



## Memorandum

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| File No.: | 20-369-SC  | Date:  | December 22, 2020 |
| To:       | Sunshine Coast Regional District (SCRD), Attention: Stephen Misiurak   |        |                   |
| Email:    | Stephen.misiurak@scrd.ca   | Phone: | 604.885.6800      |
| From:     | Benjamin Tomasz, P.Eng.<br>Masoud Mohajeri, P.Eng.   | CC:    |                   |
| Subject:  | <b>Memorandum 1 – Field Review – Landslide Hazard Condition Assessment<br/>Reservoir Road Extension, Sechelt, British Columbia</b> |        |                   |

### 1.0 INTRODUCTION

Arya Engineering Inc. (Arya) presents this memorandum detailing observations taken during a recent field review conducted to evaluate a landslide that has recently occurred along the northwestern bank of Chapman Creek, at a location approximately 500 m northeast of the Chapman Creek Water Treatment Facility in Sechelt, BC. An Arya representative visited the site on December 20, 2020, after receiving notification of landslide occurrence from a representative of the SCRD. The commentary contained herein is based on Arya's field observations, conversations with SCRD personnel, and a review of published geologic and topographic information available for the area. The intent of this memorandum is to provide a description of the ground instabilities observed and preliminary recommendations for remedial actions and landslide mitigation measures to be considered in the slide area.

### 2.0 CONDIITON ASSESSMENT

During the field review, ground movement was observed along the downhill (southeast) side of an access corridor (pathway) that we understand accommodates a 600 mm diameter underground water supply main. It is our understanding that the supply main conveys water from an intake location further northeast, beyond Chapman Falls to the aforesaid water treatment facility.

As evaluated from the pathway located immediately northwest of the landslide, the slide was observed to consist of a slumped mass of material predominantly consisting of sand and gravel with trace to some fines. The slide mass appeared to have dropped in elevation by at least 1 m at the time of the field review (headscarp height), and to have resulted in approximately 2 m of slope regression, as estimated from undisturbed areas adjacent to the lateral margins of the landslide headscarp. Loose surface soils as part of the slumped mass were observed to have runout further downhill from the main body of the slump mass through sloughing and raveling. The disturbed soils were observed to be light grey, brownish-grey and strong-brown in color. An open tension crack had formed approximately 300 mm upslope from the headscarp location. The crown of the slide was measured at 7 m in width. Numerous minor tension cracks were observed adjacent to the headscarp in the form of ground depressions located parallel to the crown.



Manual probing in the vicinity of the tension crack location revealed loose soils in excess of 900 mm in depth.

Based on discussions with an SCRD site representative and measurements taken on-site at the time of the review, the 600 mm dia. supply main was estimated to be located at a setback of approximately 1.5 m to 1.8 m from the observed tension crack, at its closest point. Due to the topographic conditions in the slide area and indications of unstable terrain, visual observations of the landslide were limited to beyond the headscarp and crown area. The toe, flanks and main body of the slump mass could not be assessed. There were no indications observed on-site that either overland flow or windthrow contributed to the slope failure.

Topographic details of the study area were established based on tilt clinometer readings taken on site during the time of the field review, as well as topography provided on the SCRD's property viewer application. As discussed, the slide initiated on the downhill side of an existing access corridor that accommodates the supply main. The pathway has been benched into the side of a steep slope that maintains a prominence of approximately 80 m. As taken from the pathway location where the slide has occurred, the slope descends to the southeast to Chapman Creek below, averaging a slope gradient of 50° to 55° over a prominence of approximately 30 m. Also taken from the location of the pathway in the vicinity to the slide, the slope ascends to the northwest at an average slope of 35° over a prominence of approximately 50 m.

