



GEO-HAZARD ASSESSMENT

155 1 Avenue, Cultus Lake, BC

FOR:

**Gwyllyn Goddard
155 1 Avenue
Cultus Lake, BC V2R 4Z2**

BY:

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GEO-HAZARD ASSESSMENT

155 1 Avenue, Cultus Lake, BC

1 Introduction

As requested by Mr. Gwyllyn Goddard (the 'Client') Madrone Environmental Services Ltd. ('Madrone') performed a geo-hazard assessment of 155 1st Ave, Cultus Lake, BC (the 'Land' or 'Property' or 'Site'), PID 000-823-139.

The Land is situated within a development permit area identified in the Fraser Valley Regional District (the 'City') Official Community Plan (OCP) Bylaw, 2011, No. 1115. Among other things, the District wishes to protect existing and future development from natural hazards such as potential instability of adjacent slopes and flooding.

1.1 Scope and Objectives

We understand that the proposed development will include a single-family dwelling, and as such, a development permit and associated FCL variance is being sought. Municipal policies and EGBC guidelines requires that any new development on properties subject to or likely to be subject to geotechnical hazards requires a geotechnical hazard assessment to characterize the hazards, estimate their probability of occurrence, and provide a professional opinion that development is safe for the use intended if mitigation measures are incorporated.

We prepared this report in accordance with the guidelines for geotechnical hazard assessments as described in:

- 1 Fraser Valley Regional District Floodplain Bylaw No. 0681;
- 2 Hazard acceptability thresholds for development approvals by local government (Cave, 1993);

- 3 Guidelines for Legislated Landslide Assessments for Proposed Residential Developments in BC (APEGBC, 2010); and
- 4 Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC (APEGBC, 2018).

This geotechnical hazard assessment is limited to the property at 155 1st Ave, Cultus Lake, BC. The scope of this report does not extend to other properties; however, we considered the potential for hazards from adjacent areas to affect the subject property.

1.2 Methods

The objective of this assessment is to determine if there are hazards surrounding the property that present a hazard to the proposed dwelling. Our method involves a detailed description of the surficial geology and geomorphology of the site, with a particular focus on slope processes and flooding hazards.

Our geo-hazard analysis involved the review and characterization of the geo-hazards that may affect the Property, followed by a subjective quantitative estimate (e.g. range of annual probability of occurrence) of the geo-hazards. These estimated ranges are then compared to the safety thresholds presented in the revised 1993 report¹ by Dr. Peter Cave, which has been formally adopted by the District of Mission. We consider the Cave (1993) criteria to be an appropriate guideline for risk acceptability in this assessment. Based on these criteria the proposed development is considered a 'New Building' for our hazard criteria.

We have collected and reviewed appropriate background information, conducted fieldwork on and beyond the Property, and considered changed conditions (i.e. climate and land use). For geo-hazard analysis, we have reviewed, characterized, and estimated geo-hazards that may affect the Property, namely, possible slope instability above and below the proposed dwelling location. We have described the method of geo-hazard analysis used, referred to an appropriate and identified regional guideline for levels of geo-hazard safety, compared this guideline with the findings of our investigation, made a finding on the levels of safety on the Property based on the comparison, and made recommendations to reduce geo-hazards.

Roberta Adams visited the site on August 15, 2019 to conduct the site assessment, traversing the area surrounding the property. The area was measured with clinometer, measuring tape, and compass, surficial soil was classified, photographs and GPS placemarks were added to a handheld device. In

¹ Cave, P. W. (1993). Hazard Acceptability Thresholds for Development Approvals by Local Government. *British Columbia Geologic Hazards Workshop, February 20 & 21, 1991.*

particular, we recorded detailed observations of geologic evidence (or lack of evidence) of past flooding.

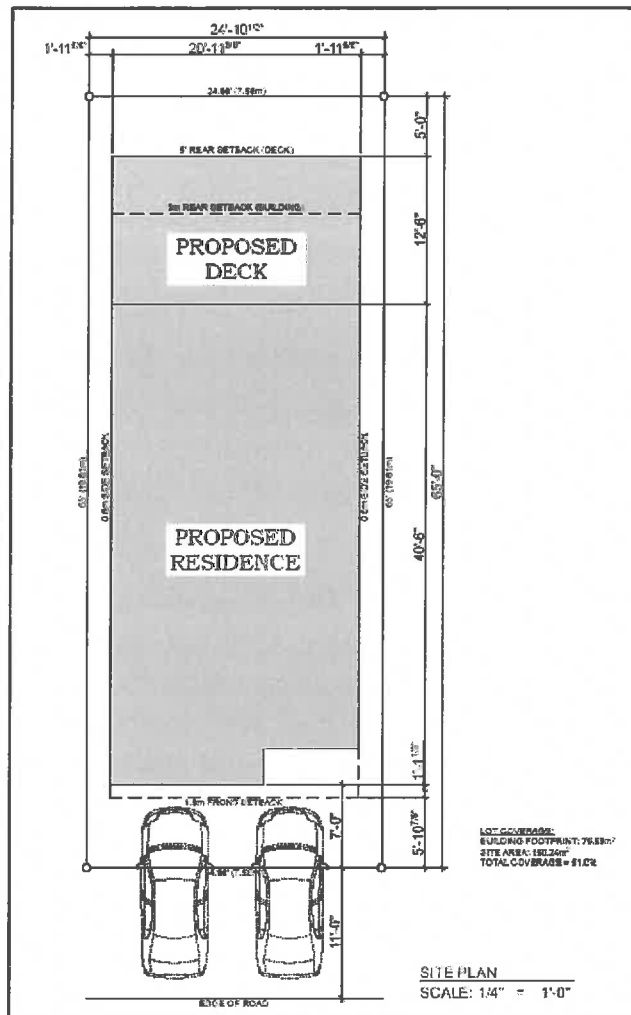


FIGURE 1: PROPOSED DEVELOPMENT, AS PROVIDED BY THE CLIENT, JULY 2019.

2 Background Information

For this assessment, we collected and reviewed:

- iMapBC²
- Air photos from 1940 to 2016 via UBC's Geographic Information Centre
- Previous reports and studies
- FVRD Webmap³
- Surficial Geology Map⁴
- Climate data⁵
- Seismic data⁶

2.1 Air Photo Analysis

As part of our assessment, we reviewed aerial photographs (air photos) available via the University of British Columbia Geographic Information Centre⁷. The photos dated back to 1940, but vary widely in quality, resolution and scale. Having the stereo-pairs (adjacent photos along a flight line) allowed viewing in three dimensions. The purpose is to track the timing of local developments, identify landsliding, or other past instability in the general vicinity of the property, as well as find features that may not be clearly visible during field assessments.

² Government of British Columbia. (updated 2015, September 3). *iMapBC 2.0*. Retrieved from <http://maps.gov.bc.ca/ess/sv/imapbc/>

³ Fraser Valley Regional District. *Fraser Valley Regional District Webmap*. Retrieved from <http://www.fvrd.ca/EN/main/services/mapping/regional-information-map.html>

⁴ Armstrong. (1977). *Surficial Geology, Chilliwack (West Half), British Columbia*. Geological Survey of Canada, Map 1487A. Scale 1:50 000. http://ftp.maps.canada.ca/pub/nrcan_rncan/publications/ess_sst/108/108875/gscmap-a_1485a_e_1980_mn01.pdf

⁵ Environment Canada. (modified January 25, 2017). *1981 - 2010 Climate Normals and Averages - Normals*. Retrieved from http://climate.weather.gc.ca/climate_normals/index_e.html

⁶ Natural Resources Canada. (modified 2017, February 10). *2015 National Building Code of Canada seismic hazard calculator*. Retrieved from http://www.earthquakescanada.nrcan.gc.ca/hazard-alea/interpolat/index_2015-en.php

⁷ <https://gic.geog.ubc.ca/> Geographic Information Centre - University of British Columbia.

TABLE 1: AIR PHOTO INTERPRETATION FOR AREA SURROUNDING SUBJECT PROPERTY.

Photo Number(s)	Year Taken	Interpretation
BC207:40	1940	Development along Cultus Lake. Debris slide off forestry road north of Lake on Vedder Mnt.
BC721:83-84	1949	Increased development along shore, small debris slides (raveling) off of forestry road on western bank.
BC1683:6	1959	No notable changes beyond the continued development of area (NN)
BC5065:237-236	1963	NN
BC5318:128-129	1969	Earthworks, logging on site NW of lake tip.
BC5584:64-63	1974	NN
BC78130:253-252	1978	NN
BC83013:112-113	1983	NN
BCC451:213-214	1986	NN
BCB93026:125-126	1993	Ascaphus Creek fan is more exposed, less trees but no sign of debris flow; maybe cleared for recreational use.
BCC96085:32-31	1996	NN
SRS6912:156	2004	Debris on Ascaphus Creek fan, but no change to size.
BCD16415:394-393	2016	NN

2.2 Previous Studies

At the time of publication, we were unable to find any geotechnical reports for similar developments in this area of Cultus Lake, however we were able to review larger regional studies. The following studies were reviewed:

- Geotechnical assessment of slope stability in the Chilliwack Valley, report to Regional District of Fraser Cheam; Thurber Consultants Ltd, June 30th, 1988.
- Emergency response to October 16-18 landslide and flood events near Cultus Lake and in Hatzic Valley; Thurber Engineering Ltd, October 31st, 2003.
- Geotechnical investigation and report, proposed 42 lot development VGES project number 42906 – 04; Valley Geotechnical Engineering Services Ltd, October 31st 2008.
- 2006 Frost Creek fan hazard zones - updated hazard zones at Lindell Beach; northwest hydraulic consultants, July 25th, 2011.
- Climate change impacts on eutrophic lake - Cultus Lake, British Columbia, Canada; Mark Gregory Sumka, Thesis, UBC August 2017.

