m elevation band which covers the south end of Larch Hills and overnight temperatures remained above freezing and melt continued through the night. The steady rain between April 16-18 and April 22 increased water flow off the plateau surface and concentrated it onto the steeper slopes below.

In 2012, it was noted that the spur road was concentrating water along the ditch-line and allowing flow to get into an increasingly steep draw which then caused the 2012 landslide to occur. It was recommended by this author that "rehabilitation of the spur road across Block B-3 be completed to disperse the ditch-line flow. The existing water-bars serve only to disperse road surface water flow, but not to intercept and disperse the ditch-line flows. This will require several cross-ditches be constructed to move water across the road and into existing shallow draws. Location of the cross-ditches should be checked to ensure a continuous drainage path into an established draw on the steeper slopes below." Since 2012, several cross-ditches were established on the spur road and the ditch-line water was dispersed across the plateau surface. Water reaching the main access road was then passed through existing culverts and new cross-ditches were installed nearby to back up the culverts. There are at least four cross-ditches which dispersed the water below the spur road, but the main access road then re-concentrated this water into two culverts.

Future efforts to control the drainage off the plateau might review this and attempt to further disperse these flows with more cross-ditches and culverts. At present water still appears to be being moved slightly southwards by the ditch-lines, it would be preferable to move it directly downslope (easterly) or even slightly northwards as the slopes get gentler to the north. Another course of action might be to completely rehabilitate the main access and spur roads in an attempt to return the drainage to a more natural condition. Any changes in drainage patterns should be reviewed in the field to ensure that proper drainage courses are used to drain the water downslope and eventually into the main stem of Metcalfe Creek.

5.0 CONCLUSIONS

The cause of the landslide is an excess of water reaching the steep slope below Block B-3 and causing a translational landslide to occur. The slide mass moved downslope into a confined draw and transitioned into a debris flow which travelled down-channel and ran out onto a mid-slope alluvial fan. It is suggested that elevated daytime temperatures and continued warm night-time temperatures caused synchronous and uninterrupted melting of the snowpack on the plateau surface. This was supplemented by the rainfall on the nights of April 16, 17, 18 and 22. The source of the water is the plateau where sub-surface flow is intercepted by roads and trails.

Following the 2012 landslide, I wrote a report which recommended that rehabilitation of the spur road across Block B-3 be completed to disperse the ditch-line flow. The cross-ditches were installed on the spur road but the main access road ditch-line re-concentrated the flows into two culverts and ran in onto the moderate slopes below. Surface flows through ditch-lines, cross-ditches and culverts all appear to return to sub-surface flow after passing through the structures, but the flow remains more concentrated in plumes below the structures rather than widespread sub-surface flow across the slope. Further work to ensure the widely dispersed drainage from the spur road is maintained below the main access road is recommended. Tracking flow paths into watercourses (draws, gullies or channels) is required to confirm that water is being directed into appropriate locations on the steeper slopes.

Presently, as water is directed downslope it is being carried slightly southwards by the ditch-lines, it would be preferable to move it directly downslope (easterly) or even slightly northwards as the slopes get gentler to the north. Another course of action might be to completely rehabilitate the main access and spur roads in an attempt to return the drainage to a more natural condition. Any changes in drainage patterns should be reviewed in the field to ensure that proper drainage courses are used to drain the water downslope and eventually into the main stem of Metcalfe Creek.

Questions on the foregoing can be directed to the undersigned at 250-828-4168 or via e-mail to: tim.giles@gov.bc.ca

