APEX GEOSCIENCE CONSULTANTS LTD.

Detailed Terrain Stability Field Review

Proposed Harvesting and Road Construction in the Salisbury Face Area (Blocks 405-1, 2, 4, 5, 6 and 7: Spurs 1-3, 4-1, 4-2, 6-1 and 6-3)

for

Cooper Creek Cedar Ltd.

W. Halleran P. Geo, L.Eng.

13/02/2020

Contents

1. Summary

Block 405-1

Timber harvesting will not significantly increase the low likelihood of landslide initiation.

Spur 1-3 (in block 405-1)

Place additional culverts as recommended. The last ~ 110 meters of the proposed road is on steep terrain. Construction recommendations for ~ last 110 meters of the road are:

1. For a permanent road, construct the pilot trail below grade, use the pilot trail to support a portion of the fillslope. The fillslope of placed blocky schist keyed into the pilot trail can be 1:1, the cut slope in rock can be 0.5:1, in colluvium it should not exceed 1:1.
2. For a temporary road, leave high stumps on the fill side, place large woody debris in the fill to span the stumps. Reclaim within 5 years.
3. Construct as a forwarding trail, reclaim after harvesting.

If the recommendations are followed construction of Spur 1-3 will not significantly increase the low likelihood of landslide initiation.

Block 405-2

There are no terrain concerns along proposed spur 1-3 within the proposed block. Timber harvesting will not significantly increase the low likelihood of landslide initiation.

Spur 1-3 (in block 405-2)

Proposed additional culverts are recommended. If the recommendations are followed construction of Spur 1-3 will not significantly increase the low likelihood of landslide initiation.

Block 405-4

The proposed block will be accessed by the existing FSR and proposed spurs 4-1 and 4-2. There are two small zones of moderate likelihood of landslide initiation. Timber harvesting will not significantly increase the likelihood of landslide initiation. Timber harvesting in the rest of the proposed block will not significantly increase the low likelihood of landslide initiation. This area has a low landslide hazard.

Spur 4-1

Spur4-1 is positioned to access the upper southern portion of block 405-4, the spur is just upslope of and slightly impinges on some historic instability. If the recommendations to build the spur as a 5-year temporary road are implemented, construction of the road will not significantly increase the low likelihood of landslide initiation. An additional culvert is proposed just north of road station 5.

Spur 4-2

An additional culvert is proposed at saldr 8, water should be discharged off the back end of the end landing. There are no terrain concerns along Spur 4-2. The proposed development will not significantly increase the low likelihood of landslide initiation.

Block 405-5

Cable yarding of block 405-5, utilizing the existing FSR for setup and processing will not significantly increase the low likelihood of landslide initiation.

Block 405-6, Block 405-7, Spur 6-1

Portions of Blocks 405-6 and 405-7 and all of spur 6-1 are within a currently unstable terrain area. Under natural conditions debris slides are initiated during extreme climatic conditions (~ 250 yr. return, Pa = 0.004).

The existing roads have altered the slope drainage resulting in very high likelihood of landslides (~10yrs, Pa = 0.1).

Currently the slides are small and run out on the slopes just below, this area poses a low landslide hazard for the elements assessed for risk.

Although there is a low hazard, there is a very high likelihood of landslides. Construction of Spur 6-1 will likely result in additional slides, it is recommended that Spur 6-1 not be constructed as proposed. Spur 6-1 can be constructed as a forwarding trail and recontoured within 1 year.

Cable yarding or trails in the blocks could alter the slope drainage. It is recommended that the blocks be harvested in the winter on at least a 1m of snow. Bladed trails (cut exceeding 50cm in mineral soil) are to be avoided, if the cut exceeds 50cm the trail must be reclaimed immediately after harvesting is complete.

Outside the unstable terrain there is a low likelihood of landslide initiation in the remainder of the proposed blocks.

Existing Road Drainage

The drainage on the slope traversed by the existing FSR is complex, flutes sub parallel to the contour of the slope break up downslope drainage patterns. No significant drainage diversions or concentrations were observed along the existing road. No additional culverts were prescribed for the existing roads.

Within the unstable area within block 6 and 7 the slope drainage has been altered, but installing additional culverts would likely result in shifting the initiation point of the small debris slides. Due to the slope configuration and micro-topography, deactivating the roads is unlikely to re-establish natural drainage patterns. Currently small slides are associated with culvert discharges, maintaining the culvert locations will ensure that slides will not occur elsewhere along the slope.

The field drainage assessment of the remaining existing road network did not find any significant active slope drainage interception or diversions.

Drainage control along the proposed roads:

The culvert locations proposed by the road layout crew are well located and for the most part will maintain natural drainage patterns. Apex located six additional proposed culvert locations as tabulated below.

Title	Description	Spur	recommendation
sal 48	cross upper head scarp, likely wet, place culvert just north of sta. 5. 55%.	Spur 4-1	Culvert (north of sta, 5)
sal 76	water likely sub surface, can go either way, if water intercepted place culvert, here sta.29 road heading down into swale.	Spur 1-3	Culvert (sta. 29)
sal 77	block 3 boundary just before swale.	Spur 1-3	Culvert

Title	Description	Spur	recommendation
sal92	+60%/-55%, sandy colluvium, small swale just ahead. just before station 45.	Spur 1-3	Culvert
sal 96	+85%/-75%, just off bench, here blocky colluvium, swale on slope below.	Spur 1-3	Culvert
saldr 8	very subtle feature, culvert just before station 12.	Spur 4-2	Culvert (just west of station 12)
saldr 9	swale upslope, cedar "flats" here if this is back of landing, discharge off back.	Spur 4-2	Discharge off back of landing

2. Introduction

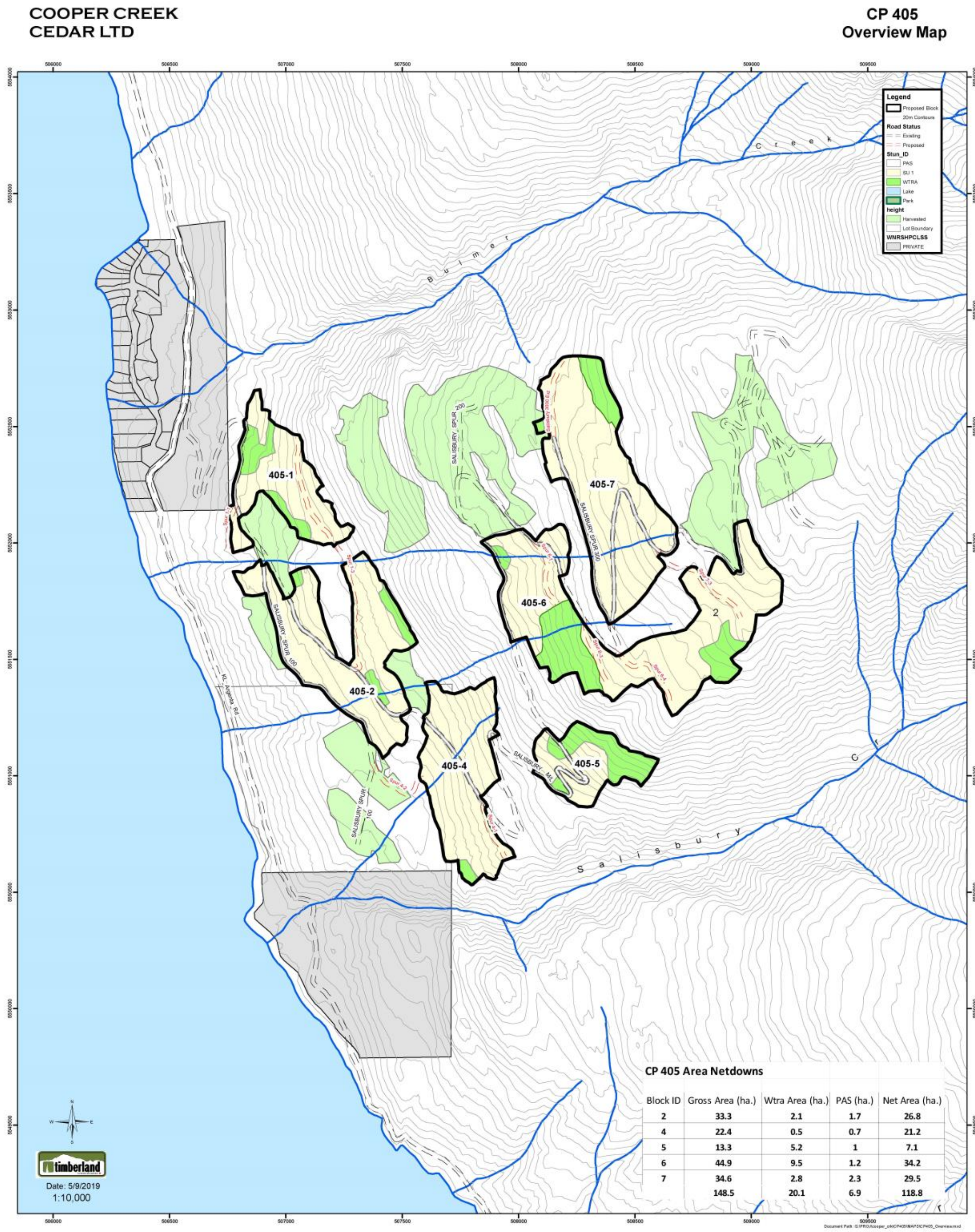
In early May 2019, Mr. Bill Kestell RPF of Cooper Creek Cedar Ltd, requested:

1. A terrain stability field review of potential harvesting and road construction on Salisbury Face.
2. A review of drainage control on the existing road network.
3. An assessment of stability of the existing roads on sections where possible fillslope failures could progress to debris slides.
4. Assess the sensitivity to increased or altered slope drainage on downslope areas.
5. A Terrain Stability Field Review of the lower blocks (where they impinge on Terrain Stability Mapped polygons of IV and V)
6. A Risk analysis for the lower blocks for water quality/intake and private property.

At the time of the request, partial retention (12-14 stems to 35-40 stems per hectare) was proposed for the lower blocks. The original proposed development is shown in figure #1, blocks 405-6 and 405-7 (and associated spurs) have been significantly modified to account for Caribou Management. The modifications include significant increase in reserves for both blocks, and for block #7 retention of 30 and 145 stems per hectare, Spurs 7-3, 6-3 and 6-4 have been deleted.

After the terrain stability assessment, Cooper Creek Cedar requested Apex Geoscience to conduct a Karst inventory assessment and to determine if a Karst Vulnerability Assessment was required. The results of the karst assessment will be reported in a later report.

Figure 1



CP 405 Area Netdowns

Block ID	Gross Area (ha.)	Wtra Area (ha.)	PAS (ha.)	Net Area (ha.)
2	33.3	2.1	1.7	26.8
4	22.4	0.5	0.7	21.2
5	13.3	5.2	1	7.1
6	44.9	9.5	1.2	34.2
7	34.6	2.8	2.3	29.5
	148.5	20.1	6.9	118.8

3. Methods, Limitations and Reliability

Google earth imagery; Bing maps satellite imagery; historical air photos; and previous reports were reviewed prior to the field assessment.

CCC supplied Lidar DEM files; and 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 June 13th and 14th, when the weather was hot and dry, and Sept 26th and 27th when the weather was cool and windy. Inferences are made from observations of materials in soil pits, road cuts, and tree churns within and adjacent to the proposed blocks 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 analysis presented in this report is based the conventions outlined in Land Management Handbook 56 “Landslide Risk Case Studies in Forest Development Planning and Operations”.

A specific risk analysis was conducted on those portions of the roads and blocks that have a greater than low likelihood of landslide initiation and pose a potential hazard to the elements considered for risk. 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.

Terrain Stability Mapping:

A review of the terrain mapping titled “Quality and Completeness Status of Terrain Mapping Argenta & Johnson’s Landing, was included as an appendix in W.H. Wells DTSFA. Mr. Wells reports the “Terrain stability mapping for this area was undertaken and completed for B.C. Ministry of Forests between 1980 and 1983 by Kutenai Nature Investigations Ltd. The mapping predates the RIC standards but was reviewed by W.H.

Wells P. Ag in 2002”. Mr. Wells determined that the mapping met the requirements for TSIL B Terrain Interpretations. Terrain stability mapping assumes conventional road construction (balanced cut and fill) and clearcuts with ground based skidding. The terrain stability classes I to III are deemed stable, a Class IV polygon may contain areas of potentially unstable terrain, and a Class V polygon has active natural instability (landslides). The mapping is meant to “red flag” areas where more detailed assessments may be required.

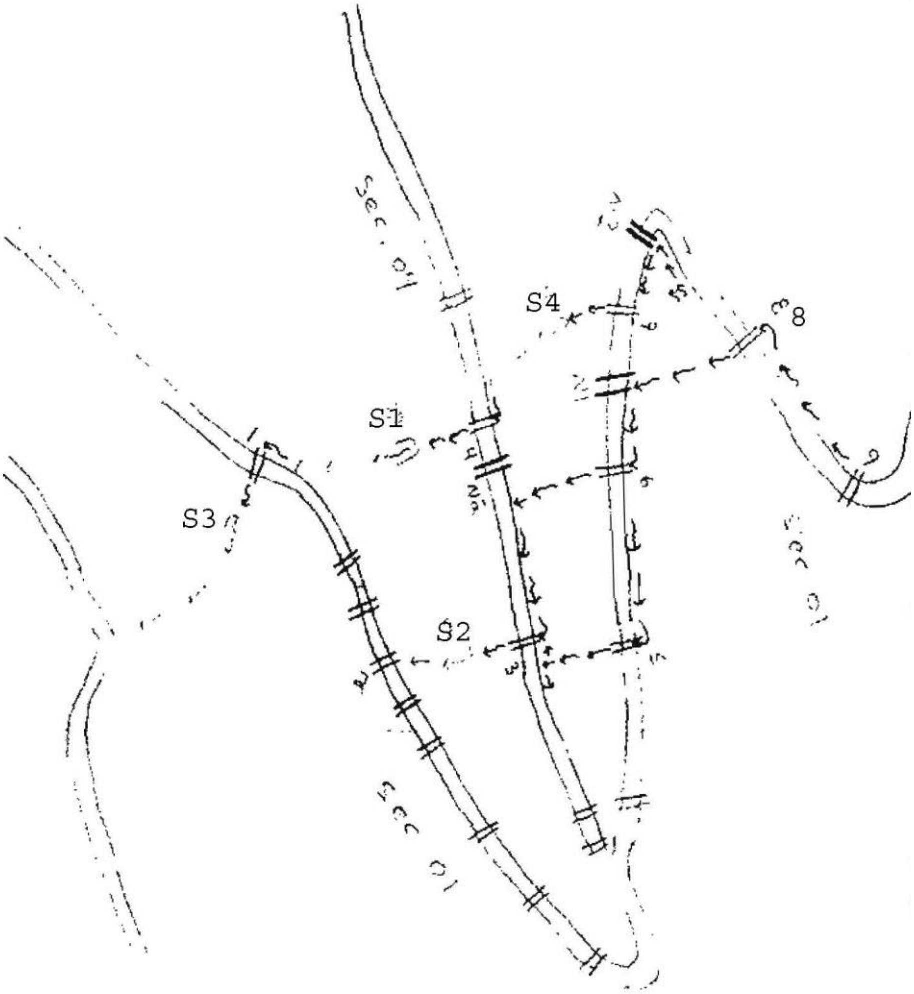
Resource Inventory of Argenta-Johnsons Landing Watershed by Greg Utzig P. Ag, William Wells, and Alison Warner of Kutenai Nature Investigations Ltd. August 10th, 1983.

This is a comprehensive report that covers a large area, including Salisbury Face, Salisbury Creek and Bulmer Creek.

Within the hydrology portion of the report, it is stated “differential rock weathering and glacial scour” coupled with “infiltration into permeable soluble bedrock (i.e. Limestone and calcareous schists) interbedded with impermeable Quartzite has reduced the surface component” of slope drainage “resulting in low density and poorly developed drainage patterns” on face units. The authors speculated that ground water contributes a significant proportion of base flow for some of the streams in the area, but not Salisbury Creek.

Salisbury Creek FSR Field Review by Doug Nicol P. Eng: On June 7th, 2002 Doug Nicol and Della Peterson of MoF investigated 4 slides that occurred on May 21st between 6.4 km and 7.5 km on of the Salisbury FSR. Mr. Nicole is of the opinion that two initial drainage diversions were responsible for all the slides. Mr. Nicol concluded that “all the slides occurred because of the road concentrating the runoff flows from a rain event (with some snowmelt) of May 21st. Mr. Nicol further describes the chain of events that contributed to the four slides and recommended removal of two culverts and the addition of culverts to reduce the volume of water flowing to slide scarps. Mr. Nicol commented that the rain event did not appear to be extreme and culvert placing was within the norms for FSR’s. It is unclear from the report and included sketch, if the recommendations were designed to restore natural drainage and/or reduce the likelihood of additional slides.

Sketch 1



Detailed Terrain Stability Field Assessment (Terrain Survey Level A) Timber Sale License A42081 Block 1, A-38, Salisbury Creek, Kootenay Forest District by W.H. Wells P.Ag 2002: In addition to the 2002 report, Mr. Wells completed two previous DTSFA's in this area, one in 1996 (Bulmer-Salisbury FSR extension) and one in 1998 (A42081 Block 2 Salisbury Creek). I was unable to review these reports.

The 2002 report was completed after the debris slides of May 2002. The assessment was requested because of the occurrence of the slides within a proposed block area. The objective of the report was to provide planners with advice regarding constraints needed on the canopy removal in the proposed block area, as well as advice on any further drainage structures needed on the road through the area.

Mr. Wells reported the 2002 slides occurred in pre-existing gullies (post glacial) and that "*All the (2002) slides appear to have a relationship to drainage structure outflows on the road*". He states that "*the outside verges of the road route and numerous localized Sub hygric sites…. indicate a discharge of water from bedrock which then drains down across the gullied slope*". Mr. Wells apportioned the drainage to ground water because the fluted terrain and slope configuration precluded significant upslope surface drainage flowing into this area.

Mr. Wells delineated the area as a "<u>High Hazard Zone</u>" and concluded that there was "*a High Likelihood of Landslides similar to those that recently occurred"* ....…and "*there will continue to be a high likelihood if further canopy area is removed from the remaining areas of the proposed block, or upslope of these areas*". Mr. Wells concluded that the "*slide activity is an indicator that the natural drainage capacity was stressed to handle the water volumes, but the road structure concentrated water that evidently contributed to four slides. Further development is not recommended for a large portion of the proposed block. Road deactivation for a portion of the FSR is prescribed*."

Within the report is a road deactivation prescription which mostly prescribes cross-ditches because the road was still required for operational purposes. The report also asserts that "*Since failures are likely to occur with the continued presence of the road, plans should be implemented to permanently deactivate the road structure by complete removal and recontouring*".