- Groundwater conditions of the Columbia Valley aquifer, Cultus Lake BC; Mark Zubel, Ministry of Environment, Lands, Parks and Water Management, January 2000.
- Cultus Lake underwater habitat assessment and water quality surveys 2005 final data report; Kynoch Resources, April 2005.
- Cultus Lake watershed numerical groundwater flow model; Shannon Holding and Dr. Diana Allen, SFU, January 2012, prepared for the Department of Fisheries and Oceans Canada.
- Chilliwack River hazard management study interim report; Hay & Company Consultants Inc July 1992.

3 Location Description and Observations

The property is located approximately 10 km due southwest of the City of Chilliwack town center, on the west bank of Cultus Lake in the Columbia Valley. The approximate (unverified) elevation is 45 to 47 m above sea level (a.s.l.).



FIGURE 2: OVERVIEW OF REGION, SUBJECT PROPERTY PINNED IN YELLOW. FROM GOOGLE EARTH PRO.

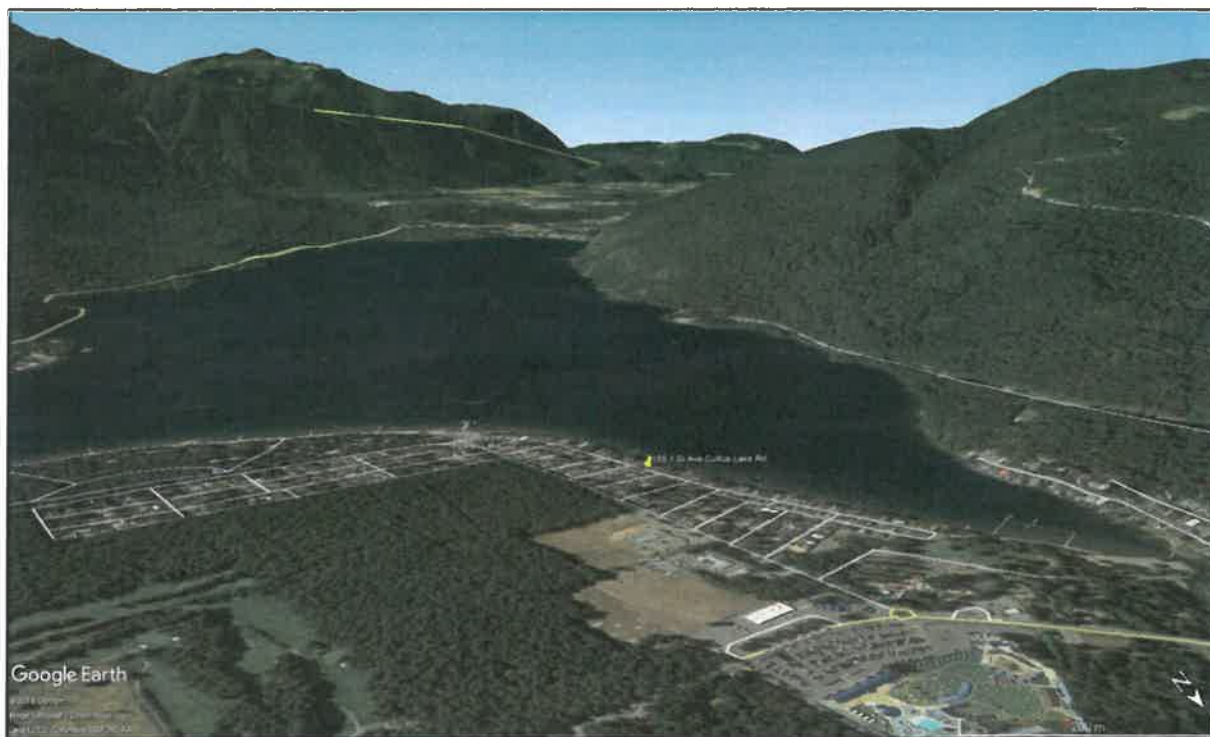


FIGURE 3: PERSPECTIVE VIEW OF SUBJECT PROPERTY, LOOKING SOUTHEAST. FROM GOOGLE EARTH PRO.

3.1 Geology

Bellefontaine et al (1994)⁸ mapped the bedrock geology of the area as Upper Jurassic Kent Formation sedimentary rocks, locally consists of conglomerates and coarse clastics; however, no bedrock outcrops were observed on the subject property.

The surficial geology in the area is Sumas Drift age outwash gravel and sand up to 10+ m thick [Sa]. Further up the valley is mapped as [SAj] postglacial Salish Sediments, mainly channel gravel and minor sand up to 10+ m thick.⁹

Well data from the surrounding area is consistent with the mapped geology and field observations, the majority documenting sand and gravel and cobbles (wells #52963 and 98912)¹⁰.

⁸ Bellefontaine, K., Alldrick, D. and Desjardins, P.J., 1994:

http://webmap.em.gov.bc.ca/mapplace/minpot/bedrock_publications.asp?NTS=103

⁹ Armstrong, J E. Geological Survey of Canada, "A" Series Map 1487A, 1977, 1 sheet, 1:50,000 .

¹⁰ Groundwater Wells and Aquifers: Well Summary <https://maps.gov.bc.ca/ess/hm/imap4m/>

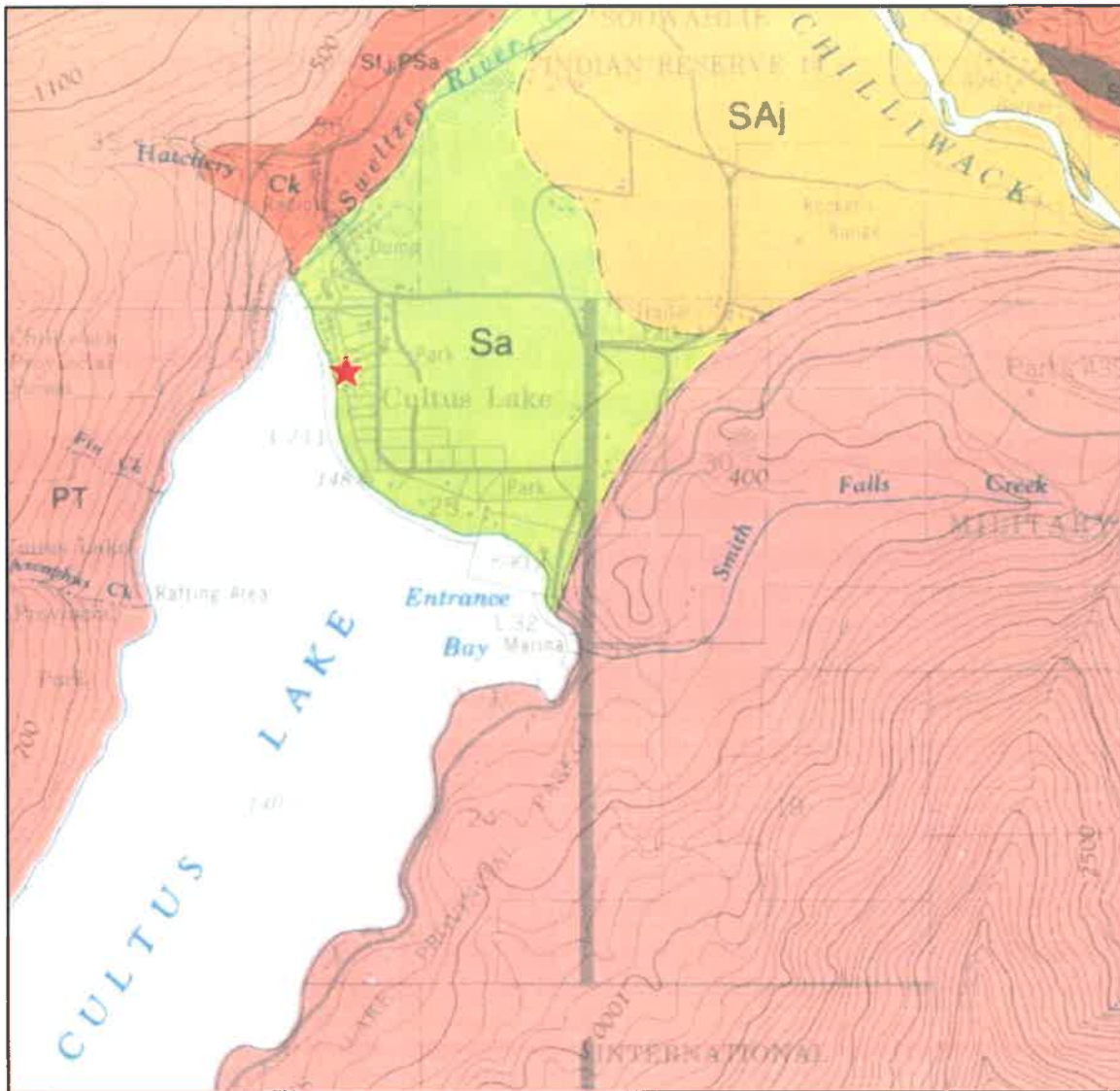


FIGURE 4: SURFICIAL GEOLOGY OF THE AREA, FROM ARMSTRONG (1977). RED STAR IN APPROXIMATE LOCATION OF SUBJECT PROPERTY.

