APEX GEOSCIENCE CONSULTANTS LTD.

Detailed Terrain Stability Field Review

Proposed Harvesting and Road Construction For Wildfire Interface Control in the Selous Creek, Schesnuk Creek and Ward Creek Areas(CP K079)

for

Kalesnikoff Lumber Company Ltd.

W. Halleran P. Geo, L.Eng.

01/08/2020

1. Summary

The proposed roads are located on stable terrain, maintaining natural slope drainage will not significantly increase the downslope likelihood of landside initiation.

A Partial Risk Analysis is presented in this report, Risk Assessment and/or Risk Management is the responsibility of the stakeholders.

Observed instability was grouped into 5 areas as shown on Figure #6 in the report.

Area #1:

There is minimal proposed harvesting upslope of Area #1. The proposed development is unlikely to significantly increase the Pa>0.002 probability of landslides which is a low annual likelihood of landslides.

Highway 3 is not at risk from a landslide originating along this segment of the slope.

The debris slide gullies/swales terminate on a 60m wide < 20^{o} upslope of the Rail Trail and private land, there is a moderate likelihood landslides would reach the trail or private land.

Slides are unlikely to significantly damage the rail trail but could possibly impact private land. Slides pose a moderate risk to private land.

Area #2 Schesnuk Creek:

At least two significant debris flows down Schesnuk creek have occurred in the past ~ 20 yrs. (1997 and 2012). The recurrence rate of major debris flows is assigned a 1 in 20-year return for a Pa of 0.05, this is deemed a very high likelihood of landslides. The debris flows impacted the rail trail, deposited sediment on private land, caused sedimentation in Cottonwood creek and impacted water infrastructure. Highway 3 is not at risk.
The proposed development encompasses most of the remaining timbered area of the upper catchment, including portions of two proposed roads and will likely increase the likelihood of debris flows.

Debris flows in Schesnuk Creek are deemed a very high hazard and pose a high risk to the trail, a very high risk to water quality, infrastructure, and private property.

<u>Area #3:</u>

Isolated rockfall and topple occurs every 5 to 10 years off bluff faces, terminating along the upper to mid portion of the blocky talus slope, making it unlikely to reach the lower slopes and impacting structures or the highway. The forested slope below the talus will further reduce the likelihood of rocks reaching the trail or highway.

Yarding trees upslope over the bluffs may dislodge some blocks from the bluffs and the upper portions (steeper) of the talus slope. There is a very high likelihood of rockfall and a low likelihood that the rocks will reach the elements a risk, rockfall is deemed a high hazard and very high risk for private properties and Highway 3.

<u>Area #4:</u>

There are a series of >500 yrs debris slide scars and headscarps along this slope (low likelihood of landslide initiation). The swales and gullies reach the lower slopes, making it likely that if a debris slide did occur, it would reach the lower slopes. No water intakes are plotted along the lower slope, there is the rail-trail and a road just below the trail. Impact on the trail will likely be moderate with minor damage to the lower road. It is likely that debris will reach private property at the toe of the slope.

Landslides occurring in Area #4 pose a moderate risk to the trail and lower road and a high risk to private properties and Highway 3

<u>Area #5:</u>

There is one ancient slide that is far removed from elements considered for risk, the proposed development will not significantly increase the low likelihood of landslide initiation.

2. Introduction

Mr. Gerald Cordeiro of Kalesnikoff Lumber Company (KLC) requested a terrain stability field review of potential harvesting and road construction on the slopes between Ward Creek and Selous creek as outlined in Figure #1. The proposed development is prescribed to reduce the severity of wildfires in this interface area.
The comparative risks between wildfire and timber harvesting are best completed by affected stakeholders.

3. Methods, Limitations and Reliability

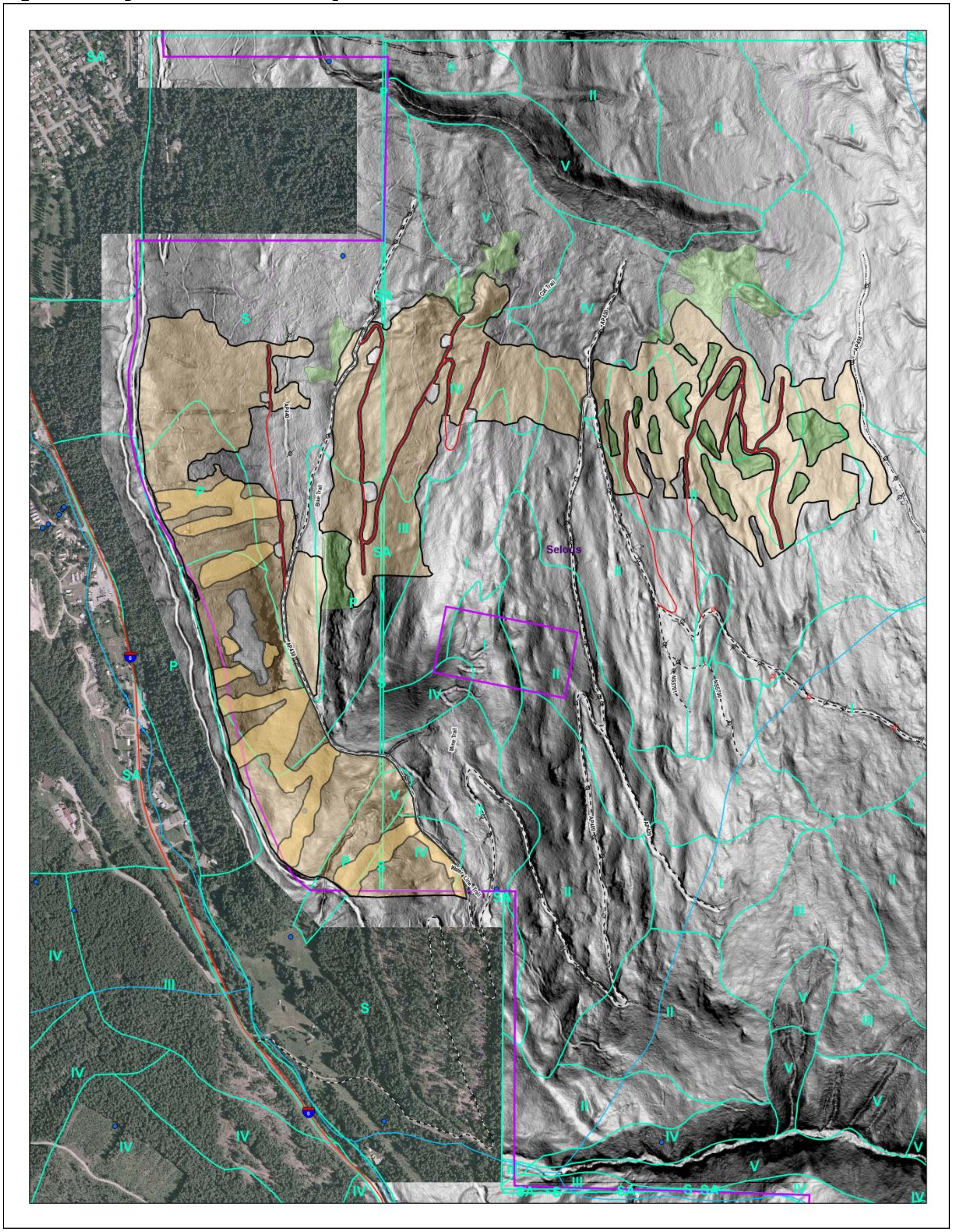
Previous DTSFA reports (Apex Geoscience), Slide investigation reports (Apex), detailed drainage plans (Apex), slope drainage survey (Kalesnikoff), Google earth imagery, Bing maps satellite imagery, historical air photos, historical photos, mineral exploration assessment reports, and Ministry of mines annual reports were reviewed. KLC supplied Lidar DEM files; development and hill shade maps with the proposed development, previous development and terrain stability polygons marked on it. A Samsung android tablet with the Avenza maps program with the imported hill shade map was used for navigation and note taking. QGIS slope drainage model was employed to delineate likely slope drainage patterns.

The field assessment was completed by W. Halleran P. Geo L. Eng. on August 7th, 9th and 21st 2019, weather was warm with occasional rain. Inferences are made from observations of materials in soil pits, road cuts, and tree churns within and adjacent to the proposed block and roads during the field review.

The terrain stability assessment made in this report is based on generally accepted practice described in “Guidelines for Terrain Stability Assessments in the Forest Sector-October 2010” published by APEG of BC. The risk assessment presented in this report follows the conventions outlined in Land Management Handbook 56 “Landslide Risk Case Studies in Forest Development Planning and Operations”.

A partial risk analysis was conducted on those portions of the roads and blocks that pose a potential hazard to the elements considered for risk.

Figure 1: Proposed interface Development.



This review assumes road good construction standards are met. Even if all standards are met there is still a possibility of landslides. Terrain assessment can reduce the likelihood of landslides, not eliminate it.

3.1 Review of selected previous reports and information.

Archival photos of the area show that it experienced an extensive forest fire in the late 1800's which appears to have removed ~ 100% of the forest cover. The photo below is from 1892 looking south towards Ward Creek.

Photo 1

Commercial timber harvesting started in 1889 to supply mine timbers and building construction lumber. It is reported that the mills apparently had a difficult time finding enough timber.

<u>Mineral Exploration</u>: There has been extensive mineral exploration in this area from the late 1800's to the 1990's. Pre 1970's work is poorly documented, a general summary of work conducted in the area is reported in the 1939 Annual Mines report. Much of the work conducted from the 1970's on is documented in Mineral Assessment Reports. Mineral exploration assessment reports from the 1970's to 90's for the area include reports 1990, 03091, 07377, 07393, 10605, 11720, 15654, 17686, and 21255, some of these focus on the area to the south of the proposed development but most discuss works done within or close to the proposed development area.

Mineral exploration and development work done from the early 1900’s to 1930’s include the original discovery of the “Lizzie” showing and likely the “North” showing. The Lizzie showing is located within the Schesnuk Creek “draw”, upslope and south of the proposed development, the North showing is situated to the south of the proposed development at the junction of roads 400 and 430. During this time, trenches (both hand and hydraulic), pits, adits, shafts and winzes were excavated on various showings from the North Showing to the Lizzie Showing. By 1969 there was a “road” from Selous Creek to just north of the North showing and another road crossing the lower reaches of Schesnuk creek from the north. Additional bulldozer trenching was conducted in the 1970’s although records are sparse. Reports from the 1990’s state that between 1980 and 1983 a bulldozer road was constructed from the North showing to (and likely beyond) the Lizzie showing. This road incorporated some of the old trenches on the Lizzie showing.

Terrain Stability Mapping: Terrain stability mapping (Level C) was completed over the eastern portion of the area by D. Putt in the 1990’s. It appears Level D mapping was conducted over the western portion; it is likely that this was converted from the Corridor Hazard Mapping conducted by P. Jordan (regional geomorphologist for MoF) in the early 1990’s.

1997 Schesnuk Creek Slide: (Figure #2) This slide occurred in April 1997 during a period of extremely heavy rain fall and rapid snow melt (D. Putt -level C report). The fall of 1996 was extremely wet, the winter had a deep snowpack which lingered late into the spring and the extreme precipitation (Environment Canada assigned a 1:100 return) continued into the spring. The debris slide entered Schesnuk creek resulting in a debris flow down the stream gully, severely damaging a disused rail trestle, depositing significant sediment on private land and stream sedimentation into Cottonwood Creek. There are multiple headscarps at the initiation zone (Complex Headscarp). The slide initiated on a 65% slope underlain by sandy gravel till, it is possible that there was some local over steeping as a result of bulldozer trenching (1980’s) pushing material onto the slope.

The complex headscarp area is 30 meters downslope of a mining road. A 3-5m deep 8-meter-wide trench runs from the road, across a 20% gradient bench, discharging at the southern edge of the complex headscarp area, just below a 65/30% slope break. The configuration of the mining roads upslope of this area may have directed slope drainage down this trench onto the headscarp area. Road 400 (Spur 430) has been constructed ~ 25m upslope of the debris slide scarp. In 2008 the debris slide scar was grassy with scattered alders. The headscarp was nearly vertical but the crown appeared stable.

TA07KL01: An earlier drainage review for portions spur 300 CP 29 (now designated AP400) identified areas of instability along the "P" line. The instability was noted as recent slides (25 yrs.) within larger older (100-150 yrs.) slide complexes, likely related to the extensive forest fires in the late 1800's and the record flood of 1894. Report TA07KL01 was the follow up DTSFA for those section of roads. Cut and fill angles were recommended, the slides posed a low risk to assessed values.

TA08KL01: On September 18, 2008 W. Halleran P.Geo, Eng. L. of Apex Geoscience Consultants (Apex) and D. Thorburn RPF of Kalesnikoff Lumber Company (KLC) conducted a field review of portions of a proposed road (Spur 440) and portions of the 1997 Schesnuk Creek debris slide.

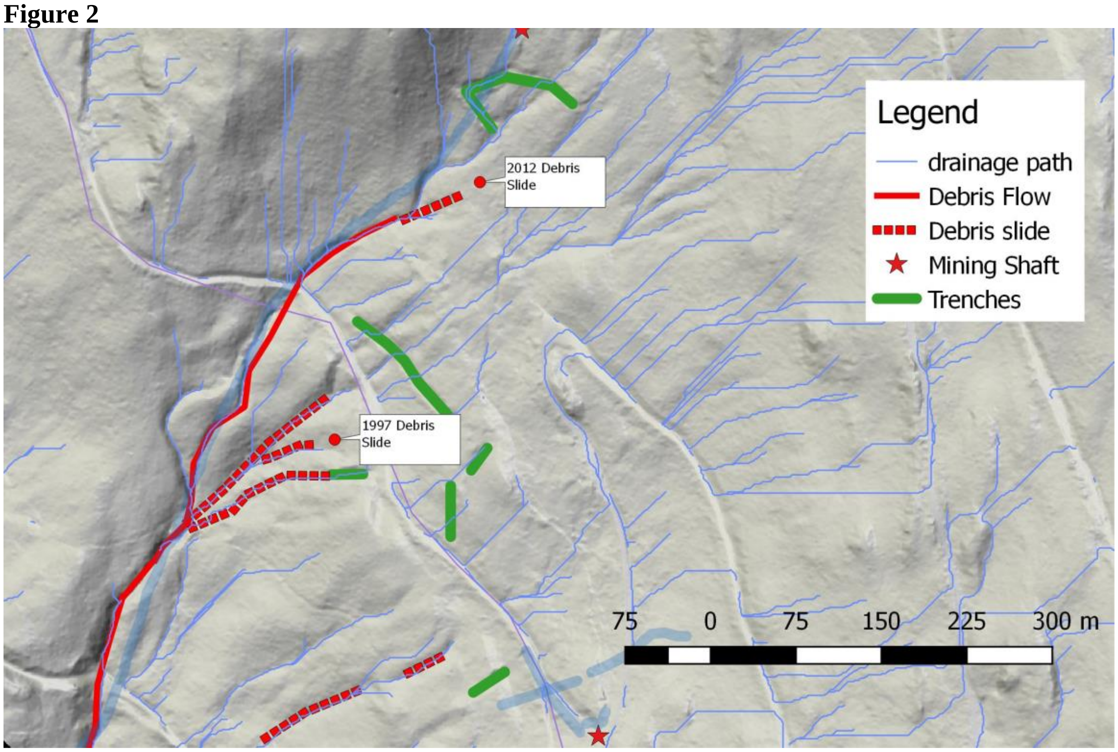
The report summary states "*Road construction as recommended in this report and timber harvesting (beetle infestation) will not significantly increase the low likelihood of landslide initiation provided natural slope drainage patterns are maintained.*

At the time of the 2008 report, the road crossing of Schesnuk creek was reported as two sub-parallel 50% gradient swales with no evidence of surface flows (no channel or erosion) in either swale. The swales joined just down slope of the road crossing.

2012 Schesnuk Creek Slide. (Figure #2) There was widespread flooding and numerous slides in the B.C. interior in 2012, including the Johnson's Landing slide and Fairmont Hot Springs debris flow. The deep snowpack lingered late into the spring/early summer. Between May 3rd and 6th the Maximum Daily Temperature increased from ~9 ^{o}C to >20 ^{o}C, resulting in a rapid snow melt.

Although no report was submitted, a debris flow down Schesnuik creek in 2012 was investigated by W. Halleran P.Geo of Apex. The debris flow occurred in early May. A debris slide entered Schesnuk Creek upstream of Spur 430 triggering a debris flow down the stream channel. At the time of assessment there were tension cracks on the crown 2m back from the scarp face. The possible upslope drainage contribution of timber harvesting was investigated. The mining trenches and road upslope of the slide were reviewed by W. Halleran, Peter Jordan of MoF, and Stan Hadikin of Kalesnikoff. A "spring" was noted flowing onto the road (trench) out of the tailings of the adit on the Lizzie showing by Stan Hadikin. Mr. P. Jordan had reviewed the logging roads upslope of the area and noted that at the time of the slide the roads where still covered in snow. On May 24th, W. Halleran followed discontinuous forest floor scour in a swale from mining road upslope into block 24-2 and noted that the possible headwater catchment of the swale had been harvested. A ridge on the west side of the swale directs water flowing from the east, down the scoured swale (Schesnuk Creek). It was also noted that parallel swales in the unharvested area had no evidence of scour.

