North Arm Farm Tasting Room - Geotechnical Report

August 18

2023

The property owners at 1888 Sea to Sky Highway propose to construct an addition to an existing farm storage building. The addition is proposed as approximately 41'wide x 30', with a small vestibule and washrooms of 25ft x 15ft long attached. The added space is proposed to be used for a brewery tasting room.

PK Read Eng Ltd.

Lot A, DL 214, Lillooet District, Plan EPP68874 PID 030-277-922

Image above - North Arm Farm July 20th 2023. PKR

A hardcopy sealed version is available with Mr. & Mrs Sturdy.

Contents

1. Scope

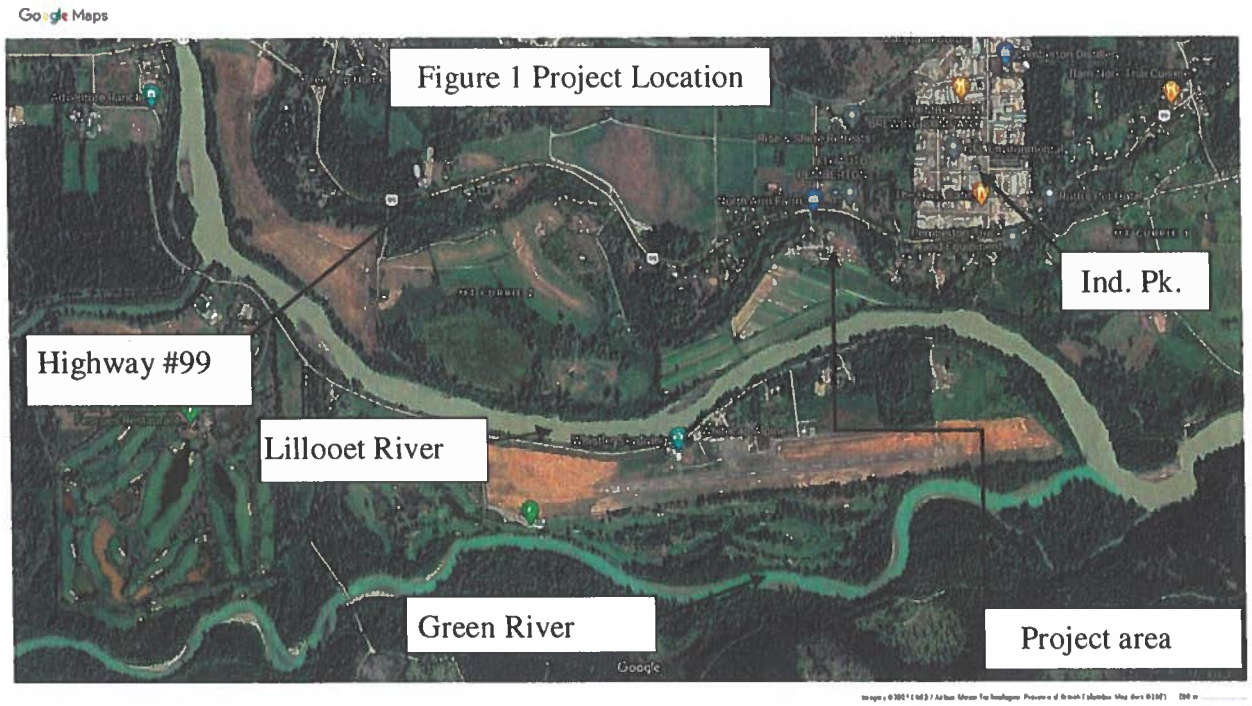
PK Read Engineering Ltd. is requested by J. Sturdy, of North Arm Farm, to provide a geotechnical service for the purpose of construction of a tasting room with roughly a 30' x 41'footprint, with added washrooms and entry sections. Adjoining covered patios are also a feature of the development. The proposed building is understood to join the existing farm storage building as shown in preliminary designs (June 15th 2023) by PLACE Architect Inc. of West Vancouver.

As outlined in Section 56 of the Community Charter, the Building Inspector may require a report certified by a professional engineer with experience in geotechnical engineering that the land may be used safely for the use intended. It is the scope of this report to satisfy such requirements and is further aimed to satisfy the legislated requirements of the BC Building Code 2018 9.4.4.4

and align with the guidelines of the EGBC guidelines for landslide and flood assessments for development approvals.