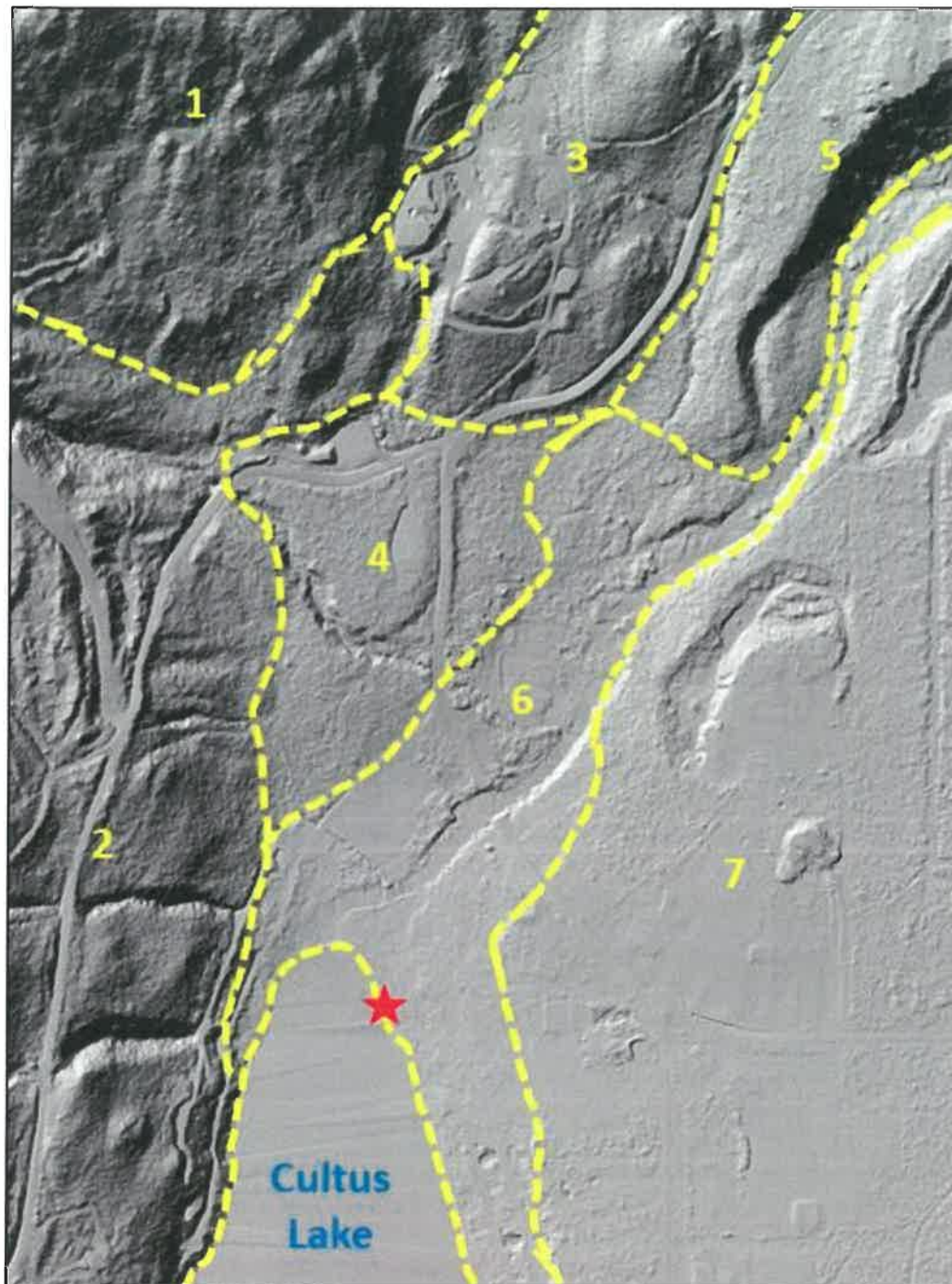


FIGURE 5: SURFICIAL GEOLOGY AND GEOMORPHOLOGY FROM CITY OF CHILLIWACK 1 M RESOLUTION LIDAR.

1= hummocky bedrock, 2= colluvium veneers over bedrock, 3= colluvial mantels, 4= alluvialfan, 5= glacial washed till, 6= fluvial sediments, 7= glaciofluvial sediments. For demonstration purposes only.

3.2 Hydrology and Climate

Climatic conditions at the Property are likely very similar to those recorded at the nearest Environment Canada weather station (i.e. 'Chilliwack, at 11 m elevation')¹¹. During the period 1981-2010, the mean annual precipitation was 1667 mm including a mean annual snowfall of 85 cm, while extreme daily precipitation was 122 mm on Dec 29, 1979. Snow accumulation will be slightly higher due to the elevation difference between the station and the property.

Cultus Lake has input flow from a series of mountain streams from Vedder Mountain to the east and International Ridge to the west. The three major inputs are Frosst Creek, Watt Creek, and Smith Falls Creek; whereas there is only one major outflow stream, Sweltzer Creek, which flows north towards Chilliwack River at a gradient of 0.005¹².

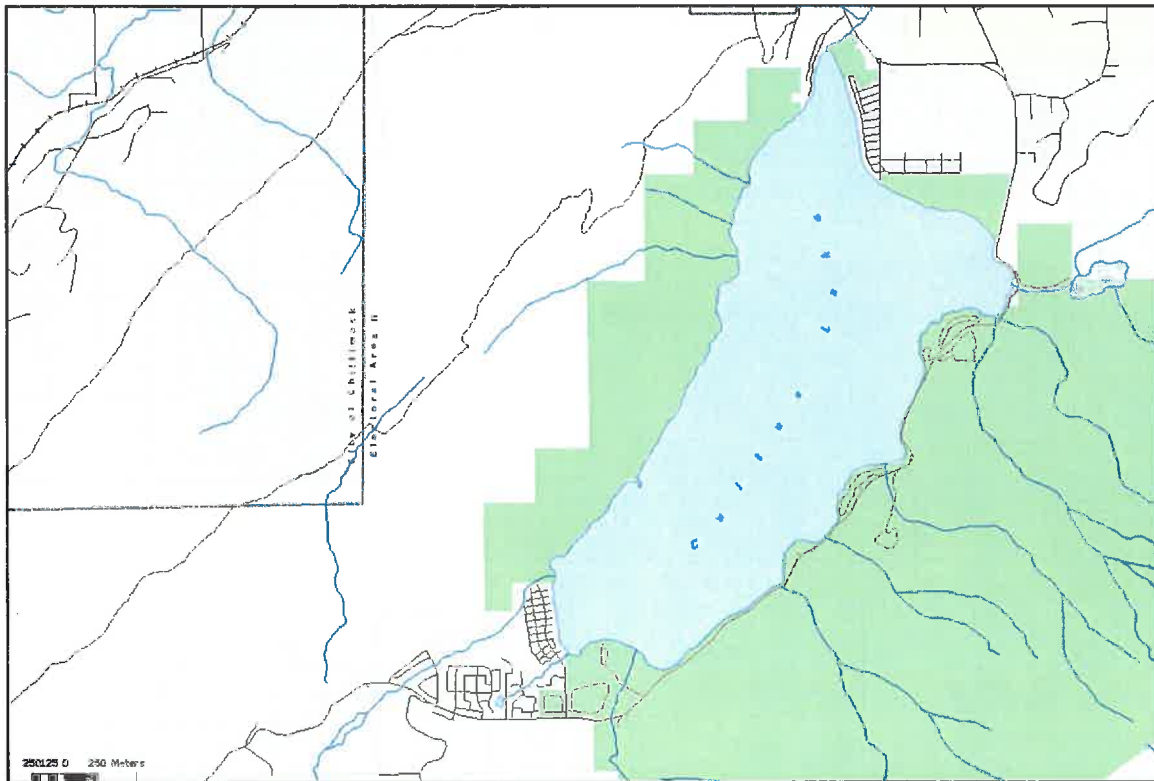


FIGURE 6: HYDROLOGY IN THE AREA, FROM FVRD WEBMAP.

¹¹ Canadian Climate Normals, http://climate.weather.gc.ca/climate_normals/index_e.html

¹² <https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0354396>



FIGURE 7: MAPPED STREAMS AND WATER WELLS WITHIN THE SUBJECT PROPERTY AREA. FROM IMAPBC.

3.3 Field Observations

The subject property is located on the eastern side of Cultus Lake near the northern tip. There is an existing house on site; it currently is in line with the majority of existing houses along 1st Avenue. The house utilizes the majority of the parcel, therefore hand-dug pits were dug along the eastern property boundary in the only area available for digging, to determine if there is evidence of past flooding from Cultus Lake.

The pits exposed interbedded sands and gravels of various size, which is consistent with the glacial history of the area. Within the A and B Horizon, I did not see any evidence of recent sediments deposited by flooding of the lake. The easternmost property boundary is approximately 10 m from the shoreline of Cultus Lake.