Figure 2



3.2 Likelihood of Landslide Determination

In this report the annual likelihood (Pa) of an event occurring is <u>estimated </u>by considering the age of the event (in this case, landslide). Slide reports and field observations are used to determine the age, cause, distribution, type, size and materials of both natural and development related landslides. In the absence of other information; for purposes of this report, the age of the landslide is assumed to equal to the return period of the conditions/climatic event that triggered the slide, i.e. a 500-yr. old event is associated with a 1 in 500-year return period (Pa). This will likely result in a higher estimate of the annual likelihood of an event occurring than is actually present.

For the natural terrain stability, field evidence for events that occurred less than 20 years ago, (Pa >0.05) will be obvious and likely appear relatively fresh (i.e. exposed mineral soil, broken and/or scarred timber, etc.). These areas are deemed to have a very high annual likelihood of landslides.

Field evidence for events that occurred between 20 and 100 years ago, (Pa = 0.05-0.01) should be obvious (i.e. change in vegetation, sharp slide scarps, scarred trees, buried soil horizons, absence of developed soil profile in the scar and scarp, etc.). These areas are deemed to have a high annual likelihood of landslides.

Field evidence associated with events that occurred between 100 and 500 years ago, (Pa=0.01-0.002) are usually more subdued (muted slide scars, multiple and/or thicker buried soil horizons, less developed soil profile within the scar compared to the adjacent slope, lack of burnt snags within the slide path if present on the adjacent slope). These areas are deemed to have a moderate annual likelihood of landslides.

Unless very large, field evidence for events associated with greater than 500-year-old events (Pa < 0.002) can be hard to notice (muted slide scars, old gullies, may have deep thick buried soils horizons). These areas are thought to have a low annual likelihood of landslides.

If a debris slide enters a “stream channel” a debris flow may result. The following assumptions are made[1]:

- A debris slide entering a low-order channel of gradient less than 10^{o} (17.5%) stops
- A debris slide entering a low-order channel of gradient greater than 10^{o} at an intersection angle of 45^{o} or less becomes a debris flow.
- Debris flows are erosive in channels of gradient greater than 10^{o}; they continue downstream but start depositing material at gradients less than 10^{o}.

[1] From “A landscape-scale landslide model” ESI 2002.

- At channel junctions, if the gradient of the receiving channel is less than 20^o (36%), but greater than 3.5^o (6%), a debris flow continues if the junction angle is less than 70^o, otherwise it deposits on a fan.
- A debris flow entering a channel of gradient greater than 20^o will continue downstream, no matter what the junction angle.

Debris flow channels are most likely broadly U shaped. Trimlines (scoured side slopes), scarred trees adjacent to the channel, and buried soil horizons on levees or deposition sites can indicate the age and frequency of events. Along lower gradient reaches and/or in unconfined sections, debris deposition often occurs as levees or debris lobes.

Observations of how previous development has influenced terrain stability, experience and professional judgment are used to determine how the proposed development will influence terrain stability.

The following formula is used to <u>estimate</u> the likelihood of an event occurring during the lifetime of a specific structure/element (long-term likelihood).

$Px=1-[1-(Pa)]^x$

Where Pa is the annual probability, x is the lifespan of the “structure” and Px is the probability during the lifetime of the structure.

For this report the <u>likelihood</u> of an event occurring during the lifetime of the structure (Px) is defined as:

Greater than 50% is deemed Very High likelihood; from 50% to 20 % is a High likelihood; from 20% to 5% is a Moderate likelihood; less than 5% is a Low likelihood of landslide initiation.

3.3 Hazard Determination

For this report a hazard is a defined as a source for potential harm in terms of human injury, Highway 3, private property, trail infrastructure, water quality or water intake infrastructure. For this report, the hazard is a function of the likelihood of a landslide/rockfall and the likelihood that the slide/rock can reach the considered elements.

The relative rating for landslides and rockfall are shown in Table 3.3.1 and 3.3.2.

Table 3.3.1. Likelihood of a Debris slide or Sediment Reaching or Affecting elements considered for risk

Relative Rating of Likelihood of a Landslide Affecting elements	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly affect elements considered for risk.
Moderate	There is a run-out slope of<20º gradient and <200 m in length, or another terrain configuration which could possibly intercept or dissipate a potential landslide debris and/or sediment from erosion (e.g. irregular or benchy rock-controlled terrain) below and between the development and the elements considered for risk.
Low	Landslide debris and/or sediment from soil erosion is unlikely to reach or affect the elements considered for risk at the time of an event. There is a run-out slope of <20º gradient for >200 m, or another terrain configuration which would likely intercept or dissipate sediment or landslide (e.g. irregular or benchy rock-controlled terrain), below and between the development and elements considered for risk.

The relative rating for landslides is shown in Table 3.3.2

Table 3.3.2. Likelihood of a Rock Reaching or Affecting elements considered for risk

Relative Rating of Likelihood of Rock Fall/topple Affecting Elements assessed	Description of Activity and/or Geomorphic Conditions
High	Multiple rocks will reach or directly impact private property or Rail Trail. The elements are within 30º shadow zone of rockfall
Moderate	There is a run-out slope of <30º gradient and <50 m in length, or another terrain configuration which could possibly intercept or dissipate rockfall energy. (e.g. irregular or benchy rock controlled terrain, hollows, depressions, ridges) below the rockfall area.
Low	Rockfall is unlikely to reach or affect private property and/or rail Trail. There is a run-out slope of <30º gradient for >50 m, or another terrain configuration which would likely intercept or dissipate sediment or landslide (e.g. irregular or benchy rock-controlled terrain), upslope of the elements considered for risk.

The “Hazard” is determined via the matrix shown in Table 3.3.3

Table 3.3.3 Matrix for determining Hazard rating.

		Likelihood that the Landslide, Sediment Delivery or Rockfall Will Reach or Otherwise Affect Selected Elements		
		High	**Moderate**	**Low**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low

1) Modified from Wise et al (2004), Table 8, page 26.

3.4 Partial Risk Analysis Methodology

The risk analysis presented in this report is qualitative and is based on information gathered during this project and reviews of previous reports.

The elements assessed for risk for this project are:

a) water intakes
b) private land below the development
c) Rail Trail
d) Highway 3.

For this report, the risk is defined as hazard x consequence. Hazard has been defined in section 3.3, and consequence is the possible effect of the event. For the purposes of this report, due to uncertainty of vulnerability of private residences and private land; and due uncertainties regarding traffic volumes, line of site, speed of traffic and vulnerability of the traffic, the Consequence of rockfall or a landslide reaching private residences, private land or the highway land is deemed to be High.

Consequences to POD and Rail Trail are defined in tables 3.4.1 and 3.4.2.

Table 3.4.1: Water quality and water supply infrastructure

Consequence	***Effect***
High	Long-term or permanent deterioration of water quantity/ quality. Complete destruction of water intake structures.
Moderate	Short-term deterioration of water quality quantity, repairable damage (1 week) to water intake structures.
Low	Short-term (less then 1 week) deterioration of water quality/quantity, “damage” to water intake structures repairable during regular maintenance.

Table 3.4.2: Rail Trail

Consequence	**Effect**
High	Structural Damage
Moderate	Moderate damage, moderate damage to access road (repairable).
Low	Minor damage to Minor erosion to/or deposition on the access road (minor repairs, still useable).

Partial risk is the product of the hazard and the consequence as shown in table 3.4.3

Table 3.4.3 Matrix for determining partial risk for trail and water resources.

		Consequence		
		High	**Moderate**	**Low**
Hazard	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low
	Very Low	Low	Very Low	Very Low

Table 3.4.3 Matrix for determining partial risk for private properties/Highway 3.

		Consequence
		High
Hazard	**Very High**	Very High
	High	Very High
	Moderate	High
	Low	Moderate
	Very Low	Low

4. Observations:

Observations sites are shown on figure 3, observations are tabulated in Appendix 1.

4.1 Geology:

The western portion of the area is underlain by massive granite of the Nelson Batholith in Fault Contact with the Rossland Volcanics and associated syngenetic intrusions to the east (Figure 4)

The Nelson Batholith granite forms small bluffs with associated blocky talus aprons. Sub vertical and horizontal fractures on the bluff faces result in “loose” blocks which occasionally topple.

The Rossland Volcanics are a steeply dipping, north east striking, series of massive andesite/basalt, pillow basalts, lapilli tuffs, argillite, chert, diorite (to Gabbro), granodiorite, and lamprophyre. Shear zones sub parallel to the strike of the units occur throughout the area. In places units are sheared and altered to phyllites; the granodiorite and diorite are weathered or sheared to sand and sandy gravel.

4.2 Surficial Geology:

West of the “fault Contact” the slope is predominantly underlain by sandy rubble soils including areas of blocky talus.

South of Schesnuk Creek and east of the fault contact, the slope is predominantly underlain by silty sandy gravel (varies from sandy gravel to silty gravel), areas of granite boulders suggest washed ablation till glacial deposits.

The northern portion of the proposed development, south of Ward Creek is underlain by variable sandy gravel Till, silty colluvium and sand. Sand predominates adjacent to Ward creek. Intrusive and mafic volcanics exposed in rock cuts here are deeply weathered to sand.

Figure 3

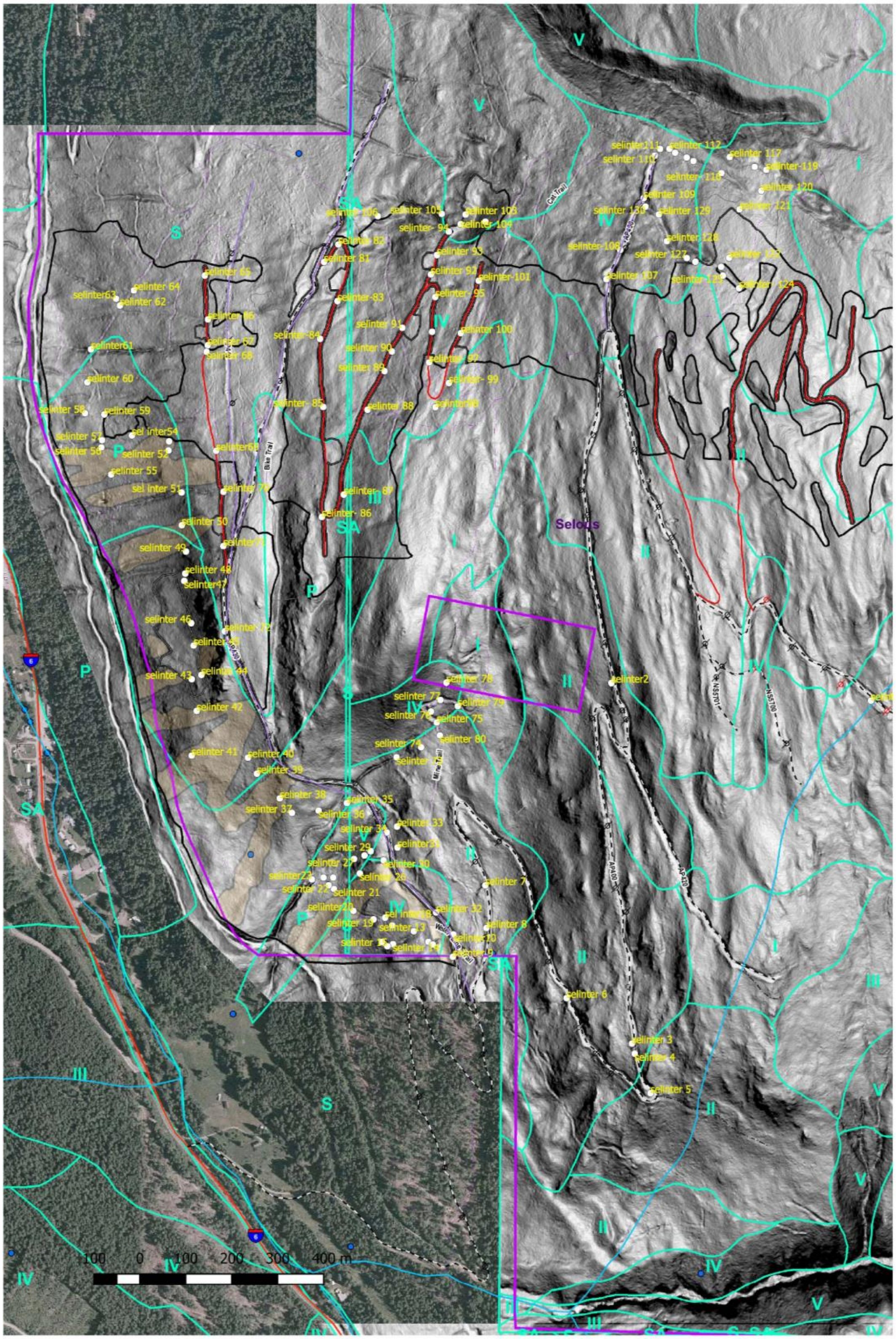
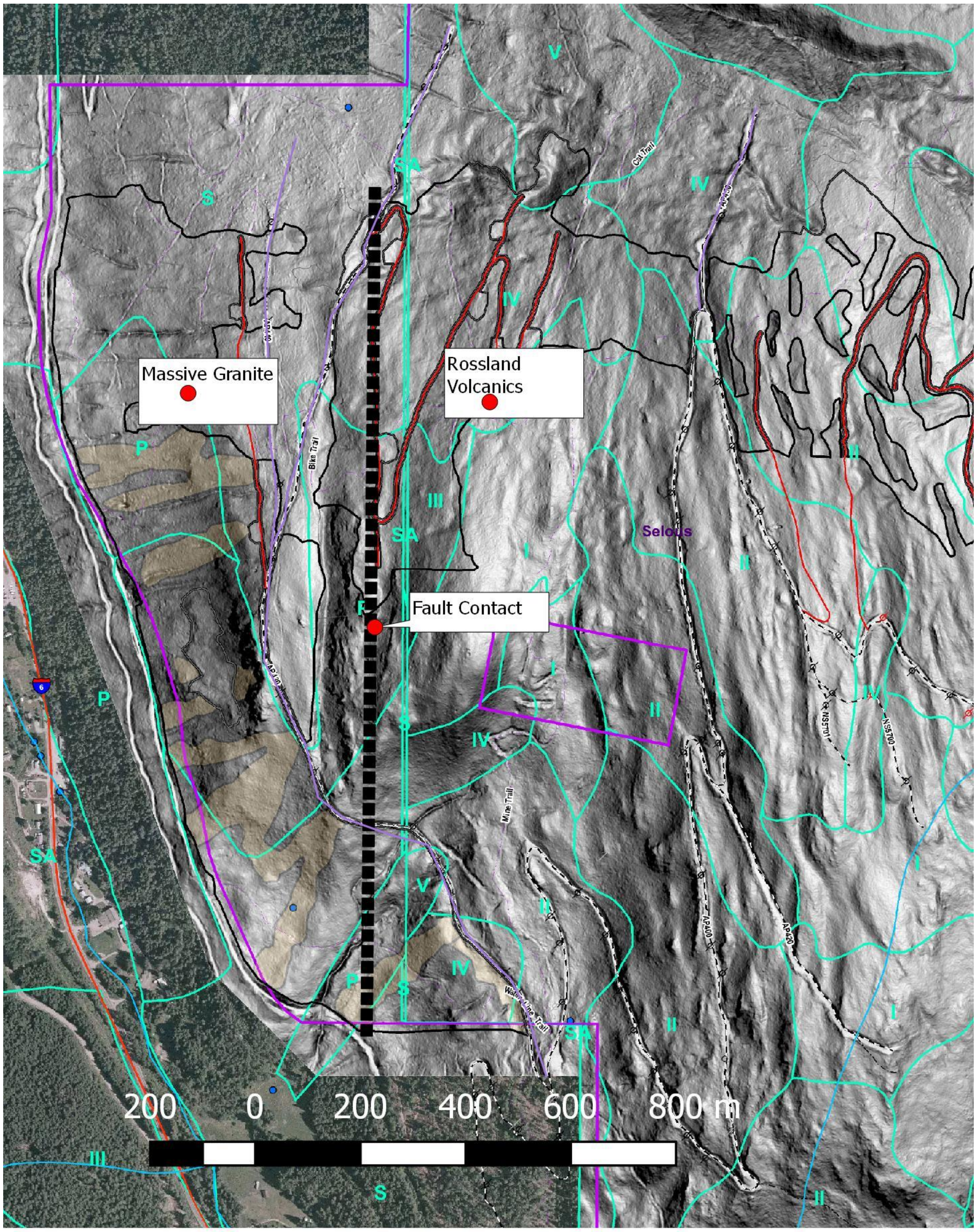


