December 22, 2015

Reference No. 1537191-001-L-Rev0

Al Richmond, Cariboo Regional District Chair and Area G Director
Cariboo Regional District
Suite D, 180 North 3rd Avenue
Williams Lake, BC
V2G 2A4

Walt Cobb, City of Williams Lake Mayor
City Hall, 450 Mart Street
Williams Lake, BC
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HODGSON ROAD LANDSLIDE

Dear Mr. Richmond and Mr. Cobb,

The Hodgson Road Landslide is a large ancient slide-mass located west of Highway 20 on the south side of Williams Lake.

Since 1993, the Hodgson Road Landslide has moved episodically, with total recorded displacements now in the range of 0.3 to 0.4 m. Over the last three years the landslide movements havereportedly become increasingly severe with time. It is understood that the landslide movements are damaging a business centre, a seniors/adult residential complex, a single family house (now abandoned), Highway 20, Dog Creek Road, FortisBC gas lines and City of Williams Lake water mains. The area of ground movement, originally measured at 600m by 600m, has now expanded upslope by a further 300m into the lower part of the Dog Creek Road residential subdivision. The areas of detected movement in 1999 and 2014 are shown in Figure 1, together with the interpreted full outline of this ancient slide mass.

This expansion of the affected area takes the landslide beyond the Williams Lake boundary and into the Cariboo Regional District (CRD). As the total displacements increase and the affected area expands into the upslope residential subdivision, the damage is increasing and there is the potential for more people to be directly impacted. There is also the potential for the landslide to accelerate if its retrogression (movement up slope) into the Dog Creek subdivision severs, or otherwise interrupts use of upslope, domestic wells that are presently assessed to be acting as an unintended dewatering system. For the CRD, the landslide is a key obstacle to providing a proper replacement water supply for that subdivision both in terms of the technical issues associated with maintaining infrastructure on an active landslide, and the immediate destabilizing impact that the importation of outside water and the cessation of pumping from domestic wells would have on the entire Hodgson Road Slide if implemented prior to effective remedial treatment.

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Currently, the prognosis is that the area of ground movement will grow, and with that expansion, the damages will increase and spread over a wider area, affecting many more people. With gas lines, waterlines, roads, and buildings being damaged, the risk of related injury or fatality is also assessed to be increasing. In our opinion, the matter has become urgent. Fortunately, a previous geotechnical/hydrogeological study of the landslide by Golder, a study jointly supported by the City of Williams Lake and the Ministry of Transportation and Infrastructure (MoTI), indicates that the slide can be controlled by means of an array of pumped wells. Other options considered as part of the study are possible but more costly. With a solution at hand, it is urged that every effort be taken to complete final design and implement remedial treatment forthwith.

The following sections of this letter provide a synopsis of geotechnical and hydrogeological findings plus other pertinent comments relating to hazard posed by the Hodgson Road Landslide, and the defined solutions.

1.0 BACKGROUND

1.1 Work Completed

In early 1997, Golder Associates Ltd. was retained by University College of the Cariboo (UCC) to investigate distress in its Campus building on Hodgson Road. Monitoring data collected by the UCC's consultants suggested the distress was caused by deep-seated ground movement, so three deep boreholes were drilled and instrumented to measure ground displacement and groundwater pressure at depth. After a few months of monitoring, Golder determined that there was a deep-seated landslide, with the shear surfaces at the borehole locations some 20 to 30 m below existing grade. From that information and review of stratigraphy and landforms, it was interpreted that the new ground movement was a local reactivation of a large buried ancient landslide with the approximate outline shown in Figure 1.

While UCC was suffering building distress, the Ministry of Transportation and Infrastructure (MoTI) was experiencing a large heave in the west bound lanes of Highway 20, located roughly 250 m west of the UCC Campus Building.

Concluding the two issues were likely related, UCC, MoTI and the City of Williams Lake (City) joined together on a second stage investigation. For this larger investigation, the City retained Golder to conduct the geotechnical and hydrogeological assessments, and related analysis and reporting, while MoTI provide the drilling, logging and instrumentation of seven boreholes. UCC provided ongoing line-of-sight survey data, and monitoring displacement of their building. .