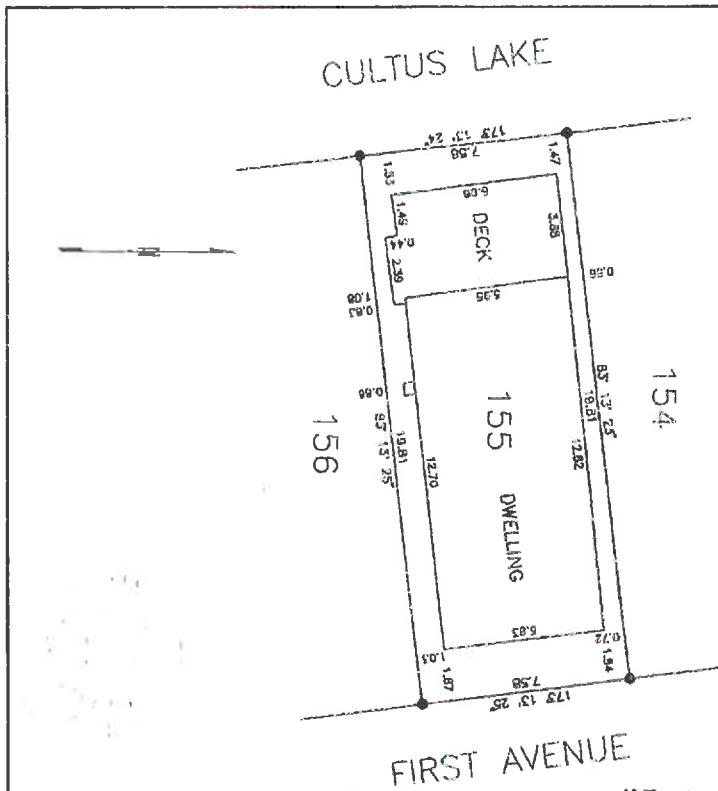


FIGURE 8: MOST RECENT SURVEY ON RECORD, FROM CULTUS LAKE PARK BOARD.



PHOTO 1: PITS DUG RELATIVE TO PROPERTY'S WESTERN BOUNDARY.



PHOTO 2: LOOKING AT PROPERTY FROM EDGE OF CULTUS LAKE, FACING EAST.

4 Geomorphic Hazards

In 1993, Dr. Peter Cave, then Director of Planning for the Regional District of Fraser-Cheam, published a report¹³ recommending levels of (geo)hazard acceptability for development approvals by local government. These levels of geo-hazard safety have been formally adopted by the Fraser Valley Regional District; therefore, we will refer to these criteria for level of geo-hazard safety.

Cave distinguished the following geo-hazards based on their effects:

- 1** inundation by flood waters,
- 2** mountain stream erosion and avulsion,
- 3** debris flows and debris torrents,
- 4** debris floods,
- 5** small-scale, localized landslides,

¹³ Cave, P. W. (1993). Hazard Acceptability Thresholds for Development Approvals by Local Government. *British Columbia Geologic Hazards Workshop, February 20 & 21, 1991.*

- 6 snow avalanches,
- 7 rock fall,
- 8 massive catastrophic landslides, and
- 9 river erosion and avulsion.

Cave identified five municipal responses to a development permit application, ranging from outright refusal, through approval with various conditions, to unconditional approval. He also distinguished seven types of proposed development ranging from minor renovation to major rezoning. Then, for each type of geohazard and each type of development permit, he specified the appropriate municipal response to various ranges of the geohazard's probability of occurrence.

For this purpose of this report, we have combined each applicable type of geo-hazard and the types of approval to form a matrix for the type of proposed development, which is a new building. After reviewing air photos, previous geotechnical reports, and conducting a field assessment, we believe the property is subject to inundation by floodwaters as described in Cave (1993); further analysis is presented below.

In the assessed area and under reasonably foreseeable conditions (including climate change and seismic events), it is our opinion that the property is not subject to any of the other hazards identified by Cave, and they are therefore not analyzed further in this report.

One hazard that may be applicable to the property that was not reviewed due to the scope of work is the effects of a landslide from Vedder Mountain into Cultus Lake (also known as a landslide-induced tsunami). While this is a known hazard in other lakes in the lower mainland i.e. Harrison Lake, we did not find any research related to this hazard for Cultus Lake and are therefore unable to estimate the effects of such a hazard on the development at this time.

TABLE 2: ACCEPTABLE ANNUAL HAZARD PROBABILITIES FOR NEW BUILDING

	Approval without conditions ¹⁴	Approval without conditions, but with covenant ¹⁵	Approval, but with siting or protective requirements ¹⁶	Approval, but with covenant and with siting or protective requirements ¹⁷	Not approvable
	— Increasing probability of occurrence →				
Inundation by Flood	<1:200	N/A	1:40 to 1:200	>1:40	N/A
Mountain Stream Erosion or Avulsion	<1:500	1:100 to 1:500	N/A	N/A	>1:100
Debris Flows/ Debris Torrent	<1:10,000	N/A	1:500 to 1:10,000	1:200 to 1:500	>1:200
Debris Flood	<1:500	N/A	1:200 to 1:500	>1:200	N/A
Localized Landslide	<1:10,000	N/A	1:500 to 1:10,000	1:50 to 1:500	>1:50
Snow Avalanche	<1:10,000	N/A	N/A	1:30 to 1:10,000	>1:30
Rock Fall	1:1000	1:500 to 1:1000	N/A	1:100 to 1:500	>1:100
Catastrophic Landslide	<1:1000*	N/A	N/A	N/A	>1:1000*
River Erosion and Avulsion¹⁸	Setback greater than 100-year erosion limit	Setback between 100-year erosion limit and single-event erosion limit ¹⁹	N/A	Setback less than single-event erosion limit	N/A

*Should be 1:10,000 as per APEGBC Guidelines for Legislated Landslide Assessments (2010)

4.1 Inundation by floodwaters

The property lies on glaciofluvial deposits and is on the west side of Cultus Lake, outside of the 200-year flood limit for the Chilliwack River²⁰. However, the property is subject to the FVRD Bylaw No. 0681, specifically, the following portions of the bylaw apply to the property:

¹⁴ Approval without conditions relating to hazards.

¹⁵ Approval, without siting conditions or protective works conditions, but with a covenant including "save harmless" conditions.

¹⁶ Approval, but with siting requirements to avoid the hazard, or with requirements for protective works to mitigate the hazard, or both

¹⁷ Approval, but with covenant including "save harmless" conditions as well as siting requirements to avoid the hazard, or with requirements for protective works to mitigate the hazard, or both.

¹⁸ Cave did not apply this generally, but only to the Chilliwack River.

¹⁹ Where threat of erosion or avulsion is immediate or extreme, building permit may not be available until approved bank protection is provided

²⁰ FVRD Bylaw No. 0681

Section 6: Floodplain Specifications

a.) Flood Construction Levels:

The following elevations are specified as Flood Construction Levels, except where more than one Flood Construction Level is applicable, the higher elevation shall be the Flood Construction Level:

- i. The Flood Construction Level for a specific property, as determined by interpolation from those Flood Construction Levels shown on Schedule A. Or where the Flood Construction Level is not shown on Schedule A the following shall apply*
- ii. 6.0 metres above the Natural Boundary of the Fraser River.*
- iii. 3.0 metres above the Natural Boundary of Anderson Creek, Anderson River, Carratt Creek, Cascade Creek, Chehalis River, Chilliwack River, Clayburn Creek, Coquihalla River, Deroche Creek, Emory Creek, Frosst Creek, Harrison River, Holachten Creek, Hunter Creek, Jones Creek (Wahleach Creek), Legace Creek, Lillooet River, Lorenzetta Creek, Lost Creek, Nahatlatch River, Nicolum Creek, Norrish Creek, Pattison Creek, Pitt River, Pye Creek, Scuzzy Creek, Siddle Creek, Silverhope Creek, Slesse Creek, Sumallo River, Stave River, Stulkawhits Creek, Squakum Creek, Sweltzer River, Vedder River, Weaver Creek and Yale Creek.*
- iv. 1.5 metres above the Natural Boundary of any other watercourse.*
- v. Specified Lakes:*
 - 1. Hatzic Lake 9.3 metres Geodetic Survey of Canada datum.*
 - 2. Harrison Lake 14.55 metres Geodetic Survey of Canada datum.*
 - 3. Lake Errock 16.5 metres Geodetic Survey of Canada datum.*
 - 4. Lilloette Lake 201.00 metres Geodetic Survey of Canada datum.*
 - 5. Pitt Lake 5.18 metres Geodetic Survey of Canada datum.*
 - 6. Stave Lake 83.8 metres Geodetic Survey of Canada datum.*
- vi. 1.5 metre above Natural Boundary of any other lake, pond or marsh.*

It is our understanding that Cultus Lake lake levels are monitored and adjusted by the Department of Fisheries and Oceans near the Sweltzer River outlet, which accommodates recreation in the summer and increased inflow in the winter. On average, the lake level below 45 m above sea level; as of the date of this report it stands at approximately 44.5 m²¹. Given the regulation of the lake by the DFO at the Sweltzer River outlet, we estimate the 5-year highwater mark as the natural boundary of the lake at this time. Survey elevations surrounding the property were provided by the Cultus Lake Park Board and show that the wharf to the south of the property is within 15 cm of the lake's average water level, and decreasing elevations on wharfs to the north. At this time, no land survey has been done for the property, however for the purposes of this report, we estimate the elevation of the 5-year highwater mark is roughly equivalent to the elevation of the wharfs, and therefore is approximately 45 m. The bylaw requires an FCL of 1.5 m above the natural boundary of the lake; this means that the FCL required for the subject property should be approximately 46.5 m.