Figure 4



4.3 Slope Drainage:

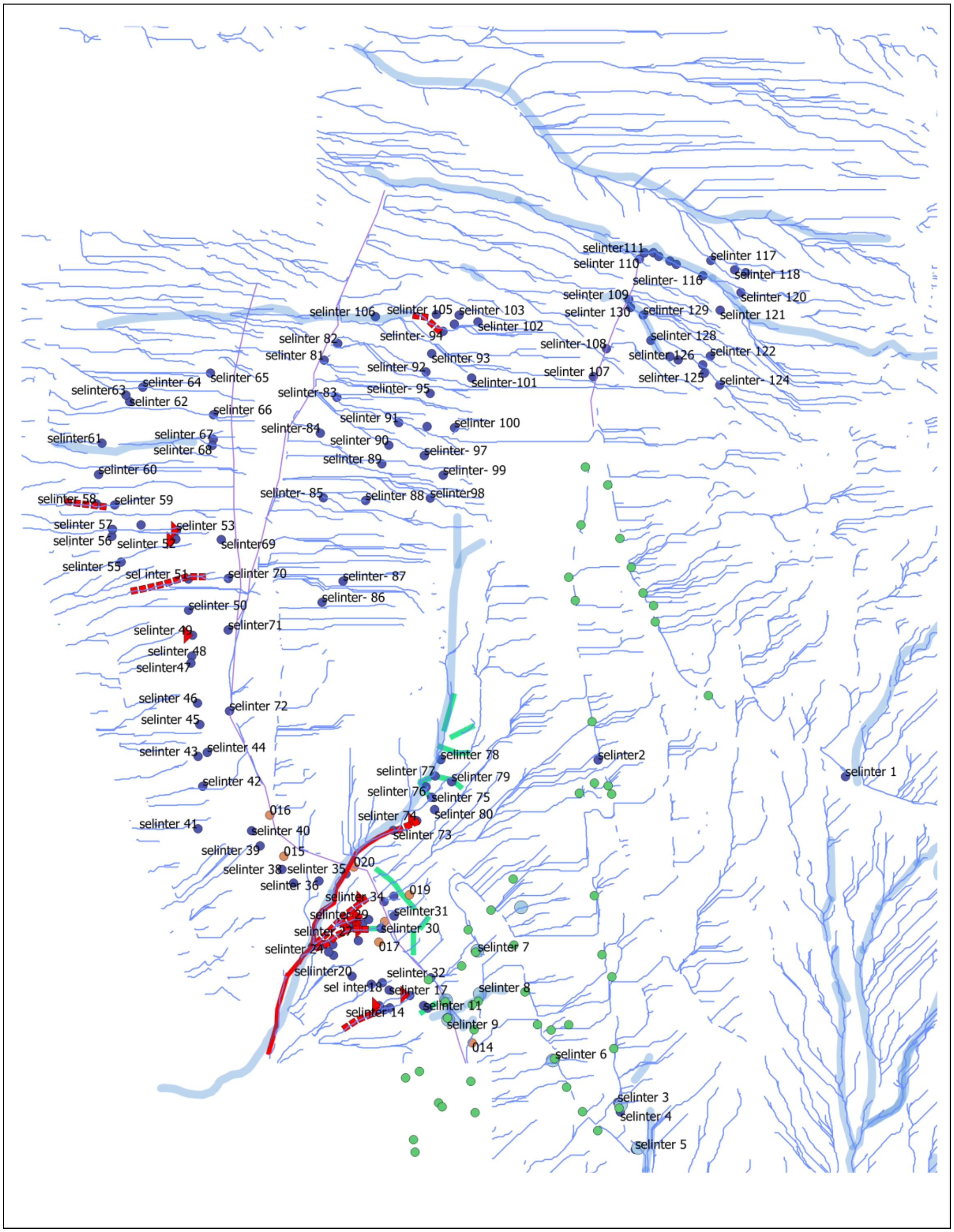
QGIS SWAT (Soil & Water Assessment Tool) slope drainage program was run using the lidar DEM, the slope drainage patterns (Figure 5) are dependent on the resolution of the DEM data and may miss small ridges, benches and other surface features that could divert the drainage. Roads and trails can also impact the accuracy as culvert locations are not incorporated. Subsurface drainage patterns are not modeled by this method. Springs without accompanying topographical support (i.e. swales or gullies) are also underrepresented. The field observations for the most part confirm the drainage patterns determined by the SWAT drainage model. An attempt was made to alter the catchments of the derived slope drainage by incorporating the known culvert and spring locations.

During this field assessment evidence of slope drainage (i.e. slope wash, scour, sediment deposits, springs and moisture indicating plants) and topographical features (i.e. swales, draws, gullies, and bowls) were noted in the observations (Table II Appendix)). Along road alignments, proposed culverts were noted, additional culverts were flagged in the field with three blue flags or yellow flags.

Occasionally old scour or sediment deposits were noted in the otherwise dry swales, (such as at stations 14, 22, 40, 64, 67, 83, 85 and 88) suggesting the some of the swales host surface flows for very short periods of time during the freshet or under extreme weather conditions (many more likely hosted surface flows soon after the last forest fire). It is possible that subsurface flows are located within many of the swales. Road cuts through swales often expose wet conditions (i.e. seeps, springs, wet plants in the ditch) at depth below the surface elevation of the bottom of the swales.

Information from previous dtsfa’s, slide investigations, proposed road drainage assessments (CP 28 and CP 29) and Doug Thorburn’s stream surveys (plotted as the wider light blue lines on figure 5) confirmed and added to the observations. It was noted that on the existing roads there are several “springs” flowing out of rock cuts with no associated surface expression, usually 1-2 meters below the ground surface, likely associated with small shear zones or contacts in the volcanics. Prior to road construction of the existing roads several surface springs (some with associated caliche) were also noted and mapped.

Figure 5



Except for Schesnuk Creek, there is very little natural concentration of slope drainage within the development area. Most of the slope drainage pattern is dispersed over the face with numerous parallel to sub parallel features.

The upper catchment of Schesnuk Creek is mostly a west aspect slope which drains into a southerly flowing draw which turns west at about the Lizzie Showing. During the 2012 slide review, it was noted that scour occurred from within the cut block to just upstream of the Lizzie showing, at which point the stream was disrupted by mineral exploration workings.

The small stream along the northern edge of the development that parallels Ward Creek shows evidence of scour and sediment deposition behind woody debris about 5 yrs. old. Older levees (large ones 100 yrs. or more, smaller ones 25 yrs.) suggest this stream has hosted debris floods or flows in the past. The older larger levees are likely related to deforestation during the last large forest fire, the smaller newer ones are likely related to the 1997 rain on snow event, the most recent scour is likely related to the 2012 event. There are permanent pools of water in the ditchlines at the end of Spur 430 and a permanent spring in a draw just to the south on Spur 450.

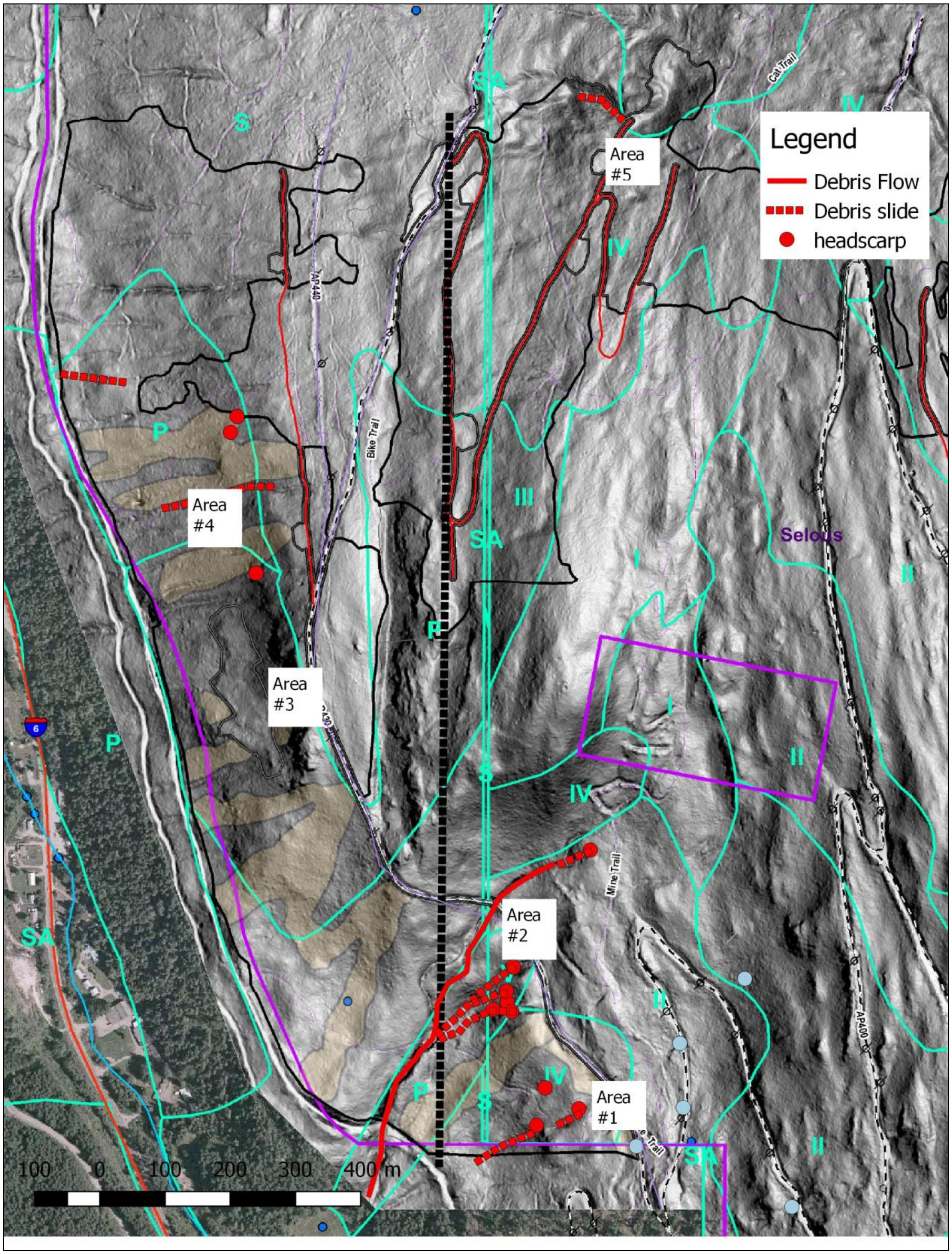
4.4 Terrain stability:

The identification, age and recurrence of terrain stability features in this area are complicated by the historic mineral exploration activities, especially hydraulic trenching which mimics, and in places, occurs within historic debris slide, debris flow and slump features.

Except for the slides in the Schesnuk Creek area, the features are either ancient or ~100 yrs. old. It is possible the ~100 yr. old slides are related to the last major forest fire and or historic mineral exploration activities. For the purposes of this report, unless otherwise stated, the instability is assumed to be natural and/or conditions contributing to the instability are still present.

The observed instability is grouped into five areas as shown in figure 6.

Figure 6


Legend
Debris Flow
Debris slide
headscarp
Area #5
Area #4
Area #3
Area #2
Area #1
Selous
Bike Trail
Mine Trail
Cat Trail
AP440
AP400
S
SA
P
I
II
III
IV
100 0 100 200 300 400 m

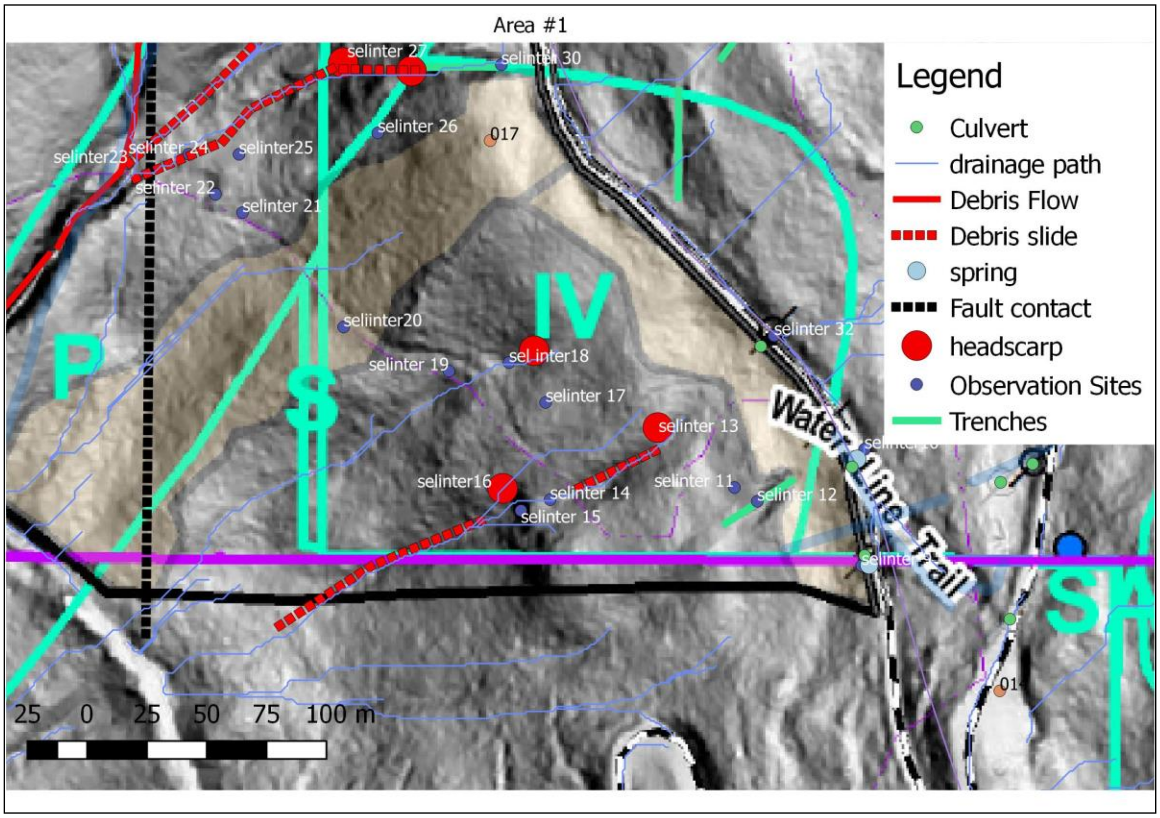
Area #1: Stations 13, 16, and 18; Figure #7.

A small subdued headscarp (station 13) feeds into an erosional gully (V shaped). There are large vets in the bottom of the gully and no trim lines suggesting >500 yrs. The surficial material is loose sandy sub angular gravel. Further down the gully at station 14 there is evidence of minor old erosion (50-100 yrs.). The gully becomes unconfined at a small old sediment wedge of brown sandy soil (likely from the 50-100 erosion). The channel diverts around the wedge onto steeper slopes below. The steeper slope becomes a small rock step (station 15). At the base of the rock step there is an ancient shallow debris slide (>500yrs). The area was stable through the last fire, more recent erosion and deposition may be associated with mining activity or surface erosion in response to the last fire.

Station	Feature	Age	zone
selinter 13	Old debris slide gully.	>500	erosional
selinter16	ancient shallow slide.	>500 yrs.	erosional
sel inter18	broad gentle headscarp area.	500-100	initiation

Further north along the slope there is a similar headscarp (Station 18). This scarp has mixed soil horizons suggesting there was some activity about 100 yrs. ago. There is a 3m wide bench below the scarp, upslope of steeper slopes and mining trails with no evidence of a debris slide or flow, suggesting the mixed soil on the scarp was a result of shallow sloughing that did not progress to a debris slide.