Golder undertook a composite geotechnical/hydrogeological study. The geotechnical assessment was required to assess ground stability, but the key to remediating landslides of this nature is generally found in the site hydrogeology.

1.2 Results of Investigation

The results of investigation were provided in 3 volumes:

- Technical Memorandum 1, Data Synopsis, Hodgson Road Slide (Golder, 1998)
- Technical Memorandum 2, Hydrogeological Analysis, Hodgson Road Slide (Golder, 1999A)
- Technical Memorandum 3, Slope Stability Analysis, Hodgson Road Slide (Golder, 1999B)

1.2.1 Stratigraphy

The results of investigation indicated that the landslide was up to 65 m deep at the locations investigated. In those deeper parts, the stratigraphy consisted of approximately 30 m of glacial till, 30 m of ancient slide debris consisting of broken rock and clay), underlain by intact Kamloops Group Bedrock. The major ground displacements were assessed to be occurring in a thin shear zone at the base of the slide debris.

1.2.2 Region of Detected Ground Movement in 1999

The area of detected ground movement in 1999 is shown in Figure 1. At that time, all the detected/measured movement was north of Dog Creek Road. The overall ancient landslide may be much larger than the area of detected movement as the toe of a large slide can move faster and sometimes independently of the overall slide mass.

1.3 Analysis

To support detailed analysis, a calibrated groundwater flow model and a geotechnical stability model were constructed. Both models were needed to assess probable cause and remedial treatment options for the landslide.

1.3.1 Probable Cause

Three identified site condition changes were modelled to test their relative impact on the stability of the Hodgson Road Landslide, as indicated below.

Case Analyzed	Percentage increase/decrease in Calculated Factor of Safety
Cut made to widen Hwy 20 after 1972	-2.4%
Introduction of domestic wells in Dog Creek area	+7.2%
Assumed wet year condition (2 m rise in head)	-12.9%

A review of precipitation data showed the 10 year running average precipitation rate at the Williams Lake Airport monitoring station was 400 mm from 1961 to 1979, then rose quickly up to a 10 year running average of 450 mm thereafter.

When considered in combination, the highway cut and the introduction of private water wells in the Dog Creek area would be assessed to increase the Calculated Factor of Safety FoS by +4.8%. Accordingly, it was the wet year conditions (increased average precipitation plus the effect of wet years) that were assessed to be the probable cause of the reactivation of the Hodgson Road Slide.

1.3.2 Remedial Treatment Options

Remedial treatment options considered in the study were (a) a large toe berm to buttress the slide, (b) 2 drilled underdrains, (c) 5 pumped wells and (d) 9 pumped wells, with results as follows.

Treatment	Estimated Capital Cost (1999 dollars)	Calculated Stability Increase	Capital Cost per Percent Stability Increase (1999 dollars)
Toe Berm	$2,700,000	2.4%	$1,125,000
2 lateral underdrains	$6,000,000	61.8%	$97,087
5 pumped wells	$ 800,000	17.0%	$47,058*
9 pumped wells	$1,300,000	30.8%	$42,207*

* included allowance for sewer and electrical connections but excluded taxes, engineering, contingencies, and ongoing operation and maintenance

The findings were that the Toe Berm was neither particularly technically effective nor cost-effective. Two lateral underdrains were a high-risk, high-cost option that, if they worked, could be highly effective. The risks of the underdrain option included a risk of unsuccessful installation, the risk that with only two drains there would be a high likelihood of one or both becoming plugged or in some other way rendered ineffectual, and that is was an 'all-in' option with only limited potential for staging the work. Pumped wells were a lower risk and more cost-effective treatment option and, if the installations are staged, could be assessed as they are installed. Pumped wells were also the most flexible option, allowing for incremental adjustments such as adding addition wells at other locations as needed at limited additional cost.