²¹ <https://www.fvrd.ca/EN/main/about-the-fvrd/electoral-areas/cultus-lake-water-levels.html>

Given there is no recent topographic survey of the property, we estimated the elevation of the property to be between 45 and 47 meters. Therefore, part of the property is below the required FCL. The Client has requested a variance for their development permit recently; Colin Johnson, P.Eng. of Out-of-the-Box Engineering previously provided a letter recommending an FCL of 45.5 m as reasonable given there has been no previously established 200-year flood level for the lake, and the outlet of the lake is lower than the 45 meter high water mark.

Madrone does not find any evidence to the contrary of Mr Johnson's FCL of 45.5 m as reasonable. A regional flood study of Cultus Lake and the associated watersheds associated with the lake would need to be undertaken in order to give floodplain extent and an exact FCL beyond the general bylaw guidelines.

Madrone took into account the effects of a 200-year flood of the tributary streams or inflow streams, that enter into Cultus Lake. Given that the lake levels are controlled at this time, the size of the lake relative to the stream discharge into the lake, the surficial geology and local hydrogeology relationship, we believe it is likely that there would be minimal flooding during a 200 year event under the current conditions and infrastructure at the outflow. Air photos from the 1940s and 1950s show no evidence of flooding affecting the lake or surrounding area; although in a different watershed, this is significant as the 1948 flooding of the Fraser River is now considered a 100-year event and its effects were seen throughout the lower mainland due to the rapid snow melt causing water levels to rise dramatically. Outside of current conditions and including climate changes, we estimate the approximate annual frequency of flooding to be between 1:40 to 1:200, and therefore recommend approval with protective measures.

The portions of the development that will be below 45.5 m will be within a waterproof structure as described in the plans provided by the developer. Any increase in lake levels would result in laminar flow, and therefore no scour protection would be required for any portion of the development. In addition to the waterproofing as designed by a qualified professional, we recommend the lot is graded away from the dwelling starting at an elevation of 45.8 m.

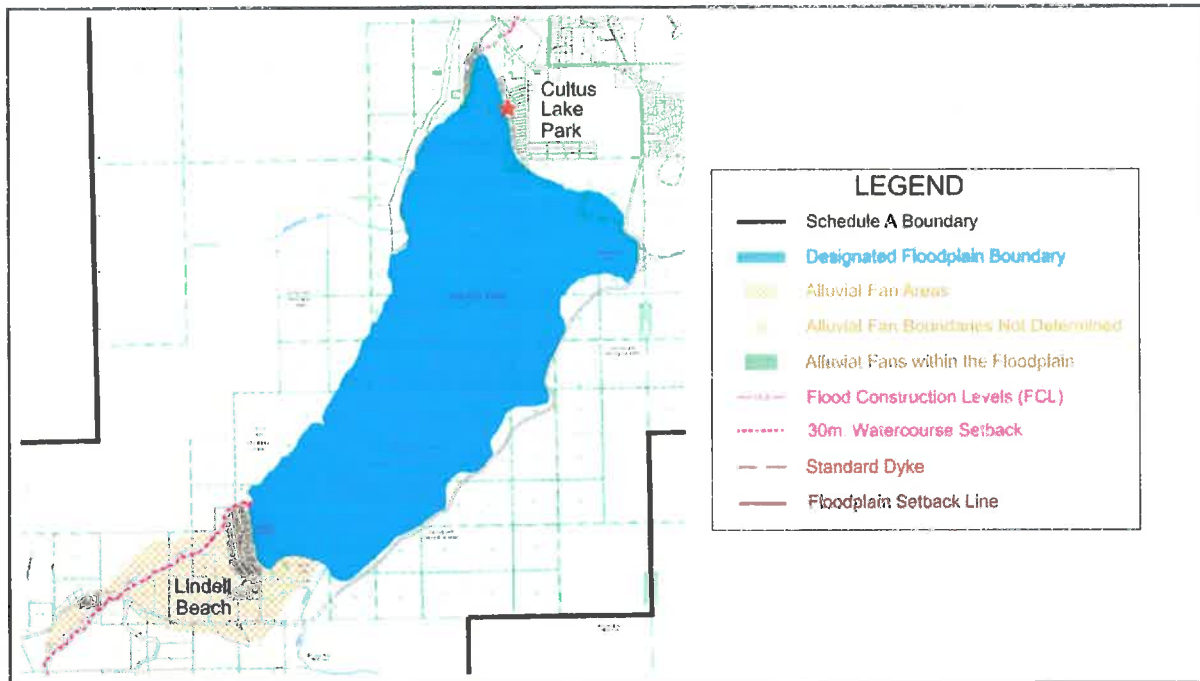


FIGURE 9: ELECTORAL AREA E, SNAPSHOT FROM THE FVRD FLOODPLAIN BYLAW.

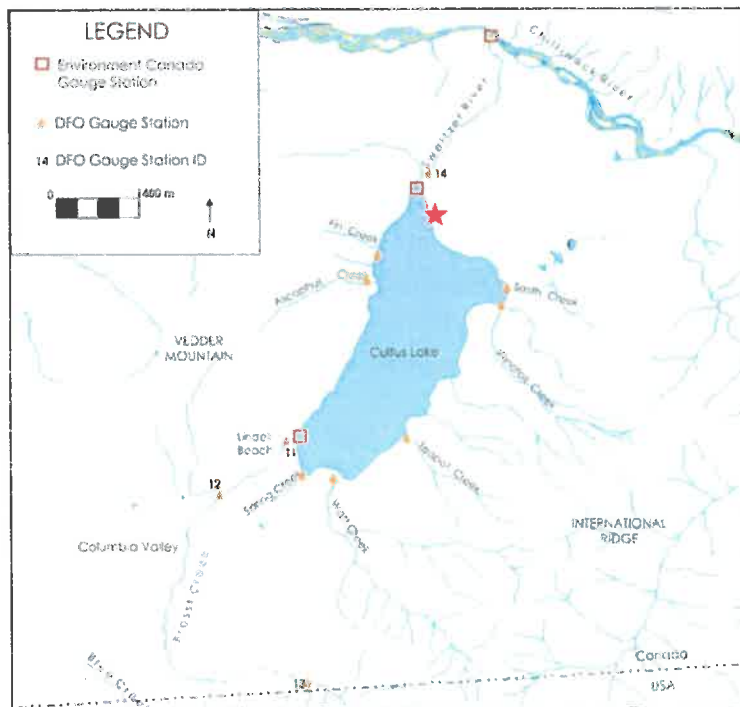


FIGURE 10: MONITORING STATIONS AND LOCAL SURFACE HYDROLOGY, FROM SUMKA 2017.



FIGURE 11: APPROXIMATE LOCATION OF MEASURED WATER LEVELS, UNVERIFIED, FOR DEMONSTRATION PURPOSES ONLY. 45 m average HWM for Cultus Lake level show above property.



PHOTO 3: EASTERN SHORELINE OF CULTUS LAKE, LOOKING NORTH TOWARDS SWELTZER RIVER.

5 Conclusions and Recommendations

We have identified that the property is subject to inundation by floodwaters. We compared these findings with the levels of safety (i.e. regulatory responses) described by Cave (1993) and provide our recommendations for avoidance and protective measures. If the mitigation recommendations are followed, the property is safe for the intended use of single-family dwelling (classified as a new building) with no significant transfer of risk to other properties.

We recommend:

- Any development below the FCL of 45.5 m, as per Mr Johnson, be designed and signed off by a qualified engineering professional to be "geotechnical- and structurally -engineered waterproof" as described in the variance request.
- Grading away from the development to an elevation of 45.8 m.

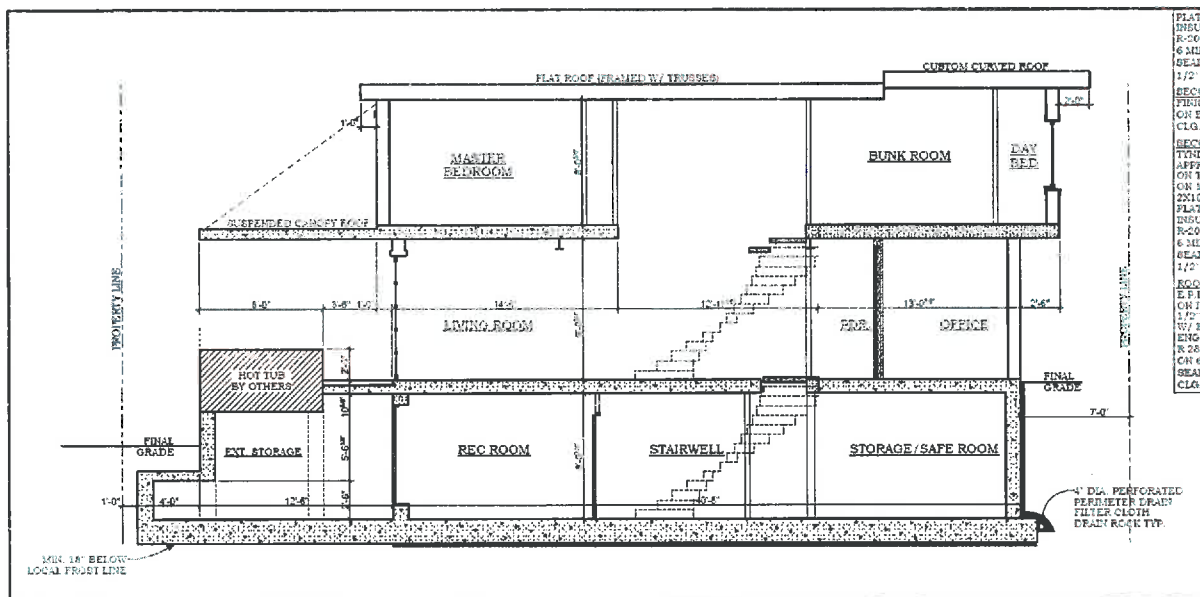


FIGURE 12: PROPOSED DEVELOPMENT, CROSS SECTION, AS PROVIDED BY CLIENT, AUGUST 2019.