Visual assessment of exposed surface soils located on the uphill side of the access corridor suggests an undisturbed soil profile consisting of a thin veneer of podzol (50 mm to 100 mm), underlain by a loose, strong-brown sand and gravel deposit with some fines (150 mm to 600 mm), further underlain by Vashon Stade lodgement till. The till was described as a matrix of sand and gravel and trace silt and trace coarse soils consisting of cobbles and boulders. This deposit was observed at multiple locations across the pathway and was typically described as very moist, brownish-grey in color, highly weathered and friable. This material was observed to readily disintegrate upon disturbance with a soil probe.

Outcropping bedrock was observed below the slide location along the channel of Chapman Creek. No groundwater conditions including seepage were observed in the vicinity of the landslide. The soil stratigraphy observed is consistent with published surficial geologic information for the area which locates the slide area at the contact of bedrock, granular fluvial deltaic, fan and channel deposits and ground moraine deposits.

## **2.0 FAILURE MODE AND MECHANISM**

The conditions observed suggest localized debris slide failure, which is a characteristic landslide mode across the Sunshine Coast in similar ground conditions (veneer of loose, unconsolidated surface soils over granular till on steep open slopes). These slides are either translational or rotational in nature or consist of a combination of translational and rotational movement. Given the spatial characteristics of the slide and observations of the exposed soils across the headscarp location, and across observable areas of the



slump mass, it is anticipated that the landslide failure plane propagates through the glacial till matrix to some depth.

It is expected that the primary condition initiating localized debris slides is continual weathering of the glacial till near surface. Locally, this material is predominately comprised of weakly to moderately cemented sand and gravel which contains relatively high shear strength when unweathered. However, continual precipitation and infiltration of surface waters results in wetting of the glacial till contact which gradually decreases the cementation related cohesion (“apparent cohesion”) and reduces the shear strength of the soil mass comprising the slopes. While the driving forces in a given slope section essentially remain static with time, the resistance forces (“apparent cohesion”) decrease to a point where the slope geometry can no longer support its own weight, and landsliding ensues.

A seasonal phenomenon on the Sunshine Coast generally consists of several discrete days over the winter months where intense rainfall occurs, and numerous localized debris slides are triggered in similar terrain and ground conditions, and which realize identical failure geometries to the slide observed during the field review. It is anticipated that during these precipitation events, elevated transient groundwater conditions at the glacial till contact, partial infiltration of surface water into the till matrix, and/or the continual weathering of the till during these events reduces the shear strength parameters of the soils sufficiently to trigger landsliding.

## **2.0 RECOMMENDATIONS**

The landslide observed on site has resulted in the oversteepening of the downhill side of the pathway (near vertical headscarp) and the removal of vegetation from this section of the slope, further increasing susceptibility to ground movement. Regression of the oversteepened headscarp through erosion and/or subsequent retrogressive slope failures is likely. Forthcoming precipitation may further trigger landsliding either through mobilization of the current landslide mass, and/or mobilization of a regressive landslide toward the supply main. Given the current setback of the supply main (1.5 m to 1.8 m uphill of existing tension cracking) and the apparent height of the headscarp (at least 1 m), urgent remedial action in the form of a permanent, or semi-permanent slope stabilization or supply main stabilization strategy is strongly recommended.

Provided mitigation of only shallow slope instability is required, securing the slope sections immediately adjacent to and downhill of the supply main with micro-piles and/or soil anchors may be a feasible design and construction strategy for this failure, given the site conditions and access constraints of the slide location. A supply main underpinning strategy through micropile/soil anchor installation may also be a feasible design alternative.

During the time of the field review and through subsequent correspondence, Arya has provided instructions to SCRD personnel to immediately close access to the pathway and to weather protect the landslide area with plastic sheeting. These interim measures should be maintained until a more permanent remedial action plan is undertaken. All reasonable efforts should be undertaken to direct surface water runoff originating from the hillside away from the slide area. If practical, redirected surface



waters should be concentrated in closed pipes and directed to Chapman Creek below; however, given the prominence and steepness of the hillside, this may not be a practical. As in interim strategy, concentrated surface water could otherwise be directed to locally constructed energy dissipators (PVC outflow connected to a T-fitting surrounded in blast rock or coarse granular material) constructed across the pathway. Collected and concentrated surface water should not be discharged immediately on the slope below the pathway.

