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February 17, 2010 Reference: 091-02075

BC Conservation Society
#3 – 1200 Princess Royal Avenue via email: pstephenson@bccf.com
Nanaimo, BC V9S 3ZT cc: jdamborg@bccf.com

Attention: Ms. Pat Stephenson

Slope Stability Review
Broadway Run, Cowichan River, B.C.

Dear Ms. Stephenson:

As requested, Trow Associates Inc. (Trow) has completed a review of a somewhat unstable slope area adjacent to the Cowichan River in an area known as Broadway Run. The purpose of our work was to identify areas of historical and recent slope failures and provide a characterization of subsurface soils forming the slope structure with interpretations of failure mechanisms and contributing factors. In addition, possible mitigative measures to reduce slope failures and/or their impact on the river will be presented.

Information used during the course of our work includes:

- Recent reports related to sediment loads in the river;
- Surficial geology plan maps;
- Topographic plan maps;
- Aerial photographs;
- An aerial photograph mosaic of the river showing changes in channel alignment over the period 1968 to 2005;
- A LIDAR survey conducted over the lower portions of the slope in the summer of 2009;
- Site reconnaissance during both dry and wet times of the year with significant features photographed and located with hand-held GPS (See Drawing 091-02075-02)

Attached to this report are a Location Plan, a Site Plan, a Schematic Slope Section and Site Photographs.

SITE DESCRIPTION

The slope area under review is approximately 150m in length and is located on the south side of the Cowichan River in a river section known as Broadway Run which flows in a southeast to easterly direction. The subject area is located is located approximately 15 km west of the town of Duncan, B.C. where the river outlets into the ocean. The river alignment in this area begins a gentle curve to the east with the study area being on the outside of the bend (see Drawing 091-02075-02). The south bank of the river is located at the toe of a mountain, within the Seymour Range, which rises to an elevation of about 950 m geodetic. Vegetation within the subject area consists of a wide variety of trees and underbrush in the lower areas with the

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upper areas having been recently logged. Underbrush in the lower areas of the slope frequently consists of ferns, bulrushes and other wetland vegetation.

Site reconnaissance was conducted in the summer and again in the Fall of 2009, primarily in the area from the river to about 250m south (upslope) of the river. The south side of the river consisted of a small near vertical incised bank about 0.6m in height. Soils exposed by river erosion appeared to be varved silty CLAY with trace to some sand. There appeared to be some small areas of active soil flows and recent deposits of sand and gravel in small fan-like features along the river bank originating from slopes immediately adjacent to the river bank.

Above the river bank ground topography rises steadily with an average inclination of approximately 20^{o} although the area is hummocky with local slopes varying from flat lying to steeply inclined. Localized hummocky areas with small soil scarps above were common, particularly within about 100 metres of the river. In these hummocky areas, trunks of trees were noticeably curved along with numerous fallen trees. About 50m from the river (OP #9 thru OP #11) we noted an area of scarps approximately 50m in length and up to about 8m in height. The subgrade soils exposed in this area had little vegetation cover. At the toe of these, exposed soil slopes sloughed soils were noted. During our Fall reconnaissance, this area was noted to be undergoing active erosion, in addition to soil flows originating from the steep slope. The slope had undergone significant changes since our Summer reconnaissance. Soils in this area were generally identified as dense SAND and GRAVEL overlain by stiff clayey SILT. Surficial clayey silts were noted to become very soft when saturated both in place and where sloughed silts had recently deposited.

Approximately 200m from the river, a long continuous near vertical scarp approximately 2 to 3m in height was noted trending sub-parallel to the river. Topography immediately above the crest of the scarp appeared to flatten with the ground surface below the scarp appearing hummocky. Soils exposed in this scarp were generally very dense silty SAND with some gravel, cobbles and small boulders (till-like soils). Vegetation in the area of the scarp generally consisted of ferns and deciduous trees with some stumps likely left from previous logging. No changes to the scarp from the Summer reconnaissance were noted during our Fall reconnaissance.