2. Introduction & Site Description

The site lies within the Pemberton Valley, 160km north of Vancouver within the British Columbian Southern Coastal Mountains & is part of the Lillooet River Floodplain.
The proposed property development is within the jurisdiction of the Squamish Lillooet Regional District. The image below, Figure 1, taken from google maps shows the proposed project area in relation to the nearby industrial park, airport infrastructure and other natural features.



The property is situated between a 300m wide strip of land between the Sea to Sky Highway and the Lillooet River. The 22.81 Ha sized property is bounded to the south by the Lillooet River and the North by Highway #99, and extends east west over an approximate distance of 1060m. The property is part of the Agricultural Land Reserve (ALR). The majority of the property is cleared and utilized as a mixed use farm with a variety of crops. The property includes a farm produce shop as part of the barn.
Ground is relatively level and composed of unconsolidated alluvial depositions from overbank floods of the Lillooet River. An older remnant channel (now non-flowing) of the Lillooet which

follows the northern boundary and the highway gives the farm its namesake as the North Arm (of the Lillooet River).

3. Planned Development

The proposed building is represented by plans dated June 2023, from Place Architecture, and include:

- A 30ft. x 41ft. enclosed timber frame addition to an existing farm storage building which is a single pitch roof, single storey, pole framed building with concrete slab near surrounding grade.
- A 25 x 15 washroom
- A small entry vestibule
- Added covered patio zones front and side (north and east)

3.1 Planned Use

The proposed building planned use is proposed as a tasting / serving room for brewed products

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4. Procedures and Equipment

The nearby areas have been assessed at various times by the author for other projects. Specifically during 2017 for an added accommodation block, and during 2021 for the installation of the produce storage (and brewery) building.
To provide foundation design recommendations for the tasting room two test pits were excavated by a small backhoe machine to review the near surface underlying soils.
In terms of assessing of hazards the author has reviewed several reports including those listed below, and draws conclusions from the results of these studies specific to the development:

- Mt. Currie Landslide Risk Assessment, by BGC for SLRD dated Jan 16th 2018.
- Rock Slope Movements along Mt. Currie "fault scarp" Can. J. Earth Sci. Vol. 32 1995. Michael J. Bovis & Stephen G. Evans
- $^{\Phi}$ Impact of a Quaternary volcano on Holocene sedimentation in Lillooet River valley, British Columbia P. A. Friele, J.J. Clague, K. Simpson, M. Stasiuk
- Lillooet River Flood Mapping Final Report November 22 2018. By Northwest Hydraulic Consultants, for Pemberton Valley Dyking District.

5. Revealed and Anticipated Soils

The soils within North Arm Farm proximity are from experience known likely to be over-bank deposits and channel fill of the Lillooet (main influence) and Green Rivers. That is alluvial layers of silts and sands predominantly with smaller amounts of finer clays and coarser sands. Trace organics have been noted, however peat layers (of significance) have not been recorded previously by excavation or drill hole investigations yet are assumed to remain a possibility at depth.

The water table within the soils is reflected by adjacent river levels and will fluctuate with river levels. Experience from nearby excavations indicates the water table as relatively deeper, and typically a minimum of 2m and up to 3m of today's natural grades.

July **20th 2023 Observations:**

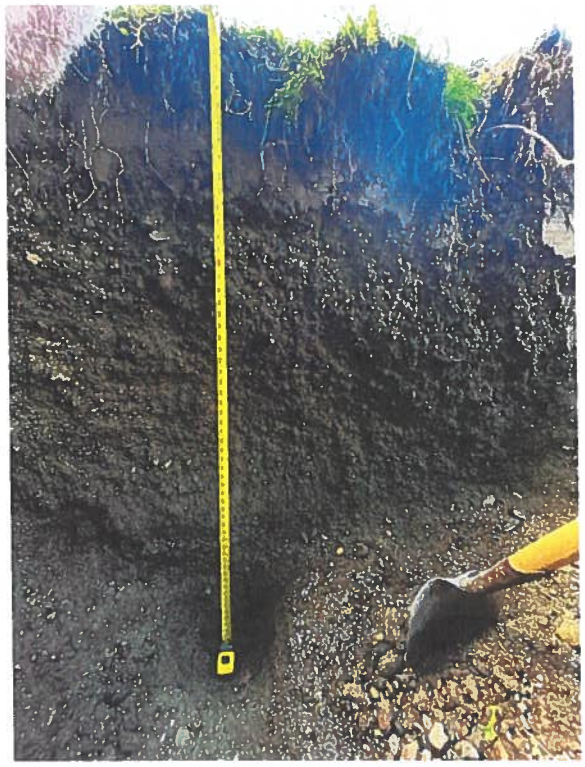
Two test pits were excavated slightly beyond the proposed building footprint Test Pit #1 was located within 20ft of the NW corner, and # 2 within 10ft of the existing NE corner foundation. Both pits showed quite similar layering and characteristics:

Test pit #1 –

'0-10"	Lawn and darker topsoil mix with grass roots – c/w sands & gravels
10"-16"	Rounded Sand & Gravel sizes <25mm GM.
16"-25"	Coarse sand with trace gravel. Note one wall intersect some old caution tape – assumed as earlier (now abandoned) irrigation trench
25"-26"	Thin lense fine sand & silt
26"-64"	Channel Fill granular deposits, estimated fines as < 5%. All rounded. Pumice inclusions. No free water noted. Some moisture. Relatively firm and moderately dense. Negligible compressibility.

Test Pit #2 -

'0-10"	Similar mixed lawn and grass root layer
10"-60"	Sand & Gravel bar deposit – GM. Med. Dense. Gravel sized at 2 -4"



6. Geological Setting & Discussion of Potential Hazards

The Lot lies within a steep sided glaciated valley, of the BC Coastal ranges. The under-laying natural soils consist of non-consolidated alluvial deposits from the Lillooet River. These near surface unconsolidated alluvial layers have been created by "over-bank" floods and "channel fill" within the last 2000 years, and previous deltaic deposits, as the delta of Lillooet Lake advances. The flat valley floor at this section is roughly 1.7km wide, with the Green River running along the southern edge of the valley along the toe of Mt Currie. The Lillooet River flows between 700 and 900m from the same valley side.

The forested, talus and exposed bedrock slopes of Mt Currie gradually steepen from the Green River at elevation 204m to the ridge at 1600-1800m elevation and are some 2.8km in horizontal distance.

Flooding

The property lies on the Floodplain of the Lillooet River, as indicated on 1990 MoE floodplain mapping (Sheet # 3 of 11). The 200 year return event (FCL) is noted on the 1990 mapping as 205.00 m. Kerr Wood Leidal updated the data with further studies during 2000 which increased FCL's by approximately 1m to 206m in this project area.
More updated studies were undertaken during 2018 by NHC and the 200 year construction levels for the proposed building location are noted from this most updated and recent study as between 206.5 and 207.0m geodetic (I.e. **206.75m** allowing for freeboard and referenced to the new 2013 datum).

Historical floods;
There have been several significant floods in the last 80 years with 4 of them in the last 40 years;
1940 – Dike breach occurred with entire valley flooded.
1981 - (November) – slightly lower levels to 1940
1984 (October) – Flows of 1310m3/sec (instantaneous) recorded. Dike breach near Miller Creek, backup from CN Track-bed. Evacuations, major damage to property and infrastructure.
1991 (August) – Instantaneous flow of 1410m3/sec recorded at station 08MG005. Estimated as a 1 in 200 year event. "*floodwater totally inundated the municipal airport facility and a temporary trailer camp for the Ministry of Forests "Rap Attack" crew. Airplanes, vehicles and trailers at these locations were damaged, equipment and supplies were lost. Floodproofing of the airport electrical, weather and control facilities proved effective.*" Referenced from Hydrology Branch (Victoria BC) Report Jan. 1995 by Coulson, Corner, Reksten et al.
2003 (Fall) – Instantaneous flow of 1490m3/sec recorded. Unprotected areas inundated. Other Dike crests "full"
2016 (Nov 9th) – Rain on snow event. Unprotected areas inundated. I. e. North Arm Farm. Discharge record at 08MG005 as 800m3/sec

Ongoing flood events are to be expected. Sediment delivery to the Lillooet River lower reach system (from NHC 2018 study) is in the order of 50,000m3 to 200,000 m3 per year, which, when unchecked will have the longer-term effect of gradual ongoing raising of the FCL. Considerable efforts are ongoing to mitigate this aggradation effect through sediment removal from bars on a seasonal basis. Climate changes and other factors will continue to influence future flood levels and flood characteristics.