TABLE 3: GEOTECHNICAL HAZARDS ASSOCIATED ANNUAL RETURN FREQUENCY AND RESPONSE TO BUILDING APPROVAL APPLICATION AS APPLICABLE TO THE SUBJECT PROPERTY.

Hazard	Annual Return Frequency	Response to Building Approval Application	Recommendations
Inundation by Flood Waters	1:40-1:200	Approval, but with siting or protective requirements	Waterproof design, as designed by a Qualified Professional, for areas of the property below the FCL, and grading away from the house (see details above).
Mountain Stream Erosion or Avulsion	<1:500	Approval without conditions relating to hazards	
Debris Flow / Debris Torrent	<1:500	Approval without conditions relating to hazards	
Debris Flood	<1:10,000	Approval without conditions relating to hazards	
Localized Landslip	<1:10,000	Approval without conditions relating to hazards	
Snow Avalanche	<1:10,000	Approval without conditions relating to hazards	
Rock Fall	<1:10,000	Approval without conditions relating to hazards	
Catastrophic Landslide	<1:1,000	Approval without conditions relating to hazards	

6 Closure

We trust that this report meets the applicable requirements. We grant permission to the Fraser Valley Regional District to use this report. Please contact us if you require further information or services.

Prepared by:

Reviewed by:

**This is a digitally signed duplicate of the official manually signed and sealed document.*



Roberta Adams, M.Sc., P. Geo.

**This is a digitally signed duplicate of the official manually signed and sealed document.*



Ken Hughes-Adams, M.Eng., P. Eng.



APPENDIX A

Limitations and Conditions

The contents of this Report remain the copyright property of Madrone.

By using the Report, including but not limited to providing the Report to other parties or relying on the information, observations, findings, suggestions, recommendations and opinions contained in the Report, a person who uses the Report (User) accepts and agrees to the limitations and conditions set out below.

To the extent that these limitations and conditions of use conflict with any previous agreements between Madrone Environmental Services Ltd. (Madrone) and the Client, these limitations and conditions will prevail.

Madrone grants the Client a non-transferable license to use this Report in connection with the particular project for which it has been prepared. This license does not apply to any draft version of any document. The Client may not use the Report in connection with any other work, or project without prior written approval by Madrone. If the Client is in breach of any obligation to make payment to Madrone, Madrone may revoke the license referred to above and the Client will cause to be returned to Madrone the Report and any associated documents and all copies thereof and the Client will remove from its computer systems any electronic copies of any of the documents.

Unless Madrone provides written consent, no party other than the Client may rely on the observations, data, interpretations, findings, or recommendations of this report, except that regulatory authorities may rely on it with respect to the project for which it was prepared. Madrone will consider any reasonable request by the Client to provide consent for other parties to rely on this report.

If a User, including but not limited to the Client, provides the Report to another party, the User will provide the other party with the entire Report including these limitations and conditions of use, and the User agrees to indemnify Madrone against claims by such other party arising from the failure of the other party to comply with the limitations and conditions of use.

All documents generated as part of the services for the Client with respect to the project for which the Report has been prepared, including drawings, reports, instructions, and correspondence, whether hardcopy or electronic, but excluding draft documents, are inherent components of the Report. To properly understand the information, observations, findings, suggestions, recommendations and opinions contained in the Report, reference must be made to the whole of the Report. Madrone is not responsible for use by any party of portions of the Report without reference to the whole Report and its various components.

The User agrees that the no portion of the Report, whether electronic or hard copy, no matter who owns or uses them, may be altered by any party except Madrone. If Madrone has submitted both

electronic and hard copy versions of the Report, only the signed and sealed hard copy versions shall be considered final and legally binding upon Madrone.

Madrone will maintain professional liability insurance that is usual and customary for similar firms. The total amount of all claims arising from the Report, by all Users, against Madrone or any present or former partner; executive officer, director, stockholder, employee or agent thereof, including but not limited to claims for negligence, and negligent misrepresentation, will be strictly limited to the amount of any professional liability insurance that Madrone may have available for such claims.

Madrone will not be liable for any consequential loss, injury or damages suffered by any User, including but not limited to loss of use, earnings and business interruption.

No User may bring a claim against Madrone in contract or tort more than two (2) years after Madrone's involvement in the project.

Madrone has conducted this investigation and prepared the Report in a manner consistent with the level of care normally exercised by professionals currently practicing in the area under similar conditions and budgetary constraints. No other warranties, either expressed or implied, are made.

Madrone has assumed that information provided to Madrone by the Client or other individuals or organizations is factual, complete, and accurate. Madrone is not responsible for any inaccuracies, deficiencies, or omissions resulting from receipt of incorrect or fraudulent information.

The Report pertains only to development plans and project design disclosed to Madrone by the Client at the time the Report was prepared. The applicability and reliability of any of the information, observations, findings, suggestions, recommendations and opinions contained in the Report are only valid to the extent that there have been no material alterations to or variations from any of the said descriptions provided by the Client to Madrone unless the Client has specifically requested Madrone to review and revise the Report in light of such alterations or variations. If the project does not commence within two (2) years of the Report date, no party may rely on the Report unless Madrone has been engaged to review it.

Madrone has made reasonable efforts to collect information and site observations that are representative of conditions in the relevant portions of the site; however, conditions may vary from place to place and conditions may change with the passage of time. Site information contained in the report pertains specifically to the points and dates of observation.

The findings of this investigation and report are based in part on Madrone's visual observations of site conditions. Madrone's opinions do not extend to portions of the site that were unavailable for direct

observations due to circumstances reasonably beyond Madrone's control. Madrone is not responsible for detecting conditions in areas beyond the site, if the conditions could not reasonably be known by Madrone given restrictions to accessing such areas and the budgetary and time constraints under which the investigation was performed.

Classification and identification of the soils, rocks, and geologic units of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Madrone does not warrant or guarantee the exactness of the descriptions.

If unexpected conditions are encountered on the site, the Client must notify Madrone in order that Madrone may determine if modifications to the findings are necessary.

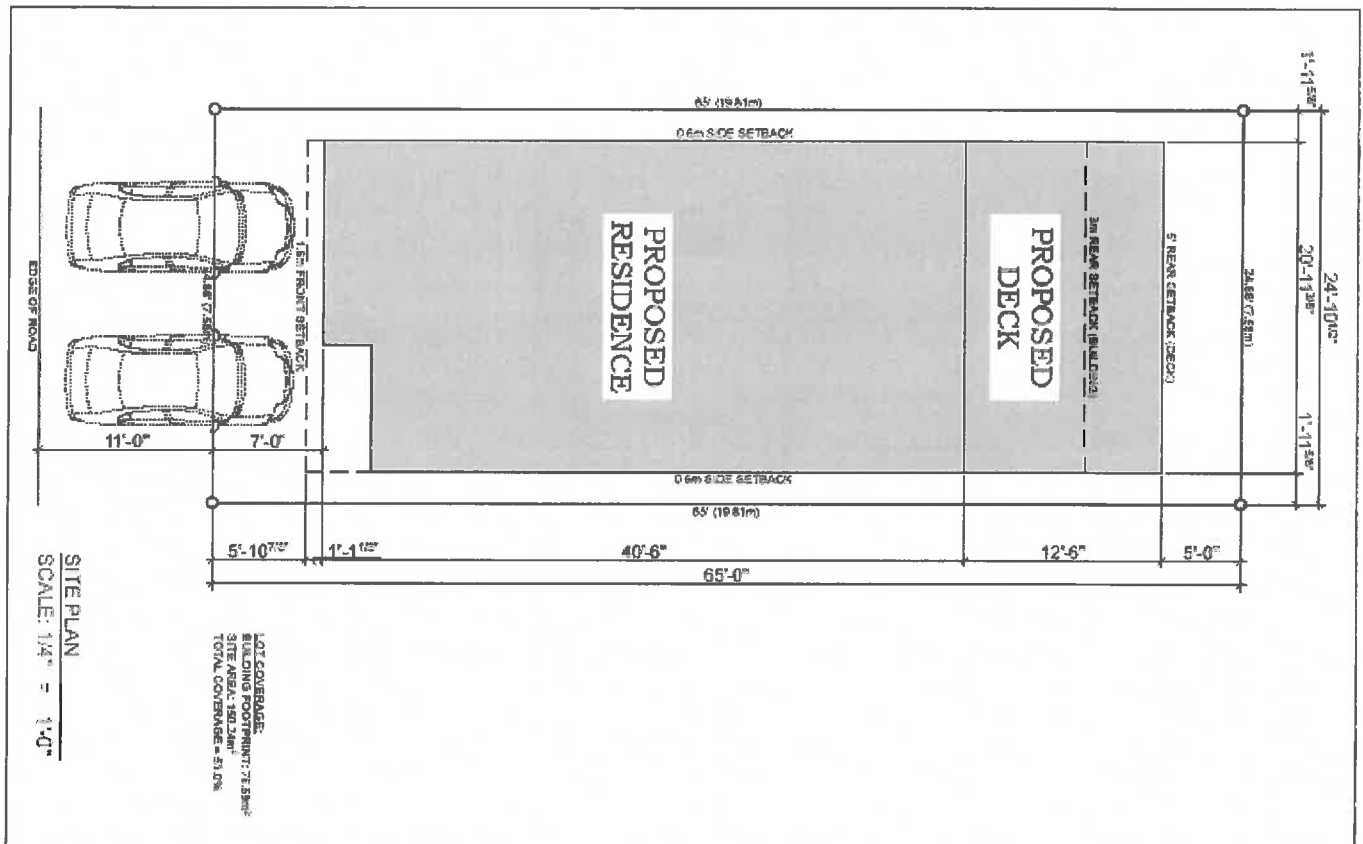
The exploration and review provided in the Report are for geotechnical purposes only unless otherwise specifically stated and identified in the Report. Environmental aspects of soil and groundwater have not been included investigated or addressed in any other way.