A brief reconnaissance of slope cuts along the existing logging roads above our study area indicated that slopes in the area are bedrock controlled with localized areas of thin soil veneers overlying bedrock.

In general, soils exposed in scarps along the south river bank within the subject area, with the exception of the upper most scarp about 200m from the river, were typical of glacio-lacustrine deposits. The upper scarp exposed soils are typical of glacial till deposited by glaciers. The glacio-lacustrine soils were likely deposited adjacent to the till deposits following down cutting into the till by melting glacial water. A subsequent damming or plugging of the watercourse may have resulted in the observed lake deposits immediately adjacent to the river.

SLOPE STABILITY

The lower portions of the slope near the river appear to be currently unstable with several areas of active slope movement. Curved tree trunks as observed throughout the study area are often indicative of ongoing surficial soil movement. Further evidence of localized slope failures is shown on attached Photographs of OP#9 to OP #11, which shows soil flows and intact soil blocks at the toe of slopes. This debris was not present during our site reconnaissance in July, 2009, indicating that wet weather is having an influence in this area.

Based on our observations and interpretations of site conditions, we are of the opinion that slope

instabilities are a result of increased surface runoff and seepage flow with the slopes back from the rivers edge. We expect that rainfall infiltration within mountain areas upslope from the river makes it way through soil and bedrock into the glacio-lacustrine deposits close to the river edge. The increased flow and seepage pressures causes saturation and erosion of loose soils within veneer zones of existing slopes. This increase in regional groundwater flow is likely increasing pore pressures within the soil structure forming the core of existing slopes, which can reduce the stability of slopes leading to larger scale failures toward the river. As the more active soil failures appear to be very recent (over the last few years), a change in the water drainage patterns in the mountain slope areas above the river edge slopes may be responsible for the recent activity. The stratigraphy of the active soil failures near OP #9 (sand and gravel overlain with silt and clay) support this opinion. In addition, wetland vegetation observed at the toe of several of failure scarps indicate groundwater is coming to surface near these locations. A sketch of the possible mechanism is shown on Drawing 091-02075-03.

The larger scarp above an active slope area (OP #20) appears to be much older than soil failures noted closer to the river. Re-activation of this failure would likely have a significant impact on the river in terms of soil deposition as this feature may involve movement of the entire slope between the scarp and the river. Should this older failure re-mobilize, it is possible soil debris could move into the river will restricting flow and generating a large silt load.

Erosion of the toe of the soil slopes by the river appears to be on-going; however, the majority of the observed slope failures, erosion and soil flows are away from the river bank indicating that the river is not currently a major cause of slope failures at this time. However, it should be noted that the study area is on the outside of a river bend and, as such, future erosion of the bank should be anticipated. In the event erosion and regression of the rivers edge were to occur, larger scale slope instabilities would likely occur, as noted above.

MONITORING and MITIGATION

Silt deposition into the river within the study area is being sourced from both erosion of the river bank and from small slough failures and soil flows from slopes adjacent to the river unrelated to river erosion. Slope failures away from the river are not likely a large contributor to soil deposition into the river at this time; however, these small failures may grow in size in the future and ultimately provide sufficient material to affect the river. In addition, re-mobilization of larger, older slide would likely have significant implications on the river.

In order to mitigate erosion of the river bank, rip rap could be placed along the bank. This would provide some protection for the soil bank. It may be possible to construct the rip rap bank in such a way as to create catchment areas for soils generated from nearby slope failures above the rivers edge.

Logging roads above the study area were noted to have ditching along the upslope side directing water parallel to the roadways. Further re-directing of surface water flow by use of ditches and cut-offs above the site would likely have only a nominal effect on reducing water infiltration into the soils forming slopes adjacent to the river.