Use and application of building in terms of flooding:
The use will allow gathering of public yet during high precipitation events, and warnings thereof, this use is not anticipated. Although likely not required, there is some protection offered to the proposed tasting room from the property non-standard ring dyke in terms of allowing exit of

occupants to parking areas. It is recommended to ensure the building is closed prior to and at times of potential flood events.

Statement regarding use and flood hazard.
In terms of flooding hazards; the author can support the intended use of the building as a tasting room, with conditions to ensure any flood damage or effects are limited. See development recommendations in section 7.4.

Debris Flows
A potential hazard has also been identified by others of a catastrophic slope failure on the (60km away) Mount Meager volcano. A discussion of this hazard is given below:

Drilling studies during 2002 have shown evidence of historical events, triggered from Mt. Meager Landslides, which have caused debris flows reaching 20-50km downstream from Mt. Meager. Specific events have been recorded in the order of 2350, 4000 and 6200 years ago. Ongoing landslides from the Meager Complex are to be expected. The magnitude of the recent landslide, of August 6th 2010, was estimated as 49 million cubic meters (i.e. $10^7 - 10^8$, and the second largest in Canadian history). This event did not reach any inhabited areas, and travelled 10km from Capricorn. Instantaneous debris flows (and subsequent floods) which are considered large enough to reach 50km downstream are thought – from modeling – to be in the order of 10^9 cubic meters. The exact trigger location, route and material make-up will influence the run-out travel distance. Landslide induced Debris flow material may create debris floods further downstream, which size are difficult to accurately predict. Frequencies of such large cascade events are somewhat subjective, yet from field evidence reported, appear to be much greater than 1 in 2500yr events.

Landslides or eruptions causing river flow blockage, damming and subsequent flow back-up, could also generate adequate warnings from the installed, real-time, monitoring systems & emergency programs of potential outburst flooding, thus reducing risks of personnel injury or fatality. However, influence from the Mt. Meager area upon the Lillooet River, as a source of debris floods or surge levels is evident.

More recent awareness of the fumarole activity within the Meager massif, and studies by G. Roberti have identified larger unstable sections of Mt. Meager and recommend InSAR slope monitoring as offering some mitigation against inevitable collapses. Certainly localized land use such as recreation, hydropower sites, forestry or other industrial activities could be warned of imminent collapses. Temporary damming of the Lillooet River from such collapses can cause outburst events that increase the chance of debris floods down-stream, and potentially at the property on a very low frequency basis.

Consequence & Risk Study Basis: At present there is no formal risk acceptance criteria adopted by the SLRD. I.E. What is "safe"? Several papers and policies highlight the Hazard, Consequence and Risk relationship. With reference to the Fraser-Cheam model, provided in the SLRD 1994 Terrain-Stability Analysis of the Mt. Currie - D'Arcy corridor; the category – Debris Flood -suggest an acceptable risk for a **new building** as 1:500 to 1;10,000, subject to mitigation works. And for a catastrophic landslide as < 1:10,000, and unconditional.
Given the distance of the property, +/- 60km to the intersection of Meager Creek, it is the author's opinion that the annual return frequency of building area impact, from a debris flood, is in the order of 1:5000, and that the resulting consequences in terms of building damage or personnel injury are lower. With reference to the Fraser Cheam model these estimated event frequencies are deemed as within the threshold for acceptable return frequencies, with some mitigation included.

Rock-falls (& Catastrophic Landslide)
A potential hazard of a Mt. Currie collapse was identified during the 1980's. Subsequent studies and monitoring over a four year period, from 1987 to 91, near the north east ridge (Bovis & Evans 1995) and concluded that toppling and planar sliding is occurring within blocks, and that the ongoing ridge scarp movements observed are more likely a gravitational feature (as opposed to "neo-tectonic"). Features and mechanisms capable of allowing larger collapses which could constitute a "catastrophic hazard" were not considered present. Conclusions of the study included;"*Although this structural condition exists at Mt Currie (one where rock layers defined by the toppling set are closely spaced) the general northerly to north-easterly direction of toppling along set D1 means that progressive development of through-going shear surfaces, with a westerly to northwesterly dip toward Green River, a situation which would pose the greatest threat, is unlikely at this site.'*