A main line bypass without terminating service of the main may also be feasible as a means of temporarily rerouting the supply main located closest to the landslide headscarp. This strategy would reduce the likelihood of imminent retrogressive slope failure that could otherwise interfere with the performance of the supply main. This strategy would also facilitate access to the headscarp location for further geotechnical review, as needed to gather the requisite site information needed to establish an appropriate long-term remediation plan.

### **3.0 CLOSURE AND LIMITATIONS**

Arya has provided several remediation designs for similar type failures in limited access locations across the Sunshine Coast through the utilization of micro-piles and soil anchors, and through other means. We are available to provide additional design consultation and project support upon request.

In consideration of the subsurface conditions and topographic conditions observed, the potential for deep-seated slope failure would need to be assessed as part of establishing a suitable long-term solution. It's also important to note that the commentary and recommendations contained herein are based on our general project experience with the local geomaterials and topographic conditions observed on-site. Detailed geotechnical field investigation would be required to confirm the failure mode and triggering mechanisms presented herein in support of providing an appropriate remediation plan.

This report has been prepared for the exclusive use of the Sunshine Coast Regional District for the development of the proposed structure and auxiliary building on the subject site. The recommendations provided in this document reflect Arya's best judgment based on the information available to Arya at the time of preparation of this document. If conditions other than those are noted during subsequent phases of development, Arya should be notified immediately and given the opportunity to review and revise the current recommendations, if necessary.

This report remains the property of Arya Engineering Inc., and Arya does not accept damages caused by the unauthorized third-party use of the information contained herein. The assessment was conducted in accordance with current geotechnical engineering practice and principles.



We trust this document provides the information required at this time for project continuation. If you have any questions regarding the document, please do not hesitate to contact us.

Sincerely,

**Arya Engineering Inc.**

**Prepared By:**

**Reviewed By:**

Benjamin Tomasz, P.Eng.  
Principal | Senior Geotechnical Engineer

Masoud Mohajeri, Ph.D., P.Eng., PMP  
Principal | Specialist Geotechnical Engineer