As discussed previously, there is potential for large scale slope failures to occur. These failures could possibly impact the river by impeding flow and/or generating increased SILT load. Our expectation is that movement of these large scale failures would be progressive (incremental with time) rather than a sudden large scale movement. Therefore, monitoring of slope movement could be considered as a means of characterizing the rate of slope movement and the risk that this movement may present to the river. Monitoring should encompass the area from the river bank to a point above the large scarp about 200m

from the river. Data collected should include horizontal and vertical positions of points marked in the field in such a manner as to be easily found for several years. Measurements taken approximately every 6 months should be sufficient to assess the extent of possible slope movement. Should significant slope movement be identified by monitoring, increased frequency of monitoring should be undertaken and mitigation plans developed if necessary.

Possible remedial measures such as moving the river away from the affected area may need to be considered.

CLOSURE

As there was no subsurface investigation conducted, we have provided a qualitative assessment of the existing slope stability based on our characterization of the subject site including identified recent and historical slope failures. Our characterization of the subject site is based on site reconnaissance, topographic plan maps, surficial geology plans, previous reports on other portions of the Cowichan River, and Trows' previous experience with similar sites throughout British Columbia. We would be pleased to discuss the contents of this report along with options regarding longer term monitoring of this site.

The above noted and attached information is provided for the exclusive use of our client and their designated consultants and agents and may not be used by other parties without the written consent of Trow Associates Inc. The attached "Interpretation and Use of Study and Report" forms an integral part of this report and must be included with any copies of this report.

Yours truly,

Trow Associates Inc.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA E. G. SYKES Feb 17/10

Evan Sykes, P.Eng.
Senior Engineer

Reviewed by:

Jim O'Brien, P.Eng.
Senior Engineer

Enclosures: Interpretation and Use of Study and Report
Location Plan (Drawing 091-02075-01)
Site Plan (Drawing 091-02075-02)
Cross Section (Drawing 091-02075-03)
Photographs

ES/es

INTERPRETATION & USE OF STUDY AND REPORT

1. STANDARD OF CARE

This study and Report have been prepared in accordance with generally accepted engineering consulting practices in this area. No other warranty, expressed or implied, is made. Engineering studies and reports do not include environmental consulting unless specifically stated in the engineering report.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report which is of a summary nature and is not intended to stand alone without reference to the instructions given to us by the Client, communications between us and the Client, and to any other reports, writings, proposals or documents prepared by us for the Client relative to the specific site described herein, all of which constitute the Report.

IN ORDER TO PROPERLY UNDERSTAND THE SUGGESTIONS, RECOMMENDATIONS AND OPINIONS EXPRESSED HEREIN, REFERENCE MUST BE MADE TO THE WHOLE OF THE REPORT. WE CANNOT BE RESPONSIBLE FOR USE BY ANY PARTY OF PORTIONS OF THE REPORT WITHOUT REFERENCE TO THE WHOLE REPORT.

3. BASIS OF THE REPORT

The Report has been prepared for the specific site, development, building, design or building assessment objectives and purpose that were described to us by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the document are only valid to the extent that there has been no material alteration to or variation from any of the said descriptions provided to us unless we are specifically requested by the Client to review and revise the Report in light of such alteration or variation.

4. USE OF THE REPORT

The information and opinions expressed in the Report, or any document forming the Report, are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT OUR WRITTEN CONSENT. WE WILL CONSENT TO ANY REASONABLE REQUEST BY THE CLIENT TO APPROVE THE USE OF THIS REPORT BY OTHER PARTIES AS “APPROVED USERS”. The contents of the Report remain our copyright property and we authorise only the Client and Approved Users to make copies of the Report only in such quantities as are reasonably necessary for the use of the Report by those parties. The Client and Approved Users may not give, lend, sell or otherwise make the Report, or any portion thereof, available to any party without our written permission. Any use which a third party makes of the Report, or any portion of the Report, are the sole responsibility of such third parties. We accept no responsibility for damages suffered by any third party resulting from unauthorised use of the Report.