During the 2019 assessment it was noted that the road has not been recontoured, but it appears that most of the timber harvesting recommendations were followed.

<u>Hydrological Assessment of the Argenta-Johnsons Landing Watersheds Phase 1 Interim Report by EBA (2003)</u>. This report commented on the various watersheds in the area. Within this report there is a statement that a 2002 report by Peter Jordan P.Geo (MoF Regional Geomorphologist for the Kootenay Region) remarked that the area delineated by W.H. Wells as being the area of greatest concern (Well's High Hazard zone) has a Moderate Risk "*and that a recommendation for no further development made by W.H. Wells (2002) is not justified*".

3.2 Likelihood of Landslide Determination

In this report the annual likelihood (Pa) of an event occurring is estimated 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 be 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 results in a higher estimate of the annual likelihood of an event occurring than is 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.

Debris slide paths are most likely U-shaped swales. Along lower gradient reaches and/or in unconfined sections, debris deposition often occurs as levees or debris lobes.

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. 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 estimate 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 likelihood 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 defined as a source for potential harm in terms of human injury, private property, water quality or water intake infrastructure. An event is deemed to be a hazard if it can materially adversely affect the element(s) assessed for risk (specific hazardous event –P (H)). For this report, the hazard is a function of the likelihood of a landslide and the likelihood that the slide can reach the considered elements (P(HA)-Hazardous slide or Landslide Hazard).

The elements considered in this analysis are:

1. water quality at the intakes on Salisbury and Bulmer Creeks,
2. Private Property along the lower slopes by Salisbury and Bulmer Creeks.

Each element considered will have a specific hazardous event associated with it.

The relative rating for landslides is shown in Table 3.3.1.

Table 3.3.1. Likelihood of a Debris slide/ Debris Avalanche or Sediment Reaching or Affecting Salisbury Creek, Bulmer Creek or Private Land.

Relative Rating of a Landslide Affecting Salisbury or Bulmer Creek.	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly affect Salisbury Creek, Bulmer Creek or Private Land.
Moderate	There is a run-out slope of<20º (36%) 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 benched rock-controlled terrain) below and between the development and Salisbury Creek, Bulmer Creek or Private Land. Some secondary transport of suspended sediment and small wood debris by accompanying water runoff may reach the Creeks.
Low	Landslide debris and/or sediment from soil erosion is unlikely to reach or affect Salisbury Creek, Bulmer Creek or Private Land 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 bench rock-controlled terrain), below and between the development and Creek.
Negligible	Landslide deposition will not impact the considered elements.

The ranking of a Hazardous Slide (P(HA)) is a product of the likelihood of a landslide occurring and the relative rating of that landslide as illustrated in the matrix below.

Table 3.3.2 Matrix for determining Hazardous slide, P (HA).

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Salisbury, Bulmer Creek, or private land; given that the Landslide/Soil Erosion Occurs			
		High	**Moderate**	**Low**	**Negligible**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High	(Low)
	High	Very High	High	Moderate	Low
	Moderate	High	Moderate	Low	Very Low
	Low	Moderate	Low	Very Low	Very Low

3.4 Specific Risk Analysis Methodology

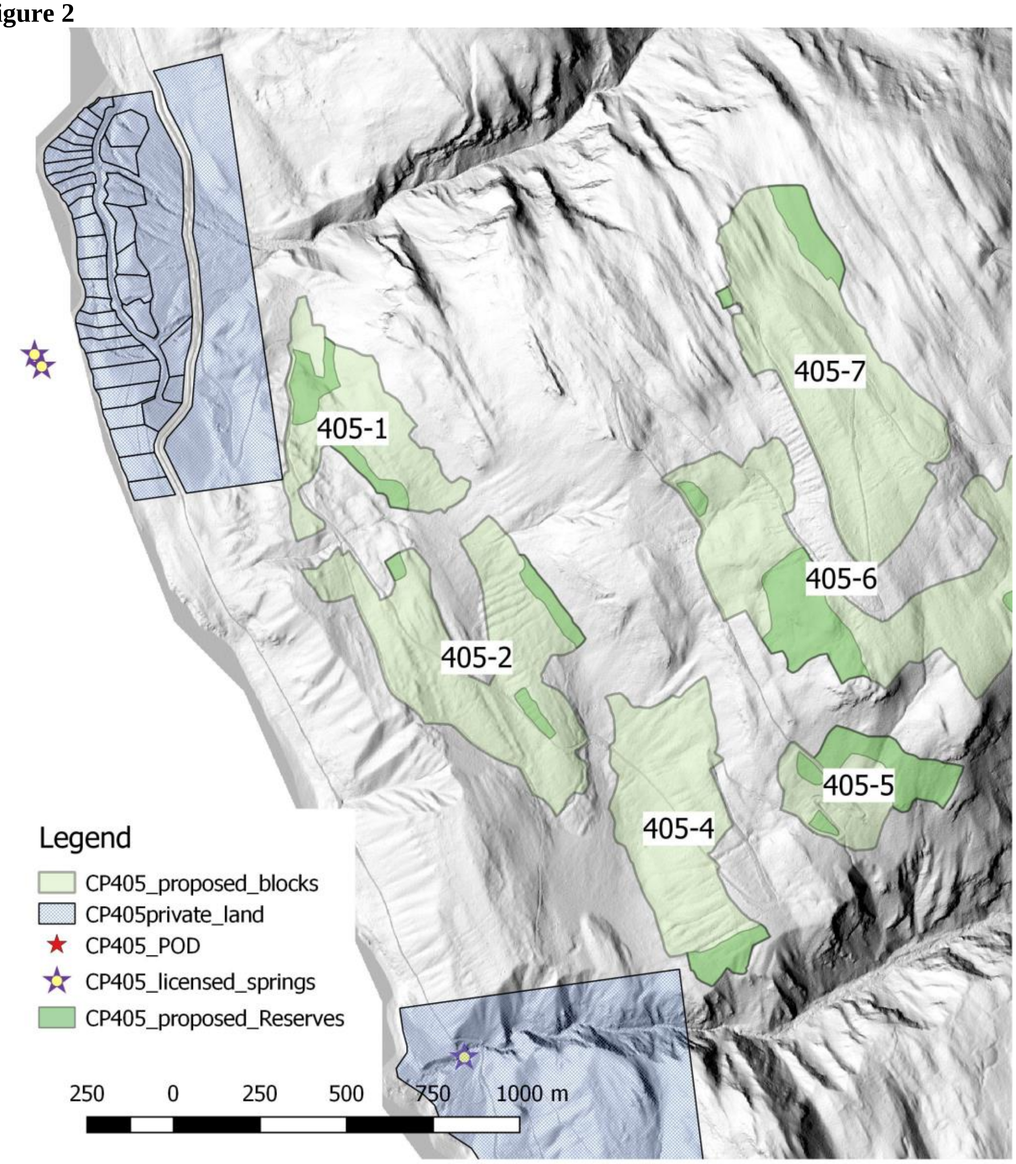
The risk analysis presented in this report is qualitative and is based on information gathered during this project and reviews of previous reports.

The elements assessed for risk for this project are:

a) water intakes/water quality at the POD's,
b) private land below the development.

The licensed intakes (POD), springs and private land are shown on figure 2. As can be seen in the figure the POD's and private land are on Bulmer Creek fan and along the lower reaches of Salisbury Creek.

Figure 2



For this report, the risk is defined as hazard (P(HA)) x consequence. Hazard has been defined in section 3.3, and consequence is the possible effect of the event. The vulnerability of the elements is not well defined. For this analysis, water intakes are assumed to be within the stream channels and any impact on private land is considered a high consequence. For this project, a specific risk analysis will be conducted if there is a moderate or higher hazard.

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 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.

Specific Risk is the product of the hazard and the consequence as shown in table 3.4.2

Table 3.4.2 Matrix for determining 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

Table 3.4.3 Matrix for determining specific risk for private properties.

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

4. Observations:

The terrain stability assessment was focused in areas mapped as Class IV or V. Apex observation locations are prefixed with sal, kar, or sadr to differentiate the primary objectives of the observations (Terrain stability, Karst, Drainage); Timberland road and block stations are prefixed with sta.

4.1 Geology:

The proposed development is predominately underlain by Lardeau Group rocks, which in this area, is an interbedded sequence of Phyllite, Schist and Quartzite with occasional thin beds of carbonates. Although there is local variability in the strike (folding and shearing), the strike is mostly ~170^o, with very steep (subvertical ~80^o) westerly dip.

Glacial scouring of the slope selectively removed the phyllite leaving small ridges of Quartzite forming flutes sub-parallel to the contours. The carbonate units were partially scoured (likely removing areas that had been impacted by dissolution). The quartzite units likely act as an aquitard to downward flowing ground water, and as barriers for downslope flowing surface water.

4.2 Surficial Geology:

The slopes are predominately underlain by loose sandy gravel to variably dense silty sandy gravel with significant areas of silty rubble colluvium and lessor areas of slightly cohesive silty gravel (likely weathered phyllite). The rubble colluvium is usually associated with short steep rock steps (usually quartzite). Areas of kettled sandy gravel deposits occur along the lower slopes. Ancient debris flow cones and alluvial fans occur along the benches below ancient drainage pathways.

4.3 Slope Drainage:

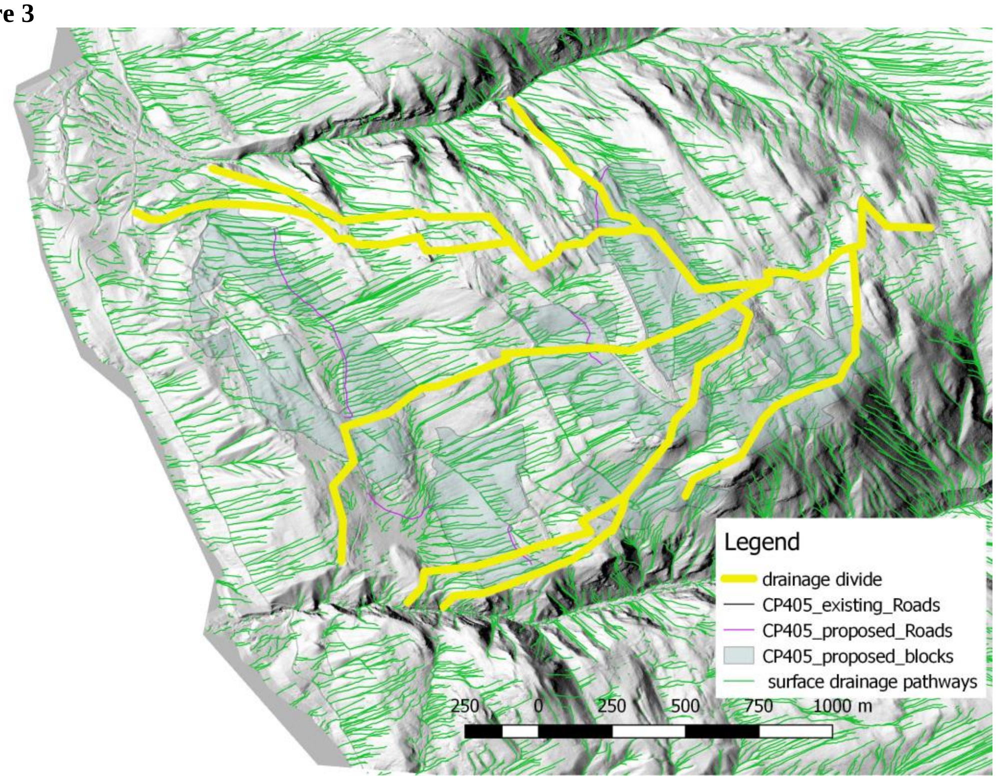
QGIS SWAT (Soil & Water Assessment Tool) slope drainage program was run using the lidar DEM, the slope drainage patterns (Figure 3) are dependent on the resolution of the DEM data (~1m) and may miss small ridges, benches and other surface features that could direct the drainage. Roads and trails can also impact the accuracy as culvert locations are not incorporated. Subsurface drainage patterns are not modeled by this method. The field observations for the most part confirm the surface 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 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 in the Appendix II). Along proposed road alignments, proposed culverts were noted, additional culverts were flagged in the field with three blue flags or yellow flags.

After the field investigation, tentative catchment boundaries were approximated using a combination of Swat derived drainage channels, SWAT derived drainage basins, hillshade imagery, and field notes. In some areas such as along large colluvial cones/fans the boundaries are subjectively drawn; it is likely that there is subsurface flow that may go either way.

There are possible interception and diversions of slope drainage along the FSR between blocks 6 and 7. The field review of the existing roads failed to locate any other significant diversions or interceptions of slope drainage.

Figure 3



4.5 Proposed Development:

4.5.1 Block 405-1 and the north section of Spur 1-3, Figure #4:

The proposed block is located along the lower slope position, portions of the block are just upslope of private land. Salisbury FSR forms most of the lower block boundary. The northern most portion of the block drains towards Bulmer Paleo Fan but does not drain directly into Bulmer Creek.

The upper portion of the proposed block is within a Class IV polygon. The Class IV polygon is mostly benched terrain underlain by sandy gravel (sand 25%, rounded to subrounded, loose, well graded coarse fragment 75%) to silty sandy angular gravel. There is a steep step (65% to 100%) underlain by phyllite and quartzite capped with silty rubble that angles down from sal96 to sal101. The slope terminates at a small north west pitching draw. The southwest side of the draw is a ridge of well-rounded sandy gravel (esker?). The lower slopes (sal 102) is underlain by kettled sandy gravel.

North section Spur 1-3: The northern portion of Spur 1-3 is located along the upper boundary of the proposed block partially within the Class IV terrain stability polygon (described previously).

From Sal 88 to 89 (150m) proposed Spur 1-3 crosses 40% gradient slope underlain by rounded to sub rounded sandy gravel. Coarse angular rubble at the bottom of a swale at sal 89 suggests the rock is about 2-3m below the surface. This swale appears to currently have seasonal flows.

From Sal 89 to 91 (160m) the proposed road is underlain by sandy rubble (GW-coarse fragment content 75 to 85%) on a short 45% gradient slope step between benches.

The proposed road crosses a 55% gradient slope between sal 91 and 95 (170m), the slope is underlain by sandy rubble (GW). Sal 95 is on a small flat approximately 10m from -85% slope, the steep slope is rubble colluvium with short sub vertical schist outcrops. The foliation dip of the schist forms the sub vertical faces. There is no evidence of natural instability.

From sal 95 to the end of the road at sal 97 (110m) the road is on or just above an 80% gradient slope underlain by coarse blocky sandy rubble. At sal 96 the road is just upslope of a 90% gradient headscarp of a swale.

There is no evidence of recent instability within the proposed block.

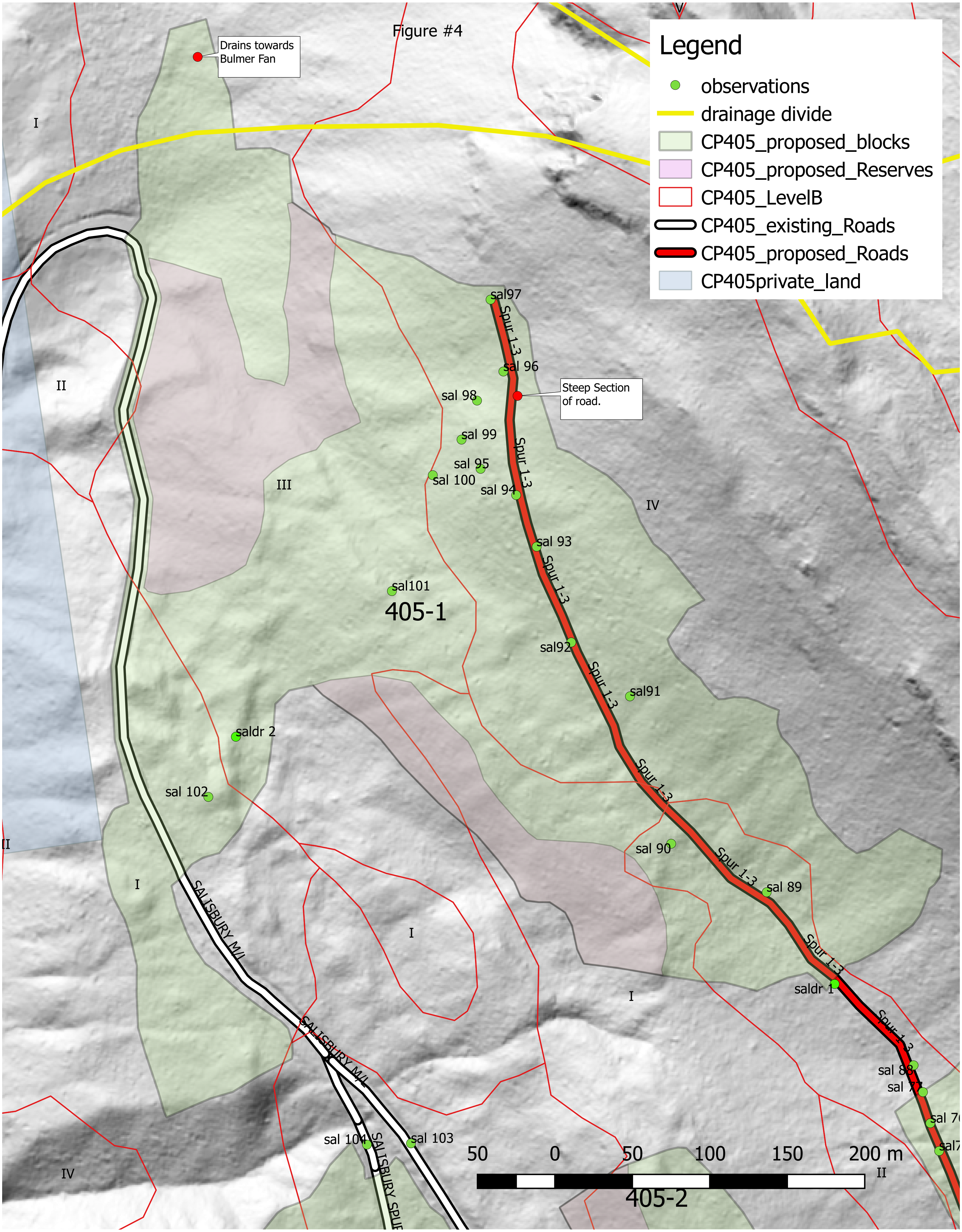


Figure #4
Drains towards Bulmer Fan
Legend
observations
drainage divide
CP405_proposed_blocks
CP405_proposed_Reserves
CP405_LevelB
CP405_existing_Roads
CP405_proposed_Roads
CP405private_land
Steep Section of road.
Spur 1-3
sal97
sal 96
sal 98
sal 99
sal 95
sal 100
sal 94
sal 93
sal101
405-1
sal92
sal91
saldr 2
sal 102
sal 90
sal 89
saldr 1
sal 88
sal 77
sal 104
sal 103
SALISBURY M/L
SALISBURY SPUR
405-2
I
II
III
IV
50 0 50 100 150 200 m

4.5.2 Block 405-2 and south section of Spur 1-3 (Figure #5).

The proposed block is Y shaped with a northeastern, northwestern, and southern lobe. The proposed block is located along the lower slopes mostly on Salisbury Face and a small portion of the southern lobe is partially within a secondary catchment to Salisbury Creek.