**Attachment: Terms and Conditions**



## TERMS AND CONDITIONS OF ENGAGEMENT

1. **GENERAL:** Arya Engineering Inc. (ARYA) shall render the Services, as specified in the attached Scope of Services, to the Client for the Project in accordance with the following terms and conditions of engagement and related articles. ARYA may, at its discretion and at any stage, engage sub-consultants to perform any part or all of the Services.
2. **DEFINITIONS:**
  - a. Agreement – is this Prime Agreement for professional Services.
  - b. Consultant – shall mean professionals and other specialists other than ARYA or its officers, employees and agents engaged by the Client directly.
  - c. Contractor – is the party contracting with the Client for the provision of labour, materials and equipment for the execution and quality control of the Work.
  - d. Contract – is the agreement between the Client and the Contractor for the provision of labour, materials and equipment for the execution of the Work by the Contractor.
  - e. Contract Documents – shall comprise all documents relating to the Project issued by or through ARYA, including the plans, drawing, specifications and schedules, and all variations and modifications thereto approved by ARYA.
  - f. Field Services – shall mean applying such selective sampling and inspection procedures at the project site during construction as ARYA, and at ARYA's professional discretion, considers necessary to enable ARYA to ascertain whether the Contractor is carrying out the Work in general conformity with the design concept for the Project.
  - g. Project – shall refer to the project described in the recital clauses to this Agreement.
  - h. Services – shall mean ARYA's duties and responsibilities to the Client as set forth in the attached Scope of Services and Authorization to Proceed.
  - i. Sub-Consultant – shall mean any registered professional engineers or other specialists engaged by ARYA in connection with the Project.
  - j. Work – is the totality of all labour, materials and equipment used or incorporated into the Project by the Contractor pursuant to the Contract Documents.
3. **REPRESENTATIVES:** Each party shall designate a representative who is authorized to act on behalf of that party and receive notices under this Agreement.
4. **AUTHORIZATION TO PROCEED:** Verbal authorization by the Client, either in person or over the telephone, or by written instructions will serve as authorization for ARYA to proceed with the services called for in this services agreement and those delineated in related correspondence between ARYA the Client. This Agreement, including attachments incorporated herein by reference, represents the entire agreement between ARYA and Client. This Agreement may be altered only by written instrument signed by authorized representatives of both Client and ARYA.
5. **EXTENT OF AGREEMENT:** Work beyond the Scope of Services or redoing any part of the Project through no fault of ARYA, shall constitute extra Work and shall be paid for on a time-and-materials basis in addition to any other payment provided for in this Agreement. If, during the course of performance of this Agreement, conditions or circumstances are discovered which were not contemplated by ARYA at the commencement of this Agreement, ARYA shall notify the Client either verbally or in writing of the newly discovered conditions or circumstances, and the Client and ARYA shall renegotiate, in good faith, the terms and conditions of this Agreement.
6. **COMPENSATION:** Charges for the Services rendered will be made in accordance with ARYA's Schedule of Fees and Disbursements in effect from time the services are rendered. ARYA's Schedule of Fees and Disbursements are included in ARYA's budget estimate. All charges will be payable in Canadian Dollars. ARYA shall invoice the Client for the services performed under this Agreement and shall provide a summary of costs upon request. The Client shall pay such invoice upon receipt. Invoices not paid within thirty (30) days of the invoice date shall be subject to a late payment charge of 1.5 percent per month (18% per annum) from the date of billing until paid. The invoice amounts shall be presumed to be correct unless the Client notifies ARYA in writing within fourteen (14) days of receipt. Overdue accounts over ninety (90) days will be forwarded to a collections agency. The Client and ARYA expressly agree that ARYA's fee shall be payable by the Client even in the event that the Client does not, for any reason, proceed with the Project as described in the Contract Documents. The Client and ARYA further expressly agree that payment of the ARYA's fee by the Client pursuant to this Agreement shall be a condition precedent to the Client's use of the Contract Documents and models for the execution of the Work.
7. **PROBABLE COSTS:** ARYA does not guarantee the accuracy of probable costs for providing Engineering Services. Such probable costs represent only ARYA as a professional and are supplied only for the general guidance of the Client. The parties expressly acknowledge and agree that the cost of the Services and contract time estimates provided by ARYA to the Client under this Agreement are subject to change and are contingent upon factors over which ARYA has no control. ARYA does not guarantee the accuracy of such estimates.