Ongoing erosion through mechanical (e.g. frost jacking) and chemical weathering of the Mt Currie slopes is very evident and active. Rock-falls and rock debris flows are often seen and heard seasonally, with accumulations building within the basal fans. During 2016 a noticeably more frequent rock-fall activity prompted an assessment conducted by BGC in 2017, and results were made available (from Jan 2018) on SLRD & Pemberton Village websites. The report findings indicated a similar very low probability of a Mt Currie collapse and are summarized below:

- There was a lack of any evidence (through seismic survey and field traverses) of previous major collapses of Mt Currie. I.E. No buried rock debris fields were evident in the slope toe regions. Although it is acknowledged that landslide events can occur also without pattern, and limited locations for seismic survey were undertaken.
- Discontinuities within the rock were mapped with similar features highlighted to the 1980/90 studies.

- A kinematic analysis was undertaken. The orientation of discontinuities was viewed in relation to slope orientation and the potential for wedges, planar and/or toppling failures was assessed.
- A statistical method whereby the known events of other rock avalanches within a 70km radius was used to attempt to create a potential frequency for a rock avalanche at Mt Currie. The data within the kinematic assessment(s) was used to adjust the regional parameters, with other inputs based on judgement and field observations. The report acknowledges the adjustments may be higher or lower, and that a substantial subsurface and monitoring program would be required to increase the confidence in values used.
- The study considered climate change as a significant potential instability driver.
- 2 larger zones were identified and assigned with possible event frequencies of 1 in 5000 and 1 in 11,000.
- The 2 larger zones were modelled for run-out prediction, using established software (DAN 3D).
- The 1 in 11,000 yr return event (scenario referenced 2b) was shown to reach the valley floor south of the project location, and should a splash zone develop (i.e. a reaction from water or saturated materials to a larger mass impact), it is shown reaching highway 99.

The risk study also shows the potential subsequent effects of partial damming of the Green and Lillooet rivers from larger rock-fall events. Subsequent flooding and River redirection from blockages would likely negatively affect the property (with both scenarios).

It is noted during the subsequent 6 year(s) (2017-23) the rock-fall frequency and intensity within the same source zone on the central north face of Mt Currie has appeared to have abated. This then increasingly questions the credibility of the concept of a main instability driver being climate change, and that Mt Currie has significant structures reliant on ice presence for stability.

In summarizing the existing landslide studies in relation to the proposed development: Landslide events which may cause loss of life at the proposed location are not reported as possible on frequencies more often than a 1 in 10,000 chance of annual occurrence, in either study.

For a new building this criteria would be acceptable in terms of the Fraser Cheam approach.

Caveat – *The conclusions of this report are based on the currently available data and may require modifying as risk criteria are established, monitoring results and future studies into the downstream influences of Mt. Meager complex landslides, or studies of Mt. Currie provide other information. Any development in mountainous terrain is subject to some degree of geologic hazard risk. The absolute safety of the buildings cannot be guaranteed, and users of this report must accept some level of risk.*

7. Development Recommendations

7.1 Settlement & Bearing Capacity

The underlying soils to the 1.5m depth are seen as made up of channel fill sands and gravels which are relatively uncompressible. The project area soils appear as characteristic of a previous gravel bar or levee of the Lillooet river.

Foundation style recommended is a conventional concrete reinforced strip and pad style. It is recommended to limit the design allowable bearing capacity as 75Kpa to ensure post-construction settlements are less than the standard 25mm. The foundations bearing surfaces are recommended as being as high as possible I.e. 2ft below existing grade to provide a minimum frost cover. Some minor residual risk of post construction settlements greater than 25mm is accepted by the developer with this foundation approach.
Proximity to existing slab and pole supports; it is recommended to create a thickened slab tied into the existing slab edge and/or grade beams to transfer the add-on loads (Some local slab removal/replacement is likely required). Existing posts are understood as within mass concrete which is considered possible to connect at the new 2ft deep perimeter locations.

Site grading will be dictated by the existing slab grade. Utilities will require location and possible redirection. Site preparation is recommended to include sub-grade excavation to the exterior/perimeter foundation depths of 30 inches and to include a 6 inch layer of angular crushed product such as SGSB and compacted with a minimum 1000lb plate compactor. Interior slab preparation should include removal of the upper 10 inches and placement of a free draining, 4 inch thick drain rock layer under the slab and assumed insulation layer.