Madrone makes no representations whatsoever, as to the legal significance of its findings, or as to other legal matters touched on in the Report, including, but not limited to, ownership of any property, or the application of any law to the facts set forth in the Report.

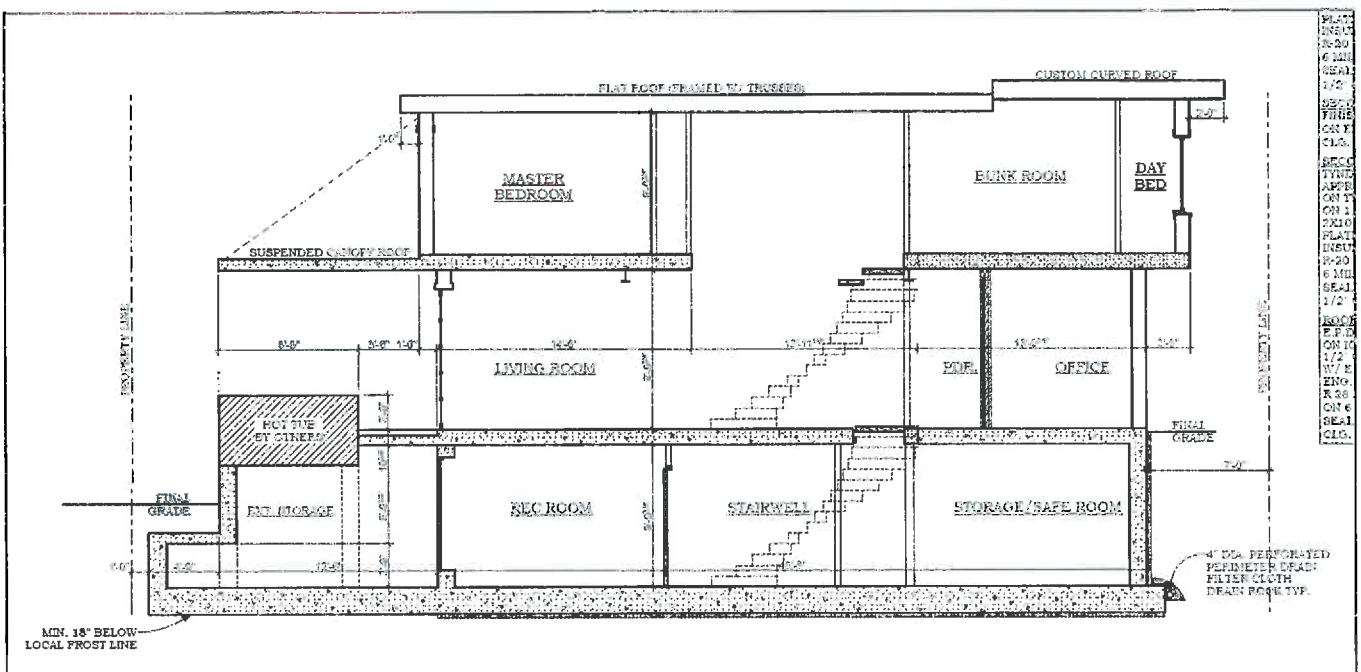


APPENDIX B

Development Figures



APPENDIX FIGURE 1: SITE PLAN, AS PROVIDED BY THE CLIENT, AUGUST 2019



APPENDIX FIGURE 2: PROPOSED DEVELOPMENT, CROSS SECTION, AS PROVIDED BY CLIENT, AUGUST 2019.



APPENDIX C

Assurance Statements

Geo-Hazard Assurance Statement

for Development Approvals

A. Project Information

Date August 22 2019 FVRD File No. _____

Property Information

Project Name & Description 155 1st Ave Cultus Lake BC Geohazard Assessment
Legal Description Lot 155 Land District 36 Lease Cultus Lake Park, Area-Jurisdiction-Roll 15-733-070
Site Address 155 1st Ave Cultus Lake BC PID 000-823-139

Client Information

Name Gwyllyn Goddard
Role ☒ Property Owner ☐ Developer ☐ Other
Client Address 155 1st Ave Cultus Lake BC

Qualified Professional Information

Name Roberta Adams
APEGBC Designation ☐ P.Eng. ☒ P. Geo. ☐ Eng.L ☐ Geo.L
Company Name Madrone Environmental Services Ltd
Mailing Address 202-2790 Gladwin Rd Abbotsford BC
Email Address roberta.adams@madrone.ca Phone # 604-504-1972

Geo-Hazard Report Reference

Title Geohazard Assessment 155 1st Ave Cultus Lake BC 19.0291 Date August 22 2019

Personal information on this form is being collected in accordance with Section 27 of the Freedom of Information and Protection of Privacy Act, RSBC 1996 Ch. 165; Part 9, Division 1 [Building Regulation] and Part 14 [Planning and Land Use Management] of the Local Government Act, RSBC 2015 Ch. 1; and Section 56 of the Community Charter, SBC 2003 Ch. 26 and will only be collected, used and disclosed for the purpose of administering geo-technical hazard reviews and assurance statements related to development approvals. Questions? Contact FVRD Privacy Officer at 45950 Cheam Avenue, Chilliwack, BC V2P 1N6; 604-702-5000 or 1-800-528-0061; or FOI@fvr.ca.



Geo-Hazard Assurance Statement

for Development Approvals

B. Assurance

Based on the contents of this Assurance Statement and the Report, I hereby give assurance that:
(check as applicable)

☒	Development Permit	The Report will "assist the local government in determining what conditions or requirements under it will impose in the permit", as required by the <i>Local Government Act</i> (Division 7)
☐	Building Permit	
☐	Community Charter	"The land may be used safely for the use intended", as required by the <i>Community Charter</i> (Section 56)
☐	Seismic Slope	The Report addresses the requirements of the BC Building Code 2006, 4.1.8.1.6 (8) and 9.4.4.4 (2), as detailed in the BC Building & Safety Policy Branch Information Bulletin B10-01, Jan 18, 2010
☒	Floodplain Management Bylaw Exemption	"The land may be used safely for the use intended", as required by the <i>Local Government Act</i> . (Section 524)
☐	Subdivision	"The land may be used safely for the use intended", as required by the <i>Land Title Act</i> (Section 86).
☐	Other (e.g. Zoning Bylaw Amendment, Official Community Plan Amendment, Temporary Use Permit, etc.)	<Insert statement as appropriate>

C. APEGBC Professional Practice Guidelines

The Report and this Assurance Statement should be completed in accordance with the current version of one or both of the following Professional Engineers and Geoscientists of BC (APEGBC).

- *Legislated Flood Assessments in a Changing Climate in BC*
- *Legislated Landslide Assessments for Proposed Residential Development in British Columbia, ("APEGBC Landslide Guidelines")*.

These two documents are collectively referred to as the "APEGBC Guidelines". The italicized words in this Assurance Statement are defined in the APEGBC Guidelines.

The Report has been prepared pursuant to the following APEGBC Guidelines (check one or both as applicable).

- ☒ APEGBC Flood Guidelines
- ☒ APEGBC Landslide Guidelines

Geo-Hazard Assurance Statement

for Development Approvals

If the Report is not prepared pursuant to either of the APEGBC Guidelines, please explain.

D. Background Information

Qualified Professionals **must** confirm and check that each item is included in the Report.

- ☒ 1. Property location map — 8.5 x 11 size
- ☒ 2. Development proposal site plan — 8.5 x 11 size. *If a subdivision, show the parent parcel and all lots to be created, including any remainder.*
- ☒ 3. Description of the proposed development project (including building use) to the extent this is known at the time of Report preparation.
 - ☒ residential
 - ☐ industrial
 - ☐ commercial
 - ☐ institutional
 - ☐ other _____

Geo-Hazard Assurance Statement

for Development Approvals

E. Technical Requirements

Qualified Professionals **must** review, confirm and check completed items (as applicable).