8. **STANDARD OF CARE:** ARYA shall perform its services in a manner consistent with the standard of care and skill ordinarily exercised by members of the profession practicing under similar conditions in the geographic vicinity and at the time the Services are performed. This Agreement neither makes nor intends a warranty or guarantee, either expressed or implied.
9. **INDEMNITY:** Client waives any claim against ARYA, its officers, employees and agents and agrees to defend, indemnify, protect and hold harmless ARYA and its officers, employees and agents from any and all claims, liabilities, damages or expenses, including but not limited to, delay of the project, reduction of property value, fear of or actual exposure to or release of toxic or hazardous substances, and any consequential damages of whatever nature, which may arise directly or indirectly, to any party, as a result of the services provided by ARYA under this Agreement, unless such injury or loss is caused by the sole negligence of ARYA.
10. **INSURANCE, LIMITATION OF LIABILITY:** The Client agrees to limit ARYA and its officers, employees, and agents liability due to professional negligence and to any liability arising out of or relating to this Agreement to fifty thousand dollars (\$50,000) or the amount of ARYA's fee, whichever is less. This limit applies to all services on the project, whether provided under this or subsequent agreements, unless modified in writing, agreed to, and signed by authorized representatives of the parties. No claims may be brought against ARYA in contract or tort more than two (2) years after Services were completed or terminated under this engagement. If for any reason such insurance shall not be available or shall not apply to any claim made by the Client against ARYA in respect of the Services, then the liability of ARYA to the Client under this Agreement shall be absolutely limited to the amount of any professional liability available at the time such claims are made. In this case, any liability arising out of or relating to this Agreement will also be limited to fifty thousand dollars (\$50,000), or the amount of ARYA's fee, whichever is less. Note: ARYA will not be responsible for water ingress related problems as ARYA's insurance policy contains an Absolute Water Ingress Exclusion. For special projects, higher liability limits are available from our underwriter for an additional fee. ARYA warrants it is protected by WorkSafe BC Insurance, General Liability Insurance, Professional Errors and Omissions Insurance, and Automobile Liability Insurance. Certificates for such policies of insurance shall be provided to the Client upon request.
11. **RESPONSIBILITY:** ARYA is not responsible for the completion or quality of work that is dependent upon or performed by the Client or third parties not under the direct control of ARYA, nor is ARYA responsible for their acts or omissions or for any damages resulting there from. ARYA shall not be responsible for the following:
  - a. The failure of a Contractor, retained by the Client, to perform the Work required for the Project in accordance with the applicable Contract Documents;
  - b. The design of or defects in equipment supplied or provided by the Client for incorporation into the Project;
  - c. Any cross-contamination resulting from subsurface investigations;
  - d. Any damage to subsurface structures and utilities which were identified and located by the Client;
  - e. Any Project decisions made by the Client if the decisions were made without consultation of ARYA or contrary to or inconsistent with ARYA's recommendations;
  - f. Any consequential loss, injury, or damages suffered by the Client, including but not limited to, loss of use, earnings, and business interruption; and,
  - g. The unauthorized distribution of any document or report prepared by or on behalf of ARYA for the exclusive use of the Client.
12. **CLIENT'S RESPONSIBILITIES:**
  - a. Make available to ARYA all relevant information or data pertinent to the project which is required by ARYA, and instruct ARYA fully in writing as to the Client's total requirements in connection with the Project. ARYA shall be entitled to rely upon the accuracy and completeness of such information and data furnished by or through the Client, including information and data originating with Consultants, whether such Consultants are engaged at the request of ARYA or otherwise. Where such information or data originates either with the Client or with Consultants, then ARYA shall not be responsible to the Client for the consequences of any error or omission contained therein or arising from ARYA's use of this data;
  - b. When required by ARYA, to engage Consultants directly to perform services necessary to enable ARYA to carry out its duties and responsibilities. Such Consultants engaged by the Client shall be subject to the joint approval of the Client and ARYA;
  - c. Authorize ARYA to act as the Client's for such purposes as are necessary to ARYA's rendering of its Services pursuant to this Agreement;
  - d. Give prompt consideration to all sketches, drawing, specifications, tenders, proposals, contracts and other documents relating to the Project laid before the Client by ARYA, and whenever prompt action is necessary inform ARYA of the Client's decisions in such reasonable time so as not to delay the Services of ARYA, or to prevent ARYA from forwarding drawings or instructions to the Contractor or the Consultants or to Sub-Consultants in good time;
  - e. Pay ARYA's fee and reimbursable expenses as provided for in this Agreement;