7.2 Seismic / Liquefaction

During a seismic event, the lower saturated sand layers are likely susceptible to some degree liquefaction, however, a punching type failure of the light foundation is considered unlikely, and exit of occupants would be possible. It should be realized that in the event of the design seismic event the structure could still incur settlement-induced displacement and sustain damage. Site classification is recommended as E based on local experience. It is recommended to ensure that all supporting pads are connected by grade beams or concrete slab to provide lateral resilience to potential liquefaction events.

7.3 Backfill & Drainage

The foundation base levels are recommended to be close to 204.6 (old 28 Datum). Backfill to the foundations should be symmetrical and minimal, yet ensure 0.75 m standard frost protection. Standard foundation perimeter 4 inch PVC drain-tile at the foundation base elevation is recommended to drain to the north and discharge to a standard dry well (rock-pit) a minimum of 5m form the building. There should be no redirection of roof run-off to foundation zones. Surface grading should be directed away from the building.

7.4 Flood Protection & FCL

The use of the building is noted as a tasting room, and as an addition to a farm storage building. Its intended use is considered as a non-habitable use. Surrounding grades are likely 205.3m asl, and discounting freeboard this would indicate a 4 to 5ft (1.2 – 1.5m) potential 200 year inundation level. However, it is recommended that the building will be constructed with due regard to flood damage below the 206.75 level. This would include:

a) Electrical panels or mechanical systems should be installed at levels higher than 206.75m geodetic
b) Concrete or other materials resistant to water & floating debris damage, to be used below 206.75m geodetic, with enclosed spaces designed to allow either minor water ingress or the minor potential hydraulic uplift.
c) Any hazardous materials or those with the potential to negatively impact fish or fish habitat must be stored at or above the FCL.
d) Any equipment or materials damageable by floodwaters are to be stored at elevations above 206.8m geodetic.
e) Ensuring wastewater systems are installed with adequate backflow prevention valves.
f) Ensuring the facility is not operated (open to public) during periods of flood warnings.

Flood levels may be updated for the Lillooet River Corridor in the future, and as such, flood hazards are subject to future studies.

8. Field Reviews

Please notify P K Read Eng. Ltd. at the following stages:

A. Sub-excavation stage completion prior to angular crush placement.
B. Prior to formwork and concrete placements.
C. Upon drainage and backfill installation.
D. Final grading.

9. Conclusion & Summary

Based on the information provided for the construction of tasting room, and given adherence of the recommendations herein, it is the opinion of the author *that the land may be used safely for the use intended.*

I trust this report meets with your requirements, please contact if further information is needed.

Phill Read
P. Eng.

Aug 18 '23

Practice # 1000200

References

1. *EGBC Practice Guideline for Legislated Flood Assessments in a Changing BC Climate*
2. *Environment Canada Inland Waters, British Columbia Ministry of Environment Floodplain Mapping Lillooet River File No. 01-000-S.1 Drawing No. 88-44-6, Dated September 30, 1990.*
3. [β] *P. K. Read Eng. Geotechnical reports for CYPS Hangers (2020)*
4. [Φ] *Impact of a Quaternary volcano on Holocene sedimentation in Lillooet River valley, British Columbia P. A. Friele, J.J. Clague, K. Simpson, M. Stasiuk*
5. *SLRD Floodplain Management Policy 6.10 2014*
6. *Canadian Foundation Manual 4th Edition*
7. *BC Building Code 2018*
8. *Rock Slope Movements along Mt. Currie "fault scarp" Can. J. Earth Sci. Vol. 32 1995. Michael J. Bovis & Stephen G. Evans*
9. *KWL 2002, Engineering Study for the Lillooet River Corridor[κ]. Report for SLRD.*
10. *Mt. Currie Landslide Risk Assessment, by BGC for SLRD dated Jan 16th 2018.*
11. *Lillooet River Flood Mapping Final Report November 22 2018. By Northwest Hydraulic Consultants, for Pemberton Valley Diking District.*
12. *Landslides & glacier retreat at Mt. Meager Volcano; Hazards & risk challenges, G. Roberti et al 2018.*
13. *Hazard Acceptability Thresholds for Development Approvals by Local Government (DR P Cave. Nov. 1993)*
14. *A review of the Floodplain Mapping for the Lillooet River nr. Pemberton BC. Hydrology Branch Victoria BC Jan. 1995*