5. INTERPRETATION OF THE REPORT

a. Nature and Exactness of Descriptions: Classification and identification of soils, rocks, geological units, contaminant materials, building envelopment assessments, and engineering estimates have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature and even comprehensive sampling and testing programs, implemented with the appropriate equipment by experienced personnel, may fail to locate some conditions. All investigations, or building envelope descriptions, utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarising such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and all persons making use of such documents or records should be aware of, and accept, this risk. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. Where special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.

b. Reliance on Provided information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to us. We have relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, we cannot accept responsibility for any deficiency, misstatement or inaccuracy contained in the report as a result of misstatements, omissions, misrepresentations or fraudulent acts of persons providing information.

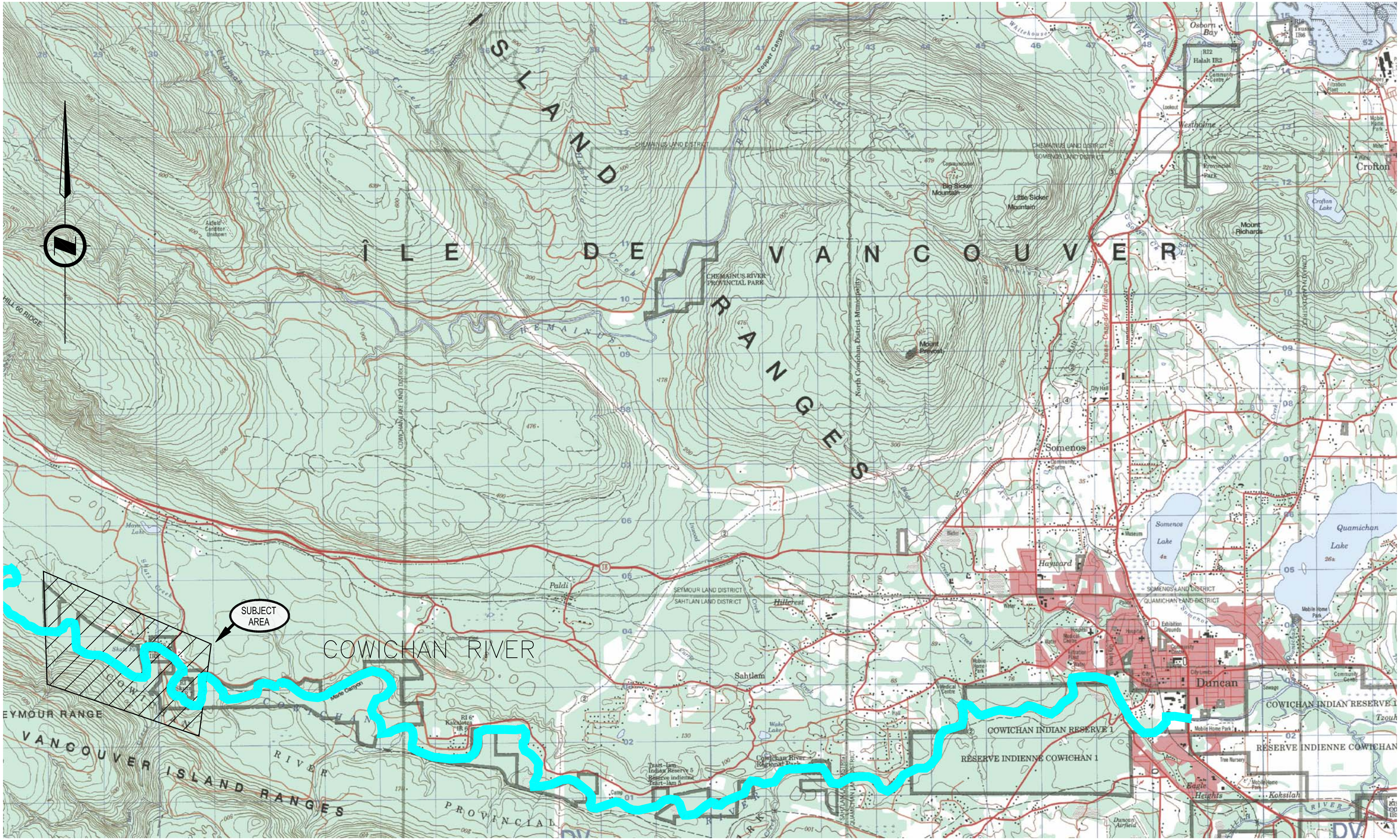
c. To avoid misunderstandings, Trow Associates Inc. (Trow) should be retained to work with the other design professionals to explain relevant engineering findings and to review their plans, drawings, and specifications relative to engineering issues pertaining to consulting services provided by Trow. Further, Trow should be retained to provide field reviews during the construction, consistent with building codes guidelines and generally accepted practices. Where applicable, the field services recommended for the project are the minimum necessary to ascertain that the Contractor’s work is being carried out in general conformity with Trow’s recommendations. Any reduction from the level of services normally recommended will result in Trow providing qualified opinions regarding adequacy of the work.