Figure 7



<u>Area #2 Schesnuk Creek Area; Figure 8</u>:

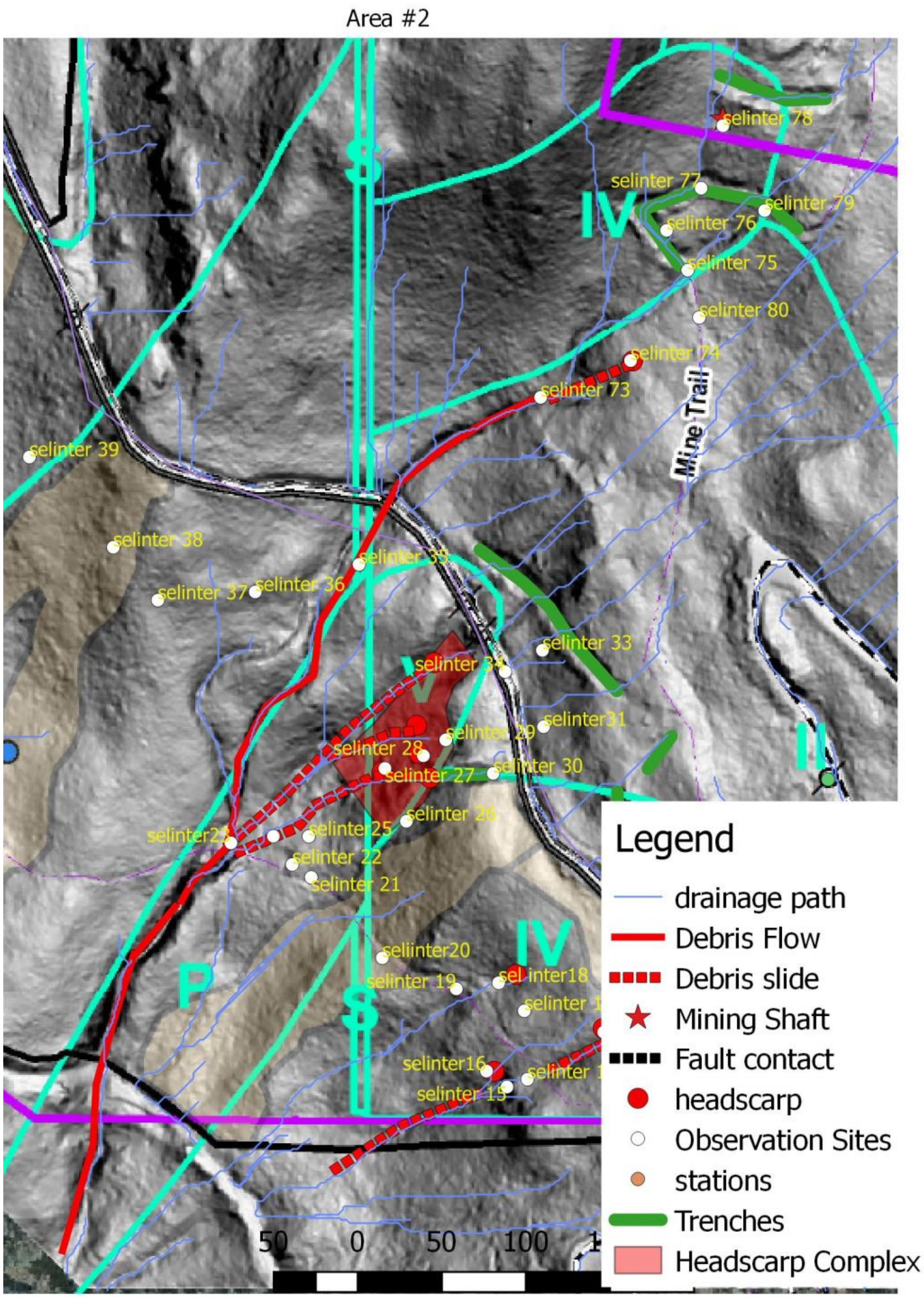
There are two areas of recurring debris slides, the slides enter Schesnuk creek (>20% gradient) at less than 30^{o}, triggering debris flows down the creek. There were major debris flow events in 1997 and 2012, down Schesnuk Creek. A debris slide below Spur 430 triggered the 1997 event, a debris slide upslope of the spur contributed to the 2012 event. Both events are associated with late snow packs. The debris flows impacted downslope resources including the trestle bridge (rail trail), private land, water intakes and Cottonwood creek.

In 1997 heavy rainfall (rain on snow) was the primary trigger. In 1997 a debris slide initiated directly below mineral exploration working. The slide and antecedent conditions have been described previously. This slide occurred before the present existing haul road was constructed and upslope harvesting completed.

The 2012 slide occurred after road construction and timber harvesting within the Schesnuk Creek catchment. At the time of the 2008 DTSFA the channel of Schesnuk

Creek (at the proposed road crossing) was described as two parallel swales with no stream channel or evidence of recent debris flows. In early May there was a rapid rise in temperatures, which likely caused a rapid melt of the deep late snowpack triggering the debris slide.

Figure 8



An earlier inspection of this slide is summarised in the review section. During this review it was noted that part way down the main slide scarp a spring flows out the base of weathered diorite. The slide scarp is complex with multiple crowns and scarps, 22-year-old trees in a scar and recent debris piled against trees indicated active and ongoing instability. Although the debris flow down Schesnuk Creek appears to post-date the road assessment, it is apparent that debris slides have been going on for some time. At Station 26 there are scattered old to ancient small debris slides in the forest adjacent to the active slide scarp, the slope gradient is 90% and is underlain by sandy to silty gravel.

Investigation of the main slide scarp associated with the 2012 event, found that there is a draw which ends at a 2.5m high rock face above the scarp, upslope of the rock face there is a broad wet area. A 2m wide boulder swale sweeps in from the south, just to the south there is a 5m deep trench that discharges directly into the scarp area. It is likely that the “wet bench” was drained by the deep trench triggering the original debris slide on the south side of the recent unstable area. Upslope of the bench, a debris cone deposited on the old mining road (1983) below a trench (or draw) indicates mass wasting from upslope, this is directly below the “spring” noted previously flowing out of the tailings pile. It was noted that there is water pooled in the Lizzie adit which has been partially blocked by a bulldozer push. It is possible that at times water flows out of the adit, down the trench (or draw) and is directed onto the wet bench (and subsequently to the scarp) by a shallow cross-ditch. Debris slides entering Schesnuk Creek channel trigger debris flows when there is enough water in the creek to mobilise the debris. Although there are older debris slides, there was no evidence of debris flows prior to 2008, suggesting increased slope drainage in Schesnuk Creek may be at least partially responsible for the transition from debris slide to debris flow.

Additional harvesting and road construction were done in 2017. There was no evidence of increased slope drainage in the swales and draws in the newly harvested area to the south of Schesnuk Creek Catchment.

Station	Description	Age	Mode
selinter 22	Slough in debris deposition,	25	deposition
selinter23	Debris against trees	5-35	transport

Station	Description	Age	Mode
selinter 24[2]	numerous 1 to 1.5m channels and 1 to 1.5m levees,	15-50	Transport/ deposition
selinter25	edge of slides. debris against trees.	15-50	Transport/ deposition
selinter 26	Debris slide, multiple events, (slump then slide)	5-50	Initiation
selinter 27	multiple crowns/headscarps,	15-50	Initiation
selinter 28	Top scarp.	15-50	Initiation
selinter 73	debris slide enters Schesnuk creek.	5	erosional
selinter 74	crown, two scarps,	5	Initiation

Figure 9

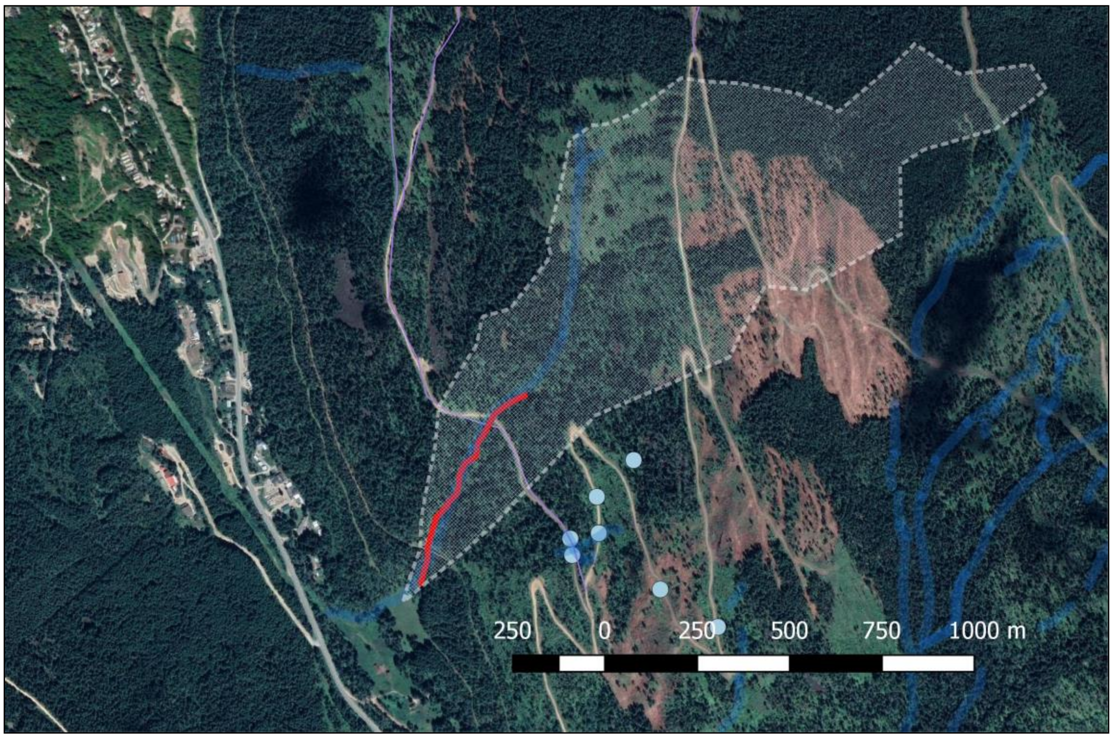


Figure 9 illustrates the development in Schesnuik Creek Catchment.

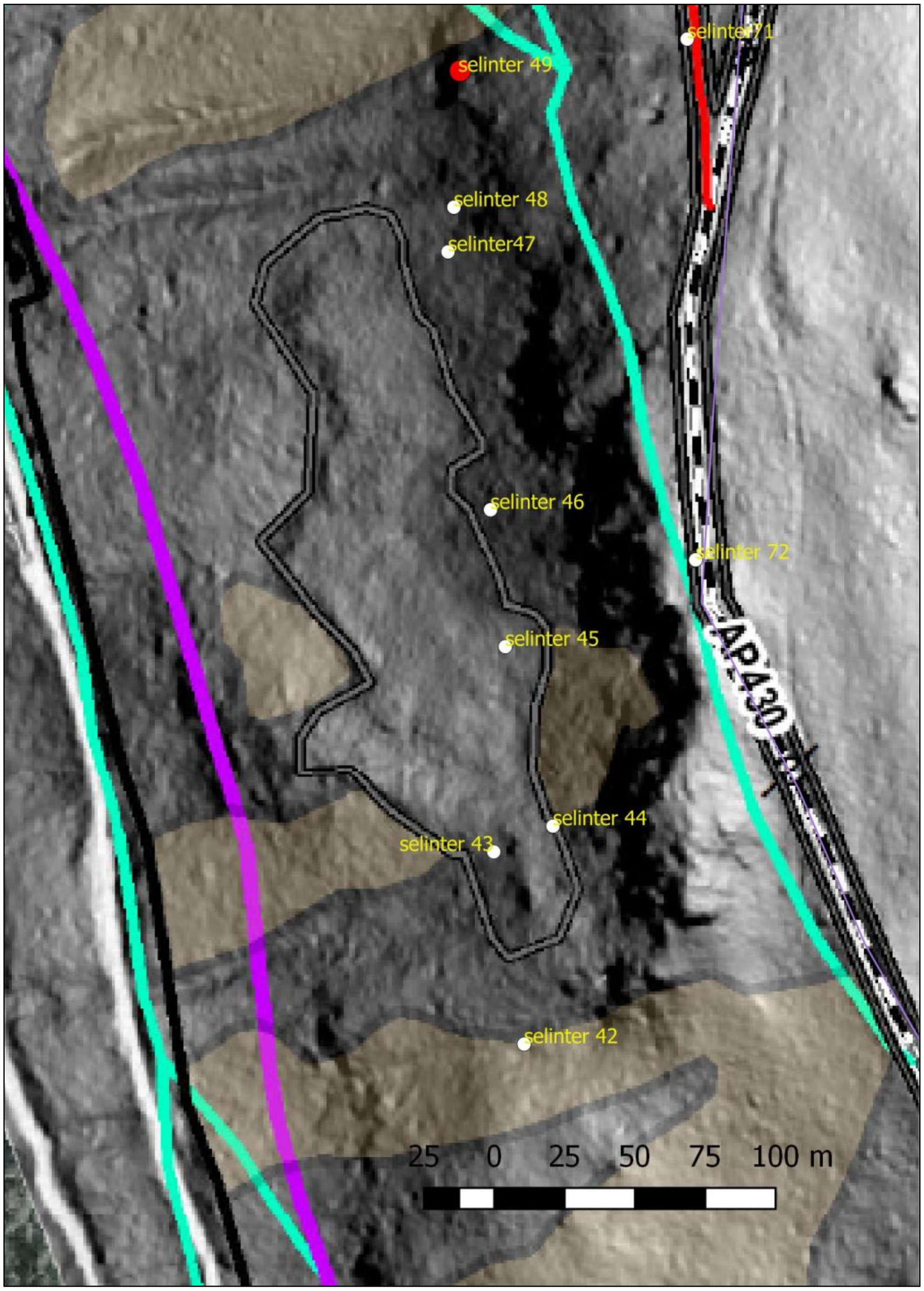
<u>Area #3: Stations 42 to 47; Figure 10:</u>

Rockfall/topple occurs along the bluff faces. Individual blocks currently are stopping along the upper to mid portion of the blocky talus slopes below the bluffs. The blocky talus slopes average 65% and are rough and loose. Bluffs are up to 20m high. Inclinometer sighting on buildings below is about 45% (~24^{o}).

These events are ongoing but isolated, likely triggered by frost heaves and tree churns.

[2] Located between stations 23 and 25 on figure #8.

Figure 10



Area #4: Stations 48 to 59; figure 11:

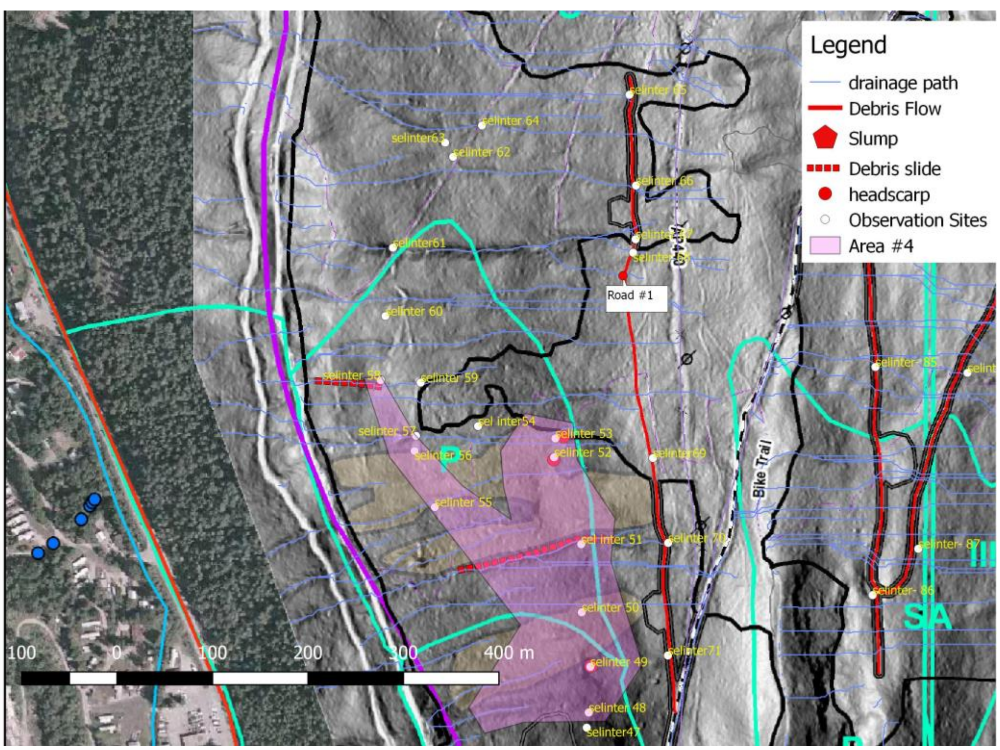
This area is underlain by at least 2m of variably sandy (from 30 to 100% sand) loose gravel. Several swales (2m deep floored in rock) occur across the slope. These swales are likely ancient to historic debris slide scars. Soil pits give variable thicknesses of Bm indicating some modification of the soil profile. At station 51 there are two debris slide swales parallel to each other, the smaller one has a good Bm profile in the bottom, the soil in the bottom of the larger of one has no Bm suggesting a debris slide (or extensive wash) 50 to 100 yrs. ago. It is possible that the swale was "washed" due to increased slope drainage after the last fire, or water was diverted down the swale for mineral exploration.

Old mining trails and recent mountain bike trails crossing the slope have intercepted and diverted slope drainage.

There is a complex headscarp between two deep swales at station 52. The soil profile is not as well developed as on adjacent slopes indicating some activity ~100 yrs. ago.

Station	Comment	age	mode
sel inter 51	Debris Slide.	50 -100 yrs.	erosional
selinter 52	Complex headscarp between 2m deep swales.	100 yrs.	Initiation
selinter 58	debris slide or hydraulic trench on 55% slope, sandy boulder gravel, no sign of water.	100 yr.	erosional

Figure 11



Area #5 Ancient Debris slide, station 94:

Just downslope from station 94 there is an ancient debris slide fed by a semi arcuate draw ahead of the station. The draw is likely an ice contact feature or ancient anti-scarp. This slope has been modified by mineral exploration.