The groundwater modelling results indicate that it is possible to effectively lower the groundwater pressure on the shear surface using pumped wells. The pumped well system proposed is similar to systems currently in place to stabilize landslides in Quesnel and Kamloops. It is noted that, if a dewatering system is installed to stabilize a landslide, the dewatering will generally be required to operate in perpetuity to maintain ground stability.

1.4 Period Following The 1999 Landslide Assessments

Shortly after the 1999 reports were issued, UCC abandoned their Hodgson Road Campus Building. With the UCC campus gone, the impetus to move forward with measures to stabilize the Hodgson Road landslide appeared to falter and, to our knowledge, no further actions were taken.

It is understood that the UCC Campus building suffered little or no further distress in the subsequent years. The Campus building was subsequently purchased in 2004 by the Pioneer Family Land Partnership who undertook measures to strengthen the building, to lower lateral loading on the building, and to improve drainage behind the building. Once the repairs and improvements were completed, the Pioneer Complex, a business centre, was opened.

2.0 GROUND MOVEMENTS AND DISTRESS – PAST AND FUTURE

2.1 Past Ground Movements Updated

The episode of ground movement in the Hodgson Road Slide appeared to pause for nearly a decade after the UCC Campus Building was abandoned and subsequently purchased for the Pioneer Complex.

The recent movements are understood to have begun about 2012, which is the approximate time that distress began to appear again in the building and recurrent cycles of pavement heave and repair began again along Highway 20.

Building position measurements by Exton and Dodge Land Surveyors Inc. (Exton and Dodge) indicate that there was just under 300 mm displacement of the Pioneer Complex between 2006 and 2015. Considering that there was apparently little or no distress to the building between 2004 and 2012, it is likely that most, if not all, of that movement occurred between 2012 and 2015. Further, it is reported that the incremental distress accelerated through the last three years, with much of the distress occurring in the spring of each year.

If Exton and Dodge ground and building measurements from the earlier period of 1997 to 1999 (typically 66 to 95 mm) are added to the readings from 2006 to 2015 (typically 270 to 295 mm), the combined displacements are in the range of 300 to 400 mm. These displacements were large enough to sever most of the instrumentation installed in previous geotechnical investigations.

While the Pioneer Complex and Highway 20 have been the primary indicators of slide movements; increasingly, other parties have become directly affected, having reported distress consistent with, and attributed to, the new movement of the Hodgson Road Landslide. The additional slide indicators have been :

- Terra Ridge Village, an adult/seniors residential townhouse complex, has recently experienced structural distress to one of its townhouses and differential movement on roads and sidewalks;
- City has suffered several water main breaks including one on Hutchison Road north of Terra Ridge Village, and one or more on Hodgson Road by Terra Ridge Road, near the inferred edge of the landslide;
- A heaving of the road and gas pipeline and damage on Dog Creek Road at the Roberts Drive intersection have affected the CRD and FortisBC;
- An abandoned home downslope of the heave in Dog Creek Road with significant distress to the structure in line with the heave was observed by Golder; and,
- Cracking and repairs to Shaw Road just south of Roberts Drive.

The distress reported near the intersection of Dog Creek Road at Roberts Drive (heave, gas pipe line and distressed house) suggests that the slide area affected by ground movement has retrogressed roughly 300 m upslope, well into the CRD and the lower edge of the upslope rural subdivision.

2.2 Future Ground Movements

Landslide movements can sometimes be episodic, pausing for a while before pushing forward again. There are many possible causes for this behaviour such as short term fluctuations in recharge (precipitation), or progressive movements where the bottom part of the slide moves, followed by the middle part, later returning to the lower part. Once started, however, the landslide is likely to continue to move, either continuously or episodically, until effectively treated.

The evidence suggests that the area of recent movement is retrogressing (working its way up-slope), and that it is gradually expanding to encompass a growing portion of development area to the south.

As the cumulative movement increases, the slide mass becomes increasingly disturbed and will begin to break apart by differential movement within the mass. Accordingly, it is to be expected that parties on the landslide which previously did not suffer distress, will gradually become more directly affected. The new distress on the Terra Ridge Village development is an early example of this. The congregation of the church located to the north of Terra Vista are, we understand, actively concerned, if not yet directly affected by distress in their church building.