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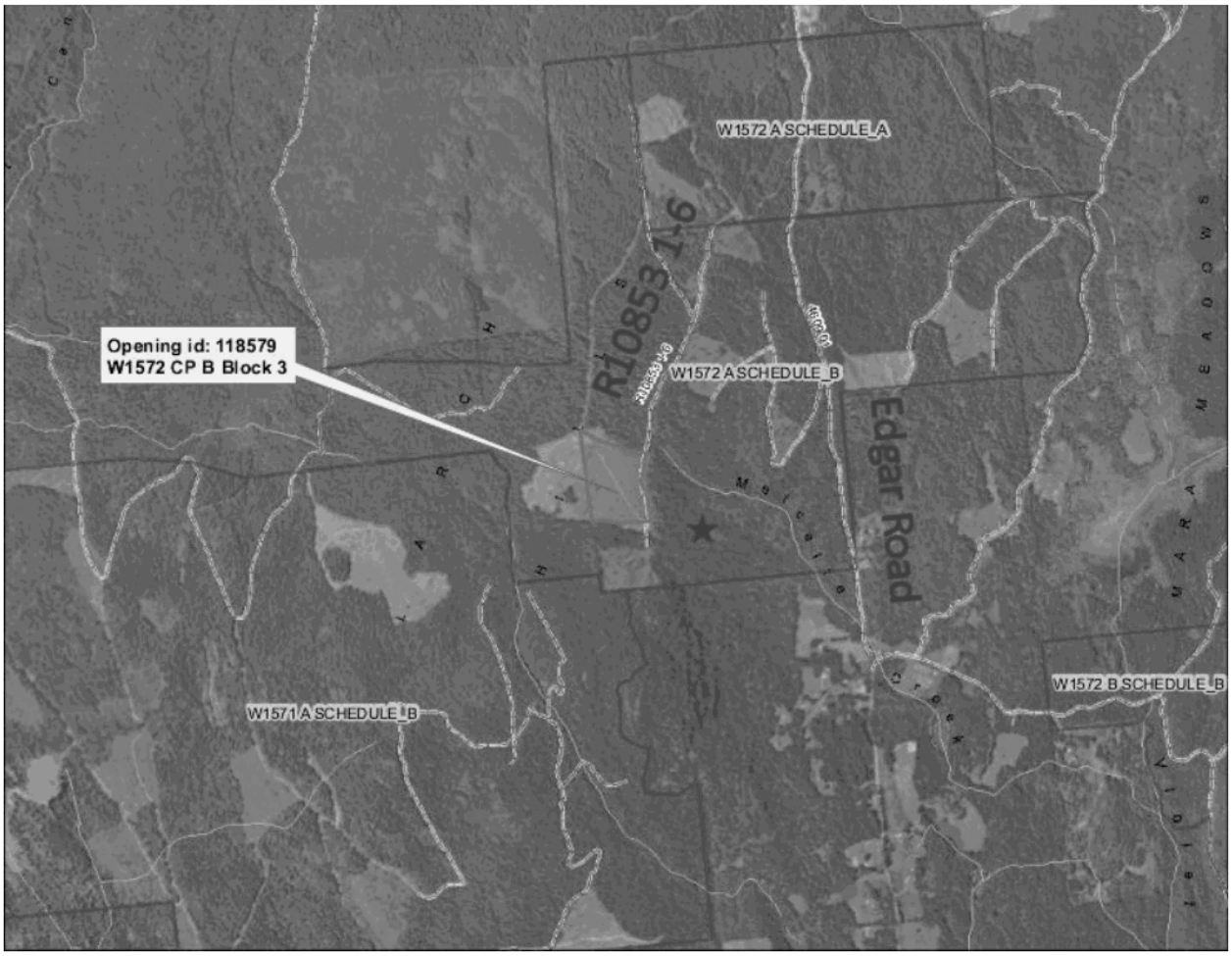

Figure 1: Location map of the Woodlot 1572 showing the main road (R10853 1-6) access across the woodlot to the plateau and block B-3. The spur road is visible crossing block B-3 from southeast to northwest. The approximate location of the 2014 landslide initiation point is marked with a star.