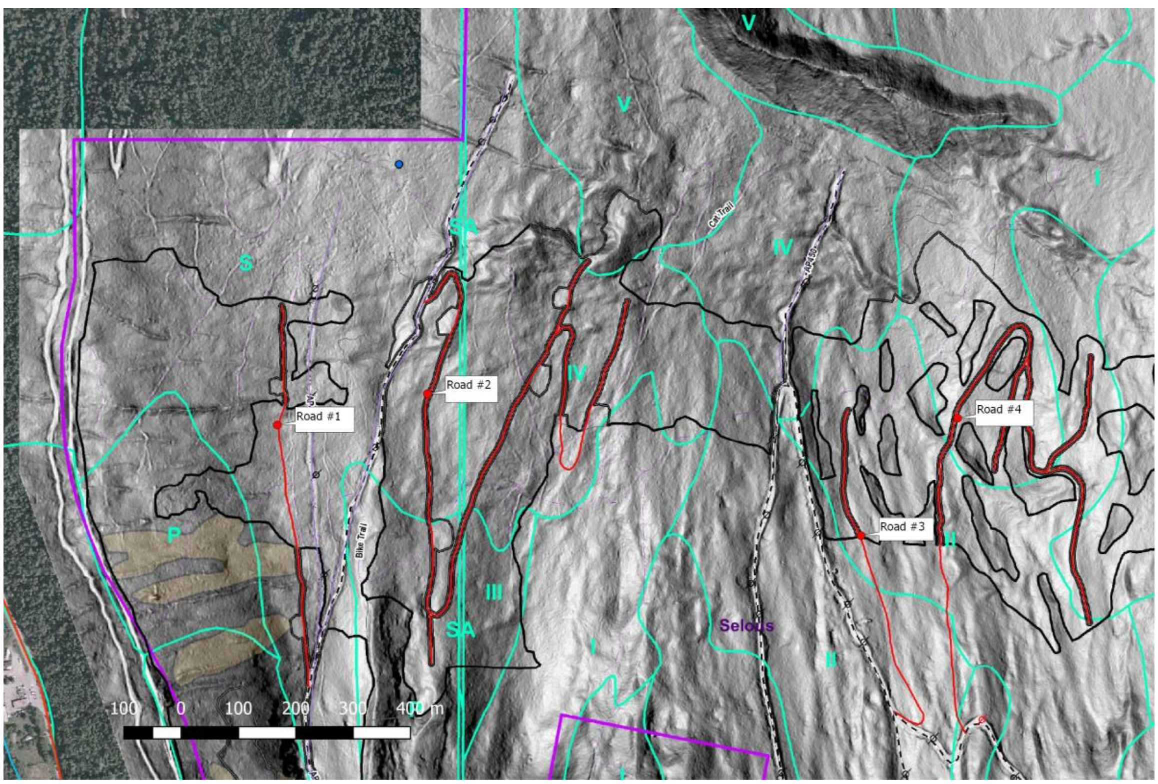
Station	comment	age	mode
selinter- 94	Debris slide below	>500 yrs.	initiation

Failures on the slope do not progress to significant debris flows and slides and do not impact downslope resources.

4.5 Proposed Roads:

There are four new roads proposed for this development. For the purposes of this report the roads are designated Road #1, Road #2 , Road #3 and Road #4. (figure 12). Roads 1 and 2 were traversed during this assessment, the area north and downslope of Road 4 was inspected to determine and possible impacts to Ward creek. Road #3 was not field assessed, the road is immediately upslope of the existing Main Road.

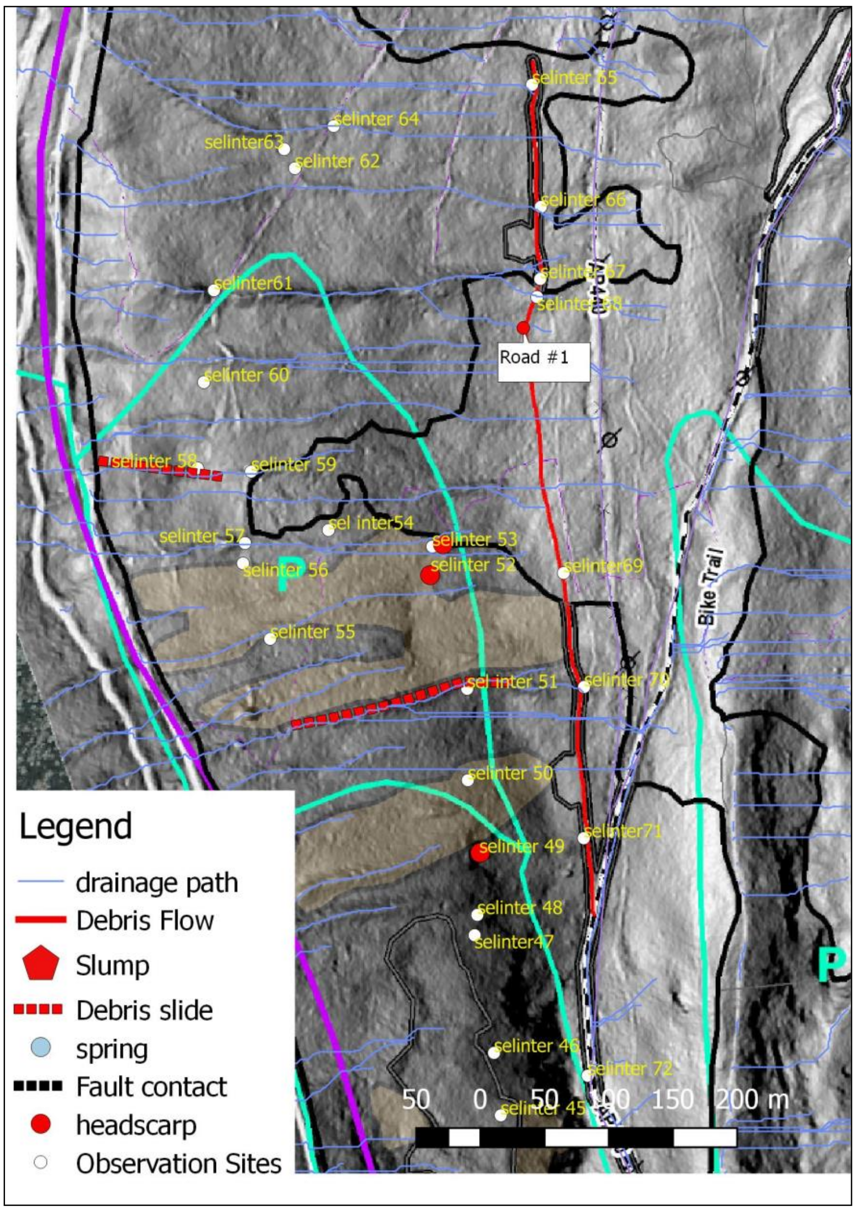
Figure 12



Road #1 (Stations 65-71, Figure 13).

The POC of the road is off Spur 430. The proposed road is situated downslope of spurs 430 and 440, spur 440 has been deactivated. Old mining trails and roads are common on this slope. The slope traversed by the road has a gradient less than 55% with no evidence of instability. Proposed culvert locations are well situated, additional culverts were marked in areas of minor flows and old wash. The proposed road is partially upslope of Area #3 and is upslope of Area #4. There are no slides associated with existing Spurs 440 and 430.

Figure 13



Station	Comments
selinter 65	on road minor wash below, or game trail, no evidence on old road, ancient slump below. culvert? minor swale above. not marked.
selinter 66	station r6 spur1 cp79-1, dry swale, on old road, culvert already marked. 45%.
selinter 67	small swale, minor evidence of flow (in past). hole in trail. possible water, blue culvert, mossy boulders below, 30%.
selinter 68	just past r5, dry small headwall? likely dry, feeds same swale as one back, check after construction. edge of existing block. blue 2
selinter69	to 45% or less o obvious drainage, match upslope road.
selinter 70	45%, headscarp of swale, looks stable, old mining trail terminates at head, may have been used to direct water, culvert marked already, no obvious water. 45% slope, did cross short section of 55%, steeper below.
selinter71	55%, right below road, small swale, 2 blue, no obvious culvert on upper road.

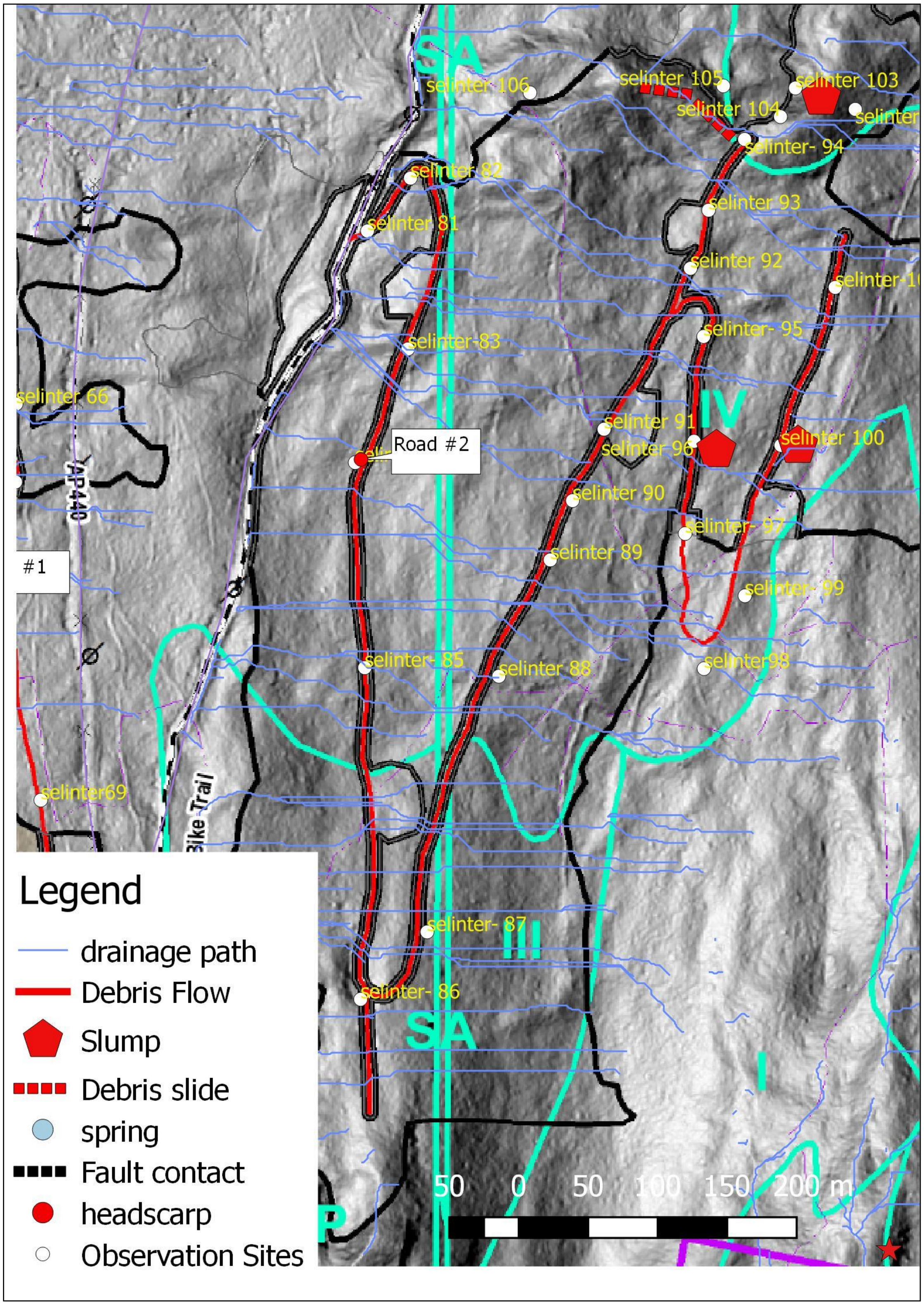
Road #2 (stations 81-101) Figure 14:

Except for very short slopes, the slope gradient is predominantly 45% or less. The short steep slope coincides with ancient rock slump scarps. For the most part proposed culverts are well located, suggested additional culverts are marked in the field with three blue flagging or yellow flagging. The lowest portion of the road appears to coincide with the fault trace, road cuts may intercept springs. The road switches through small flats, draws and rocky knolls. The northern portion of the road is underlain by sand rich soils.

Station	Comments
selinter 81	poc road.
selinter 82	road switch by swale, make sure water into swale, rock mounds.
selinter-83	+60%, flat and swale below, small swale, culvert previously marked, looks like old wash from flats upslope, may be small depression, human caused?
selinter-84	at end of bench, pitches from north slightly to here, loose sandy angular rubble (mostly granitic), +/-30%, no sign of water on skid trail. old mining trails upslope.
selinter- 85	from 84 to here on skid trail, slope 40% or less, minor erosion here, road culvert, possible small granite outcrop just back.
selinter- 86	small rock knoll/bench -55%, rock steps, +55%, to here terrain generally 45% or less, mod compact sand 25%, silt 10%, sub rounded well graded gravel 65%, sandy gravel Till. culverts marked where I would place them
selinter- 87	sandy angular rubble, mostly granite, some volcanic and mafic, 55 to 60%. occ small outcrops and rubble, could be small trenches.
selinter 88	dry swale road culvert, blocky terrain to here, small bench below, occ outcrops, sandy Till increasing, slopes 60% or less. swale is sinuous with small piles of dirt in places on side, trench?
selinter 89	old mining bulldozer trail, no evidence of scour or erosion.
selinter 90	just past rp11, skid cut, looks like water came out of forest floor, slight erosion, mod compact sand till, 45%, culvert yellow. possibly redirect3d from upslope cat road, recently clear3d, skid.
selinter 91	on 60%/30% break, old bulldozer trail just upslope, silt sandy subangular to angular volcanics, silt 20% sand 20% cf 60%, sub vert cut on cat trail.

selinter 92	onto bench, +70%, short, trench or small adit on slope, timber shoring exposed in cut, could have been reopened in 60's or 80's then re blocked.
selinter 93	multiple zones of old forest floor wash, complex swale upslope old tree churns redirect flows, just before sta. 17, road culvert, stepped and mounded terrain occ small volc outcrop, check in freshet. 40% average, this culvert will discharge into a small depression below, there is wash here, back would discharge into discontinues swales., south pitching bench ahead ends at culvert location.
selinter- 94	road ends at shallow swale across bench, fed by deeper arcuate draw from north feeds ancient debris slide swale on 55% slope below bench, large granite boulder just peaks out in swale, further down deeper draw. this slope has been modified by mineral exploration, the arcuate draw likely ancient feature (ice contact). slump scarp.
selinter- 95	at toe of short7 0% slope, bench at base, small pits and diggings, silty angular colluvium, 85% cf rock at top of break, 15m up. just before r19, pot spur 1, possible spoil from diggings, then onto base of 55%, silty sandy colluvium (siliceous, cf 75%), likely rock close in places.
selinter 96	start cross angle up short 60% ancient small slump scarp, head right here, silt 20%, sand 20%, sub angular cf 60% some black phyllite, -40%.
selinter- 97	onto bench, back 55%, here -55%, +35%, stepped and benched. just before cleared zone, block boundary flags. just back old bulldozer shallow trench running downhill, push against tree, just ahead old bulldozer trail.
selinter98	top of switch? bulldozer trails.
selinter- 99	short 65% step, silty colluvium, road at toe on bench, large flat benches upslope. large tree churns pull up rock.
selinter 100	broadly stepped, occ ancient slumps, some with antiscarp. stable, average slope 40%.
selinter-101	to here, on bench, from here 55% rubble block apron deposited on 30% slope from short 65% slope to end of road. slope above step, broadly benched, no need to check.
selinter 102	+/-80 to90%, silt 5%, sand%, angular volcanic, tuff, rubble 90%, no sign of instability, deep antiscarp below would limit runout. dry well drained, no trails.
selinter 103	knoll. granitic.
selinter 104	80%, mossy rock, aplite with fine grained volcanic.
selinter 105	80%, mossy rock, aplite, fine grained volc.
selinter 106	ancient boulder deposits.
selinter 107	6m high 100% cut, broken intrusive, sandy matrix, breaks to small rubble, loose, permeable, zones of volc light.
selinter-108	sandy swale, moist in ditch, no channel
selinter 109	mossy spring in draw, pool by ditch, disperse below road, mostly in one swale, crumbly augite porphyry, silty sand.
selinter 110	small sharp swale just off road.

Figure 14


SA
selinter 106
selinter 105
selinter 103
selinter 104
selinter- 94
selinter 82
selinter 81
selinter 93
selinter 92
selinter- 95
selinter-83
selinter 66
IV
selinter 91
selinter 96
selinter 100
Road #2
AP440
selinter 90
selinter- 97
#1
selinter 89
selinter- 99
selinter- 85
selinter 88
selinter98
selinter69
Bike Trail
Legend
drainage path
Debris Flow
Slump
Debris slide
spring
Fault contact
headscarp
Observation Sites
selinter- 87
III
selinter- 86
SA
I
50 0 50 100 150 200 m
P

Road #4: (Stations 107 to 130) Figure 15:

Road #4 is potentially partially within Ward Creek Catchment. The field assessment was to determine if there was a direct linkage to Ward Creek and if there were indicators of instability within the proposed development area that could impact Ward Creek. The surficial material around Ward creek has a high sand component. The proposed development is set back from the steep side slopes to Ward Creek. There is a small seasonal stream (stations 111-116) that parallels Ward Creek, this channel forms the boundary of the existing blocks and was surveyed in as part of the CP 29 stream assessments. There are old sand levees and recent scour within, and adjacent to, this channel. The most recent levees are likely related to the last fire, the recent scour is likely related to recent increased slope drainage (likely correlates to the recent slides).