Most of the field work was conducted in the northeastern lobe, which impinges on the lower portion of Class IV and V terrain stability polygons. Spur 1-3 forms the lower boundary of this portion of the block. Salisbury FSR and an existing Spur road transect the northeastern and southern lobes.

At sal 79 along the upper portion of the northeastern lobe, there is a swale near the apex of the ancient fan with a 2m high levee (>500yrs) of sandy cobble/rubble with occasional blocks. Just upslope the swale becomes a well confined gully.

South of the swale the upper portion of the block has a +/-80% slope gradient (mostly within a reserved area) and is underlain by loose rapidly drained angular colluvium (silt 5%, sand 10%, angular rubble 85%) with occasional phyllite and quartzite outcrops that dip steeply into the hillslope. Below this slope, blocky rubble colluvium accumulates as an apron (65%) on a bench (35%). At the toe of the apron, on the bench, there are a series of >500-year-old slide scarps (sal 83-86), blocky colluvium has accumulated within the scarps. Debris flow gullies/swales run down 45% gradient slope, the swales quickly become deeply incised downslope, terminating on a broad flat at the base of the slope ~ 100m downslope. To the south, between sal 86 and 87, the slope gradient is 35%.

South section of Spur 1-3:

Spur 1-3 forms the lower boundary of the eastern lobe of the block.

From sal 68 to 75 (345m) the proposed road crosses the transport/deposition zone of a series of debris slide/flows (from sal 83-86). The slope gradient varies from 35 to 65% and is mostly underlain by silty sandy angular gravel (GM).

From Sal 75 to 78 (150m) the proposed road crosses a large ancient fan. The material varies from silty sandy gravel (sub rounded) to sandy gravel. The road crosses a several ancient/old channels. There was no evidence of surface flows within the channels.

From Sal 88 to 89 (150m) the proposed road crosses 40% gradient slope underlain by rounded to sub rounded sandy gravel. Coarse angular rubble at the bottom of a swale at sal 89 suggests the rock is about 2-3m below the surface. This swale appears to currently have seasonal or occasional flows.

Northwestern and South Lobes:

The existing Salisbury Spur 100 (sal 60-66; Sal 104-110) road forms much of the lower boundary of the proposed block. The block is "upslope" of a Class IV terrain polygon which is traversed by the Johnson's Landing Road (Sal 52-59). Most of Spur 100 is on low gradient terrain underlain by sandy gravel. From about sal 66 the slope drains southeast, carried across the road by a cross-ditch at sal 110. There does not appear to be a significant amount of drainage intercepted along the lower road.

Stations sal 107 and 108 are on the steep slope within the Class IV polygon. At sal 107 the slope gradient is -60%/ +0%, underlain by slightly dense silt 10%, sand 25%, rounded to sub angular cf 65%. The slope appears very dry and there is no evidence of surface flows. Just below at sal 108 the slope is +/-70%, there is a good Bm soil development and no evidence of instability and no evidence of springs or seeps.

Salisbury FSR cuts through the middle of the northwestern and southern portions of the block. North of sal 68, the road is excavated into loose sandy gravel, south of sal 68, the cutslope is predominately in silty gravel with occasional Phyllite exposed in the cut.

Except for the very old slides noted in the northeast portion, there is no evidence of instability within the proposed block.

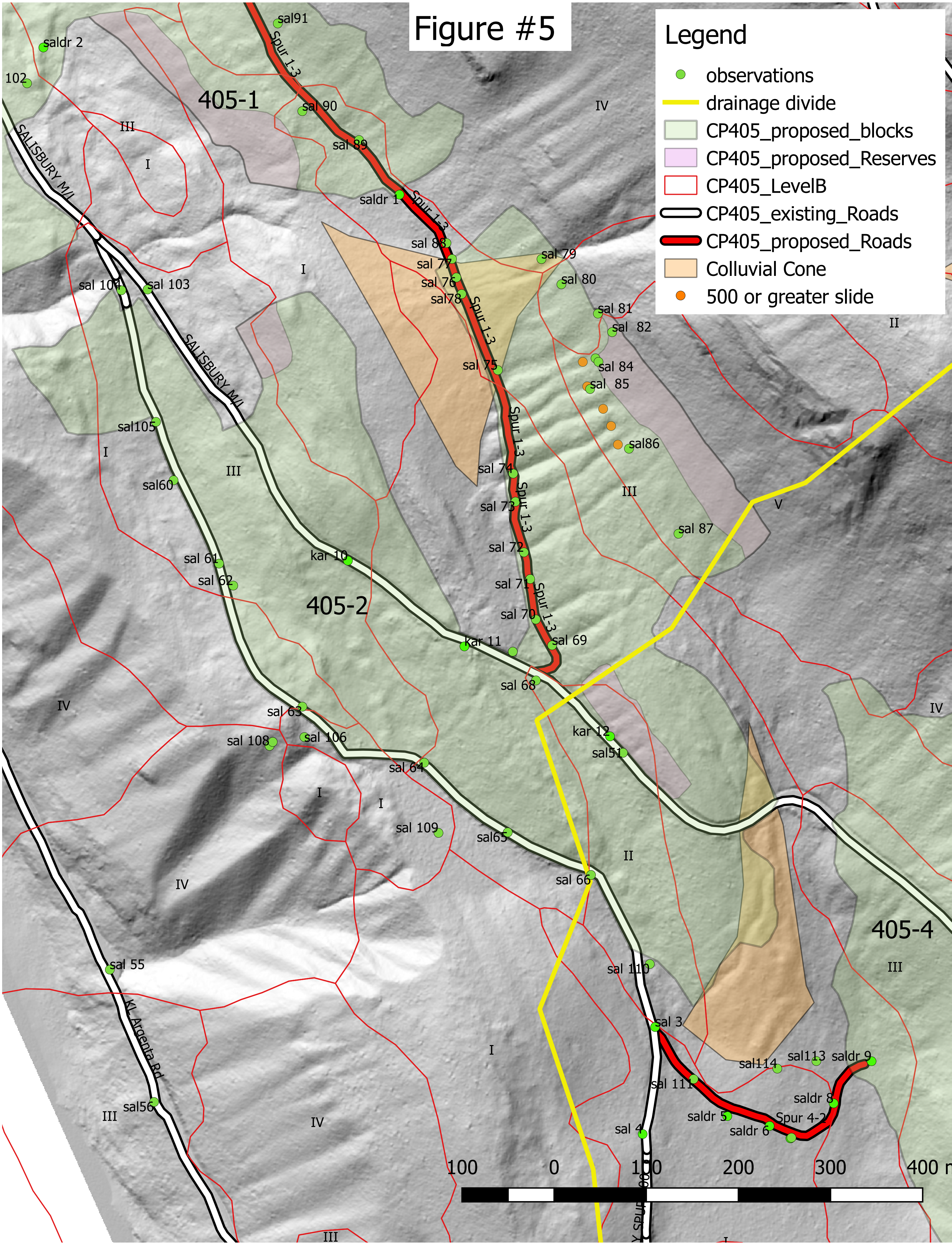


Figure #5
Legend
observations
drainage divide
CP405_proposed_blocks
CP405_proposed_Reserves
CP405_LevelB
CP405_existing_Roads
CP405_proposed_Roads
Colluvial Cone
500 or greater slide
405-1
405-2
405-4
Spur 1-3
Spur 4-2
SALISBURY M/L
KL Argenta Rd
sal91
saldr 2
102
sal 90
sal 89
saldr 1
sal 88
sal 77
sal 76
sal78
sal 79
sal 80
sal 81
sal 82
sal 84
sal 85
sal86
sal 87
sal 75
sal 74
sal 73
sal 72
sal 71
sal 70
sal 69
sal 68
kar 10
kar 11
kar 12
sal51
sal 104
sal 103
sal105
sal60
sal 61
sal 62
sal 63
sal 108
sal 106
sal 64
sal 109
sal65
sal 66
sal 110
sal 3
sal 111
sal 4
saldr 5
saldr 6
saldr 8
sal114
sal113
saldr 9
sal 55
sal56
100
0
100
200
300
400 m

4.5.3 Block 405-4, Spur 4-1, and Spur 4-2 (Figure #6)

The proposed block is located along the lower slope position. The northeast and southern corners of the block are within Class V terrain polygons.

The slope gradient within the northeast corner of the block varies from 65 to 85% with short small 150% gradient rock outcrops (quartzite and phyllite). Most of the slope is mantled by well-graded, loose, coarse gravels with good Bm development; scattered small mossy talus slopes occur downslope of the rock outcrops. There are small areas underlain by moderately dense silty gravel.

One old (>100 yrs.) debris slide was noted within this area (Sal 15, slide S11), soil pits in the debris slide expose 2cm thick Bm (15cm on adjacent slopes). The headscarp is rock and the crown appears stable (65% gradient), the crown is within a broad dry swale. Older, adjacent slides have well developed soil profiles and are likely >500 yrs. old. It is likely that the more recent slide was a small event contained within an older feature.

There is a take-off ditch at the switchback at sal 12 along the FSR, that directs road drainage through the block towards the swales between sal 21 and 22, no instability was noted.

There is a large “bench” running through the central portion of the block (sal 21 to sal 24) (30% to 40% gradient slope) capped with silty sandy gravel. Swales running downslope from the bench are likely ancient erosion features, none had evidence of significant water along the FSR. There is a culvert along the FSR upslope (sal 26) of sal 23, there is no sign of erosion or point sources of slope drainage along the road here.

Downslope of the block, on the existing FSR (sal 49), the 130% cutslope is excavated into phyllite and silty gravel. The ditch is blocked and there is minor scour down road from here, possibly causing the cracked fill at sal 50 (photo 1). The slope below is -80%, the cutslope is sub vertical rock cut. The next culvert up road gradient is at sal 28 (fed by a culvert at sal 27).

Photo 1 Fillslope Tension Crack at Sal 50.

The swales in the southeastern portion of the block are ancient to old debris slide channels. There has been some timber harvesting through the debris slide swales as indicated by old cut stumps (30 yrs.?). It is possible that some of the logs were skidded up or down the swales causing soil disturbance. The deposition zone of the slides is along the lower slope (60% gradient) and on the bench below the proposed block. Soil pits (sal 31) in a debris cone exposed 30cm of unweathered grey silty sand with some rounded cf, then a slightly weathered (light brown) silty sandy gravel. The debris must have quickly dewatered to have been deposited in this slope, deposition is estimated to be 200 to 100? yrs.

Sal33 and 34 are within a debris slide gully. The gully has a sharp bottom with areas of no Bm on sides (trim?) and areas of no Bm in the bottom. But other areas of thick Bm on sides and bottom. It is possible that trees have been skidded within the gullies.

The scarps (sal 30, sal 32, and sal 43) have an ~85% gradient and are typically 3.5m wide and 1.5m deep. Pits in the scarps give silty sand then slightly dense dark grey silty sand with increasing phyllite fragments at depth, possibly weathered rock. The scarps develop on a short 75% gradient slopes between +40% and -60% gradient slopes. Within the scarps the soil is moist to wet, the soil is dry on the adjacent slope.

The portion of the south corner within the terrain class V polygon is reserved. Sal 35 is on the reserve boundary, the gully just within the block (65% sideslope) may have seasonal flows but there is no channel, no trim line and good Bm soil profile throughout.

Prior to the steep slope to Salisbury creek there are a series of broad south west trending swales that would direct water away from the steep slope.

The steep slope (Class V polygon) to the creek is a series of rock steps (photo 2).

Photo 2 Slope to Salisbury Creek.

Spur 4-1

Spur 4-1 cuts along the top of the southern portion of the block. The 80% cutslope along the FSR at the poc of Spur 4-1 is slightly cohesive silt 25%, sand 25%, with 50% gravel (GM).

This spur is positioned to access the upper southern portion of block 405-4. The proposed road is predominately on 40 to 45% gradient slope underlain by slightly dense/cohesive silty gravel (GM), just set back from -55 to 65% slope. The spur is just upslope of several debris slides (100 to 250 yrs., sal 30, sal 32, and sal 43) that initiated on the slope below the proposed road. The crown of the slides are on ~ 40/60% slope break underlain by slightly dense silty sandy gravel.

Along the Spur, the proposed culverts are located at natural drainage locations. The road terminates just past a “stream” swale upslope of an old scarp. At sal 48 (just north of rd. sta. 50) the proposed road crosses the upper scarp of a swale (likely a wet area), 3 pink flags were hung to mark a suggested culvert location.

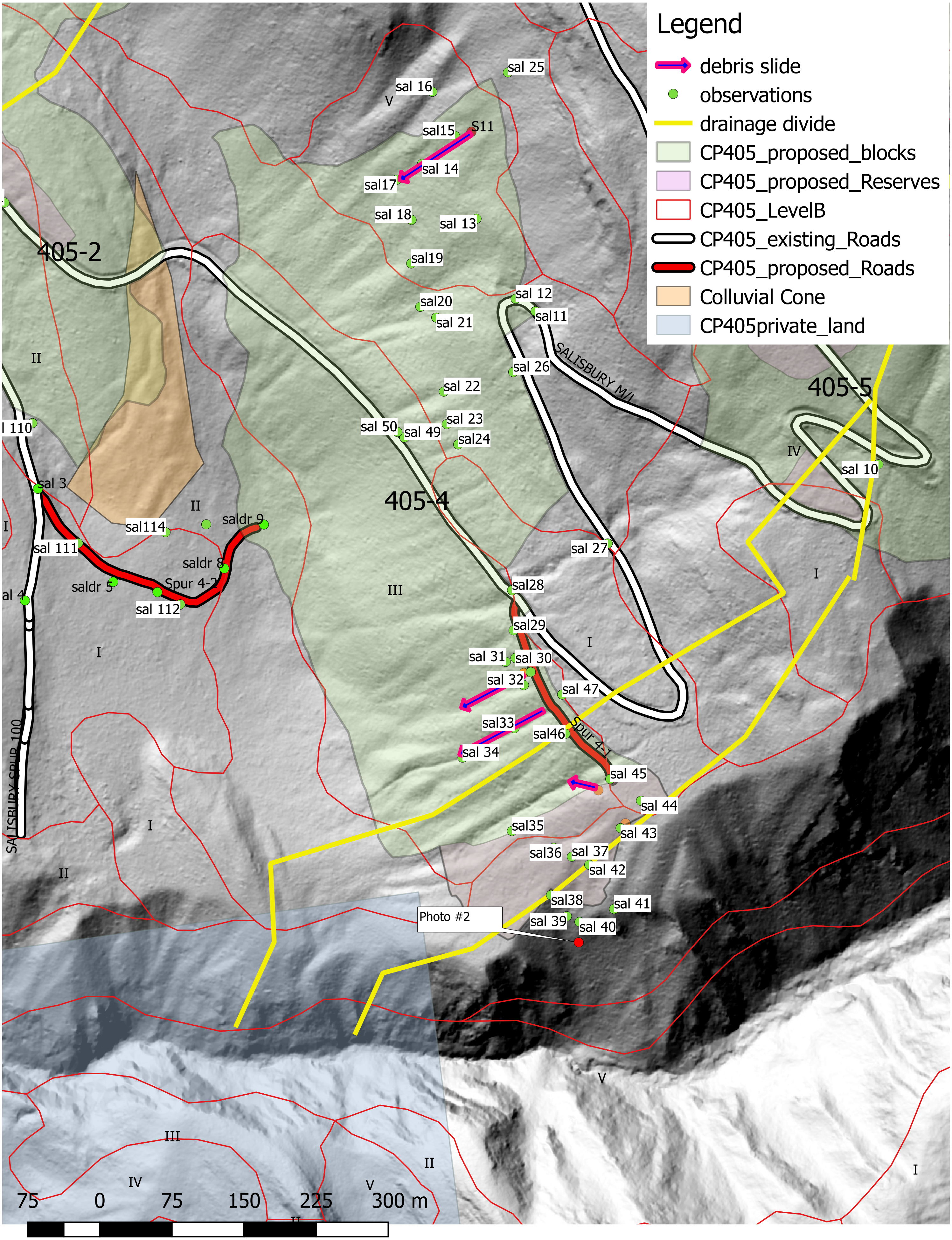
Spur 4-2

Spur 4-2 is located to access the lower portion of Block 405-4.

At sal 110 on Spur 100 there is a small channel directed to the southeast through a cross-ditch, the “channel” continues southeast parallel to the existing road. Prior to the proposed road crossing at sal 111, the “draw” terminates at a broad flat. Although there is no channel a road culvert was marked here. The proposed road continues across an ancient fan, a road culvert is marked at sal 112 (Sta. 10), which is downslope of a shallow swale (sal 113). At saldr 8 the road angles up a swale (old channel).