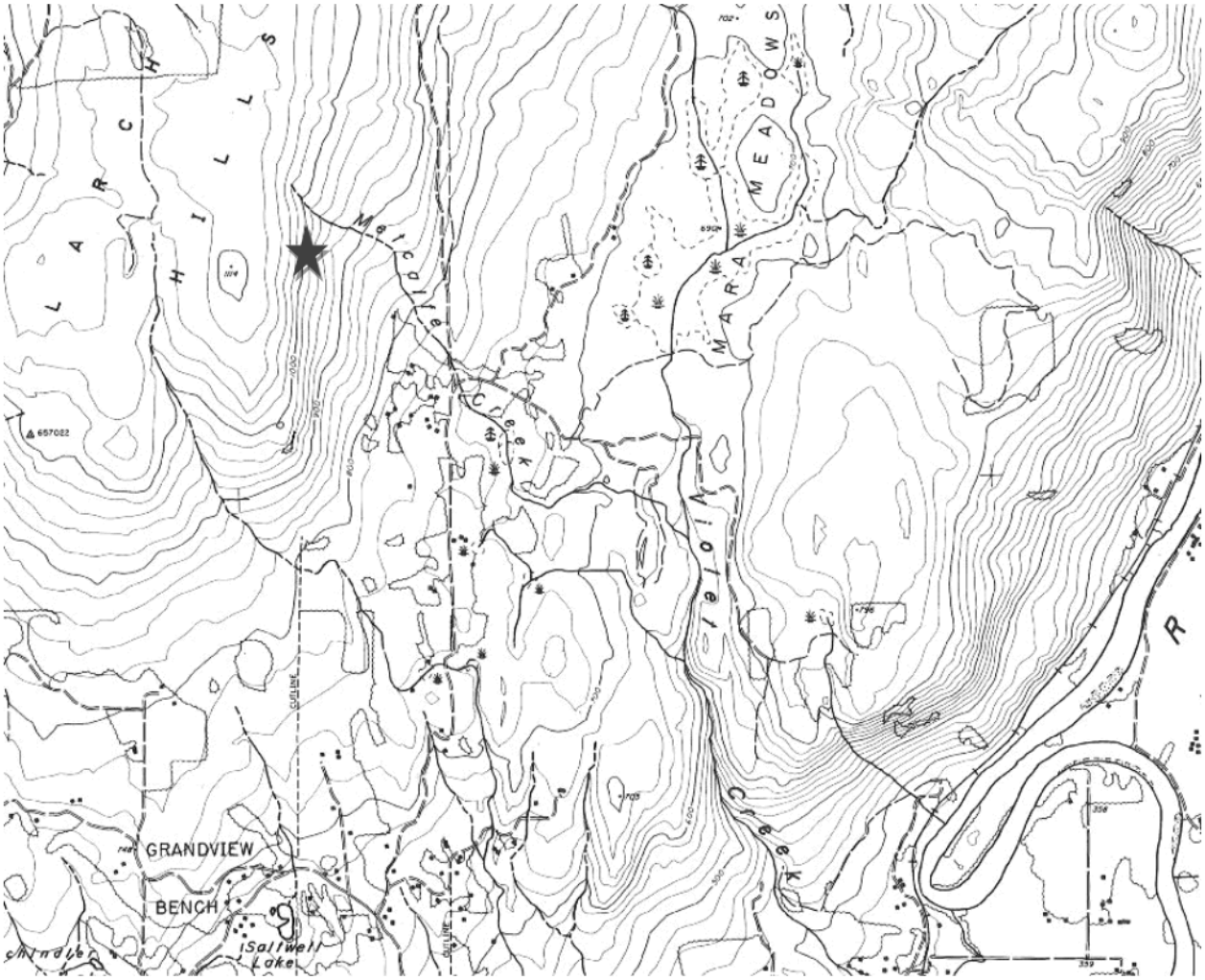

Figure 2: Approximate location of initiation point of the 2014 landslide. Block B-3 located upslope to the west on the top of the upland plateau (see Figure 1).

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Project # 1288CURT

February 19, 2013

Larch Hills Development Corp.
1120 – 54th Ave. SE
Salmon Arm, BC
V1E 3P5

Attn: Curt Olson, RPF

Ph: s.22
Email: s.22

RE: Woodlot 1572 landslide field review (April 2012)

1.0 Introduction

At the request of Mr. Olson, Boxwood Forest Products and Services Ltd. (Chris Cole, P.Eng) completed a field review of a landslide on Woodlot 1572 in the Larch Hills area, near Salmon Arm, B.C. In addition, an office review of an investigation report written on the landslide event by the Ministry of Forests, Lands, and Natural Resources Operations (Tim Giles, P.Geo) was completed. A copy of this report is attached for reference. The Ministry of Forests, Lands, and Natural Resources Operations report indicates the landslide occurred on April 26, 2012. Chris Cole completed a field review of the area in the company of Curt Olson on July 21, 2012. A background summary of the woodlot, associated cutting permit, block, and watercourses influenced by the landslide event are identified in Tim's report.