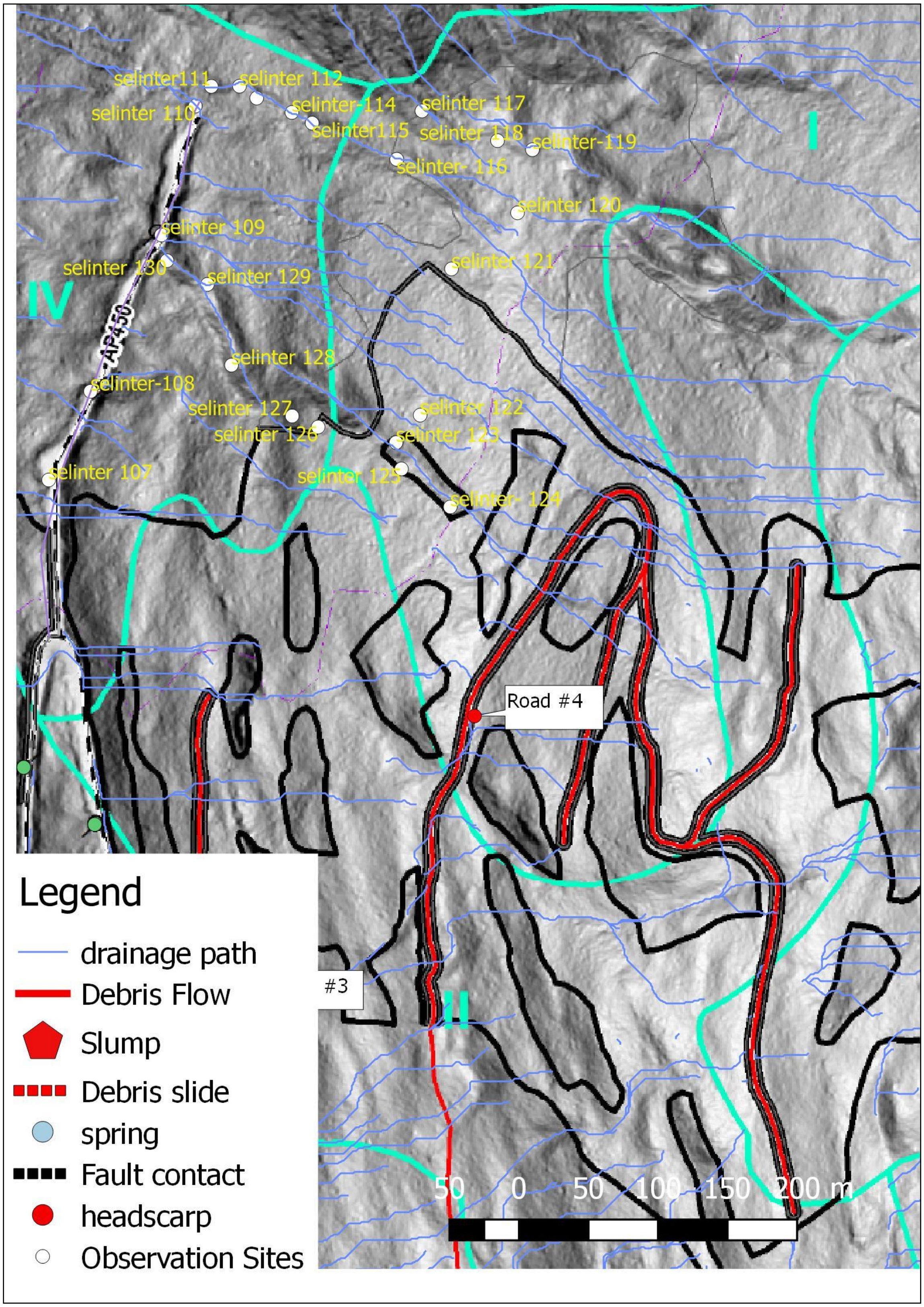
The headscarp of this portion of Ward creek (117-119) is a series of ancient broad slumps, large debris slides (pre-date last fire) and smaller debris slides (postdate last fire). This area is within the reserve and is unlikely to be impacted by the proposed development.

Station	Comments
selinter 107	6m high 100% cut, broken intrusive, sandy matrix, breaks to small rubble, loose, permeable, zones of volc light.
selinter-108	sandy swale, moist in ditch, no channel
selinter 109	mossy spring in draw, pool by ditch, disperse below road, mostly in one swale, crumbly augite porphyry, silty sand.
selinter 110	small sharp swale just off road.
selinter111	silty sand, apparent weak cohesion, recent minor scour, old levee on south side (100yrs?). 45%. floored in blocky rubble at scour steps.
selinter 112	sed behind trees, bm on trim, but could have sloughed in. no bm on recent small scoured banks, later sloughed in.
selinter-113	either large sand levee or excavated.35%, light bm on top.
selinter-114	tree churn at top of levee, poorly confined, older small channel parallel from, here, no mostly flows in main channel. 1m confinement upstream from here.
selinter115	3m broad confinement, scoured channel, 45%.
selinter-116	top of deep confinement, broad swale here, overall 3m deep, 5m wide, sand sed wedges with Bm, so levees started at outlet of deep confinement 45% on 30% slope, here 35%, not as obvious scour, some scour and erosion after fire, recent 8ncrease in erosion, historic debris flow channel but more recently just wash and transport of sand sloughing in.
selinter 117	very wide, 2m deep debris slide 55%, good bm in bottom 2m rounded scarp on sides, burnt snags, old but not ancient, soil silty sand. series of, these slide across the slope, in this on north edge, pit compact sand, no, burn, smaller slide within bigger slide, after fire.

Station	Comments
selinter 118	head of large slump? debris slides at edge, small ones off scarps postdate fire, moist soil, draw discharges onto head just upslope, +10%/-45%, trees seem straight but lots of deadfall marking trees.
selinter-119	actually, draw splits around knoll head.
selinter 120	swale seems dry here, 25%-35%, possible multiple upslope, must crossed 2 shallow swales, quickly confined downslope.
selinter 121	dry swale starts just upslope, 30%, likely before drainage pattern established flow3d off flats in a number of places, caution upslope for diversions. tree churn just in block 30%, veneer of silty sandy till over crumbled augite porphyry
selinter 122	25 to 35% slope, deep swale just upslope, seems like dry spring on open slope below.
selinter 123	short 70% sideslope, sandy rubble into dry draw, upslope less confined, caution of diversions, but likely deeper water.
selinter-124	gps lower than trail, headed up to trail, dry swale, headscarp of parallel swale just to south. +15%-30%. no erosion on bike trail,
selinter 125	this is where gps says 124 is.
selinter 126	60% gully 5m sideslope, looks dry, 30% slope here but steep coming up.
selinter 127	65%, underlain by crumbly augite porphyry. gully cut mostly through the step. except for last 4m no channel on slope, adjacent swale dries above step,
selinter 128	55% gradient to 15%, road flat, confining sideslope reduced ahead, no obvious spring yet. step likely due to geology change, felsic tuff chunks in tree churns.
selinter 129	tree churns show water pooled here, black elderberry, 35% to a small step just ahead.
selinter 130	spring out of bottom of south sideslope, sideslope 3m high. just above road, likely from bottom.

There is a permanent spring within a draw crossed by spur 450 downslope of the proposed road. The spring (station 130) occurs just “upstream” of the road crossing, the draw was inspected within and downslope of the proposed development to the road crossing (Stations 123 -130). At station 123 the draw is a dry sandy rubble draw, upslope at station 124 the draw is a swale and is crossed by a mining trail. The draw (s) is dry with no evidence of surface flows until around 129 where water is pooling in tree churns in the broad draw bottom, at station 130 there is a strong spring out of the south side slope of the draw. The flow is carried across the road in a culvert and discharged onto what appears to be a broad scarp, the stream disperses across the slope, there are no obvious draws or swales downslope in the existing cut block.

Figure 15


selinter111
selinter 112
selinter 110
selinter-114
selinter115
selinter 117
selinter 118
selinter-119
selinter- 116
selinter 120
selinter 109
selinter 130
selinter 129
selinter 121
I
IV
AP450
selinter 128
selinter-108
selinter 127
selinter 126
selinter 122
selinter 123
selinter 107
selinter 125
selinter- 124
Road #4
#3
II
Legend
drainage path
Debris Flow
Slump
Debris slide
spring
Fault contact
headscarp
Observation Sites
50 0 50 100 150 200 m

5. Implications, Recommendation and Risk Analysis

Proposed Road Construction:

Roads and trails can alter slope drainage patterns by reducing soil infiltration (along road surfaces), routing water down road surfaces and ditches, intercepting and concentrating dispersed slope drainage into plumes below culvert outlets, intercepting sub surface water, and altering catchment boundaries.

Road #1:

The slope traversed by the road has a gradient less than 55% with no evidence of instability. The proposed road is partially upslope of Area #3 and is upslope of Area #4. Existing roads upslope of the proposed road do not appear to be associated with downslope instability. To maintain downslope stability natural drainage patterns must be maintained. In general, match the road drainage to the upslope roads, during the assessment two additional culvert locations were marked (stations 67 and 71). A small dry headwall at station 68 should be inspected after construction for evidence of a spring.

Station	Comments
selinter 67	small swale, minor evidence of flow (in past). hole in trail. possible water, blue culvert, mossy boulders below, 30%.
selinter 68	just past r5, dry small headwall? likely dry, feeds same swale as one back, check after construction. edge of existing block. blue 2
selinter71	55%, right below road, small swale, 2 blue, no obvious culvert on upper road.

If current slope drainage is maintained the construction of the road will not significantly increase the likelihood of landslide initiation.

Road #2:

Road #2 switches through predominately gentle to moderate gradient slopes.

For the most part proposed culverts are well located, one additional culvert location is suggested at station 90, just past RP 11, marked in the field with yellow flagging. At Station 82 the road switches by a swale, ensure the water is directed into the swale. The lowest portion of the road appears to coincide with the fault trace, road cuts may intercept springs, check after construction.

Station	Comment
selinter 82	road switch by swale, make sure water into swale, rock mounds.
selinter 90	just past rp11, skid cut, looks like water came out of forest floor, slight erosion, mod compact sand till, 45%, culvert yellow. possibly redirected from upslope cat road, recently cleared, skid.

If the current slope drainage is maintained construction of the road will not significantly increase the likelihood of landslide initiation.

Road #4:

Construction of road #4 is unlikely to have an impact on Ward Creek drainage.

Proposed Harvesting:

Depending on the percent of canopy removal, timber harvesting can alter snow accumulation and melt rate, which can result in increase in slope drainage. Removal of understory may result in increased soil moisture. Depending on the silviculture prescriptions (i.e. no planting, reduction of basal area, recurring thinning) that are implemented for fire mitigation; hydrological recovery of the hillslope may not achieve current conditions resulting in permanently elevated slope drainage conditions. Increased soil moisture and increased slope drainage will increase any potential downslope instability.

Terrain Stability:

Areas of potential instability are grouped in 5 areas as listed below.

Area #1:

There is minimal proposed harvesting upslope of Area #1. The proposed development is unlikely to significantly increase the Pa>0.002 probability of landslides which is a low annual likelihood of landslides.

Highway 3 is located across Cottonwood Creek and is generally elevated above the creek level, as such, it is not at risk from a landslide originating along this segment of the slope.

The debris slide gullies/swales terminate on a 60m wide < 20^{o} upslope of the Rail Trail and private land. So, from table 5.1 the relative likelihood of debris reaching the rail trail and private land is:

Table 5.1. Likelihood of a Debris slide or Sediment Reaching or Affecting elements considered for risk

Relative Rating of Likelihood of a Landslide Affecting elements	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly affect elements considered for risk.
Moderate	There is a run-out slope of<20º gradient and <200 m in length, or another terrain configuration which could possibly intercept or dissipate a potential landslide debris and/or sediment from erosion (e.g. irregular or benchy rock-controlled terrain) below and between the development and the elements considered for risk.
Low	Landslide debris and/or sediment from soil erosion is unlikely to reach or affect the elements considered for risk at the time of an event. There is a run-out slope of <20º gradient for >200 m, or another terrain configuration which would likely intercept or dissipate sediment or landslide (e.g. irregular or benchy rock-controlled terrain), below and between the development and elements considered for risk.

The Hazard is determined by the matrix shown in Table 5.2:

Table 5.2. Matrix for determining Hazard rating.

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Selected Elements		
		High	**Moderate**	**Low**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low

Slides along here are unlikely to significantly damage the rail trail.

Table 5.3: Rail Trail

Consequence	Effect
High	Structural Damage
Moderate	Moderate damage, moderate damage to access road (repairable).
Low	Minor damage to Minor erosion to/or deposition on the access road (minor repairs, still useable).

Table 5.4 Matrix for determining partial risk for trail.

		Consequence		
		High	**Moderate**	**Low**
Hazard	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low
	Very Low	Low	Very Low	Very Low

Slides could possibly impact private land.

Table 5.5 Matrix for determining partial risk for private properties/Highway 3.

		Consequence
		High
Hazard	**Very High**	Very High
	High	Very High
	Moderate	High
	Low	Moderate
	Very Low	Low

Slides pose a Moderate Risk to private land.

Area #2 Schesnuk Creek:

Altered slope drainage associated with mineral exploration activities may have contributed to the 1997 debris flow. Environment Canada estimated a 1 in 100 recurrence for the June rains.

Increased slope drainage associated with timber harvesting of the upper catchment of Schesnuk creek may have contributed to the debris slide/flow in 2012.

The estimated catchment for Selous Creek is shown on the imagery in figure 9, the image also shows some of the existing development within the catchment. At least two significant debris flows down Schesnuk creek have occurred in the past ~ 20 yrs. (1997 and 2012), there is evidence of more recent debris slides off the slide scarps that have not transitioned into major debris flows (but possibly smaller debris flows that did not reach private land). The recurrence rate of major debris flows is assigned a 1 in 20-year return for a Pa of 0.05, this is deemed a very high likelihood of landslides.

The proposed development (including portions of Roads 3 and 4) encompasses most of the remaining timbered area of the upper catchment.

The proposed additional harvesting would likely increase the likelihood of landslide initiation, so an adjustment is made from a 1 in 20 year return period to a 1 in 10 year return period, giving a Pa of 0.1. Assuming 30-years to hydrological recovery (if the plans allow for recovery), using $Px=1-[1-(Pa)]^x$

$P_{30} = 1- [1-(0.1)]^{30} = .96$, there would be a 96% likelihood of a major debris flow down Schesnuk Creek within the next 30 years. The 1997 debris flows destroyed the trestle on the rail trail, deposited sediment on private land, caused sedimentation in Cottonwood creek and impacted water infrastructure (which may have been moved). Highway 3 is located across Cottonwood creek and is generally elevated above the creek level, as such, it is deemed to not be at risk from landslide originating along the slope assessed.

So, from tables 5.6 and 5.7.

Table 5.6 Likelihood of a Debris slide or Sediment Reaching or Affecting elements considered water intakes, water quality, trail and Private Land.

Relative Rating of Likelihood of a Landslide Affecting elements	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly affect elements considered for risk.
Moderate	There is a run-out slope of<20º gradient and <200 m in length, or another terrain configuration which could possibly intercept or dissipate a potential landslide debris and/or sediment from erosion (e.g. irregular or benchy rock-controlled terrain) below and between the development and the elements considered for risk.
Low	Landslide debris and/or sediment from soil erosion is unlikely to reach or affect the elements considered for risk at the time of an event. There is a run-out slope of <20º gradient for >200 m, or another terrain configuration which would likely intercept or dissipate sediment or landslide (e.g. irregular or benchy rock-controlled terrain), below and between the development and elements considered for risk.

Table 5.7. Matrix for determining Hazard rating.

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Selected Elements		
		High	**Moderate**	**Low**
Likelihood of Occurrence of Debris flow down Schesnuk Creek.	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low

Debris flows in Schesnuk Creek are deemed a Very High Hazard.

Due to the improved crossing on the rail trail the debris flow will likely have minimal impact on the trail (Table 5.8).

Table 5.8: Rail Trail

Consequence	Effect
High	Structural Damage
Moderate	Moderate damage, moderate damage to access road (repairable).
Low	Minor damage to Minor erosion to/or deposition on the access road (minor repairs, still useable).

Debris flows down Schesnuk Creek will have a low consequence to the trail, so from Table 5.9.

Table 5.9 Matrix for determining partial risk for trail.

		Consequence		
		High	**Moderate**	**Low**
Hazard	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low
	Very Low	Low	Very Low	Very Low

Debris Flows down Schesnuk Creek are deemed a High Risk to the trail.

There appears to be a water intake on Private Land on Schesnuk Creek. From the slope map it appears that most of the debris from a debris flow down Schesnuk Creek will be deposited upstream of the intake, however significant sedimentation will likely impact the intake, the vulnerability of the intake is unknown but it is likely there will be moderate damage and short term deterioration of water quality. So, from table 5.10.

Table 5.10: Water quality and water supply infrastructure

Consequence	*Effect*
High	Long-term or permanent deterioration of water quantity/ quality. Complete destruction of water intake structures.
Moderate	Short-term deterioration of water quality/quantity, repairable damage (1 week) to water intake structures.
Low	Short-term (less then 1 week) deterioration of water quality/quantity, "damage" to water intake structures repairable during regular maintenance.

The impact of the debris flow is deemed to have a Moderate Consequence. The risk is shown in table 5.11.

Table 5.11 Matrix for determining partial risk for water resources.

		Consequence		
		High	**Moderate**	**Low**
Hazard	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low
	Very Low	Low	Very Low	Very Low

Debris Flows down Schesnuk creek are a Very High Risk to water quality and infrastructure.

The debris flow will reach private land and secondary sedimentation will reach Cottonwood creek but will not reach Highway 3.