Now that the slide has retrogressed into the lower part of the Dog Creek Subdivision additional parties, particularly existing single family residences, are likely to become directly affected.

As previously noted, the upper subdivision is served by individual wells which are assessed to have a stabilizing influence on the landslide. It is cautioned that, should many of the existing domestic wells become severed by ground movement, the loss of the stabilizing influence of those wells could accelerate the landslide, making the landslide potentially more difficult to control and mitigate.

Stabilizing the lower portions of the Hodgson Road Slide – the recent movement area - would be a good step toward containing further retrogression of slide movements into the upslope neighbourhoods.

3.0 WATER SUPPLY TO DOG CREEK ROAD SUBDIVISION

The CRD is considering installing a community water system into the Dog Creek subdivision to replace the existing system of private wells on each lot. The impetus for this measure may be concerns over both ground water quality and supply; however, the installation of a community water system which imports water from elsewhere will decrease local groundwater extraction as wells are shut down, and increase recharge in the area as imported water is applied in septic fields and irrigation.

It is assessed that this combination of decreased extraction and increased recharge will increase groundwater pressures in the affected area and, it is anticipated, will have a significant de-stabilizing effect on the Hodgson Road Slide. However, the results of our previous analyses indicates that Hodgson Road Slide can be stabilized using pumped dewatering wells even with the existing domestic well systems were turned off. The timing of the switch between systems would, of course, be important;, the analysis indicates that it should be viable to install the proposed community water supply system (and decommission domestic wells) in the Dog Creek Subdivision once effective remedial treatment systems have been installed to dewater the landslide. It is noted that some additional dewatering wells may be needed to offset the increased recharge in the upslope area.

4.0 CLOSURE

To summarize, it is Golder's assessment that the Hodgson Road Landslide is likely to continue to move and to expand in size and affect many more people and properties until actively remediated. Current distress is significant and is assessed to present a hazard to persons. Accelerated movement and related distress has been noted over the past three years, with the original movements beginning more than 20 years ago. The results of a composite geotechnical / hydrogeological assessment issued in 1999 indicate that the landslide can be treated by dewatering, with pumped wells being an economical and flexible treatment method that can be incrementally adjusted to fit changing needs.

Golder recommends that detailed design and implementation of remedial treatment be carried out forthwith on an urgent basis.

Yours truly,

GOLDER ASSOCIATES LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA B. W. BOSDET 2015.12.22

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PROFESSIONAL GEOSCIENTIST PROVINCE OF BRITISH COLUMBIA N. J. SARGENT Dec 22 2015

Nick Sargent, M.Sc., P.Geo.
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BB/NS/kv

Attachments: Figure 1: Hodgson Road Landslide – Inferred Boundaries

CC Andre Chevigny, Pioneer Family Land Partnership
Dave Scouten, P.Eng., Scouten Engineering
Robert B. Wilson, P.Eng., P.Geo., Evergreen Geotechnical Inc.