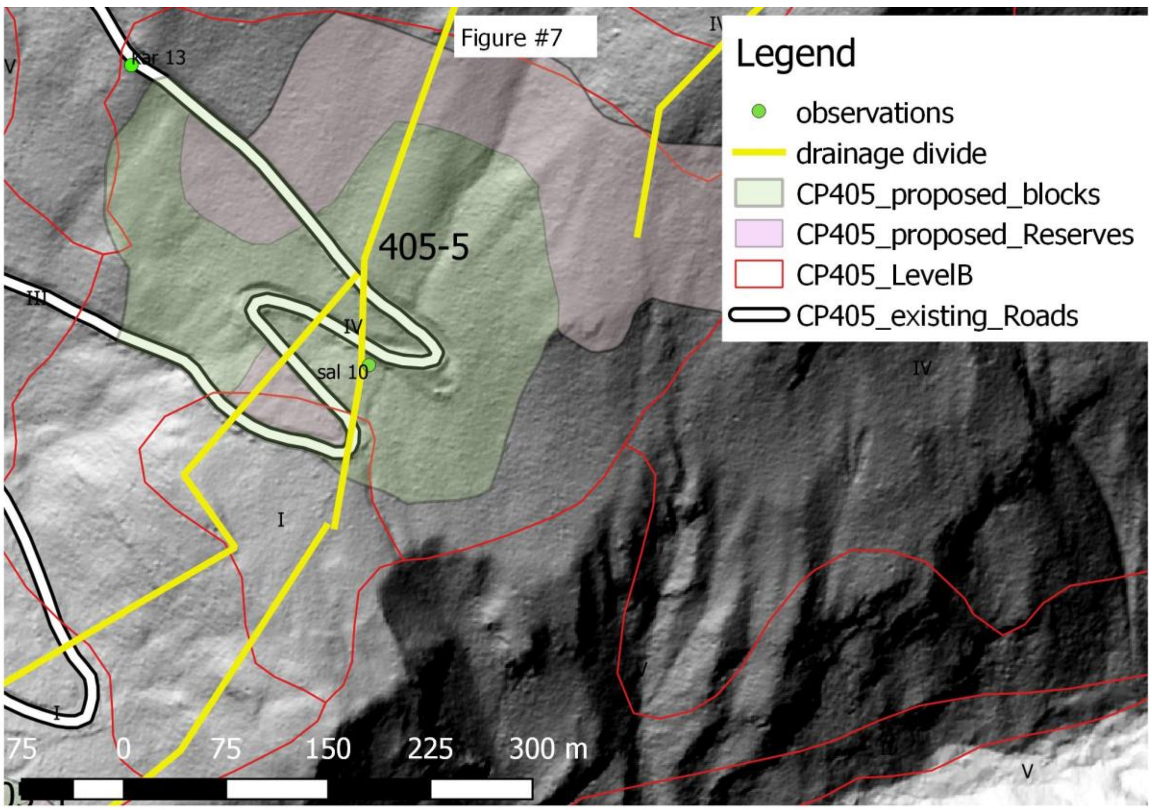
The spur crosses an ancient fan just downslope of ancient colluvial cone. Road culverts are well located.

figure #6


Legend
debris slide
observations
drainage divide
CP405_proposed_blocks
CP405_proposed_Reserves
CP405_LevelB
CP405_existing_Roads
CP405_proposed_Roads
Colluvial Cone
CP405private_land
405-2
405-4
405-5
SALISBURY M/L
SALISBURY SPUR 100
Spur 4-1
Spur 4-2
Photo #2
sal 25
sal 16
sal15
S11
sal 14
sal17
sal 18
sal 13
sal19
sal 12
sal11
sal20
sal 21
sal 26
sal 22
sal 23
sal 50
sal 49
sal24
sal 10
sal 3
sal114
saldr 9
sal 111
saldr 8
saldr 5
sal 112
sal 27
sal28
sal29
sal 31
sal 30
sal 32
sal 47
sal33
sal46
sal 34
sal 45
sal 44
sal35
sal 43
sal36
sal 37
sal 42
sal38
sal 41
sal 39
sal 40
75 0 75 150 225 300 m

4.5.4 Block 405-5 (Figure #7)

Salisbury Mainline switches up through the proposed block. The block will be cable harvested using the existing road to set up. The block is within a Class IV terrain stability polygon, the slope is underlain by silty sandy gravel with small scattered outcrops of phyllite, quartzite and minor micritic limestone. There is no evidence of instability and no evidence of intercepted slope drainage along the existing road. No trails or bladed structures are planned within the block. The proposed block is upslope of steep rock slopes which delineated by a Class V terrain stability polygon.



4.5.5 Block 405-6 and Spur 6-1 (Figure #8)

This proposed block is located along the lower midslope position mostly sandwiched between two lifts of Salisbury Mainline. The northern portion impinges on a Class IV Terrain Stability Polygon, the southern portion is upslope of a Class IV Terrain Polygon which at this location delineates small rock bluffs upslope of a broad draw. The Salisbury Mainline forms most of the lower and upper block boundary. Most of the road is excavated into phyllite and quartzite with minor Carbonate beds. There was no evidence of instability along the lower portion of the existing road.

Along the upper road/boundary there is a large fillslope failure (S9) and cutslope failure (S6) related to upslope road drainage, these failures are within the large reserve zone of block 6.

There are four recent (2002 and later) slides (S3, S7, S8 and S9) associated with road drainage within the block and a four more (S1, S2, S5, and S6) upslope of the block (discussed in block #7 section).

This area is near the top junction of 4 sub-basins, the divides, minor ridges and or shallow flutes are easily breached by the existing roads. In addition to the 8 slides mentioned above there are least two others (S4 and S10) recent debris slides in this area. All the slides are related to road drainage associated with the stacked road system. This area corresponds to Mr. Well's (2002) High Hazard Zone, which he indicated was sensitive to concentrated road drainage. Slides 1-4 are the slides reviewed by D. Nicol (2002), (these slides are numbered consistent with Nicol's numbering). After these slides, road drainage was altered, it is likely that slides 5-9 correspond with the new road drainage patterns. Slide 10 was not investigated in the field (not noted until after field season) but is indicated by the lidar.

The recent slides are contained within older slide features (250 to 500 yr.). Except for slides S8 and S9, the slides are small and runout on the slope or on benches just below the scarps. Slide 6 is a relatively wide slide that includes part of the cutslope of Salisbury Mainline, this slide appears to have blocked the ditch directing water onto the fillslope which failed as slide S9. Slide S9 is the largest slide (156m x 10m x2m), it is just to the south of slide S8 which is 156m x 2m x2m, both these slides terminate upslope of the mainline. Slide S8 is downslope of a culvert and likely is associated with the same diversion as slide S9. Slides S1, S2, S4 and S5 are discussed in more detail in Block #7 section.

<u>Spur 6-1</u>:

Spur 6-1 is directly below Salisbury Mainline within Mr. Wells "High Hazard" area and in proximity slides S3, S7, S8 and S9.

The first section of the spur is on a small bench (30% gradient) just upslope of 70% gradient slope. Just below the proposed road, at sal 158, there is a ~ 10 yr. old, 6m wide, 1m deep by 6m long, debris slide (S3). This slide initiated on the north side of an ancient debris slide path. The ancient head scarp is just to the south at sal 159. The slope is underlain by silt 15%, sand 10%, angular coarse fragments 75%.

At sal 159, the proposed road culvert will discharge onto the headscarp. Between sal 159 and 160 (sta. 6), the proposed road crosses two swales on a 35% gradient slope just back from -65% slope, underlain by wet silty sandy soil. From sal 160 to 161 (sta. 7) the road enters a broad bowl which is likely the head scarp of an ancient failed slump. The soil is a poorly graded, slightly cohesive, silty sandy gravel (50% cf). There is good soil development across the slump scarp. A recent (15yrs) small debris scar (S7) is located within the larger older scarp. The gully downslope is still treed, indicating relatively short runout. The slide scar is 2m wide, 0.25m deep, and 15m long.

From sal 161 to sal 163 the proposed road crosses a 35% gradient slope underlain by loose, well sorted, sandy gravel. Just upslope of a 65% gradient slope underlain by loose, silty gravel (with phyllite chunks).

At sal 163 (Sta. 12) there is a broad 2.5m flat bottomed swale in loose sandy gravel on a 45% gradient slope, the swale terminates on a 70% gradient slope (likely rock). From here to sal 165 the terrain shows evidence of periods of high moisture, (i.e. little erosion swales, bigger swales, and debris slides).

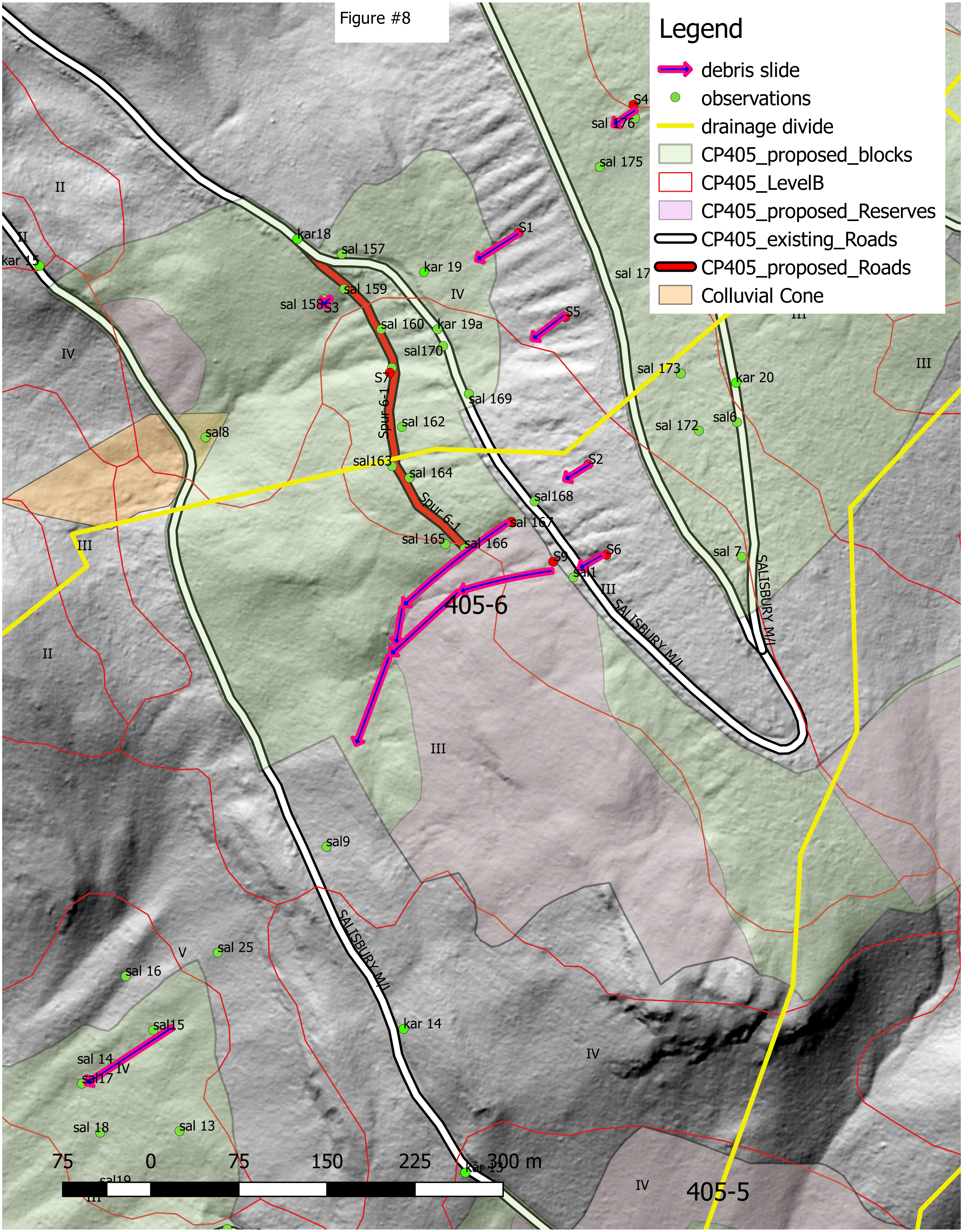
At sal 165 the proposed road heads into the headscarp of old debris slide on 60% slope. After crossing the slide scarp, the proposed road terminates (sal 166) on -55%, +65% slope just before debris flow path (S8). The debris flow is shallow with logs and debris on the sides. The scar has no trees in it. The slide is estimated to be between 25 to 50 yrs. This slope has experienced debris slides and flows in the loose sandy gravel.

A culvert (sal 168) on the existing road discharges onto the headscarps of S8, the culvert at 169 does not currently appear to carry much flow. The culvert at sal 170 discharges onto slide S3.

At sal 167 (S8) there is a stepped debris slide, which starts in a broad older head scarp with displaced material in it. To the south is a more defined debris slide flow within the wtp (S9). This slide originates at the same debris slide headscarp as S8. The headscarp developed on 70% gradient slope underlain silty sandy gravel. A soil pit in the scarp exposed wet soil with poorly developed Bm.

Except for the short steep step that the slides initiated on, the slopes with the block are moderately steep with small rock benches and ridges (parallel to slope). No other instability was noted within the proposed block.

Figure #8



Legend
debris slide
observations
drainage divide
CP405_proposed_blocks
CP405_LevelB
CP405_proposed_Reserves
CP405_existing_Roads
CP405_proposed_Roads
Colluvial Cone
405-6
405-5
Spur 6-1
SALISBURY M/L
S1
S2
S3
S4
S5
S6
S7
S9
kar18
kar 15
kar 19
kar 19a
kar 20
kar 14
kar 13
sal 157
sal 158
sal 159
sal 160
sal170
sal 162
sal163
sal 164
sal 165
sal 166
sal 167
sal168
sal 169
sal 173
sal 172
sal 175
sal 176
sal6
sal 7
sal1
sal8
sal9
sal 25
sal 16
sal15
sal 14
sal17
sal 18
sal 13
sal19
75 0 75 150 225 300 m

4.5.6 Block 405-7 (Figure #9)

This block is upslope of Block 6, much of this block is within Bill Well's "High Hazard Area". This block is near the top of three subbasin catchments. The existing road switches through this area, boundaries between these catchments are subtle and are easily breached by excavated trails and roads.

The Salisbury Mainline switches up through the southern half of the proposed block, Salisbury 300 Road forms most of the lower boundary. For most of the block the terrain has been mapped as Class III, the lower most portion and Salisbury 300 Road are in a Class IV Polygon.

Within the block, at site sal 176, there are two similarly sized recent debris slides (combined as S4) within larger older slide (<250 yrs.) feature, the recent slides initiated on the older slide scarp on a -70%/+20% slope break. The southern slide looks to be about 25yrs old based on scars on trees. Most of the debris is deposited just downslope on 55% gradient slope. There are tension cracks on the crown of the northern debris slide (6m wide, 1m deep, 10m long), which is estimated to be about 10 yrs. old based on debris deposited against trees and 1.5m high alders in scar. The surficial material is silt 25%, sand 15%, with 60% angular to sub angular (mostly quartzite) coarse fragments. The existing road breaches and runs along subtle rises and flutes which likely originally controlled surface drainage patterns. On the Salisbury Mainline upslope of slide S4 the road shows sign of erosion from the switch, which would suggest water is being directed out of the Bulmer catchment onto this face (although no obvious diversions were noted). This also corresponds to one of the original diversions discussed by Nicol as directed to slide S4.

Above Salisbury 300 road, from sal 176 to sal 180 the slope gradient is ~ 60 %, underlain by silty sandy to sandy silty gravel. Within the block there is a 20m high 80% rock-controlled slope underlain by sandy silty gravel with scattered quartzite outcrops. Except for S4, no additional slides were noted along this step. Salisbury 300 road is located on a broad bench between steep steps.

Below the block and downslope of Salisbury 300 Road recent slides S1, S2, S5 and S6 occur within older slide features (250 to 500 yr.) on a small steep step the angles up from the FSR (S6) to Salisbury road 300 (just below sal 175), north of sal 175 the Salisbury 300 Road is along the slope break for ~ 200m, then it goes onto rolling/ridged terrain. The Salisbury 3000 ext. is also within the rolling/ridged terrain. Except for slide S6, the slides are relatively small and runout on the slope or on benches just below the scarps. Slide S6 is a relatively wide slide that includes part of the cutslope of the FSR, this slide appears to have blocked the ditch directing water onto the fillslope which failed as slide S9 (discussed previously). Between sal 172 and 175 the slope gradient is 55% underlain by silty gravel, there are scattered devils club.

Upslope and north of this area from kar 31 to kar 71 the terrain is dry pine flats with phyllite, and quartzite steps and small bluffs mantled with silty sandy gravel. Broad flutes, depressions and benches are variably wet, some with devil's club and cedar. The slope gradient (excluding the short steep bluffs) averages 25%. Two small areas of sinkholes were noted at Kar 40 and Kar 58 (discussed in Karst reconnaissance survey).

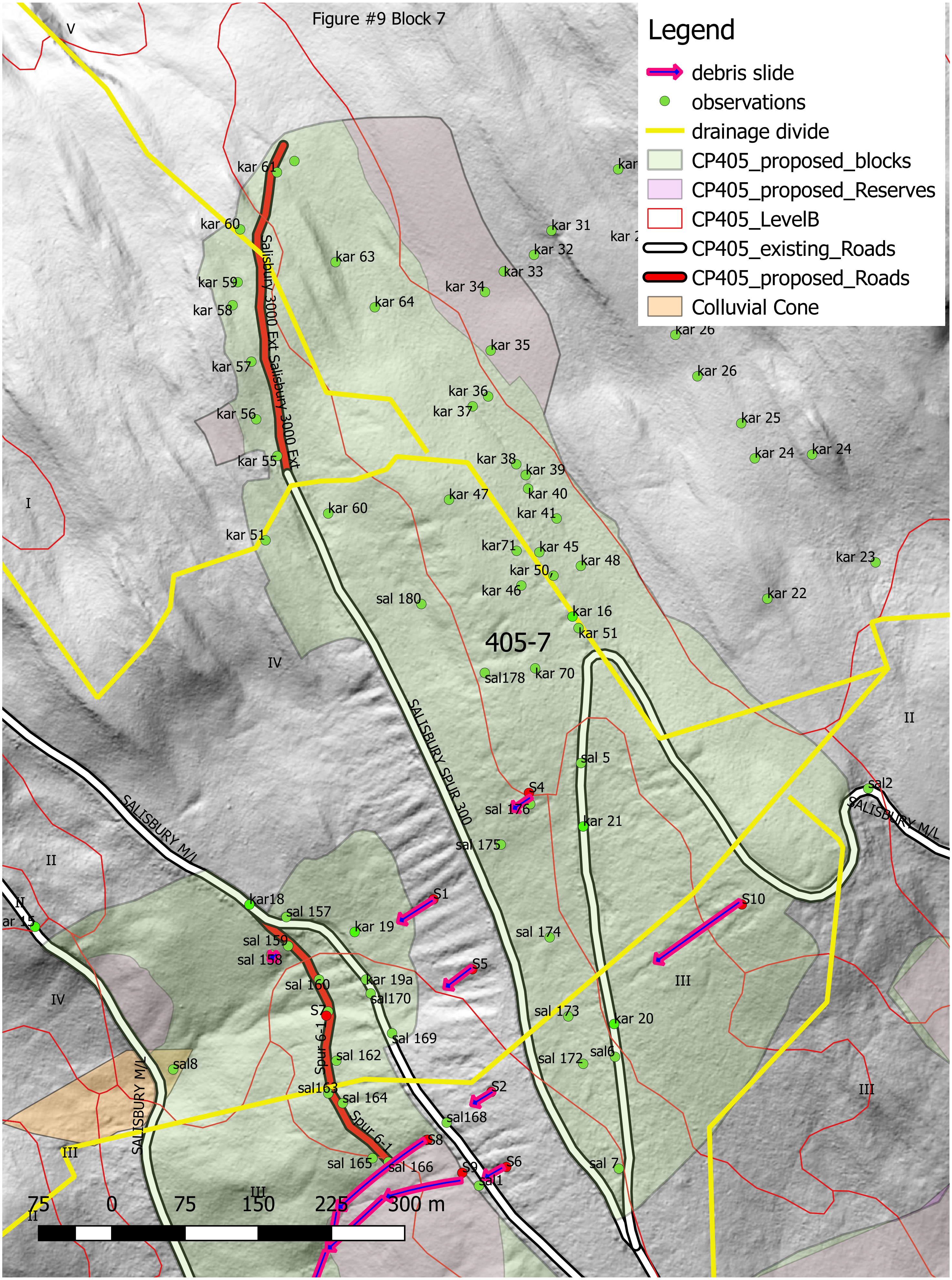


Figure #9 Block 7
Legend
debris slide
observations
drainage divide
CP405_proposed_blocks
CP405_proposed_Reserves
CP405_LevelB
CP405_existing_Roads
CP405_proposed_Roads
Colluvial Cone
405-7
Salisbury 3000 Ext Salisbury 3000 Ext
SALISBURY SPUR 300
SALISBURY M/L
Spur 6-1
kar 61
kar 60
kar 63
kar 59
kar 58
kar 64
kar 57
kar 56
kar 55
kar 51
kar 31
kar 32
kar 33
kar 34
kar 35
kar 36
kar 37
kar 38
kar 39
kar 40
kar 41
kar 47
kar71
kar 45
kar 48
kar 50
kar 46
kar 16
kar 51
kar 70
sal 180
sal178
kar 26
kar 25
kar 24
kar 23
kar 22
sal 5
S4
sal 176
kar 21
sal 175
sal2
S1
S10
kar18
sal 157
kar 19
sal 159
sal 158
sal 174
S5
sal 160
kar 19a
sal170
S7
sal 169
sal 173
kar 20
sal 162
sal 172
sal6
sal8
sal163
sal 164
S2
sal168
S8
sal 165
sal 166
S9
S6
sal1
sal 7
I
II
III
IV
V
75 0 75 150 225 300 m

5. Implications, Recommendation and Risk Analysis

5.1 Probability of Debris floods/flows down Salisbury or Bulmer

For the Private land along the fan of Bulmer or Salisbury Creek a debris flow, debris flood or large flood that reaches the Fan is considered a hazardous event.