As stated previously, for this assessment, if the landside reaches private land it is deemed high consequence. The vulnerability of private land is not taken into consideration.

Table 5.12 Matrix for determining partial risk for private properties.

		Consequence
		High
Hazard	**Very High**	Very High
	High	Very High
	Moderate	High
	Low	Moderate
	Very Low	Low

Debris Flows down Schesnuk pose a Very High Risk to private land.

Area #3:

Rock fall and topple along the bluff faces occurs upslope of large blocky talus slopes. Isolated rockfall and topple occurs every 5 to 10 years. Recent falls have terminated on the talus slopes well back from the lower slopes. Structures and the highway are at the base of the slope. Rockfall/topple off the bluffs will free fall for a maximum of 20m (highest bluffs) before impacting the ground, losing much of the energy gained during freefall. The rocks are competent and will likely remain intact. After the first impact, the rock will likely “bounce” a short distance down slope. The 65% slope gradient is likely insufficient to sustain bouncing and the block will quickly transition to “rolling” or sliding. The angular shape of the block, the roughness and looseness of the talus slopes will result in the “rolling” block stopping along the upper to mid portion of the talus slopes, making it unlikely to reach the lower slopes and impacting structures or the highway. The forested slope below the talus will further reduce the likelihood of rocks reaching the trail or highway.

Table 5.13 Likelihood of a Rockfall or Affecting elements considered water intakes, water quality, trail and Private Land.

Relative Rating of Likelihood of Rock Fall/topple Affecting Elements assessed	Description of Activity and/or Geomorphic Conditions
High	Multiple rocks will reach or directly impact private property or Rail Trail. The elements are within 30° shadow zone of rockfall
Moderate	There is a run-out slope of <30° gradient and <50 m in length, or another terrain configuration which could possibly intercept or dissipate rockfall energy. (e.g. irregular or benchy rock controlled terrain, hollows, depressions, ridges) below the rockfall area.
Low	Rockfall is unlikely to reach or affect private property and/or rail Trail. There is a run-out slope of <30° gradient for >50 m, or another terrain configuration which would likely intercept or dissipate sediment or landslide (e.g. irregular or benchy rock-controlled terrain), upslope of the elements considered for risk.

Timber harvesting, especially yarding trees upslope over the bluffs may dislodge some blocks from the bluffs and the upper portions (steeper) of the talus slope. Assuming a very high Likelihood of rockfall and a low likelihood that the rocks will reach the elements a risk. The Hazard determined by table 5.14.

Table 5.14 Matrix for determining Hazard rating.

		Likelihood that Rockfall Will Reach or Otherwise Affect Selected Elements		
		High	**Moderate**	**Low**
Likelihood of Occurrence of Rockfall	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low

The rockfall hazard is high, the partial risk is determined by the matrix in table 5.15.

Table 5.15 Matrix for determining partial risk for private properties/Highway 3.

		Consequence
		High
Hazard	**Very High**	Very High
	High	Very High
	Moderate	High
	Low	Moderate
	Very Low	Low

Rockfall poses a very high risk to the highway and private land.

Area #4:

There are a series of debris slide scars and headscarps present along this slope. Mining trails cross the swales and do not appear to have been impacted by debris flows/slides. The debris slides appear ancient but there are areas of poor soil development (no Bm), buried soils, and variable soil profiles indicate at least some erosion and/or sediment transport post fire. It is likely that these features are associated with slope wash and erosion after the last fire and/or redirected slope drainage along old mining trails.

The area is downslope of proposed road and existing roads, existing cut blocks and proposed cut blocks. It is not known what the harvest prescriptions are for the cut blocks.

For this assessment it is assumed that the debris slides are >500 yrs. (Pa<0.002; low likelihood of landslide initiation) and that the variable soil profile was caused by slope wash/soil erosion from increased slope drainage and forest floor removal caused by the last major forest (~100 yrs. ago). The proposed harvesting on the slope and upslope of the area will likely result in increased slope drainage. Unlike the forest fire however, the forest floor will remain mostly intact which will reduce the amount of soil erosion. Assuming natural slope drainage is maintained along the proposed and existing roads and a 30-year hydrological recovery: $P_{30} < 1- [1-(0.002)]^{30} < .06$ (Low Likelihood of Landslide initiation).

The swales and gullies do reach the lower slopes, making it likely that if a debris slide did occur, it would reach the lower slopes. No water intakes are plotted along the lower slope, there is the rail-trail and a road just below the trail. Impact on the trail will likely be moderate to minor damage with minor damage to the lower road. It is likely that debris will reach private property at the toe of the slope.

Table 5.16 Likelihood of a Debris slide or Sediment Reaching or Affecting elements considered water intakes, water quality, trail and Private Land.

Relative Rating of Likelihood of a Landslide Affecting elements	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly affect elements considered for risk.
Moderate	There is a run-out slope of<20º gradient and <200 m in length, or another terrain configuration which could possibly intercept or dissipate a potential landslide debris and/or sediment from erosion (e.g. irregular or benchy rock-controlled terrain) below and between the development and the elements considered for risk.
Low	Landslide debris and/or sediment from soil erosion is unlikely to reach or affect the elements considered for risk at the time of an event. There is a run-out slope of <20º gradient for >200 m, or another terrain configuration which would likely intercept or dissipate sediment or landslide (e.g. irregular or benchy rock-controlled terrain), below and between the development and elements considered for risk.

Table 5.17. Matrix for determining Hazard rating.

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Rail Trail and lower road		
		High	**Moderate**	**Low**
Likelihood of Occurrence of Debris slide/flow	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low

Table 5.18: Rail Trail

Consequence	Effect
High	Structural Damage
Moderate	Moderate damage, moderate damage to access road (repairable).
Low	Minor damage to Minor erosion to/or deposition on the access road (minor repairs, still useable).

Partial risk is the product of the hazard and the consequence as shown in table 5.19

Table 5.19 Matrix for determining partial risk for trail and lower road

		Consequence		
		High	**Moderate**	**Low**
Hazard	**Very High**	Very High	Very High	High
	High	Very High	High	Moderate
	Moderate	High	Moderate	Low
	Low	Moderate	Low	Very Low
	Very Low	Low	Very Low	Very Low

Landslides occurring in Area #4 pose a moderate risk to the trail and lower road

Table 5.20 Matrix for determining partial risk for private properties/Highway 3.

		Consequence
		High
Hazard	**Very High**	Very High
	High	Very High
	Moderate	High
	Low	Moderate
	Very Low	Low

Landslides occurring in Area #4 pose a high risk to private properties and Highway 3

Area #5:

There is one ancient slide that is far removed from elements considered for risk, the proposed development will not significantly increase the low likelihood of landslide initiation.

Respectfully Submitted,
Apex Geoscience Consultants Ltd.

Will Halleran P.Geo.

Jan 08/20

Appendix 1 notes.

Title	Description
selinter 1	cutslope slump, horse tail, no culvert.
selinter2	culvert
selinter 3	broad mossy spring.
selinter 4	end of spring, caliche.
selinter 5	rock spring, good flow off corner.
selinter 6	small mossy spring rock
selinter 7	mossy spring
selinter 8	mossy spring
selinter 9	mossy flow on rubbly cut, near mining cuts. minor tufa, almost obscured culvert. weather hot and clear.
selinter10	truck, cutslope 3.5m high, top 1 to 1.5m silty sandy till, over sandy broken rock, then broken volcanic, water out of cut at sandy broken rock, mossy, ditch shows flows, to culver at swale just down road, so road intercepts sub surface water, not flowing to much now, bench upslope, mining activity. check lower slope class IV and P.
selinter 11	mining trails trenches below road, stepped terrain, 55% rises, flats 5m wide, trench through bench.
selinter 12	3m deep trench.
selinter 13	possible ancient debris slide gully, headwalls gentle (not sharp) no obvious trim lines, large vets in bottom, slope at headwalls 40%, gully gradient 55%, sideslopes 55%. sand 35%, silt 10%, sub rounded to subangular well graded gravel 55%, loose, well drained, gully more v shaped then u, possible hydraulic trench. if natural > 500yrs, if trench >100yrs. not recurring, no sign of water.
selinter 14	minor old erosion at bottom of gully, unconfined here, small sed wedge, brown sandy soil, 30% slope here, 55% up, minor old channel around wedge onto steeper slope.
selinter 15	vertical rock face, 65% to 80% slope below.
selinter16	just below 55/85% slope break, ancient shallow slide, sand 25%, silt 10%, angular frags 65%, loose, thin soil over rock.
selinter 17	granite boulders.
sel inter18	broad gentle headscarp area, zones of mixed soils and gravel areas, rounded granite angular volcanic, good bm in places, +80%, 3m wide bench at base with large dead snag on it, then onto steep lower slope.
selinter 19	on trail 65%, 1.2m high 120%, silt 25%, sand 15%, well graded sub rounded cf 60%
seliinter20	+65%/-45%, occasional lapilli tuff outcrop in cut.
selinter 21	+45%/-35%, well graded sub angular gravel 75%. burnt snags over slope, no sign of instability.
selinter 22	small mine working face. small erosion channel. or small slump face. small old channel suggests water was moved around upslope (deliberate?). toe is boulders like it was washed, small cedar, hemlock like recent disturbance, but soil has developed. no obvious cut trees (recent). no large stumps on face or toe, base of toe two burnt stumps and 25dm cedar, one 30dm cedar at top of face. partially postdates fire. small pile of gravel sand (levee or digging) partially buried stump, fell over, doesn't appear burnt, rotten 35cm diameter. and against cedar,
selinter23	through small fir cedar hemlock (thick), old deadfall cut in trail, area is disturbed more than most recent debris flow, two small water pipes exposed in slide path. older mossy wet channel on right side, older slide. 4m high pine. follow up a bit. same age as sed wedges against trees.

Title	Description
selinter 24	numerous channels and levees, from brush area upslope, likely multiple failures 15 to 50 yrs. mostly deposition here, schesnuik slide carried through on far edge. 30 to 40 % slope here, no major draw so dissipated energy, levees 1 to 1.5m high, separated by channels 1 to 1.5 m wide.
selinter25	edge of slides. debris against trees.
selinter 26	gps seems wrong, walked up southside of slide, just in forest, 85 to,90%, sandy gravel, silty zones, no obvious tension cracks adjacent, just to south older smaller debris slide swale, burnt snags within it, trees straight, likely original location of water, smaller slides scattered all ancient, new slide is large, debris adjacent is now 2 to 3 meters above the base of the slide, likely multiple events,
selinter 27	multiple crowns, or a trail cut through, lowest crown 2 to 3 m wide no trees, 110% headscarp, removed further into slide, here scarred 25cm diameter spruce debris against 25cm diameter cedar. 22-year-old fir in scar that deposited material against cedar and scarred spruce.
selinter 28	Top scarp. sandy gravel, nose, or draw ahead, gps off. 120%, break at top of scarp. till, likely formed bench.
selinter 29	top of draw, 2.5m high outcrop, goes to slope break, 2m wide boulder swale sweeps around the south side. gps can’t be right, onto flats just to south is a 4 to 5-meter-deep sharp trench, no spoil, so possible hydraulic trenching, see an eroded channel entering.
selinter 30	trench location? feeds slide area, there may be spoil on north side.
selinter31	on road above trench 3 blue, rock in cut, culvert just ahead may miss trench but will feed slide area. looks dry.
selinter 32	culvert, over cut and down ditch.
selinter 33	point actually on the road so sifted up slope. 15 minutes, drifted to below road
selinter 34	gps point drifted to road, ditch and cut dry, swales culverted.
selinter 35	60% sideslope to schesnuik creek, dry now. silt 15%, sand 15%, loose, surrounded gravel, well drained, just back saw area of angular rubble in tree churn, likely rock close in places, bench just up slope. debris flow passed by here. even though recent deposition and trim, pits give brown soil, so soil change not indicative of age.
selinter 36	-70%/+45%, small step, loose silty sandy gravel with granite boulders.
selinter 37	+/-55%, dry granite rubble slope, with large boulders. could be wash after fire.
selinter 38	small granite outcrops, blocky rubble fields. +/-75%.
selinter 39	+/-65%, loose sand 15%, silt 5%, angular well graded rubble 80%,
selinter 40	+/-55%, coarse granite colluvium, broad shallow swale, old wash? cobble boulder "channel" on north side, no trees in swale, no soil to coarse, washed to cobble boulder?
selinter 41	to here, 35 to 55%, sandy rubble, occ outcrop of granite, here -75%/+55%, small rock lip, others down slope, large rock face down and to north, talus field below. so, these rubble slopes possible hydrophobic, now washed to coarse. old cut burnt stumps.
selinter 42	follow along 75% break, stable to base of blocky talus below bluff, blocky swale runs down, one recent block on blocky slope, blocky slope 65%, below 60%, blocks stay one blocky talus slope. stripped flagging along base of blocks.
selinter 43	+/-75%, blocky talus slope, large bluffs upslope, 55% bench between talus and bluffs.
selinter 44	large talus slopes ahead 65%, so careful back not to dislodge blocks, rare recent blocks on talus suggest occasional fall.
selinter 45	45% to top of trailer roof, photo of larger building 40%, 55% talus slope with steep toe, 100% to top of cliffs, which are 15 to 20 m high, 20m upslope.
selinter 46	forested 90% gradient rubble slope between bluffs and 60% talus slope.
selinter47	end of large bluffs, smaller outcrops, talus ends just ahead and below, here forested 85% slope, coarse colluvium.

Title	Description
selinter 48	rock headscarp of small swale, coarse colluvium, small bench below, may have seasonal wafer out of and over rock, adjacent slopes sand 25%, angular colluvium 75% (there has been no well-developed bm along this slope. +90/-80%
selinter 49	To here crossed 95% slope, shallow soils over rock, small outcrops, here, small rock head scarp, 100% fracture, vert fracture on contour, one sub vert normal to slope.
selinter 50	+/-75%, sand 15%, silt 5%, angular well graded granite 80%, loose, rock peeking out of slope.
sel inter 51	2m deep swale, floored in stepped mossy rock and coarse rubble under forest floor, likely erosion feature, 60% gradient same as slope, debris slide or induces, age? possible buried soil on side below sed, 100 yrs.? hot burn here, one overturned burnt rotten tree on side, likely post dares fire. sandy rubble then small rise to broader swale with trees in it, rise could be cone. Top of swale just upslope. good bm in bottom of swale, mon in deep swale, so first is more recent, 50 to 100 yrs. or so. from second swale about 15m upslope to 50% slope.
selinter 52	between 2 broad 2m deep swales, to here, pots are variable, from pure sand to 30% sand with sub rounded mix of rocks, good bm, more volcanics, crossed first swale 60% gradient, pits give coarse sand no bm, sandy gravel moderated bm, complex head scarp gives sandy gravel light bm, likely at least erosion post dares fire, 100 yrs.?, slope between good bm in loose sandy gravel, rounded well graded 50% slope.
selinter 53	55%, gentle headscarp at block edge (not obvious) shallow broad swale, coarse bottom but bm developed, ancient feature. existing block just ahead.
sel inter54	cross back and forth on swale, small granite outcrops silt 5%, sand 25%, well graded sub round to angular gravel 70%, bm across swale, 60%, 45% here, water has flowed down bike trail, discharged into swale, sed dep 6m down. deeper swale to south, gps may be wrong.
selinter 55	old bike trail or trail crossed steps in swales, this one evidence of water, steps are rock controlled so far most have soil on them. gps all over.
selinter 56	on mining trail
selinter 57	cuts across swale, filled in, 80s road? older trail below to headscarp. walk down gully becomes v shaped erosion, likely manmade.
selinter 58	trench crosses 3t% slope to here, then looks like debris slide or hydraulic trench on 55% slope, sandy boulder gravel, no sign of water.
selinter 59	no sign of erosion on cat road. minor sed deposition on campfire, old lawn chair.
selinter 60	lots of trails and old workings, some fairly recent Perhaps trail work. +/-40%.
selinter61	3m deep sharp v shaped gully, rutting and minor erosion on trail, large cedars in bottom om boulders, sides silty sandy boulder gravel, trail fill through. 60s road? actually rut is likely from up road gradient, no sign of recent flows but water will flow down.
selinter 62	dry swale looks like rock-controlled step below, boulders gravel, no sign of recent flow. 45% slope, step is 65%.
selinter63	v shaped below, broad above, at step just back small granite face parallel to 60% slope, step likely rock controlled, no sign of water. stripped flags, edge of block? into terrain mapped as stable.
selinter 64	looks like trench above road, road excavated through pile of material, saw small erosion channel just back likely attempt to trench or redirect.
selinter 65	on road minor wash below, or game trail, no evidence on old road, ancient slump below. culvert? minor swale above. not marked.
selinter 66	station r6 spur1 cp79-1, dry swale, on old road, culvert already marked. 45%.
selinter 67	small swale, minor evidence of flow (in past). hole in trail. possible water, blue culvert, mossy boulders below, 30%.
selinter 68	just past r5, dry small headwall? likely dry, feeds same swale as one back, check after construction. edge of existing block. blue 2
selinter69	to 45% or less o obvious drainage, match upslope road.