6.0 ALTERNATE REPORT FORMAT

When Trow submits both electronic file and hard copies of reports, drawings and other documents and deliverables (Trow’s instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by Trow shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancy, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by Trow shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of Trow’s instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except Trow. The Client warrants that Trow’s instruments of professional service will be used only and exactly as submitted by Trow.

The Client recognizes and agrees that electronic files submitted by Trow have been prepared and submitted using specific software and hardware systems. Trow makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.



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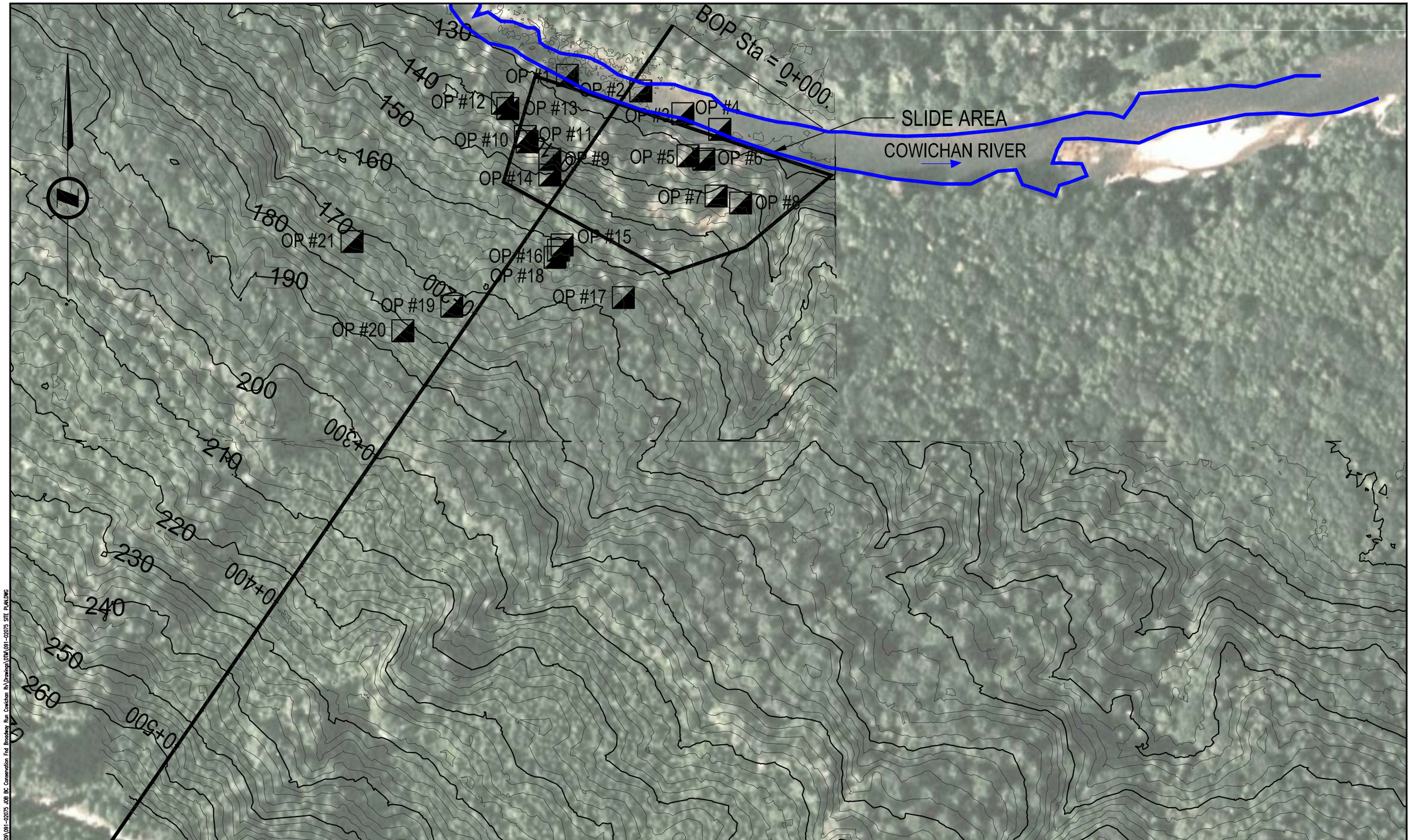
DFTR.	REVISIONS			CLIENT	TITLE:
PDL	No.	DESCRIPTION	DATE	BC CONSERVATION SOCIETY	BROADWAY RUN, COWICHAN RIVER LOCATION PLAN
DSGN.				PROJECT: BROADWAY RUN, SLOPE STABILITY	
CHK. JOB				PROJECT NO. 091-02075	DATE: JAN, 2010 — SCALE: not to scale — DWG NO. 091-02075-01