2.0 Methodology

The following materials were reviewed:

- Ministry of Forests, Lands, and Natural Resources Operations report "Investigation of the 2012 Woodlot 1572 Landslide"
- Airphotos: 15BCC01026 Nos. 74 and 75 (2001)
- Google Earth and associated add on and historical imaging tools
- Geological Survey of B.C. website, bedrock geology mapping, B.C. Ministry of Energy, Mines and Petroleum Resources, 2005
- Millard, T., 1999. Debris Flow Initiation in Coastal British Columbia Gullies. Technical Report TR-002. Research Section, Vancouver Forest Region, BCMOF. September 1999.

The road in Block B-3 was traversed, and the cutblock and surrounding area were explored. The gullies below the switchback at the SE corner of the block were accessed, and the landslide area was viewed and explored as well. The area was well documented with digital photo and video.

Terrain stability hazard mapping is not currently available for this site. Taken into account are observations of the occurrence and impacts of numerous natural and development related landslides in the Shuswap Highlands Physiographic Region of B.C. where the woodlot is located during the rainfall event in April, 2012.

3.0 Observations and Conclusions

The landslide occurred below the SE corner of Block B-3, immediately west of Edgar road. For reference, the landslide occurred at UTM E. 348510.18, N. 5617230.0 (elevation 933m above sea level) and Google Earth images with location pins have been provided below:

Figure 1 – Overview location of Woodlot 1572 landslide

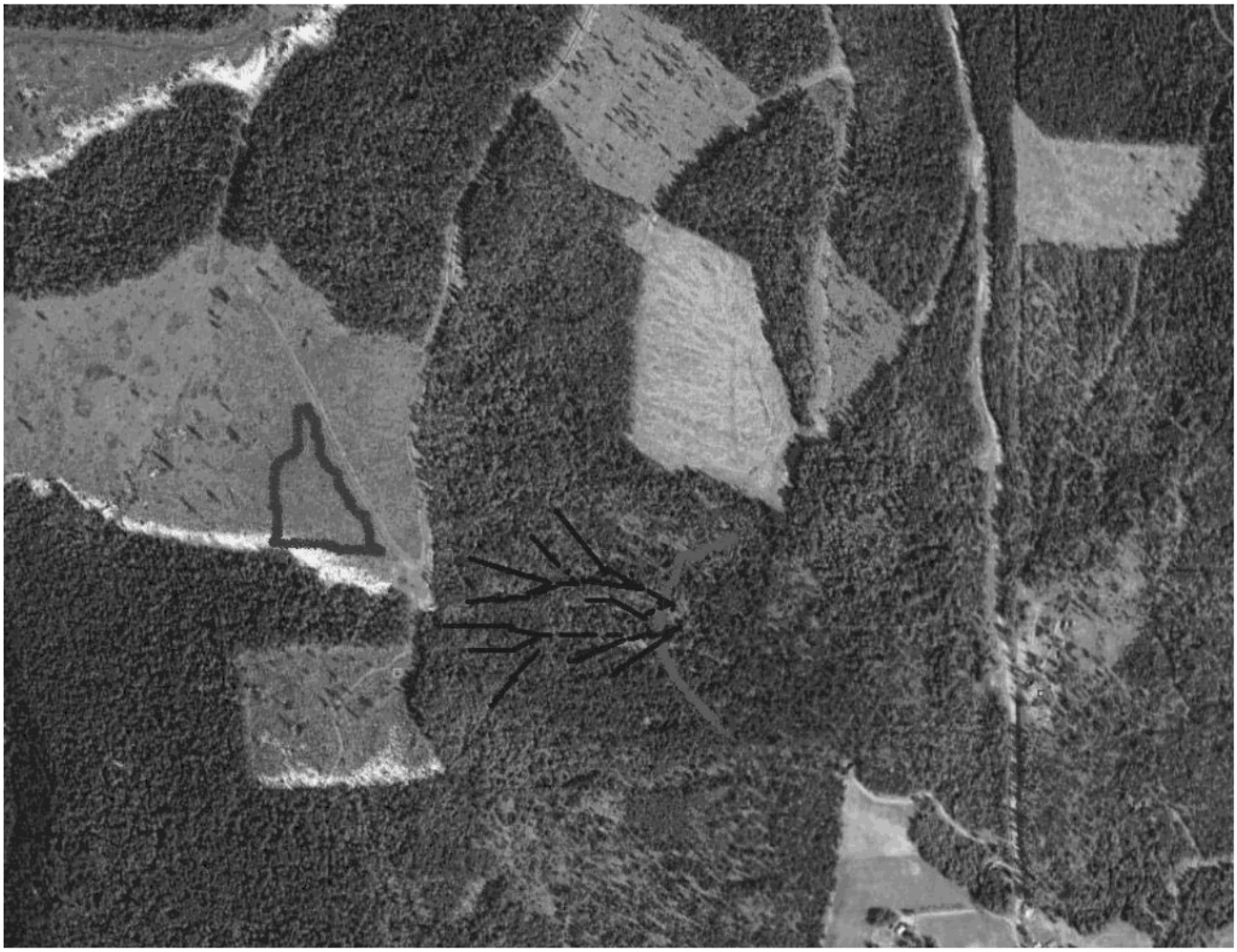

Figure 2 – Location of features observed in the field.

Red outline = area of influence by road in B-3 with no cross drains installed (max. 2ha).
Blue lines = complex of existing, well defined, incised gullies converging downslope
Magenta thick line = existing boundary of mixed deciduous trees with historical high frequency of disturbance

The Ministry of Forests, Lands, and Natural Resources Operations investigation report that followed the landslide provides good documentation of the event. The background information and field data collected provide conclusive evidence that the surface water run-off combined with saturated soil conditions lead to the initiation of the landslide event that occurred on April 26. However, there is a need to address one statement in the Conclusion of the report that was found to require further clarification. The statement is ***"The runoff from this was significant and once directed into the shallow draw saturated the shallow sediments on the steep slope and initiated a landslide."*** This statement indicates that the cause of the landslide was the spur road (without cross drains) that was constructed by the Woodlot owner. Although the spur road was constructed without adequate attention given to

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dispersing surface water and controlling drainage, this road section should only be considered a "contributing factor" as one of the variables triggering the landslide event. This statement is based on the following:

1) The soils in the area, especially the existing, well defined draws were already fully saturated by the active snow melt conditions and the heavy rains during the days preceding April 26.
2) Multiple landslide events occurred in the Salmon Arm area during the April 26 rain on snow event.
3) The physical area (shown above in red) influenced by the spur road in relation to collecting and re-directing surface water flow is very small in relation to the watershed area or area of surface water collection above the land slide head scarp. The area in the cutblock to the west or left of the red polygon in Figure 2 drains to the west, away from the area being investigated. Based on the pre-existing complex of well defined gullies (shown above in blue) that all converge down slope and lead to the initiation point of the landslide, the water would likely have ended up in the same draw if the road was not present. Although the road changed the surface drainage on a micro site scale, the water that ultimately resulted in the landslide was being introduced on a macro scale to the entire surrounding area. The relatively small flat 2 ha collection area above the spur road may not have influenced the initiation of the landslide.
4) There was an abundance of indicators found in the field that show the immediate area where the landslide initiated and ran out had very high levels of historical disturbance (area shown in magenta in Figure 2 above). In the area immediately surrounding the initiation point of the landslide, there are several other smaller slumps and small landslide disturbances from previous years.

Based the field review and the review of existing reported information, there is a high likelihood that the landslide that occurred on April 26, 2012 in woodlot 1572 would have occurred without the presence of the spur road in cut block B-3, independent of how the road was constructed. The cause of the landslide may be considered an "Act of God" or naturally occurring event based on the historic field indicators showing unstable soils in the area of the landslide initiation, and considering the abnormal high intensity rain fall and other landslides in the area that naturally occurred during the same time period.