Both Bulmer and Salisbury Creek are higher order streams (~3^{rd} order) of greater than 3km length. There is a low likelihood that debris slides into Bulmer or Salisbury Creek will transition into debris flows that could reach the fans.

Debris floods are an existing hazard for both Bulmer and Salisbury. Debris floods occur when most or all the stream bedload is mobilized during a flood event and are a function of the flood frequency of the watershed. A comparison (figures 10 and 11) of the fans indicates that debris floods occur more frequently in Bulmer Creek then Salisbury, as evidenced by the debris deposits on Bulmers large "Paleo fan". Also, the Bulmer Creek fan at lake level appears relatively large compared to current Salisbury Creek fan.

As can be seen in the figures, Bulmer Creek is poorly confined on both the Paleo fan and recent fan, Salisbury Creek is well confined through the paleo fan and moderately well confined in the recent fan. The poor confinement increases the likelihood that the stream will avulse (jump out of the channel) and flood over the fan.

Figure 10

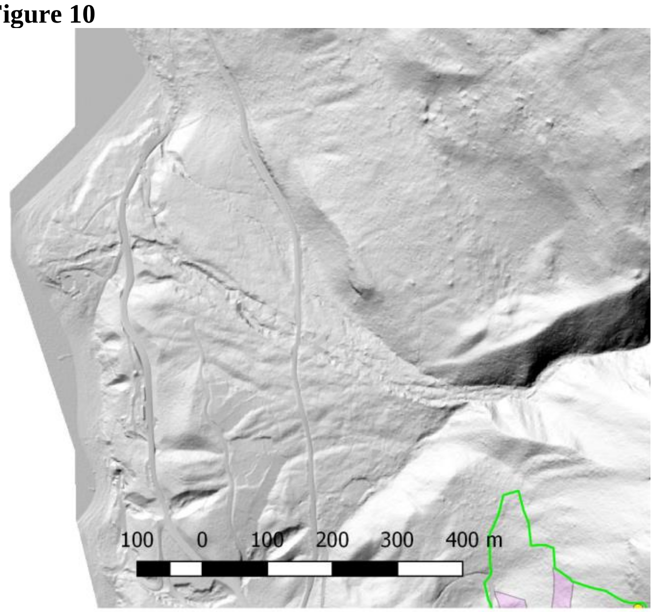
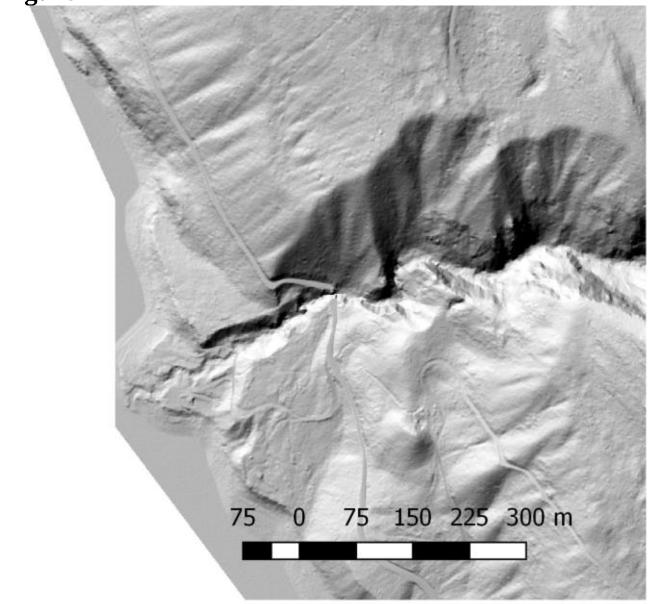
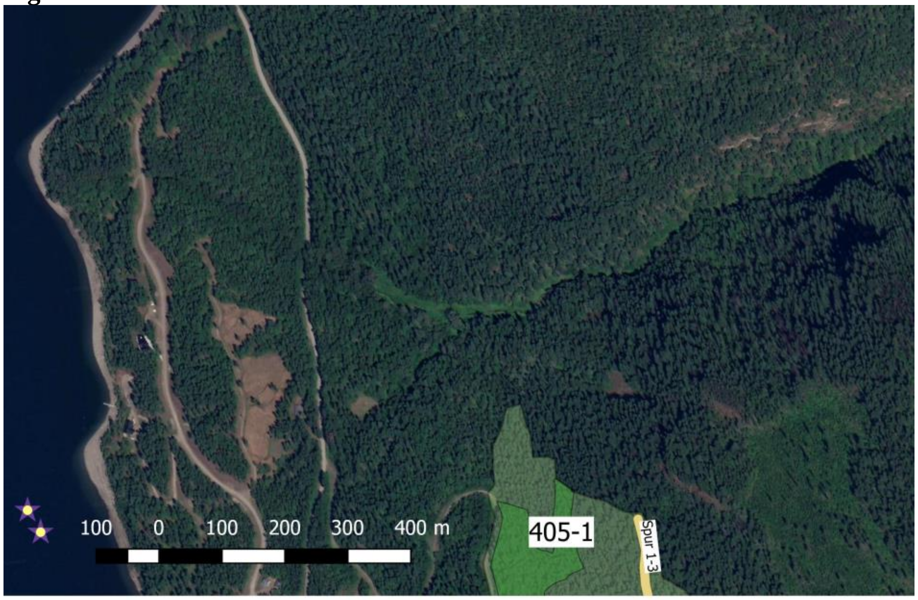


Figure 11



Although the fans were not investigated in the field, disturbed vegetation along Bulmer Creek, visible on google earth imagery, suggests that there has been a recent flood or debris flood in Bulmer Creek that terminated along the upper portions of the paleo fan.

Figure 12



Previous watershed and hydrological reports for this area indicate that that both Bulmer and Salisbury Creek hydrographs are related to higher elevation snow melt. The proposed development is along the lower and midslope positions of Bulmer and Salisbury watersheds and as such, are unlikely to impact the flood frequency of the watersheds and so will not increase the frequency of debris floods.

5.2 Block 405-1and northern section of Spur 1-3:

Provided the recommendations for Spur 1-3 are implemented, timber harvesting of Block 405-1 will not significantly increase the low likelihood of landslide initiation.

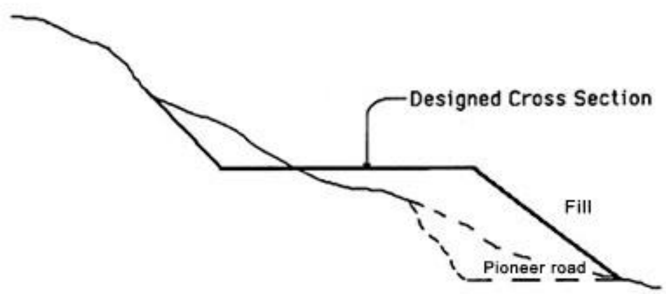
Along Spur 1-3 the proposed culverts were well located to maintain natural surface drainage patterns. Along this section of the road two additional culverts are recommended, at sites sal 92 and sal 96.

For the most part the proposed road is located on >55% gradient slopes underlain by sandy to silty sandy angular gravel. Conventional road construction will not significantly increase the low likelihood of landslide initiation.

The last 110 meters (Sal 95-97) of the Spur 1-3 is either just upslope or traversing 85% slopes. From sal 95 to 96 (~60m) the proposed road is on a bench upslope of the steep slope, the final ~50m is on the steep slope. This slope is underlain by coarse silty rubble colluvium over sub-vertical dipping schist. The schist cleaves into large flat plates and is easily broken and for soil strength it will be treated as silty angular gravel (GM), the long-term angle of stability is estimated to be 85% (~ 40^{o}). The Schist face forms an effective slip surface on the slope, increasing the likelihood of fillslope failures if unsupported. Conventional construction (balanced cut and fill) of the last 110 meters of the road will significantly increase the current low likelihood of landslide initiation resulting in a moderate likelihood of landslide initiation. The three options listed below will not significantly increase the low likelihood of landslide initiation:

- For a permanent road, construct the pilot trail below grade, use the pilot trail to support a portion of the fillslope. The fillslope of placed blocky schist keyed into the pilot trail can be 1:1, the cut slope in rock can be 0.5:1, in colluvium it should not exceed 1:1.

Sketch 2



- For a temporary road, leave high stumps on the fill side, place large woody debris in the fill span the stumps. Reclaim within 5 years.
- Construct as a forwarding trail, reclaim after harvesting.

Table 5.2.1 Spur 1-3

From/to Site	Slope	material	Prob landslide	Cut/fill	Comments	Recommendations	Residual Prob
88 to 92	45%	GW	Low				Low
92					Swale	Culvert	
92 to 95	55%	GW	Low				Low
95 to 97	85%	GM (angular)	Low			If recommendations are followed	Low
96					90% slope into swale	place coarse fill on outside. /culvert	Low

Any slide that does initiate is likely to runout on the slope or deposit debris on the large bench downslope. Slides will not impact the elements assessed for risk.

Table 5.2.2 Matrix for determining Hazardous slide, P (HA).

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Salisbury, Bulmer Creek, or private land; given that the Landslide/Soil Erosion Occurs			
		High	**Moderate**	**Low**	**Negligible**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High	(Low)
	High	Very High	High	Moderate	Low
	Moderate	High	Moderate	Low	Very Low
	Low	Moderate	Low	Very Low	Very Low

There is a very low landslide hazard.

5.3 Block 405-2, and Southern section of Spur 1-3:

Timber harvesting of Block 405-2 and construction of Spur 1-3 will not significantly increase the low likelihood of landslide initiation.

Along Spur 1-3 the proposed culverts were well located to maintain natural surface drainage patterns. Two additional culverts are recommended, at sites sal 76 and sal 77.

Table 5.3.1

From/to Site	Slope	material	Prob landslide	Cut/fill	Comments	Recommendations	Residual Prob
69 to 74	45%	GM	low				Low
74 to 77	35%	GM	Low			Crossing fan	Low
76					Swale	Culvert	
77					Swale	Culvert	

5.4 Block 405-4, Spur 4-1, and Spur 4-2

There are no terrain concerns along Spur 4-2. Apex proposed a culvert at Saldr 8 in a swale to maintain natural drainage patterns downslope.

The possible slide (S11) in the northeast corner of the block is at least 100 to 200 years old (Pa =0.01 to 0.005; moderate likelihood of landslide initiation) and likely associated with the last fire. The slide is small and ran out on the slope. The scarp is just within the upper portion of the block, timber harvesting will not significantly contribute slope drainage to the headscarp and will not significantly increase the moderate likelihood of landslide initiation.

The slides in the southeast corner of the block are 250 to 500 yr. old slides (Pa = 0.004 to 0.002; Moderate Likelihood of landslide initiation). Assuming 60 years for hydrological recovery, $P_{60}=1-[1-(.003)]^{60}=0.16$, this is deemed a moderate likelihood of landslide initiation. Timber Harvesting will not significantly increase the soil moisture in this area and will not significantly increase the Moderate Likelihood of Landslide initiation.

Spur 4-1 is positioned to access the upper southern portion of block 405-4, the spur is just upslope of the slide scarps. The Spur is predominately on ~45% gradient slope underlain by slightly cohesive silty gravel (GW), just set back from -55 to 65% slope. At sal 48 (just north of rd. sta. 50) 3 pink flags were hung to mark a suggested culvert location (wet area).

The slides are likely related to extreme climatic events (250 yrs.), if the spur is built as a temporary road and reclaimed after 5 years, $P_5=1-[1-(.004)]^5 = 0.02$, this is deemed to be a low likelihood of landslide initiation. Any slide that did occur, would run out on the large bench at the base of the slope. The slope drains north towards a large flat the likely ultimately contributes water to Salisbury Creek, but no sediment would impact the stream.

The proposed block is isolated from the steep slope to Salisbury Creek by swales within the reserve.

Timber harvesting in the rest of the proposed block will not significantly increase the low likelihood of landslide initiation.

Table 5.4.1

From/to Site	Slope	material	Prob landslide	Cut/fill	Comments	Recommendations	Residual Prob
48	45%	GW	low		Swale	Culvert	Low

Table 5.4.2 Matrix for determining Hazardous slide, P (HA). if recommendations.

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Salisbury, Bulmer Creek, or private land; given that the Landslide/Soil Erosion Occurs			
		High	**Moderate**	**Low**	**Negligible**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High	(Low)
	High	Very High	High	Moderate	Low
	Moderate	High	Moderate	Low	Very Low
	Low	Moderate	Low	Very Low	Very Low

There is a low landslide hazard.

The cracked fill at sal. 50 on the FSR should be cleaned of rotten woody debris and replaced with clean fill (1.2:1). The rock in the cut can be ripped if more material is required.

5.5 Block 405-5

Cable yarding of block 405-5, utilizing the existing FSR for setup and processing will not significantly increase the low likelihood of landslide initiation.

5.6 Block 405-6, Spur 6-1

Three recent debris slides initiated along a slope break near the top of the block just below Salisbury Mainline (at least 7 additional slides just upslope). The slides are associated with upslope road drainage. The slides are contained within older (250 yrs.) slide features. Slope drainage is naturally disrupted by flutes, ridges, and benches that parallel the slope. Low gradient slopes within flutes are receiving sites that likely allow water to infiltrate into the soils, the soils retain significant moisture resulting in "sub-hygric" soil conditions. It is surmised that under extreme climatic conditions (~ 250 yr. return, Pa = 0.004) the receiving sites and minor drainage divides are overwhelmed resulting in slope drainage flowing onto the unconditioned slopes, although the drainage is for the most part dispersed over the slope, transient concentrated plumes likely triggered the older slides.

The existing roads have altered the slope drainage by breaching the small sub-basin catchment divides and impeding the soil infiltration (road surfaces and ditches route the water to culverts). As a result, culvert or cross-ditch discharges have flowed onto the unconditioned slopes triggering small debris slides. After the original slides, culvert locations were changed, and cross-ditches constructed triggering additional slides.

Currently there is a very high likelihood of landslide (~10yrs, Pa = 0.1). It is possible that the minor rises are permanently breached and that recontouring the road will not re-establish pre-existing drainage conditions. Moving the cross-drains will likely just initiate new slides. Placing cross-ditches at all possible drainage sites would make the road inaccessible to 4X4 vehicles. Retaining current drainage patterns along the road will retain current slide initiation point locations. Currently the slides are small and run out on the slopes just below (negligible possibility of impacting the elements assessed for risk).

Table 5.6.1 Matrix for determining Hazardous slide, P (HA).

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Salisbury, Bulmer Creek, or private land; given that the Landslide/Soil Erosion Occurs			
		High	**Moderate**	**Low**	**Negligible**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High	(Low)
	High	Very High	High	Moderate	Low
	Moderate	High	Moderate	Low	Very Low
	Low	Moderate	Low	Very Low	Very Low

This area poses a low landslide hazard (P(HA)) for the elements assessed for risk.

Although there is a low hazard, there is a very high likelihood of landslides.

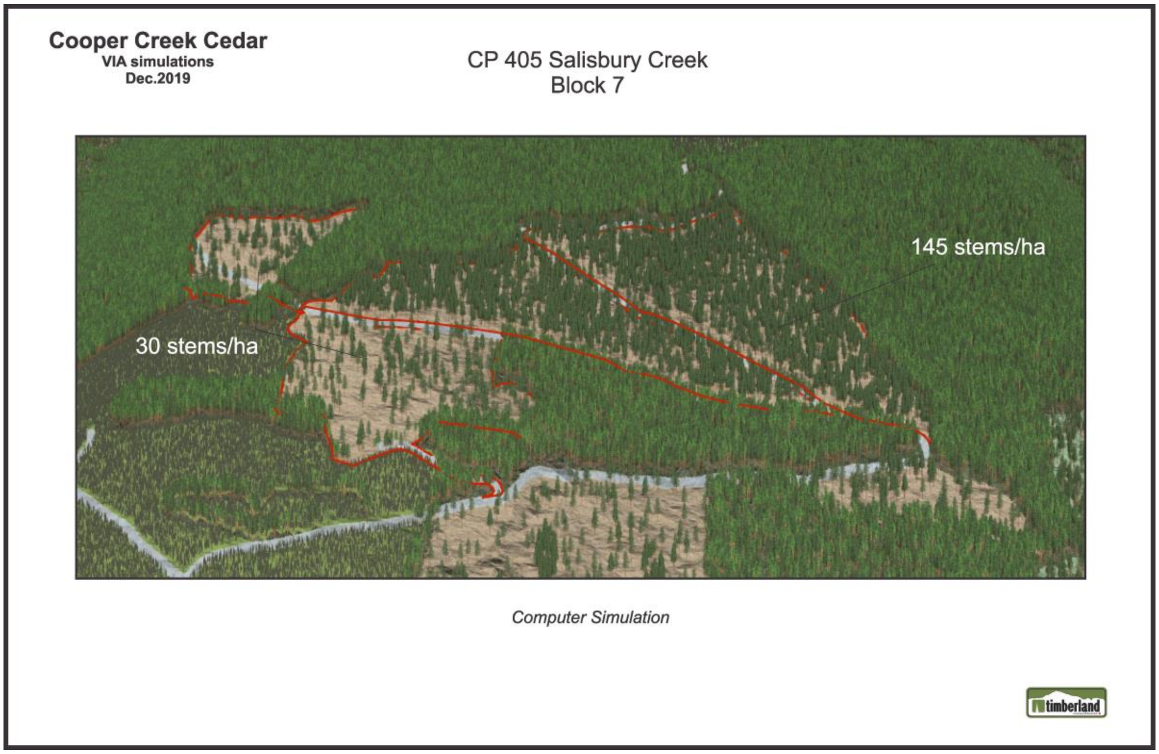
Cable yarding or trails in the portion of the block could alter the slope drainage. It is recommended that the block be harvested in the winter on at least a 1m snowpack. Bladed trails (cut exceeding 50cm in mineral soil) are to be avoided and should be recontoured within 1 year. If Spur 6-1 is required, it should be constructed as a forwarding trail, sections of the trail with 50cm or deeper cuts must be recontoured after harvesting (avoid recontouring with mixed soil and snow). If Spur 6-1 is constructed as a forwarding trail and recontoured within 1 year, the likelihood of a landslide is estimated by $P_1=1-[1-(0.1)]^1 = 0.1$, this equates to a moderate likelihood that a slide will occur.