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REVISIONS

No.	DESCRIPTION	DATE

CLIENT: BC CONSERVATION SOCIETY

PROJECT: BROADWAY RUN SLOPE STABILITY

PROJECT NO.: 091-02075

TITLE: SITE PLAN
LIDAR SURFACE

DATE	SCALE:	DWG NO.
JAN., 2010	1:2000	091-02075-02

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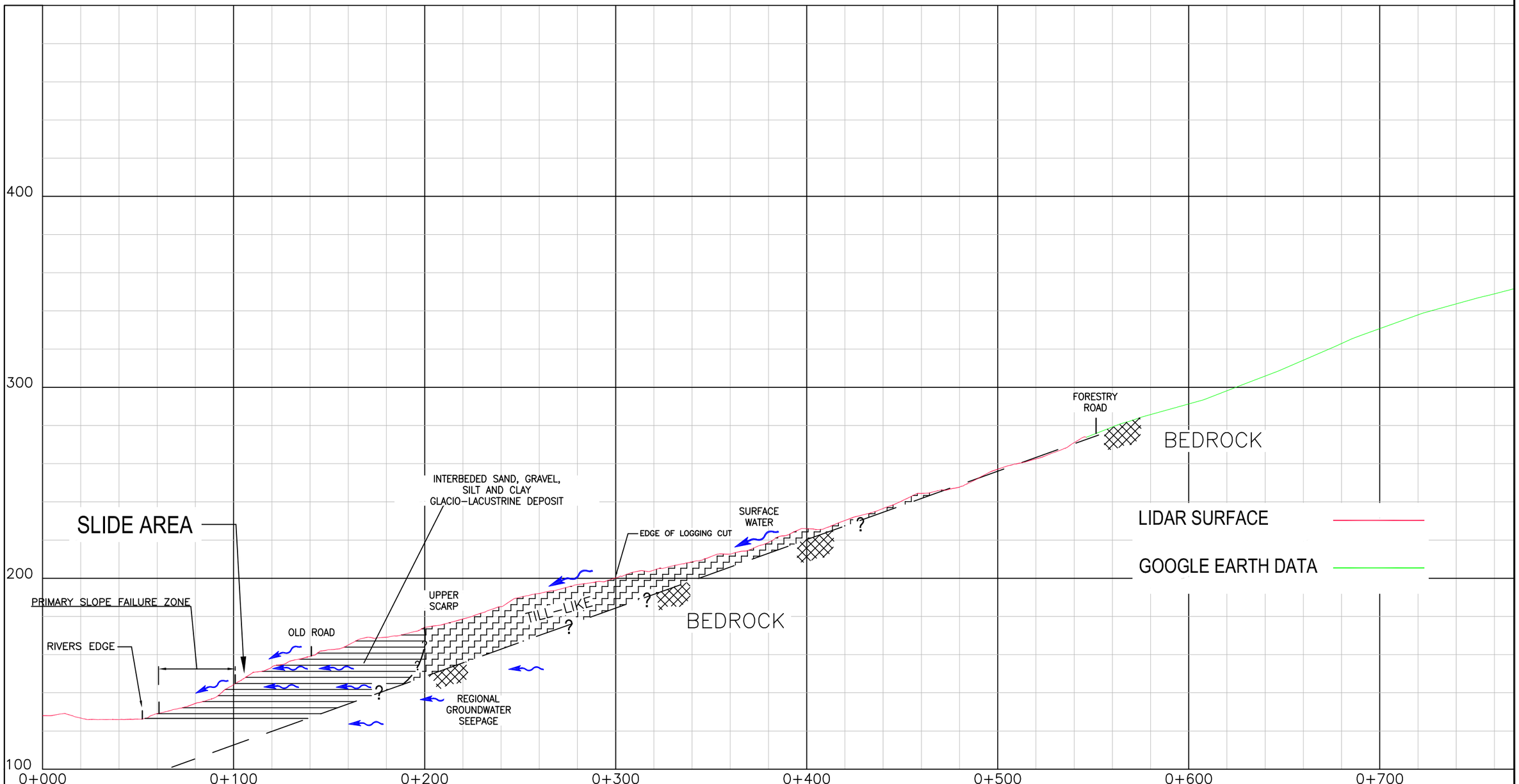
PROFILE A-A'



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PDL	EGS	JOB

REVISIONS

No.	DESCRIPTION	DATE

CLIENT: BC CONSERVATION SOCIETY
PROJECT: BROADWAY RUN SLOPE STABILITY
PROJECT NO.: 091-02075

TITLE: CROSS SECTION
LIDAR SURFACE & GOOGLE EARTH DATA

DATE	SCALE:	DWG NO.
JAN, 2010	1:2000	091-02075-03

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PHOTO 1 – OP #1 – Erosion of River Bank
(July 7, 2009)

PHOTO 2 – OP #3 – Soil Deposits in River from nearby Bank Erosion/ Sloughing
July 7, 2009

PHOTO 3 – OP #4 – Sand and Gravel Deposits on River Bank
July 7, 2009

PHOTO 4 – OP #8 – Scarp approximately 1.5m in Height
July 7, 2009

PHOTO 5 – OP #9 – Scarp and subsequent Erosion
July 7, 2009

PHOTO 6 – OP #9 – Scarp
Note Clayey SILT layer overlying Sand and Gravel
July 7, 2009

PHOTO 7 – OP #10 – Slide/ Erosion Deposition
July 7, 2009

PHOTO 8 – OP #11 – Slide Scarp approximately 8m in Height
July 7, 2009

PHOTO 9 – OP #12 – Scarp
July 7, 2009

PHOTO 10 – OP #8 – Scarp
November 2, 2009

PHOTO 11 – OP #9 – Deposition of Soil
November 4, 2009

PHOTO 12 - OP #9 – Soil Flows
November 4, 2009

PHOTO 13 – OP #11 – Scarp
November 4, 2009

PHOTO 14 – OP #20 – Scarp
approximately 2 to 3m Height
November 4, 2009