Title	Description
selinter 70	45%, headscarp of swale, looks stable, old mining trail terminates at head, may have been used to direct water, culvert marked already, no obvious water. 45% slope, did cross short section of 55%, steeper below.
selinter71	55%, right below road, small swale, 2 blue, no obvious culvert on upper road.
selinter 72	no obvious point source of water, not much scour, culvert here discharges to top cliff, no significant erosion or scour or sed deposition, omit 2blue.
selinter 73	debris slide enters schesnuik creek.
selinter 74	crown, two scarps, lower larger rock weathered to silt. eroded scarp. 35/65
selinter 75	dry swale, no erosion on road, very old small cross ditch on road above scarp. no signs of work on this road, old culvert flag here (likely mine). sed cone on top side of road.
selinter 76	old eroded cut, road through cut, sed pile on road
selinter 77	old shallow cross ditch
selinter 78	adit, partially blocked,
selinter 79	road cuts through top of swale, no obvious erosion
selinter 80	the shallow cross ditch
selinter 81	poc road.
selinter 82	road switch by swale, make sure water into swale, rock mounds.
selinter-83	+60%, flat and swale below, small swale, culvert previously marked, looks like old wash from flats upslope, may be small depression, human caused?
selinter-84	at end of bench, pitches from north slightly to here, loose sandy angular rubble (mostly granitic), +/-30%, no sign of water on skid trail. old mining trails upslope.
selinter- 85	from 84 to here on skid trail, slope 40% or less, minor erosion here, road culvert, possible small granite outcrop just back.
selinter- 86	small rock knoll/bench -55%, rock steps, +55%, to here terrain generally 45% or less, mod compact sand 25%, silt 10%, sub rounded well graded gravel 65%, sandy gravel Till. culverts marked where I would place them
selinter- 87	sandy angular rubble, mostly granite, some volcanic and mafic, 55 to 60%. occ small outcrops and rubble, could be small trenches.
selinter 88	dry swale road culvert, blocky terrain to here, small bench below, occ ou5crops, sandy Till increasing, slopes 60% or less. swale is sinuous with small piles of dirt in places on side, trench?
selinter 89	old mining bulldozer trail, no evidence of scour or erosion.
selinter 90	just past rp11, skid cut, looks like water came out of forest floor, slight erosion, mod compact sand till, 45%, culvert yellow. possibly redirect3d from upslope cat road, recently clear3d, skid.
selinter 91	on 60%/30% break, old bulldozer trail just upslope, silt sandy subangular to angular volcanics, silt 20% sand 20% cf 60%, sub vert cut on cat trail.
selinter 92	onto bench, +70%, short, trench or small adit on slope, timber shoring exposed in cut, could have been reopened in 60's or 80's then re blocked.
selinter 93	multiple zones of old forest floor wash, complex swale upslope old tree churns redirect flows, just before sta. 17, road culvert, stepped and mounded terrain occ small volc outcrop, check in freshet. 40% average, this culvert will discharge into a small depression below, there is wash here, back would discharge into discontinues swales., south pitching bench ahead ends at culvert location.
selinter- 94	road ends at shallow swale across bench, fed by deeper arcuate draw from north feeds ancient debris slide swale on 55% slope below bench, large granite boulder just peaks out in swale, further down deeper draw. this slope has been modified by mineral exploration, the arcuate draw likely ancient feature (ice contact). slump scarp.

Title	Description
selinter- 95	at toe of shortm70% slope, bench at base, small pits and diggings, silty angular colluvium, 85% cf rock at top of break, 15m up. just before r19, pot spur 1, possible spoil from diggings, then onto base of 55%, silty sandy colluvium (siliceous, cf 75%), likely rock close in places.
selinter 96	start cross angle up short 60% ancient small slump scarp, head right here, silt 20%, sand 20%, sub angular cf 60% some black phyllite, -40%.
selinter- 97	onto bench, back 55%, here -55%, +35%, stepped and benched. just before cleared zone, block boundary flags. just back old bulldozer shallow trench running downhill, push against tree, just ahead old bulldozer trail.
selinter98	top of switch? bulldozer trails.
selinter- 99	short 65% step, silty colluvium, road at toe on bench, large flat benches upslope. large tree churns pull up rock.
selinter 100	broadly stepped, occ ancient slumps, some with antiscarp. stable, average slope 40%.
selinter-101	to here, on bench, from here 55% rubble block apron deposited on 30% slope from short 65% slope to end of road. slope above step, broadly benched, no need to check.
selinter 102	+/-80 to90%, silt 5%, sand%, angular volcanic, tuff, rubble 90%, no sign of instability, deep antiscarp below would limit runout. dry well drained, no trails.
selinter 103	knoll. granitic.
selinter 104	80%, mossy rock, aplite with fine grained volcanic.
selinter 105	80%, mossy rock, aplite, fine grained volc.
selinter 106	ancient boulder deposits.
selinter 107	6m high 100% cut, broken intrusive, sandy matrix, breaks to small rubble, loose, permeable, zones of volc light.
selinter-108	sandy swale, moist in ditch, no channel
selinter 109	mossy spring in draw, pool by ditch, disperse below road, mostly in one swale, crumbly augite porphyry, silty sand.
selinter 110	small sharp swale just off road.
selinter111	silty sand, apparent weak cohesion, recent minor scour, old levee on south side (100yrs?). 45%. flor3d 8n blocky rubble at scour steps.
selinter 112	sed behind trees, bm on trim, but could have sloughed in. no bm on r3cent small scoured banks, later sloughed in.
selinter-113	either large sand levee or excavated.35%, light bm on top.
selinter-114	tree churn at top of levee, poorly confined, older small channel parallel from, here, no mostly flows in main channel. 1m confinement upstream from here.
selinter115	3m broad confinement, scoured channel, 45%.
selinter-116	top of deep confinement, broad swale here, overall 3m deep, 5m wide, sand sed wedges with Bm, so levees started at outlet of deep confinement 45% on 30% slope, here 35%, not as obvious scour, some scour and erosion after fire, recent 8ncrease in erosion, historic debris flow channel but more recently just wash and transport of sand sloughing in.
selinter 117	very wide, 2m deep debris slide 55%, good bm in bottom 2m rounded scarp on sides, burnt snags, old but not ancient, soil silty sand. series of, these slide across the slope, in this on north edge, pit compact sand, no, burn, smaller slide within bigger slide, after fire.
selinter 118	head of large slump? debris slides at edge, small ones off scarps postdate fire, moist soil, draw discharges onto head just upslope, +10%/-45%, trees seem straight but lots of deadfall marking trees.
selinter-119	actually, draw splits around knoll head.
selinter 120	swale seems dry here, 25%-35%, possible multiple upslope, must crossed 2 shallow swales, quickly confined downslope.

Title	Description
selinter 121	dry swale starts just upslope, 30%, likely before drainage pattern established flow3d off flats in a number of places, caution upslope for diversions. tree churn just in block 30%, veneer of silty sandy till over crumbled augite porphyry
selinter 122	25 to 35% slope, deep swale just upslope, seems like dry spring on open slope below.
selinter 123	short 70% sideslope, sandy rubble into dry draw, upslope less confined, caution of diversions, but likely deeper water.
selinter-124	gps lower than trail, headed up to trail, dry swale, headscarp of parallel swale just to south. +15%-30%. no erosion on bike trail,
selinter 125	this is where gps says 124 is.
selinter 126	60% gully 5m sideslope, looks dry, 30% slope here but steep coming up.
selinter 127	65%, underlain by crumbly augite porphyry. gully cut mostly through the step. except for last 4m no channel on slope, adjacent swale dries above step,
selinter 128	55% gradient to 15%, road flat, confining sideslope reduced ahead, no obvious spring yet. step likely due to geology change, felsic tuff chunks in tree churns.
selinter 129	tree churns show water pooled here, black elderberry, 35% to a small step just ahead.
selinter 130	spring out of bottom of south sideslope, sideslope 3m nigh. just above road, likely from bottom.

Table II Drainage features.

Title	Description
selinter 1	cutslope slump, horse tail, no culvert.
selinter2	culvert
selinter 3	broad mossy spring.
selinter 4	end of spring, caliche.
selinter 5	rock spring, good flow off corner.
selinter 6	small mossy spring rock
selinter 7	mossy spring
selinter 8	mossy spring
selinter 9	mossy flow on rubbly cut, near mining cuts. minor tufa, almost obscured culvert. weather hot and clear.
selinter10	water out of cut at sandy broken rock, mossy, ditch shows flows, to culvert at swale just down road.
selinter 14	minor old erosion at bottom of gully, unconfined here, small sed wedge, brown sandy soil, 30% slope here, 55% up, minor old channel around wedge onto steeper slope.
selinter 22	Small erosion channel, small old channel suggests water was moved around upslope (deliberate?).
selinter23	recent debris flow, two small water pipes exposed in slide path. older mossy wet channel on right side, older slide.
selinter 24	numerous channels and levees,
selinter 29	an eroded channel entering from north.
selinter 32	culvert, water from over cut and down ditch.
selinter 40	+/-55%, coarse granite colluvium, broad shallow swale, old wash? cobble boulder "channel" on north side, no trees in swale, no soil to coarse, washed to cobble boulder?
selinter 48	rock headscarp of small swale, coarse colluvium, small bench below, may have seasonal water out of and over rock.
sel inter 51	2m deep swale, from second swale about 15m upslope to 50% slope.

Title	Description
selinter 52	between 2 broad 2m deep swales,
selinter 53	55%, gentle headscarp at block edge (not obvious) shallow broad swale, coarse bottom but bm developed, ancient feature. existing block just ahead.
sel inter54	cross back and forth on swale, water has flowed down bike trail, discharged into swale, sed dep 6m down. deeper swale to south,
selinter 55	old bike trail or trail, crossed steps, in swales, this one evidence of water,
selinter 57	cuts across swale, filled in, 80s road? older trail below to headscarp. walk down gully becomes v shaped erosion, likely manmade.
selinter61	3m deep sharp v shaped gully, rutting and minor erosion on trial from up road gradient, no sign of recent flows but water will flow down.
selinter 62	dry swale, no sign of recent flow.
selinter63	v shaped below, broad above, no sign of water.
selinter 64	small erosion channel just back likely attempts to trench or redirect.
selinter 65	minor swale above. not marked.
selinter 66	station r6 spur1 cp79-1, dry swale, on old road, culvert already marked. 45%.
selinter 67	small swale, minor evidence of flow (in past). hole in trail. possible water, blue culvert, mossy boulders below, 30%.
selinter 68	just past r5, dry small headwall? likely dry, feeds same swale as one back, check after construction. edge of existing block. blue 2
selinter 70	45%, headscarp of swale, looks stable, old mining trail terminates at head, may have been used to direct water, culvert marked already, no obvious water. 45% slope, did cross short section of 55%, steeper below.
selinter71	55%, right below road, small swale, 2 blue, no obvious culvert on upper road.
selinter 72	no obvious point source of water, not much scour, culvert here discharges to top cliff, no significant erosion or scour or sed deposition, omit 2blue.
selinter 75	dry swale, no erosion on road, very old small cross ditch on road above scarp. no signs of work on this road, old culvert flag here (likely mine). sed cone on top side of road.
selinter 76	old eroded cut, road through cut, sed pile on road
selinter 77	old shallow cross ditch
selinter 78	adit, partially blocked, filled with water behind block.
selinter 79	road cuts through top of swale, no obvious erosion
selinter 80	the shallow cross ditch
selinter 82	road switch by swale, make sure water into swale, rock mounds.
selinter-83	+60%, flat and swale below, small swale, culvert previously marked, looks like old wash from flats upslope, may be small depression, human caused?
selinter- 85	from 84 to here on skid trail, slope 40% or less, minor erosion here, road culvert, possible small granite outcrop just back.
selinter 88	dry swale road culvert, blocky terrain to here, small bench below, occ ou5crops, sandy Till increasing, slopes 60% or less. swale is sinuous with small piles of dirt in places on side, trench?
selinter 90	just past rp11, skid cut, looks like water came out of forest floor, slight erosion, mod compact sand till, 45%, culvert yellow. possibly redirect3d from upslope cat road, recently clear3d, skid.
selinter 93	multiple zones of old forest floor wash, complex swale upslope,
selinter- 94	road ends at shallow swale across fed by deeper arcuate draw from north feeds ancient debris slide swale on 55% slope below bench.
selinter-108	sandy swale, moist in ditch, no channel
selinter 109	mossy spring in draw, pool by ditch, disperse below road, mostly in one swale, crumbly augite porphyry, silty sand.

Title	Description
selinter 110	small sharp swale just off road.
selinter111	recent minor scour, old levee on south side (100yrs?).
selinter 112	sed behind trees, bm on trim, but could have sloughed in. no bm on r3cent small scoured banks, later sloughed in.
selinter-113	either large sand levee or excavated.35%, light bm on top.
selinter-114	tree churn at top of levee, poorly confined, older small channel parallel from here, now mostly flows in main channel. 1m confinement upstream from here.
selinter115	3m broad confinement, scoured channel, 45%.
selinter-116	top of deep confinement, broad swale here, overall 3m deep, 5m wide, sand sed wedges with Bm, so levees started at outlet of deep confinement 45% on 30% slope, here 35%, not as obvious scour, some scour and erosion after fire, recent increase in erosion, historic debris flow channel but more recently just wash and transport of sand sloughing in.
selinter 117	very wide, 2m deep debris slide 55%, good bm in bottom 2m rounded scarp on sides, burnt snags, old but not ancient, soil silty sand. series of these slides across the slope, in this on north edge, pit compact sand, no bm, smaller slide within bigger slide after fire.
selinter 118	head of large slump? debris slides at edge, small ones off scarps postdate fire, moist soil, draw discharges onto head just upslope, +10%/-45%, trees seem straight but lots of deadfall marking trees.
selinter-119	actually, draw splits around knoll head.
selinter 120	swale seems dry here, 25%-35%, possible multiple upslope, must crossed 2 shallow swales, quickly confined downslope.
selinter 121	dry swale starts just upslope, 30%, likely before drainage pattern established flow3d off flats in a number of places, caution upslope for diversions. tree churn just in block 30%, veneer of silty sandy till over crumbled augite porphyry
selinter 122	25 to 35% slope, deep swale just upslope, seems like dry spring on open slope below.
selinter 123	short 70% side slope, sandy rubble into dry draw, upslope less confined, caution of diversions, but likely deeper water.
selinter-124	gps lower than trail, headed up to trail, dry swale, headscarp of parallel swale just to south. +15%-30%. no erosion on bike trail,
selinter 126	60% gully 5m sideslope, looks dry, 30% slope here but steep coming up.
selinter 127	65%, underlain by crumbly augite porphyry. gully cut mostly through the step. except for last 4m no channel on slope, adjacent swale dries above step,
selinter 128	55% gradient to 15%, road flat, confining side slope reduced ahead, no obvious spring yet. step likely due to geology change, felsic tuff chunks in tree churns.
selinter 129	tree churns show water pooled here, black elderberry, 35% to a small step just ahead.
selinter 130	spring out of bottom of south side slope, sidelope 3m nigh. just above road, likely from bottom.

Table III Instability features.

Title	Feature	Age	zone
selinter 13	Old debris slide gully, possible hydraulic trench 500yrs to 100yrs.	500-100	erosional
selinter16	ancient shallow slide.	>500 yrs.	erosional
sel inter18	broad gentle headscarp area.	500-100	initiation
selinter 22	Slough in debris deposition,	25	deposition
selinter23	Debris against trees	35-5	transport

Title	Feature	Age	zone
selinter 24	numerous 1 to 1.5m channels and 1 to 1.5m levees,	15-50	Transport/ deposition
selinter25	edge of slides. debris against trees.	15-50	Transport/ deposition
selinter 26	Debris slide, multiple events, (slump then slide)	5-50	Initiation
selinter 27	multiple crowns/headscarp,	15-50	Initiation
selinter 28	Top scarp.	15-50	Initiation
selinter 42	Rockfall/topple.	ongoing	Initiation
selinter 44	Rock Fall/topple	ongoing	Initiation
sel inter 51	Debris Slide.	50 to 100 yrs.	erosional
selinter 52	Complex headscarp between 2m deep swales.	100 yrs.	Initiation
selinter 58	debris slide or hydraulic trench on 55% slope, sandy boulder gravel, no sign of water.	100 yr.	erosional
selinter 73	debris slide enters schesnuik creek.	5	erosional
selinter 74	crown, two scarps,	5	Initiation
selinter- 94	Debris slide below	>500 yrs.	initiation
selinter 96	ancient small slump scarp/head	>500 yrs.	initiation
selinter 100	Ancient slumps, some with antiscarp.	>500 yrs.	initiation
selinter111	Levees	100	Transport/ deposition
selinter 112	Sed deposition behind trees, recent small scoured banks,	25 15	Transport
selinter-113	either large sand levee or excavated.35%, light bm on top.	100	Deposition
selinter-114	Top of levee, poorly confined.	100	deposition
selinter115	3m broad confinement, scoured channel, 45%.	100	erosion
selinter- 116	Historic debris flow channel but more recently just wash and transport of sand sloughing in.	250	erosion
selinter 117	very wide, 2m deep debris slide, old but not ancient, series of slides across slope, smaller slide within bigger slide after fire.	100	initiation
selinter 118	head of large slump, debris slides at edge, small ones off scarps postdate fire,	100	initiation