Report Content

- ☒ 4. Relevant information pertaining to the Property and pertinent potential hazards from appropriate background sources, including the FVRD online library.
 - ☒ 5. Time limitation or condition statement to describe extent the FVRD may rely on the Assurance Statement and Report for development approvals, and when resubmittal is recommended.
 - ☒ 6. Maps, illustrations and diagrams to illustrate areas referred to in the Report.
 - ☒ 7. Description of field work conducted on and, if required, beyond the Property.
 - ☐ 8. Contact and consultation with the Fraser Valley Regional District. Provide name and title of contact.
-
- ☒ 9. Review of relevant FVRD bylaws and other statutory requirements.
 - ☒ 10. Restrictive covenants registered against the Property title that pertain to geo-hazards (if registered, the Report provides relevant information about the covenants).
 - ☒ 11. Notation of any visibly apparent natural hazards or other hazards identified in background reports, which are not identified and addressed in this Report. If yes, provide details in Section H: Geo-Hazard Summary Table.
 - ☒ Yes
 - ☐ No
 - ☒ 12. Does the report rely on one or more supporting reports, each of which is independently reviewed, signed and sealed. If yes, provide details in Section H: Geo-Hazard Summary Table.
 - ☒ Yes
 - ☐ No
 - ☐ 13. For subdivision approval, the Report addresses natural hazards for:
 - ☐ the parent parcel prior to subdivision
 - ☐ any lots to be created (including any remainder)

Geo-Hazard Assurance Statement

for Development Approvals

Geo-hazard Assessment, Risk Acceptability and Risk Transfer

- ☒ 14. In considering the above-noted potential hazards that may affect the property, I have:
- ☒ reviewed and characterized the potential hazard(s)
 - ☒ estimated the potential frequency and magnitude of the potential hazard(s)
 - ☒ relied on supporting reports as noted above
 - ☐ relied on a pre-existing assessment of hazard frequency and magnitude
 - ☒ considered the potential effects of climate change in the context identified in the Report
 - ☒ considered the potential effects of changed future conditions (upstream watershed changes, forestry activity, land use changes, sea level rise, etc.) in the context identified in the Report
- ☒ 15. This Assurance Statement pertains to all geo-hazards that are assessed in the Report and any supporting reports, and accurately reflects the contents of those documents.
- ☒ 16. The FVRD has adopted "Hazard Acceptability Thresholds for Development Approvals by Local Government", which provides a specific level of hazard or risk tolerance. I have included a Hazard Summary Table which:
- ☒ lists all the potential hazards addressed by the Report and any supporting reports
 - ☒ provides an annual return frequency and acceptability threshold classification for the unmitigated condition
 - ☒ proposes mitigative measures to appropriately reduce the geo-hazard risk
 - ☒ provides an annual return frequency and acceptability threshold classification for the mitigated condition
- ☒ 17. The Report describes the potential transfer of natural hazard risk to other properties or infrastructure as a result of the proposed project (including any proposed *mitigation works*) and
- ☐ considered the potential for transfer of natural hazard risk
 - ☒ concludes that there is no significant transfer of natural hazard risk
 - ☐ identifies the potential transfer of natural hazard risk and proposes measures to offset such transfer of risk

Geo-Hazard Assurance Statement

for Development Approvals

Mitigation and Design Recommendations (if recommended)

The Report contains the following items:

- ☐ 18. Implementation steps for the identified structural mitigation works (in terms of design, construction and approval).
- ☐ 19. Clearly identified safe locations for building(s), ancillary structures, and onsite utility services (as applicable, such as a septic field) out of the natural hazard area as a preferred development alternative.
- ☐ 20. Commentary on the effectiveness of proposed structural mitigation works in terms of ability to reduce the potential hazard impact, and identification of any residual risk that would remain.
- ☒ 21. Proposed Flood Construction Level (FCL) for future development and including specification of an appropriate method of achieving the FCL.
- ☐ 22. Proposed watercourse setback, which is clearly referenced from the natural boundary, top of bank or another suitable basis.
- ☐ 23. Proposed operation and maintenance actions that will be necessary in order for the level of safety to be maintained in the future, with indications of who should be responsible for those actions and when.

Riparian Area Regulation (if applicable)

- ☐ 24. QP must review RAR assessment report to avoid conflict with Geo-Hazard Report recommendations.

F FVRD Supplemental Requirements

The following points are understood by the Qualified Professional when submitting a Report:

- ☒ 25. Permission is granted to the FVRD to use the Report in considering approval of the proposed development on the property, provided that such permission is limited only to the proposed development project for which the Report was prepared.
- ☒ 26. Methodology used in the Report is described in sufficient detail to facilitate a professional review of the study by the FVRD when necessary.
- ☒ 27. Professional liability insurance coverage of at least \$1 million per claim is carried by the QP.
- ☒ 28. Third party review or supplemental information may be required by the FVRD where complex development proposals warrant.
- ☒ 29. Permission is granted to the FVRD to include the Report in the online FVRD geo-hazard report library (as background information, not for other parties to rely).

Geo-Hazard Assurance Statement

for Development Approvals

G. Qualified Professional (QP)

Prepared by: (QP of Record)

Name Roberta Adams

Designation ☐ P.Eng. ☒ P. Geo. ☐ Eng.L ☐ Geo.L

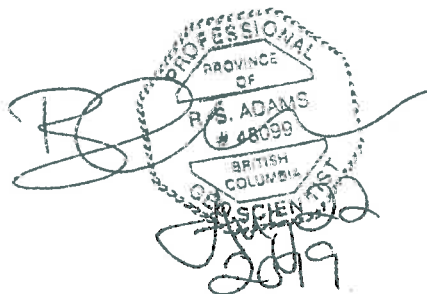
Reviewed by:

Name Ken Hughes-Adams

Designation ☒ P.Eng. ☐ P. Geo.

The Report has received appropriate technical review which is consistent with both the APEGBC Professional Practice Guidelines, and APGBC Quality Management Guidelines. The name of the reviewer is noted in the Report and below.

Professional Seal, Signature and Date:



☒ I am a Qualified Professional as defined in the APEGBC Guidelines, and I fulfill the education, training and experience requirements as outlined in the APEGBC Guidelines

☒ I have signed, sealed, dated and thereby certify, this Assurance Statement and the attached report.

Geo-Hazard Assurance Statement

for Development Approvals

H. Geo-Hazard Summary Table

The geo-hazard report and/or any supporting reports addresses the following hazard types.

Geo-Hazard Type #1		Geo-Hazard Type #2	
Fraser River and tributaries flooding			
Annual Return Frequency (Unmitigated) 1:40-1:200		Annual Return Frequency (Unmitigated)	
Acceptability Threshold Classification	3	Acceptability Threshold Classification	
MITIGATION (if necessary)			
Proposed Mitigation Measures	Yes ☒ No ☐	Proposed Mitigation Measures	Yes ☐ No ☐
Annual Return Frequency (Mitigated) 1:40-1:200		Annual Return Frequency (Mitigated)	
Acceptability Threshold Classification	3	Acceptability Threshold Classification	
Comments Re: Cultus Lake flooding		Comments	
SUPPORTING REPORT			
Was this report prepared by others?	Yes ☒ No ☐	Was this report prepared by others?	Yes ☐ No ☐
If yes, list report name, date and author. Colin Johnson, July 12 2019, Flood Level Adjustment Letter		If yes, list report name, date and author.	

Geo-Hazard Type #3		Geo-Hazard Type #4	
Annual Return Frequency (Unmitigated)		Annual Return Frequency (Unmitigated)	
Acceptability Threshold Classification		Acceptability Threshold Classification	
MITIGATION (if necessary)			
Proposed Mitigation Measures	Yes ☐ No ☐	Proposed Mitigation Measures	Yes ☐ No ☐
Annual Return Frequency (Mitigated)		Annual Return Frequency (Mitigated)	
Acceptability Threshold Classification		Acceptability Threshold Classification	
Comments		Comments	
SUPPORTING REPORT			
Was this report prepared by others?	Yes ☐ No ☐	Was this report prepared by others?	Yes ☐ No ☐
If yes, list report name, date and author.		If yes, list report name, date and author.	

Geo-Hazard Assurance Statement

for Development Approvals

Indicate which hazards were **NOT** reviewed:

- ☐ Chilliwack River Valley Erosion or Avulsion
- ☐ Debris Flow and Debris Torrent
- ☐ Debris Flood
- ☐ Fraser River & tributaries flooding
- ☐ Mountain Stream Erosion or Avulsion
- ☐ Major Catastrophic Landslide

- ☒ Seismic Effects/Liquefaction
- ☐ Rockfall - Small Scale Detachment
- ☐ Slope Stability
- ☐ Small Scale Localized Landslide
- ☐ Snow Avalanche
- ☒ Tsunami

Hazard Acceptability Thresholds Classification, as per Hazard Acceptability Thresholds for Development Approvals by Local Government dated November 1993 by Dr. Peter Cave.

- 1 Approval with conditions relating to hazards.
- 2 Approval, without siting conditions or protective works conditions, but with a covenant including "save harmless" conditions.
- 3 Approval, but with siting requirements to avoid the hazard, or with requirements for protective works to mitigate the hazard.
- 4 Approval as (3) above, but with a covenant including "save harmless" conditions as well as siting conditions, protective works or both.
- 5 Not approvable.

Additional Comments