- f. Provide necessary advertising incidental to obtaining tenders, and provide or reimburse ARYA for obtaining necessary legal, accounting and insurance counseling services;
  - g. Arrange and make provision for ARYA's entry and ready access to property (public and private) as well as to the Project site, as necessary to enable ARYA to perform its Services;
  - h. Give prompt written notice to ARYA whenever the Client or the Client's representative becomes aware of any defects or deficiencies in the Work or in the Contract Documents; and,
  - i. Obtain required approvals, licences and permits from municipal, governmental or other authorities having jurisdiction over the Project so as not to delay ARYA in the performance of Services. The Client expressly undertakes not to enter into contracts in connection with the Project which describe duties and responsibilities of ARYA which are inconsistent with the duties and responsibilities of ARYA provided for in this Agreement without obtaining ARYA's prior written agreement thereto.
13. **EXCLUSIVE USE:** Services provided under this Agreement, including all reports, drawings, plans, models, specifications and other documents, information or recommendations prepared or issued by ARYA, are instruments of service for the execution of the Project. ARYA retains the property and copyright in these documents, whether the Project is executed or not. No other use of these documents is authorized under this Agreement without the prior written agreement and remuneration of ARYA.
14. **SAMPLES:** All non-consumed samples shall remain the property of the Client, and Client shall be responsible for and promptly pay for the removal and lawful disposal of samples, cuttings and hazardous materials, unless otherwise agreed in writing. If appropriate, ARYA shall preserve samples obtained for the project for not longer than thirty (30) days after the issuance of any document that includes the data obtained from those samples.
15. **ENVIRONMENTAL:** ARYA's field investigation, laboratory testing and engineering recommendations will not address or evaluate pollution of air, soil and/or groundwater, unless otherwise specifically listed in the attached Scope of Services. ARYA will co-operate with the Client's environmental consultant during field work phase of the investigation is requested.
16. **FIELD SERVICES:** Where applicable, Field Services recommended for the Project are the minimum necessary, at the sole discretion of ARYA, to review whether the Work of a Contractor retained by the client is being carried out in general compliance with the intent of the Services and in compliance to information and recommendations presented in all reports, drawings, plans, models, specifications and other documents provided in the deliverables prepared by ARYA in fulfillment of the Scope of Services. It is understood and agreed by the Client that the performance of the Contract is not ARYA's responsibility, nor are Field Services rendered for the Contractor's benefit. The Contractor alone is responsible for the quality control of the Work. Any reduction from the level of services recommended will result in ARYA not providing qualified certifications for the Work. ARYA shall issue certifications only where Field Services have been performed by ARYA.
17. **TERMINATION:** This Agreement may be terminated by either party upon ten (10) days written notice to the other. Upon the receipt of such written notice from the Client to ARYA, ARYA shall perform no further Services other than those reasonably necessary. In the event of a termination, the Client shall pay for all charges for services performed and demobilization by ARYA, in addition to reasonable termination expenses incurred to the date of notice of Termination. The limitation of liability and indemnity obligations of this Agreement shall be binding notwithstanding any Termination of this Agreement.
18. **DISPUTE RESOLUTION:** If requested in writing by either the Client or ARYA, the Client and ARYA shall attempt to resolve any dispute between them arising out of or in connection with this Agreement by entering into structured, non-binding negotiations with the assistance of a mediator on a without prejudice basis. The mediator shall be appointed jointly by the parties. If a dispute cannot be settled within a period of thirty (30) calendar days with the mediator, the dispute shall be referred to and finally resolved by arbitration under the rules of British Columbia or by an arbitrator appointed by agreement of the parties or by reference to a Judge of the Supreme Court of British Columbia. No one shall be nominated to act as an arbitrator who is in any way financially interested in the conduct of the Project or in the business affairs of either the Client or ARYA. The award of the arbitrator shall be final and binding upon the parties.
19. **GOVERNING LAW:** This Agreement is governed by the law British Columbia, and any litigation shall be brought and tried in, the judicial jurisdiction of the ARYA office that entered this Agreement, as stated herein.
20. **NON-SOLICITATION:** The Client agrees they shall not recruit for employment or hire any ARYA employees who provide services pursuant to this Agreement during the term of this Agreement and for a period of one (1) year following its termination.