There is a low likelihood of landslide initiation in the remainder of the proposed block 6.

5.7 Block 405-7

The original layout for block 405-7 has been altered for Caribou Management. The image below is the computer-generated simulation (timberland) illustrating possible retention and distribution of the trees. The imagery shows portions of 405-6 (bottom of the image) as well.

Image 1



There are two debris slides within the block and four just downslope. The conditions and causes of the slides has been discussed in detail in Section 5.6 (Block 6).

Currently there is a very high likelihood of landslides (~10yrs, Pa = 0.1). The slides are small and run out on the slopes just below (negligible possibility of impacting the elements assessed for risk).

Table 5.7.1 Matrix for determining Hazardous slide, P (HA).

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Affect Salisbury, Bulmer Creek, or private land; given that the Landslide/Soil Erosion Occurs			
		High	**Moderate**	**Low**	**Negligible**
Likelihood of Occurrence of Landslide	**Very High**	Very High	Very High	High	(Low)
	High	Very High	High	Moderate	Low
	Moderate	High	Moderate	Low	Very Low
	Low	Moderate	Low	Very Low	Very Low

This area poses a low landslide hazard for the elements assessed for risk.

Cable yarding or trails in the portion of the blocks within area #1 could alter the slope drainage and increase the likelihood of landslides. It is recommended that the portion of Block 7 between Salisbury Mainline and Salisbury 300 road be harvested in the winter on at least a 2 m snowpack. Bladed trails (cut exceeding 50cm in mineral soil) are to be avoided and should be recontoured within 1 year.

There is a low likelihood of landslide initiation in the remainder of the proposed block 7.

Respectfully Submitted,
Apex Geoscience Consultants Ltd.

Will Halleran Digitally signed by Will Halleran
DN: cn=Will Halleran, o=Apex Geoscience Cons., ou=Geotech, email=apexgeo@shaw.ca, c=CA
Date: 2020.06.24 14:52:21 -07'00'

Will Halleran P.Geo. Eng. L.

Appendix I Tabulated Field Notes and Map.

Title	Description
sal1	cutslope fill failure debris slide. slide starts upslope in forest. possible older slide below culvert just down road, limestone terrain just back, silty material. upper reaches of road nave surface flows lower in phyllite no obvious flows.
sal2	major draw drains to south. schist.
sal 3	southerly trending shallow flutes
sal 4	back into limestone
sal 5	pool of water in ditch by block no culvert, road back showed erosion.
sal6	wet cross ditch, blocks in cut, could be placed, ditch block.
sal 7	cross ditch, there were others.
sal8	phyllite, foliation sub parallel to slope strike 120 dip 40 west.
sal9	road low point.
sal 10	silty sandy gravel and phyllite
sal11	100% cutslope in silvery grey phyllite, 20 strike 55 dip west, easily crumbled. take off ditch at switch.
sal 12	at switch 75% cut in silt 10%, sand 25%, rounded to subangular cf 65%, slightly dense, likely mix of till and colluvium.
sal 13	crossed broad shallow, swale. 75%, scattered phyllite outcrops parallel to slope. here, angular phyllite scattered on surface. pit 25cm Bm silt 15%, sand 40%, angular to rounded cf 45%, loose, Bc silt 10%, sand 25%, rounded to sub angular gravel, in pit mostly smaller than small cobble, sl. dense, well drained. slope 7p%, Douglas fir.
sal 14	broad shallow swale looks like stepped debris slide, in swale, 2cm silt Bm, charcoal on top 15cm bc1 silt 60%, sand 40%, dense, bc2 silt 25%, sand 30%, sub rounded gravel 45%, mod dense. evidence of seasonal seep on south side (plants) possible headscarp just upslope and down slope. slope av 75%, possible seasonal wet. small phyllite steps below, older debris slide adjacent just to north headscarp lower, scar on 60% slope break, pots adjacent to 1st slide and in older slide good Bm, this slide (small) may have occurred soon after last fire.
sal15	followed up swale, mostly floored in coarse colluvium, with interstitial Bm, coarse percent increases until about 100% just below head scarp which is rock, scarp 85%, crown 65%, pits on crown give silt 15%, sand 20%, cf angular 65%, tree churn pulls up silt 15%, sand 75%, pebbles10%, about 1m deep. so original pit may be deposition from wash through coarse colluvium, but why no Bm, swept trees mostly Douglas fir along slope, also see two swept spruce. scattered aspen, broad swale heading upslope feeds this area.
sal 16	boundary just into road swale, no channel, pot in bottom, 75% angular rubble, silt 10%, sand 15%, bm. to here random pits occasionally give silty sand, mostly pits give as before. swale gradient 65%.
sal17	+85%/-65%, small rock steps, occasional small blocks on surface, pits mostly give good Bm coarse soil loose, likely in swale water occasionally flows washing fines off rock.
sal 18	small mossy talus zone, looks like water has flowed through here previously to here small outcrops parallel to slope.75%
sal19	just crossed above short 150% rock step (headscarp), broad swale(s) below, just ahead deep swale.

Title	Description
sal20	broad dry swale 60%, heads down slope joins another one both road, creek marked wrong on map.
sal 21	40% bench silt 15%, sand 25%, subangular to angular well sorted cf 60%, upslope 65% slope coarse colluvial soil, downslope 50% mix.
sal 22	silty sandy gravel good Bm throughout ancient erosion feature off bench.
sal 23	30% bench, terrace, ancient erosion swales off, water off slope likely disperses on bench, if trailed decompact.
sal24	boundary flags, not on map
sal 25	followed small erosion feature down to road, road cut 75% phyllite step with silty soil, no sign of water. plotted wrong,
sal 26	only culvert I noticed on this road section, plastic no xd either. no sign of erosion or point sources
sal 27	metal culvert, swale.
sal28	culvert.
sal29	road culvert marked on proposed road, small swale, on existing road 80% cut in silt 25%, sand 25%, crumbly, slightly cohesive (silt). 40% slope just up from 65%.
sal 30	small debris slide, scarp at slope break, cut trees on scarp, silty sand, light Bm 15cm, dark grey silty sand Bc, cf ~50%. slide 3.5m wide, 1.5m deep. some debris just below, sharp scarp 250 yrs. 85% scarp, 40/60 break.
sal 31	debris cone o 60% slope, 30cm unweathered grey silty sand some rounded cf, then slightly weathered (light brown) silty sandy gravel. cut stumps. debris must have quickly dewatered, 200 to 100? yrs. larger slide just ahead.
sal 32	just crossed 2 debris slide headscarp, more subdued than first but still poorly developed Bm, silty sand. then sl dense silty sand dark grey with increasing phyllite fragments at depth, possible weathered rock, scarps on short 75% slope between 40% and 60% estimate these slides active (possibly within larger) 250 to 100. soil is moist to wet. dry on side slopes.
sal33	+70%/-55%, debris slide gully, sharp in bottom, areas of no Bm on sides (trim) areas of no Bm in bottom but other areas of thick Bm on sides and bottom, could this have been used to skid trees down? small cut stumps across slope. if slide, small within ancient feature, 200 to 100. no trees in swale.
sal 34	followed it down, no undercut banks, no debris against adjacent trees, still obvious, one 40cm large near bottom may have been scared, still cut stumps along swale, broader older debris slide to south.
sal35	gps puts me here but I am on the flagged boundary (wtp?). gully may have seasonal flows but no trim and good Bm throughout. 65% sideslope.
sal36	broad open swale, no trees, looks like small debris piles, pit gives 15cm silty sand, then orange silty sand with chunks of charcoal (Bm) then sandy gravel, could be location of high ground water after fire may result in wash or flow.
sal 37	dry swaled slope ahead, occ large yellow pine vet, 60% slope.
sal38	corner, below here block drains to north.
sal 39	+/-70%, dense, silt 25%, sand 20%, sr to rounded gravel 55%. no obvious soil development large cedar in swale.
sal 40	rock step, schist/quartzite. 100 to 90% slope.
sal 41	small bluff, 60% slope above underlain by compact silty sandy gravel to gravelly silt.

Title	Description
sal 42	60%, tree churns show mostly cf about 65% r to sr, silt 20%, sand 15% mod dense.
sal 43	headscarp of swale, ancient. near top of divide.
sal 44	20% bench seems a wet zone feeds swale subtle, just zone of little undergrowth, proposed road 15m below crosses headscarp about 10m below break, compact silty gravel, 65% slope, small bench (stepped debris slide) will catch fill. or move up to flats.
sal 45	pot spur1, above old scarp just past stream swale
sal46	35% slope, 5m back from 55%
sal 47	culvert feeds head of swale, +35%-65%, silty sandy gravel.
sal 48	cross upper head scarp, likely wet, place culvert just north of sta. 5 spur4-1 3 pink flags. 55%.
sal 49	phyllite and silty gravel in cut, blocked ditch, minor scour down road from here. 130% cut.
sal 50	cracked fill, -80%, sub vert rock cut.
sal51	shallow swale upslope, high silty gravel cut, no erosion.
sal 52	Rock (
sal 53	Bluff (quartzite)
sal 54	rock and silty blocky colluvium
sal 55	dry creek, silty rubble on north side, crudely layered gravel on south. lenses of silt and sand, compact.
sal 57	rock
sal 58	
sal 59	Salisbury creek waterfall just upstream
sal60	xd, culvert, low point in road.
sal 61	cross-ditch
sal 62	road heads up.
sal 63	cross-ditch low gradient ahead.
sal 64	cross-ditch
sal65	no obvious stream
sal 66	height of road
sal 67	block boundary. rock exposed in landing. poc of road just ahead.
sal 68	low point of road at base of higher gradient road section, bench here.
sal 69	very small swale, 50% slope, no sign of flows. Orange silt 15%, sand 15%, angular well sorted cf 70%, rock likely close. 6cm Ae.
sal 70	ancient cone/fan sandy gravel, 40%.
sal 71	45%, sta. 8 spur1-3
sal 72	swale, road culvert marked, 55%, likely seasonal sub surface flows, sta. 11. then onto short 65% slope, 50% just up, bench below, possibly nose of ancient cone, silt 15%, sand 20%, sub angular well graded cf 65%. or small rock step.
sal 73	ancient debris flow deep swale, no trim, forested across, +45%/-45%, silt 10%, sand 20%, sr to sa cf 70%, sl. dense. road culvert marked.
sal 74	4m high 60 to 65% sideslopes, 2.5m wide bottom, possible soil trim on north side 500 to 250 (no likely old tree churn, good Bm on same side just upstream), treed,

Title	Description
	silty sandy gravel, lidar shows debris deposition on flats, +45%, -35%, bench just below, road culvert marked.
sal 75	crossed three ancient debris flow swales, 2 with culverts, now Ã—/-35%. very broad shallow swale, cedars, moisture plants, 10cm Ae, no culvert marked, but culvert just back in df swale. start onto fan/cone.
sal 76	heading off edge of fan, this is a divide, mostly loose silty sandy gravel occ boulders, just back small short swales, water likely sub surface, can go either way, if water intercepted place culvert, here sta.29 road heading down into swale.
sal 77	block 3 boundary just before swale, gps wandering place on map at boundary, might be to far north. go back to place culvert.
sal78	small swale below, orange start of 8% adverse
sal 79	65% slope, here on 2m high levee 2m above bottom of swale, sandy cobble/rubble occ blocks, near apex, swale becomes gully just upslope. levee on other side as well
sal 80	+80%/-60%. Douglas fir, boundary just upslope, silt 5%, sand 10%, angular cf 85%, loose rapidly drained.
sal 81	+/-75%, angular colluvium 85%, occ outcrop slightly steeper than slope, phyllite colluvium, this outcrop quartzite. boundary splits, one heads up into rocky brushy terrain, follow wtp boundary that heads down. blocky colluvium, likely rockfall from upslope.
sal 83	+60%/-50%, near base of colluvial apron, blocky rubble.
sal 82	+/-80%, blocky colluvium, large bench just down slope. wtp boundary heading down towards bench.
sal 84	start of swale, gentle headscarp in blocky rubble colluvium, just into toe of colluvial apron, +60%/-40%.
sal 85	swale becomes deep right away just below toe of apron; top of swale filled with rubble. these features are ancient, likely formed soon after deglaciation, much wetter, water out of talus (perhaps same time) eroded channels, 35 to 40% at top, unless the headscarps are filled with colluvium which would explain the gentle tops of the swales, the slope gradient isn’t steep enough to initiate a slide.
sal86	crossed headscarp zone of swales all similar, swales mostly in silty sandy angular to sub angular gravel as noted previously. here increase in rounded cobbles. tree churn exposed silt 10%, sand 15%, rounded well graded 75%, start of flatter bench may be pockets of kame terrace or fan from upslope, -35/+45%.
sal 87	+25%/-35%, sandy gravel, stable, polygon must be mislabeled
sal 88	crossed off fan, no obvious swale. +/-40%
sal 89	to here less than 40%, mostly sandy gravel (sand 25%, r to sr well graded cf 75%) here silty sandy angular. just crossed shallow broad feature, floored in coarse colluvium, likely washed, may be moist.
sal 90	sta.38 landing, road has been on 45% step between benches, silty sandy gravel, passed a small fan, possibly place culvert just back depending on final road alignment.
sal91	just past ancient shallow debris slide, road crosses debris cone on 45% slope, +60%, silt 5%, sand 10%, sr to a cf 85%, block boundary visible just upslope.
sal92	+60%/-55%, sandy colluvium, small swale just ahead. 3 orange for culvert, no 9bvious swale here. just before station 45.

Title	Description
sal 93	sta. 46, +/-55%, just upslope of 65% underlain by silt 5%, sand 15%, a cf 80%.
sal 94	up on rock-controlled bench, +35%/-55%, capped with sandy gravel, colluvium on faces.
sal 95	gps not good jumping, near end of road, could see block flags upslope, here below road about 10m -85% slops with subvertical schist small faces. Silty sandy colluvium, no sign of instability, road on flat just back from break.
sal 96	+85%/-75%, just off bench, here blocky colluvium, swale on slope below, just back 15m below road 90% slope into swale, sandy gravel on top colluvium on face. place culvert here although likely so coarse will go subsurface. construct pilot trail below, place coarse fill on outside. platy rubble ahead +/-75%.
sal97	to here 75 to 85%, here 85%, mostly angular rubble, up to 15% fines, treat as angular gravel. pilot below.
sal 98	to here below road crossed rubble colluvium, here small 100% rock (phyllite) step foliation sub parallel to slope
sal 99	phyllite and quartz.
sal 100	off 90 to 100 % slope onto 70% silty colluvium 85% cf, can see another rock step below,
sal101	draw running northwest, on west side ridge of sandy well-rounded gravel, cobbles. glacial feature, small swales off slope (30%) feed draw. off steep slope now.
sal 102	kettled, areas where slope drainage will pool. generally, pitch northwest.
sal 103	culvert, no scour.
sal 104	crossditch
sal105	crossditch
sal 106	deep draw and small knolls.
sal107	-60%, +0%. silt 10%, sand 25%, r to sub angular cf 65%, lots of fine pieces of schist, sl. dense. very dry. steeper step just below.
sal 108	70% slope, same material just below breaks, bench to north and down slope, just below block, very dry, burnt snags good Bm, stable.
sal 109	cedars on bench.
sal 110	cross-ditch slope drains to southeast
sal 111	paralleled draw to here, cross on flats, road culvert, (unconfined here) no channel, road flats
sal 112	sta. 10 road culvert
sal113	shallow swale.
sal114	swale then ridge nose, ridge ends here.
sal 157	start of spur on small bench.
sal 158	small debris slide, 6m wide, 1m deep, 6m long, no obvious slide path below, on side of ancient debris slide path, head scarp just to south, slide is about 10 yrs.? must have been high pore pressure, 70% slope below spur, underla8n by silt 15%, sand 10%, angular cf 75%, includes block of limestone.
sal 159	spur above slide is on +35%/-60%, rubble material, road culvert ahead will feed ancient slide gully.
sal 160	to station 6, 35% slope two swales with culvert marked, silty sandy soil seem wet, here -40% just back from -60%, entering bowl draw.