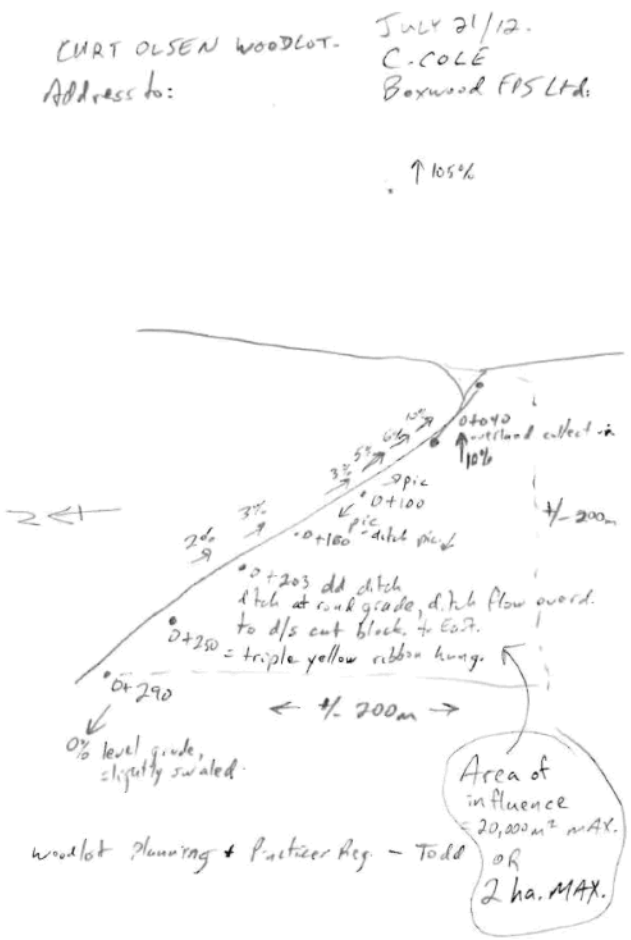

Figure 4 – Field notes indicating terrain slopes and area influenced by the spur road in B-3. Spur road length from height of land back down to switchback = 290m.

4.0 Closure

This report and recommendations are intended for the sole use of Larch Hills Development Corporation. Boxwood Forest Products and Services Ltd. does not accept any responsibility for the accuracy of any of the observations, the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Larch Hills Development Corporation, or for any Project other than the woodlot 1572 landslide field review. Any such unauthorized use of this report is at the sole risk of the user. Conclusions and recommendations presented herein are based on visual site inspections. No subsurface investigation has been carried out. The assessment has been carried out in accordance with generally accepted geoscience and engineering practice. Geoscience and engineering judgement has been applied in developing the conclusions and recommendations in this report. No other warranty is made, either expressed or implied. We trust that this report satisfies your present requirements. Should you have any questions or comments, please contact our office at your convenience.

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Sincerely,
Boxwood Forest Products and Services Ltd.

Chris Cole, P.Eng, RPF
Project Engineer

Woodlot 1572 Landslide review July 21, 2012

DSC00022

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Chris Cole. RPF, P.Eng
Boxwood FPS Ltd. 250 803-1060

Woodlot 1572 Landslide review July 21, 2012

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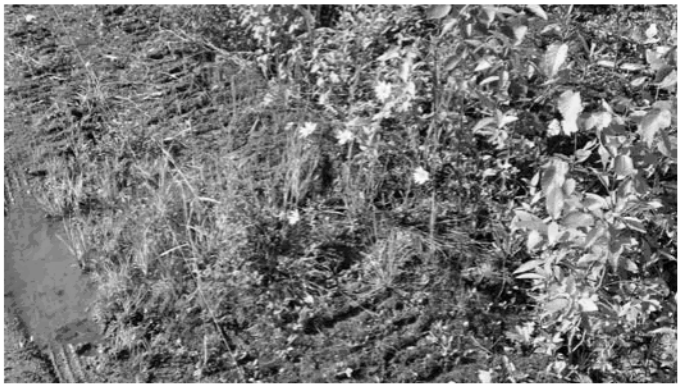

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