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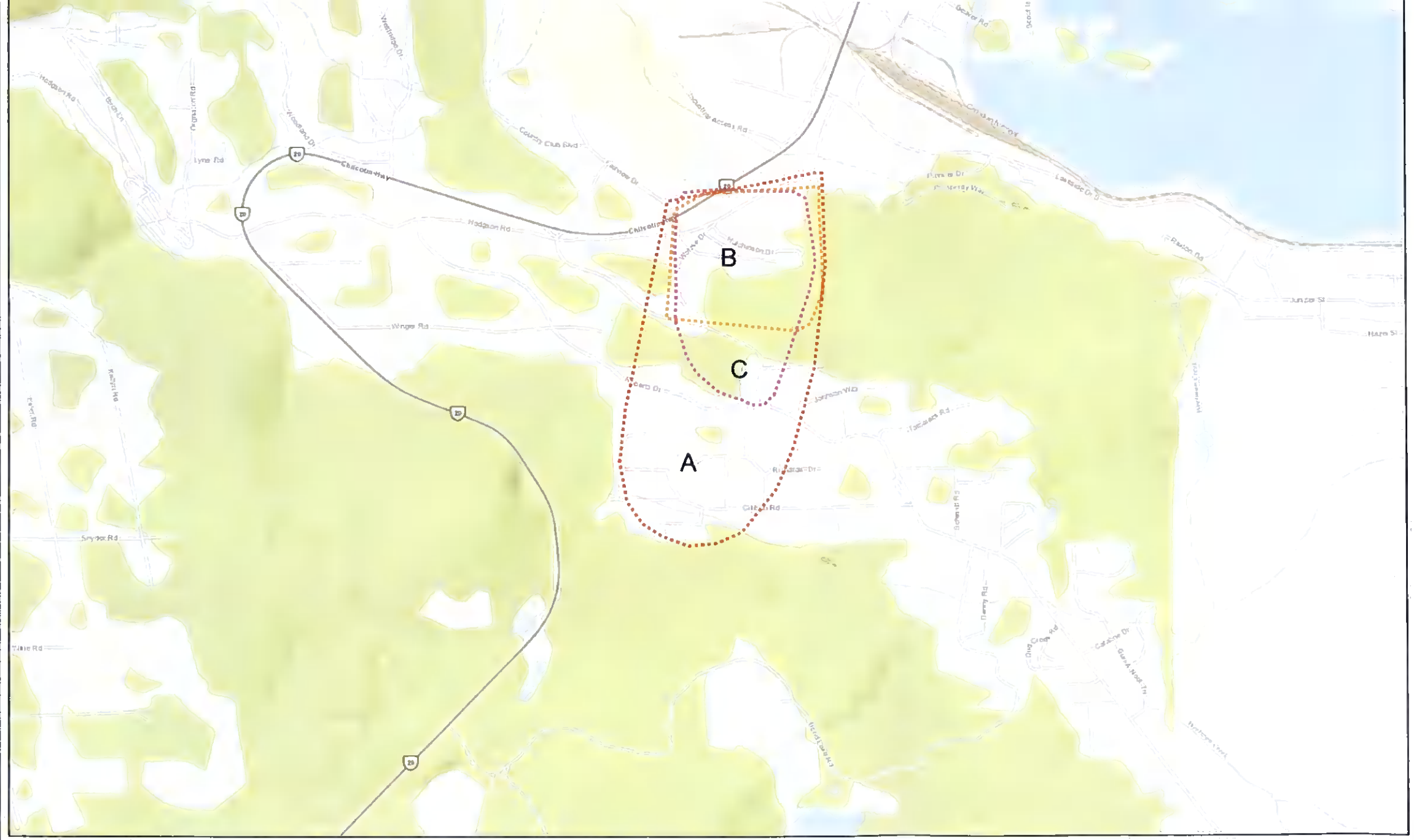

0 500 1,000

1:20,000 METERS

Outline	Description	Rough Dimensions	Basis for Assessment
A	Inferred Ultimate Limit of Landslide (1997)	750m x 1500m	Landform and Monitoring
B	Detected Limit of Ground Movement (1999)	600m x 600m	Monitoring and Observed Distress
C	Detected Limit of Ground Movement (2014)	600m x 900m	Monitoring and Observed Distress

REFERENCE(S)
1. BASE MAPPING PROVIDED BY CRD AND CITY OF WILLIAMS LAKE
2. BASE IMAGERY FROM WORLD IMAGERY GIS BASEMAP LAYER

CLIENT
PIONEER FAMILY LAND PARTNERSHIP

PROJECT
WILLIAMS LAKE, BC

TITLE
HODGSON ROAD LANDSLIDE - INFERRED BOUNDARIES

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-12-21
DESIGNED	BB
PREPARED	BKL
REVIEWED	BB
APPROVED	BB

PROJECT NO.	PHASE	REV.	FIGURE
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