Title	Description
sal161	sta. 7, bowl looks like head scarp area of partial slump, soils silt 20%, sand 30%, cf mostly small. pits give good Bm except for below station 7, here debris slide scar, older above road good Bm, small more recent slide at road, no Bm in scar, scarred trees, although there are old rotten ones, slide likely very shallow, the slide is within the older scar 2m wide, 25cm deep 15m long, 15 to 25yrs? the gully is still treed. slope here 45%. there is a culvert marked here.
sal 162	sta 9, crossed 35% slope underlain by loose silt 10%, sand 30%, well sorted gravel 50%, upslope of 65% slope lose silty gravel with phyllite chunks.
sal163	sta. 12, strange broad swale, 2.5m flat bottom 45% slope, terminates on 70% slope (likely rock control) below, loose sandy gravel, good bm.
sal 164	another swale, strange terrain here seems to have had periods of high flows like a fan.
sal 165	to here mostly on 45% slope back from 60, here onto 60. the terrain back showed evidence of periods of high moisture, i.e. little erosion swales, the bigger swales the previous debris slides, here heading into the headscarp of old debris slide flows.
sal 166	pot, just back through ancient debris slide headscarp, -55%, +65%, pot just before debris flow path, not deep. logs and debris on sides, no trees in, less soil, 25 to 50 yrs. pot +55%-65%, this slope has experienced debris slides and flows, loose sandy gravel.
sal 167	1.5 m step in debris slide scar, -55%+45%, less entrenched up from here, possibly went around trees. (it is a broad older head scarp with displaced material in it, to south is a more defined debris slide flow in wtp, wtp runs up edge of this one, small channel continues up. follow up. Was actually part of the debris slide headscarp , top scarp on 70% slope silty sandy gravel, not treed but big tree at toe, pit in scar wet soil, not as well Bm as on sides, I think this is an older scarp, as 35cm cedar at base but one is scarred 30 yrs., likely from rock rolling. so periodically wet recurring debris slides last on about 15 to 25? high likelihood. road will increase. could be related to limestone band.
sal168	culvert, fill was only about 45%.
sal 169	culvert.
sal170	culvert armoured cut.
sal 172	no, terrain concerns, why is this 4.
sal 173	wet area, 40% up from bench.
sal 174	deep silty sandy gravel 55% slope.
sal 175	55% slope, silty sandy gravel occasional pce of angular quartzite, likely close to rock in places. scattered devils club
sal 176	two debris slides, initiate on 70% slope at break with flats, most debris deposited on 55% slope below, first one looks older subdued, debris scars on trees about 25yrs, northern one more of a debris slide 6m wide, 1mdeep, 10m long, debris against trees some tension cracks on crown, 1.5m high alder, 10 yrs.? dead trees rotten, so may be older. Likely related to upslope drainage. Silt 25%, sand 15%, cf a to sa mostly quartzite 60%.
sal178	55 t0 60 % slopes, no additional slides.
sal 180	55% slope from bench to here, 80% 10, to 20m high large bench below) slope at toe of slope, 55% slope underlain by silty sandy to sandy silty gravel. steep slope

Title	Description
	sandy silty gravel with scattered quartzite outcrops, sub vert faces. slope is rock controlled.

saldr 1	did not see this point but lots of deadfall, did notice a brushy zone that may have indicated moisture.
saldr 2	possible low pt. of ridge nw draw deep shallow on se side but pitching nw here.
saldr 5	sta 5,
saldr 6	sta. 9 thimbleberries
saldr 7	sta 10 road culvert
saldr 8	very subtle feature, culvert just before station 12. three pink.
saldr 9	swale upslope, cedar "flats" here if this is back of landing, discharge off back.

Title	Description
kar 10	phyllite in cut. mostly deep gravel to here.
kar 11	silty sandy gravel
kar 12	overfold quartz rich phyllite,
kar 13	outcrop on road, grey quartzite, lots of quartz veins and sections of quartzite, approx. 1m thick bed of micritic limestone with phyllite laminations, dissolution of calcareous bands, 1 to 1cm wide, 5cm deep, dipping down hill. vertical fractures align
kar 14	almost vert black phyllite.
kar 15	to here mostly quartzite and phyllite, here micritic mudstone limey with quartz bands, quartz resistant stick out, phyllite partings. some areas more limey occasional dissolution.
kar 16	sinkhole.
kar 17	phyllite and quartzite to here
kar18	1m thick limestone in phyllite, minor dissolution along fine beds, 2cm deep, 3cm apart.
kar 19	grey and white limestone 2m wide, dissolution along bedding and along fractures, fractures (grikes) 0.5m apart, 2cm wide, at least 20cm deep. strike 170, 80 dip W. lst more common. so, from here upslope at 170 degrees possible karst areas, area for assessment
kar 19a	limestone in di5ch and along road to here, then likely under road for a while.
kar 20	limestone, 90% carbonate, minor pieces of phyllite, orange weathering zones with pelites, highly fractured, dissolution along bedding, unclear how much along fracturs, deep silty soil to here.
kar 21	possible sink no, culvert.

Title	Description
kar 22	followed old cat trail to here, float is quartzite, went up draw to bench, here small ridge to west, still on bench.
kar 23	mounded wet terrain, no rock.
kar 24	short quartzite rock face, likely resistant ridge, vert fractures, bench below underlain by silt 25%, sand 15%, mixed cf mostly phyllite and quartzite, likely flute along weaker rock. this step is likely quartzite along length.
kar 24	45% slope off bench, mostly quartzite float.
kar 25	55% slope down, flat back, vert foliated phyllitiic quartzite at break.
kar 26	6p% slope moss covered competent phyllite (quartzite), slight back lean here forms swale on bench, bench shallow to phyllite. Slope on other side of swale, small quartzite cliff. swale becomes more pronounced; pits give sandy silty phyllite soil.
kar 26	overall slope 55%, series of vertical small rock faces, phyllite and quartzite,
kar 27	base of 80% slope with small rock step at base, up about 20m to bench then a "cliff" further up, mossy here, devils club on bench at base, looks like water flows through here, foliation now into hill. Rock is laminated limestone, minor dissolution features along foliation and fractures. Quartz rich phyllite at base.
kar 27	outcrop at top quartzite, lst frags only near bottom, lst interbed?
kar 27	broad bench, small ridge on west side, steep rock slope on east, limestone may occur near the base of the slope, mostly steeply dipping rock so benches are not rock planes but glacial scour or ge9logical weak lineation's.
kar 28.	the bench started to become a steep swale, noted rounded limestone blocks and rubble. perhaps outcrop, about 15m below 3m rock step at top, went up to step, grey banded limestone 90% carbonate, dissolution on fractures narrow variably spaced, most fractures sharp, no grikes or pits.
kar 29	about 3m of limestone, then about 5m of quartzite phyllite to top of slope, stability wise okay for harvest, keep trails away from toe.
kar 30	not3d interbedded phyllite in limestone, no obvious karst features, bench is mantled, toe of slope apron, secondary bench here, then swale becoming deeper.
kar 31	pine flats with phyllite and quartz rich phyllite in churns, here edge of mossy quartzite step and small bluffs. broadly stepped slop below, no terrain concerns.
kar 32	+20/-50%, silty sandy gravel, cf 50%, open pine.
kar 33	50% slope, variable silty sandy gravel over quartzite with interned of phyllite (outcrop occasionally in tree churns),
kar 34	moss covered quartzite and phyllite.
kar 35	mostly quartzite to here, shallow soils over rock, here starting into wetter area, deeper soils.
kar 36	25% slope, silty soil, mostly phyllite frags, sharp v shaped gully swale.

Title	Description
kar 37	tree churn in swale rips up limestone block, surface weathering leaves resistant phyllite bands. could be collapsed cave. devils club in bottom.
kar 38	broader swale, opens up, start of lots of devil's club in forest.
kar 39	small pits, large ancient tree churns? 2m seep 4m across.
kar 40	into broad wet devil's club area, here small sinkholes. no obvious water flowing in, 5% slope 1m wide 3m long, across swale east west, likely fracture system crevasse. two here, one just up. Limestone exposed on side. two together 10m radius., broad devils club flat, no direct flow, bottoms covered is mineral soil, not exposed. Sinkholes just upstream from where bench becomes swale, may feed old cave.
kar 41	walked back and forth through wet area, flat, no obvious sinks to here, deep soils, silty soil with mostly phyllite,
kar 45	knoll, silty sandy gravel some quartzite frags
kar 46	another broad bench with thick patches of devil's club and copses of large cedar, hem, spruce.
kar 47	followed devils club broad swale to here, now, above swale to east (on slightly confined top ridge), slope to west gets steep, ends on slope to swale, no surface expression, no sinks.
kar 48	broad wet zone.
kar 50,	north end of knoll ridge ends abruptly at east west step, then rises slightly on other south, feeds swale on west.
kar 51	a few more little knolls, mounds, tree churns expose silt soil with rounded limestone frags, low points feed swales.
kar 51	broad bench, small rise in middle, silty sandy gravel angular, quartzite and phyllite.
kar 55	Limestone underlies bench, minor weathering quartz resistant, some separation on east fractures crevasses. quartzite and phyllite exposed just to west.
kar 56	lower bench underlain by phyllite and quartzite, upper bench by limestone at edge.
kar 57	small lst rise on bench, rounded frags, covered in moss and forest floor cannot see features very well, no obvious karst features.
kar 58	off nose of limestone rise, still limestone to west in rise, here seems start of swale, sinkhole sharp, 2m deep, 2m ns, 5m ew, forest floor across, bottom, lst exposed in south side, dry here. obvious solution of parting at base. I was able to push a stick through forest floor until roots stopped, 0.5m, may be open be earth root mat. Thought I may have seen some back but was not sure if they were not just large tree churns.
kar 59	bench continues 170 degrees (strike), road is up on another bench, likely quartzite.
kar 60	road to here in deep glacial materials, mostly silty sandy gravel, cf 50% or less, here small phyllite ridge to west.
kar 60	the slope up from bench is quartzite, here on another bench,

Title	Description
kar 61	broad mounded draw, on west side steep quartzite face confines draw.
kar 62	mounded mossy bench and broad mossy draw swale.
kar 63	broad draw, to east gentle slope 20m, to west steep slope, quartzite exposed at top, phyllite seems to be in the bottom, limestone bed is in here somewhere but likely under deep soils on gentle slope.
kar 64	swale 3nds on bench, no sinks, hummocky and broad swale to west, check it out.
kar 70	walked back and forth over strike extension of lst, no evidence, mantled with silty gravel,
kar71	no sign to here, for stability slope below bench is 55%, followed likely erosion path of water off switch, caught by swale carried down slope, other short deep swales near edge of b3nch discharge onto the slope, no evidence of surface flows, lots of devils club.

Appendix II Terrain Stability Features.

Title	Description			
sal1	Cutslope/ fill failure debris slide. slide starts upslope in forest. possible older slide below culvert just down road.	Fill/cut slope debris slide	initiation	<20yrs
sal 14	broad shallow swale looks like stepped debris slide, in swale, scar on 60% slope break, this slide (small) may have occurred soon after last fire.	Debris slide	Initiation/ Transport	>100yr s
sal15	swale mostly floored in coarse colluvium, below head scarp, which is rock, scarp 85%, crown 65%, pits on crown give silt 15%, sand 20%, cf angular 65%, tree churn pulls up silt 15%, sand 75%, pebbles10%, about 1m deep.	Debris slide Erosion	Initiation	>100yr s
sal 30	small debris slide, scarp at slope break85% scarp, 40/60 break.	Debris slide	Initiation	250 yrs.
sal 31	debris cone on 60% slope	Debris cone	Deposition	>200yr s
sal 32	just crossed 2 debris slide headscarp	Debris slide	Initiation	250
sal33	+70%/-55%, debris slide gully,	Slide gully	Erosion May be skid	>200
sal 34	followed it down,	Slide swale	Erosion May be skid	>200
sal36	broad open swale, no trees, looks like small debris piles,	Debris	Deposition	>500
sal 43	headscarp of swale, ancient. near top of divide.	Debris slide	Initiation	>500
sal 45	pot spur1, above old scarp just past stream swale		Initiation	>500
sal 48	cross upper head scarp, likely wet, place culvert just north of sta. 5 spur4-1 3 pink flags. 55%.	Debris slide	Initiation	>500
sal 50	cracked fill, -80%, sub vert rock cut.		Tension crack	
sal 73	ancient debris flow	Debris flow	Transport	>500
sal 74	4m high 60 to 65% sideslopes, 2.5m wide bottom, possible soil trim on north side 500 to 250	Debris slide/flo w	Transport/ Erosion	500
sal 75	crossed three ancient debris flow swales	Debris flow	Transport	>>500
sal 79	2m high levee 2m above bottom of swale	Debris flow	Deposition /	500

Title	Description			
			Transport	
sal91	road crosses debris cone on 45% slope,	Debris flow	Deposition	>>500
sal 158	small debris slide, 6m wide, 1m deep, 6m long, no obvious slide path below, on side of ancient debris slide path, head scarp just to south, slide is about 10 yrs.? must have been high pore pressure, 70% slope below spur, underlain by silt 15%, sand 10%, angular cf 75%, includes block of limestone.	Debris slide	Initiation	<20
sal161	below station 7, debris slide scar, older above road, small more recent slide at road, no Bm in scar, scarred trees, although there are old rotten ones, slide likely very shallow, the slide is within the older scar 2m wide, 25cm deep 15m long, 15 to 25yrs? the gully is still treed. slope here 45%. there is a culvert marked here.	Slump/ Debris slide	Initiation	<20
sal 166	pot, just back through ancient debris slide headscarp, -55%, +65%, pot just before debris flow path, not deep. logs and debris on sides, no trees in, less soil, 25 to 50 yrs. pot +55%-65%, this slope has experienced debris slides and flows, loose sandy gravel.	Debris flow	transport	25 years
sal 167	1.5 m step in debris slide scar, as 35cm cedar at base but one is scarred 30 yrs., likely from rock rolling. so periodically wet recurring debris slides last on about 15 to 25? high likelihood. road will increase. could be related to limestone band.	Debris slide	Initiation	15 yrs.
sal 176	two debris slides,	Debris slide	Initiation/ Deposition	10

Appendix III Surficial material

Title	Description	surficial	Bedrock
sal8	phyllite, foliation sub parallel to slope strike 120 dip 40 west.		Phyllite
sal 10	silty sandy gravel and phyllite	zsgMb	Phyllite
sal11	silvery grey phyllite, 20 strike 55 dip west, easily crumbled.		Grey Phyllite
sal 12	silt 10%, sand 25%, rounded to subangular cf 65%, slightly dense, likely mix of till and colluvium.	zsgMb r to sa	
sal 13	scattered phyllite outcrops parallel to slope. here, angular phyllite scattered on surface. pit 25cm Bm silt 15%, sand 40%, angular to rounded cf 45%, loose, bc silt 10%, sand 25%, rounded to sub angular gravel, in pit mostly smaller than small cobble, sl. dense, well drained.	zsg//zsMb r to sa	Phyllite
sal 14	2cm silt Bm, charcoal on top 15cm bc1 silt 60%, sand 40%, dense, bc2 silt 25%, sand 30%, sub rounded gravel 45%, mod dense.	sz/zsg sr Mod dense	
sal15	coarse colluvium, with interstitial Bm	zsrCb/	
sal 16	75% angular rubble, silt 10%, sand 15%, bm. to here random pits occasionally give silty sand	zsrCb	
sal 18	small mossy talus zone,	Talus	
sal 21	silt 15%, sand 25%, subangular to angular well sorted cf 60%, upslope 65% slope coarse colluvial soil, downslope 50% mix.	zsgCb a sa	
sal 22	silty sandy gravel good Bm throughout	zsgMb	
sal 25	, road cut 75% phyllite step with silty soil.	zMv	phyllite
sal29	silt 25%, sand 25%, crumbly, slightly cohesive (silt).	szgMb (50% sand and silt)	
sal 30	silty sand, light Bm 15cm, dark grey silty sand bc, cf ~50%.	zsgMb (50% sand and silt)	
sal 31	30cm unweathered grey silty sand some rounded cf, then slightly weathered (light brown) silty sandy gravel.	zsDb	
sal 32	poorly developed Bm, silty sand. then sl dense silty sand dark grey with increasing phyllite fragments at depth, possible weathered rock,	zsDb	
sal36	15cm silty sand, then orange silty sand with chunks of charcoal (Bm) then sandy gravel,	sgMb	

Title	Description	surficial	Bedrock
sal 39	dense, silt 25%, sand 20%, sr to rounded gravel 55%. no obvious soil development	Dense szgMb rounded	
sal 40	rock step, schist/quartzite.		Schist/quartzite
sal 41	small bluff, compact silty sandy gravel to gravelly silt.	zsg to gz	Quartzite
sal 42	cf about 65% r to sr, silt 20%, sand 15% mod dense.	szgMb	
sal 47	silty sandy gravel.	zsgMb	
sal 49	phyllite and silty gravel in cut.	zgMb	Phyllite
sal 50	sub vert rock cut.		Phyllite
sal51	silty gravel.	zgMb	
sal 52	Rock		rock
sal 53	Bluff (quartzite)		Quartzite
sal 54	rock and silty blocky colluvium	zaCv	rock
sal 55	dry creek, silty rubble on north side, crudely layered gravel on south. lenses of silt and sand, compact.	zrCb/sgFg/sz/z s	
sal 57	rock		rock
sal 69	Orange silt 15%, sand 15%, angular well sorted cf 70%, rock likely close. 6cm Ae.	zsrDb (orange)	
sal 70	sandy gravel, 40%.	sgFG fan	
sal 72	silt 15%, sand 20%, sub angular well graded cf 65%. or small rock step.	zsgCb (sa)	
sal 73	silt 10%, sand 20%, sr to sa cf 70%, sl. dense.	zsgMb sl. Dense A sa	
sal 74	silty sandy gravel.	zsgMb	
sal 76	loose silty sandy gravel occ boulders	zsgbMb	
sal 79	sandy cobble/rubble occ blocks levee,	sgFG	
sal 80	silt 5%, sand 10%, angular cf 85%, loose rapidly drained.	szrCb	
sal 81	angular blocky colluvium 85%, occ outcrop, phyllite colluvium, this outcrop quartzite	arCb	Phyllite/Quartzit e
sal 83	near base of colluvial apron, blocky rubble.	raCk	
sal 82	blocky colluvium	aCb	
sal 84	blocky rubble colluvium, just into toe of colluvial apron	arCk	
sal86	silt 10%, sand 15%, rounded well graded 75%,	szgFG (well rounded).	
sal 87	sandy gravel	sgFG	
sal 89	mostly sandy gravel (sand 25%, r to sr well graded cf 75%) here silty sandy angular. just crossed shallow broad feature, floored in	sgMb	

Title	Description	surficial	Bedrock
	coarse colluvium, likely washed, may be moist.		
sal 90	silty sandy gravel,	zsgMb	
sal91	silt 5%, sand 10%, sr to a cf 85%,	grCb	
sal92	sandy colluvium,	srCb	
sal 93	silt 5%, sand 15%, a cf 80%.	srCb	
sal 94	rock-controlled bench, +35%/-55%, capped with sandy gravel, colluvium on faces.	Sg/rCb	
sal 95	subvertical schist small faces. Silty sandy colluvium.	zsrCv	Schist
sal 96	blocky colluvium,	aCk	
sal97	angular rubble, up to 15% fines,	rCk	
sal 98	rubble colluvium, rock (phyllite) step foliation sub parallel to slope	rCk	Phyllite
sal 99	phyllite and quartz.		Phyllite
sal 100	silty colluvium 85% cf,	zrCb	
sal101	sandy well-rounded gravel, cobbles	sgFG (well rounded) cobbles	
sal 102	kettled, areas where slope drainage will pool. generally, pitch northwest.	sgFG (kettle)	
sal 106	deep draw and small knolls.	FG Kettles	
sal107	silt 10%, sand 25%, r to sub angular cf 65%, lots of fine pieces of schist, sl. dense.	sgrMb Sl. dense	
sal 108	same material	sgrMb Sl. dense	
sal 158	silt 15%, sand 10%, angular cf 75%, includes block of limestone.	zrCk	
sal 159	rubble material,	rCb	
sal 160	silty sandy soil seems wet,	zsDb	
sal161	silt 20%, sand 30%, cf mostly small. good Bm	szg Db (poorly graded)	
sal 162	loose silt 10%, sand 30%, well sorted gravel 50%, upslope of lose silty gravel with phyllite chunks.	sgMb well sorted	
sal163	loose sandy gravel, good bm.	sgFG	
sal 166	loose sandy gravel.	sgFG	
sal 174	deep silty sandy gravel.	zsgMb	
sal 175	silty sandy gravel occasional pce of angular quartzite,	zsgMb	
sal 176	Silt 25%, sand 15%, cf a to sa mostly quartzite 60%.	szrCb	
sal 180	silty sandy to sandy silty gravel with scattered quartzite outcrops, sub vert faces.	Zs=szgMb	Quartzite

Appendix IV Drainage features

Title	Description	
sal1	culvert just down road, upper reaches of road have surface flows.	culvert
sal2	major draw drains to south. schist.	Draw
sal 3	southerly trending shallow flutes	Flute
sal 5	pool of water in ditch by block no culvert, road back showed erosion.	Pool in ditch
sal6	wet cross ditch, ditch block.	Cross-ditch
sal 7	cross ditch, there were others.	Cross-ditch
sal9	road low point.	Low point
sal11	take off ditch at switch.	Take off ditch
sal 13	crossed broad shallow, swale.	Shallow swale
sal 14	broad shallow swale possible seasonal wet.	Shallow Swale
sal15	followed up swale,	Swale
sal 16	broad swale, no channel,	Swale
sal17	likely in swale water occasionally flows.	Swale (water?)
sal 18	Water looks like flows through small mossy talus zone,	Water out of talus
sal19	above short 150% rock step (headscarp), broad swale(s) below, just ahead deep swale.	Deep swale ahead, broad swale below
sal20	broad dry swale 60%, heads down slope joins another one both road, creek marked wrong on map.	Broad swale
sal 22	silty sandy gravel good Bm throughout ancient erosion feature off bench.	Ancient erosion features off bench
sal 23	30% bench, terrace, ancient erosion swales off, water off slope likely disperses on bench, if trailed decompact.	Ancient Erosion swale
sal 25	followed small erosion feature down to road, road cut 75% phyllite step with silty soil, no sign of water. plotted wrong,	Erosion feature no water
sal 26	only culvert I noticed on this road section, plastic no xd either. no sign of erosion or point sources	Culvert
sal 27	metal culvert, swale.	Culvert
sal28	culvert.	Culvert
sal29	road culvert marked on proposed road, small swale,	Small swale (proposed culvert)
sal 32	soil is moist to wet. dry on side slopes.	Wet soil
sal33	+ gully,	Gully
sal 34	followed it down	gully
sal35	gully may have seasonal flows but no trim and good Bm throughout. 65% sideslope.	gully
sal36	broad open swale,	Open swale
sal 37	dry swaled slope ahead,	swaled

sal 39	large cedar in swale.	swale
sal 43	headscarp of swale, ancient. near top of divide.	Top of swale
sal 44	20% bench seems a wet zone feeds swale subtle,	Wet bench
sal 45	past stream swale	"stream" swale
sal 47	culvert feeds head of swale, +35%-65%, silty sandy gravel.	Culvert (head of swale)
sal 48	cross upper head scarp, likely wet, place culvert just north of sta. 5 spur4-1 3 pink flags. 55%.	Apex culvert (north of sta, 5)
sal 49	phyllite and silty gravel in cut, blocked ditch, minor scour down road from here. 130% cut.	Minor scour down road blocked ditch
sal51	shallow swale upslope, high silty gravel cut, no erosion.	Shallow swale
sal 55	dry creek, silty rubble on north side, crudely layered gravel on south. lenses of silt and sand, compact.	Dry Creek
sal60	xd, culvert, low point in road.	Crossditch/culvert
sal 61	cross-ditch	Crossditch
sal 63	cross-ditch low gradient ahead.	Crossditch
sal 64	cross-ditch	Crossditch
sal 66	height of road	High point
sal 68	low point of road at base of higher gradient road section, bench here.	Low point
sal 69	very small swale, 50% slope, no sign of flows. Orange silt 15%, sand 15%, angular well sorted cf 70%, rock likely close. 6cm Ae.	Small swale
sal 72	swale, road culvert marked, 55%, likely seasonal sub surface flows, sta. 11. then onto short 65% slope, 50% just up, bench below, possibly nose of ancient cone, silt 15%, sand 20%, sub angular well graded cf 65%. or small rock step.	Culvert marked swale
sal 73	ancient debris flow deep swale, no trim, forested across, +45%/-45%, silt 10%, sand 20%, sr to sa cf 70%, sl. dense. road culvert marked.	Deep swale
sal 74	4m high 60 to 65% sideslopes, 2.5m wide bottom, possible soil trim on north side 500 to 250 (no likely old tree churn, good Bm on same side just upstream), treed, silty sandy gravel, lidar shows debris deposition on flats, +45%, -35%, bench just below, road culvert marked.	Deep Swale
sal 75	crossed three ancient debris flow swales, 2 with culverts, now Ã—/-35%. very broad shallow swale, cedars, moisture plants, 10cm Ae, no culvert marked, but culvert just back in df swale. start onto fan/cone.	3 deep swales
sal 76	heading off edge of fan, this is a divide, mostly loose silty sandy gravel occ boulders, just back small short swales, water likely sub surface, can go either way, if water intercepted place culvert, here sta.29 road heading down into swale.	Drainage divide
sal 77	block 3 boundary just before swale, gps wandering place on map at boundary, might be to far north. go back to place culvert.	Swale

sal78	small swale below, orange start of 8% adverse	Small swale
sal 79	65% slope, here on 2m high levee 2m above bottom of swale, sandy cobble/rubble occ blocks, near apex, swale becomes gully just upslope. levee on other side as well	Swale/gully
sal 84	start of swale, gentle headscarp in blocky rubble colluvium, just into toe of colluvial apron, +60%/-40%.	swale
sal 85	swale becomes deep right away just below toe of apron; top of swale filled with rubble. these features are ancient, likely formed soon after deglaciation, much wetter, water out of talus (perhaps same time) eroded channels, 35 to 40% at top, unless the headscarps are filled with colluvium which would explain the gentle tops of the swales, the slope gradient isn't steep enough to initiate a slide.	Swale
sal86	crossed headscarp zone of swales all similar, swales mostly in silty sandy angular to sub angular gravel as noted previously. here increase in rounded cobbles. tree churn exposed silt 10%, sand 15%, rounded well graded 75%, start of flatter bench may be pockets of kame terrace or fan from upslope, -35/+45%.	Head of swales
sal92	+60%/-55%, sandy colluvium, small swale just ahead. 3 orange for culvert, no 9bvious swale here. just before station 45.	Mark culvert
sal 96	+85%/-75%, just off bench, here blocky colluvium, swale on slope below, just back 15m below road 90% slope into swale, sandy gravel on top colluvium on face. place culvert here although likely so coarse will go subsurface. construct pilot trail below, place coarse fill on outside. platy rubble ahead +/-75%.	Mark Culvert
sal 103	culvert, no scour.	culvert
sal 104	crossditch	Crossditch
sal105	crossditch	Crossditch
sal 106	deep draw and small knolls.	draw
sal 110	cross-ditch slope drains to southeast	Crossditch
sal 111	paralleled draw to here, cross on flats, road culvert, (unconfined here) no channel, road flats	Out of parallel draw
sal 112	sta. 10 road culvert	Road culvert
sal113	shallow swale.	swale
sal114	swale then ridge nose, ridge ends here.	Swale
sal 157	start of spur on small bench.	
sal 159	spur above slide is on +35%/-60%, rubble material, road culvert ahead will feed ancient slide gully.	Gully/road culvert
sal 160	to station 6, 35% slope two swales with culvert marked, silty sandy soil seem wet, here -40% just back from -60%, entering bowl draw.	Swales with mark culvert
sal163	sta. 12, strange broad swale, 2.5m flat bottom 45% slope, terminates on 70% slope (likely rock control) below, loose sandy gravel, good bm.	Broad swale
sal 164	another swale, strange terrain here seems to have had periods of high flows like a fan.	Swale

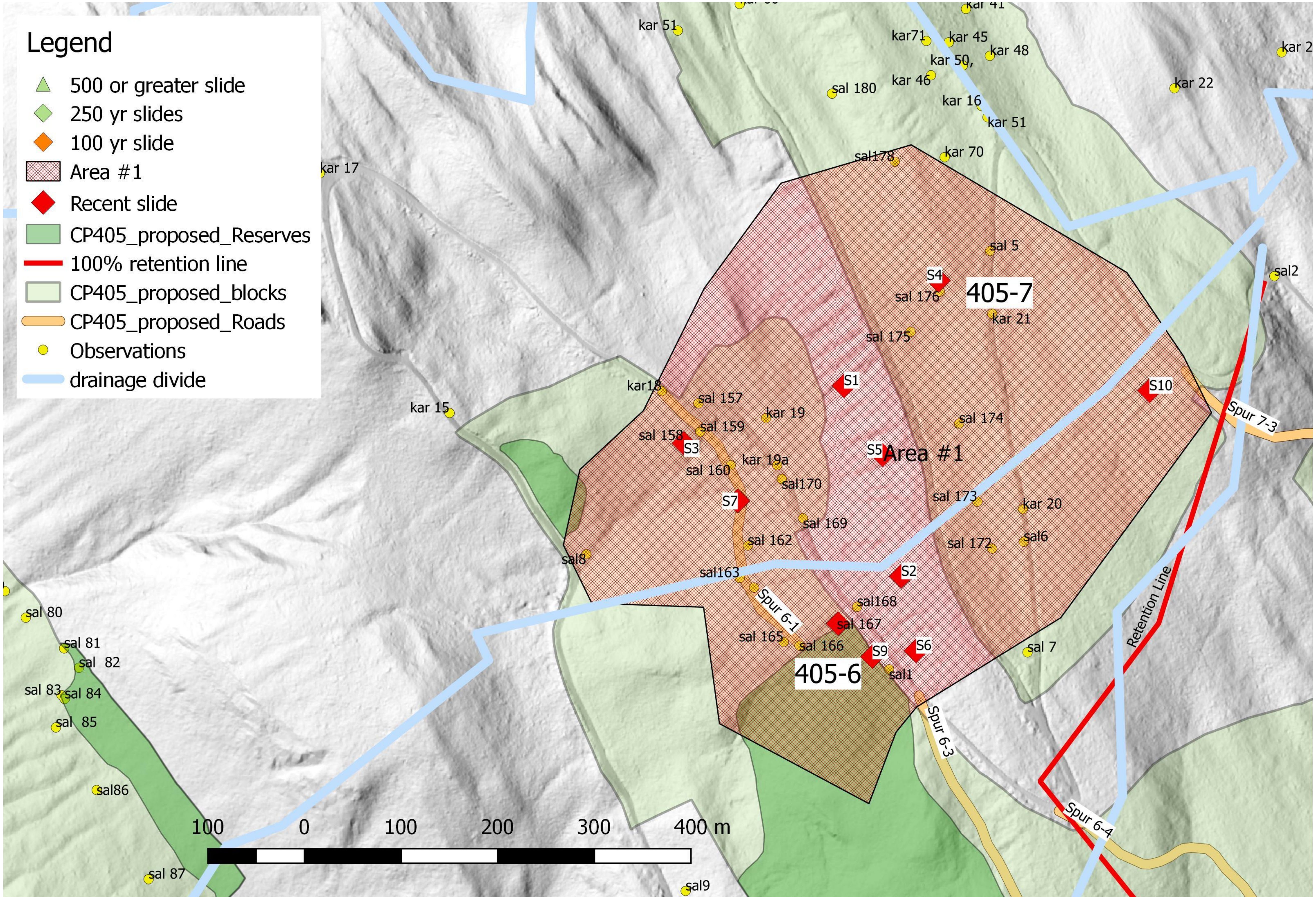
sal 165	to here mostly on 45% slope back from 60, here onto 60. the terrain back showed evidence of periods of high moisture, i.e. little erosion swales, the bigger swales the previous debris slides, here heading into the headscarp of old debris slide flows.	Little erosion swales
sal168	culvert, fill was only about 45%.	Culvert
sal 169	culvert.	Culvert
sal170	culvert armoured cut.	Culvert
sal 173	wet area, 40% up from bench.	Wet area
saldr 2	possible low pt. of ridge nw draw deep shallow on se side but pitching nw here.	Nw draw
saldr 7	sta 10 road culvert	Road culvert
saldr 8	very subtle feature, culvert just before station 12. three pink.	Mark culvert
saldr 9	swale upslope, cedar "flats" here if this is back of landing, discharge off back.	Swale
kar 23	mounded wet terrain, no rock.	Wet area
kar 26	6p% slope moss covered competent phyllite (quartzite), slight back lean here forms swale on bench, bench shallow to phyllite. Slope on other side of swale, small quartzite cliff. swale becomes more pronounced; pits give sandy silty phyllite soil.	Swale
kar 27	base of 80% slope with small rock step at base, up about 20m to bench then a "cliff" further up, mossy here, devils club on bench at base, looks like water flows through here, foliation now into hill. Rock is laminated limestone, minor dissolution features along foliation and fractures. Quartz rich phyllite at base.	Swale Wet
kar 28.	the bench started to become a steep swale, noted rounded limestone blocks and rubble. perhaps outcrop, about 15m below 3m rock step at top, went up to step, grey banded limestone 90% carbonate, dissolution on fractures narrow variably spaced, most fractures sharp, no grikes or pits.	
kar 35	mostly quartzite to here, shallow soils over rock, here starting into wetter area, deeper soils.	Wet
kar 36	25% slope, silty soil, mostly phyllite frags, sharp v shaped gully swale.	Gully
kar 37	tree churn in swale rips up limestone block, surface weathering leaves resistant phyllite bands. could be collapsed cave. devils club in bottom.	Swale
kar 38	broader swale, opens up, start of lots of devil's club in forest.	Swale
kar 40	into broad wet devil's club area, here small sinkholes. no obvious water flowing in, 5% slope 1m wide 3m long, across swale east west, likely fracture system crevasse. two here, one just up. Limestone exposed on side. two together 10m radius., broad devils club flat, no direct flow, bottoms covered is mineral soil, not exposed. Sinkholes just upstream from where bench becomes swale, may feed old cave.	Wet area
kar 41	walked back and forth through wet area, flat, no obvious sinks to here, deep soils, silty soil with mostly phyllite,	Wet

kar 47	followed devils club broad swale to here, now, above swale to east (on slightly confined top ridge), slope to west gets steep, ends on slope to swale, no surface expression, no sinks.	Swale
kar 48	broad wet zone.	Wet
kar 50,	north end of knoll ridge ends abruptly at east west step, then rises slightly on other south, feeds swale on west.	Swales below
kar 51	a few more little knolls, mounds, tree churns expose silt soil with rounded limestone frags, low points feed swales.	Swales below
kar 58	off nose of limestone rise, still limestone to west in rise, here seems start of swale, sinkhole sharp, 2m deep, 2m ns, 5m ew, forest floor across, bottom, lst exposed in south side, dry here. obvious solution of parting at base. I was able to push a stick through forest floor until roots stopped, 0.5m, may be open be earth root mat. Thought I may have seen some back but was not sure if they were not just large tree churns.	Head of swale
kar 64	swale 3nds on bench, no sinks, hummocky and broad swale to west, check it out.	End of swale
kar71	no sign to here, for stability slope below bench is 55%, followed likely erosion path of water off switch, caught by swale carried down slope, other short deep swales near edge of b3nch discharge onto the slope, no evidence of surface flows, lots of devils club.	Swales moist

Appendix V Spur 1-3 comments

site	Comment	Feature	recommend
sal 69	very small swale, 50% slope, no sign of flows. Orange silt 15%, sand 15%, angular well sorted cf 70%, rock likely close. 6cm Ae.	Small swale	
sal 75	crossed three ancient debris flow swales, 2 with culverts, now Ã—/-35%. very broad shallow swale, cedars, moisture plants, 10cm Ae, no culvert marked, but culvert just back in df swale. start onto fan/cone.	3 deep swales	
sal 76	heading off edge of fan, this is a divide, mostly loose silty sandy gravel occ boulders, just back small short swales, water likely sub surface, can go either way, if water intercepted place culvert, here sta.29 road heading down into swale.	Drainage divide	Apex culvert
sal 77	block 3 boundary just before swale, gps wandering place on map at boundary, might be to far north. go back to place culvert.	Swale	
sal78	small swale below, orange start of 8% adverse	Small swale	
sal 79	65% slope, here on 2m high levee 2m above bottom of swale, sandy cobble/rubble occ blocks, near apex, swale becomes gully just upslope. levee on other side as well	Swale/gully	
sal 84	start of swale, gentle headscarp in blocky rubble colluvium, just into toe of colluvial apron, +60%/-40%.	swale	
sal 85	swale becomes deep right away just below toe of apron; top of swale filled with rubble. these features are ancient, likely formed soon after deglaciation, much wetter, water out of talus (perhaps same time) eroded channels, 35 to 40% at top, unless the headscarps are filled with colluvium which would explain the gentle tops of the swales, the slope gradient isn't steep enough to initiate a slide.	Swale	
sal86	crossed headscarp zone of swales all similar, swales mostly in silty sandy angular to sub angular gravel as noted previously. here increase in rounded cobbles. tree churn exposed silt 10%, sand 15%, rounded well graded 75%, start of flatter bench may be pockets of kame terrace or fan from upslope, -35/+45%.	Head of swales	

sal92	+60%/-55%, sandy colluvium, small swale just ahead. 3 orange for culvert, no obvious swale here. just before station 45.	Swale	Apex Culvert
sal 96	+85%/-75%, just off bench, here blocky colluvium, swale on slope below, just back 15m below road 90% slope into swale, sandy gravel on top colluvium on face. place culvert here although likely so coarse will go subsurface. construct pilot trail below, place coarse fill on outside. platy rubble ahead +/-75%.	Swale	Apex Culvert



Legend
500 or greater slide
250 yr slides
100 yr slide
Area #1
Recent slide
CP405_proposed_Reserves
100% retention line
CP405_proposed_blocks
CP405_proposed_Roads
Observations
drainage divide
405-7
405-6
Area #1
Spur 7-3
Spur 6-1
Spur 6-3
Spur 6-4
Retention Line
S1
S2
S3
S4
S5
S6
S7
S9
S10
100
0
100
200
300
400 m