Detailed Terrain Stability/Karst Field Review

Proposed Harvesting and Road Construction in the Argenta Face Area CP 416 blocks 1 – 9; 12- 14: Bulmer Main Line and Spurs

for

Cooper Creek Cedar Ltd.

W. Halleran P. Geo, P.L.Eng.

2022-03-10

Contents

1. Summary

If the recommendations contained within this report are implemented the proposed development will not significantly increase the low likelihood of landslide initiation and will not noticeably impact karst features. The development poses a very low partial risk to Private Land, a very low to low partial risk to Argenta Creek and except for blocks 416-1 and 2 which are moderate (due to proximity), a very low partial risk to Argenta-Johnson's Landing Road.

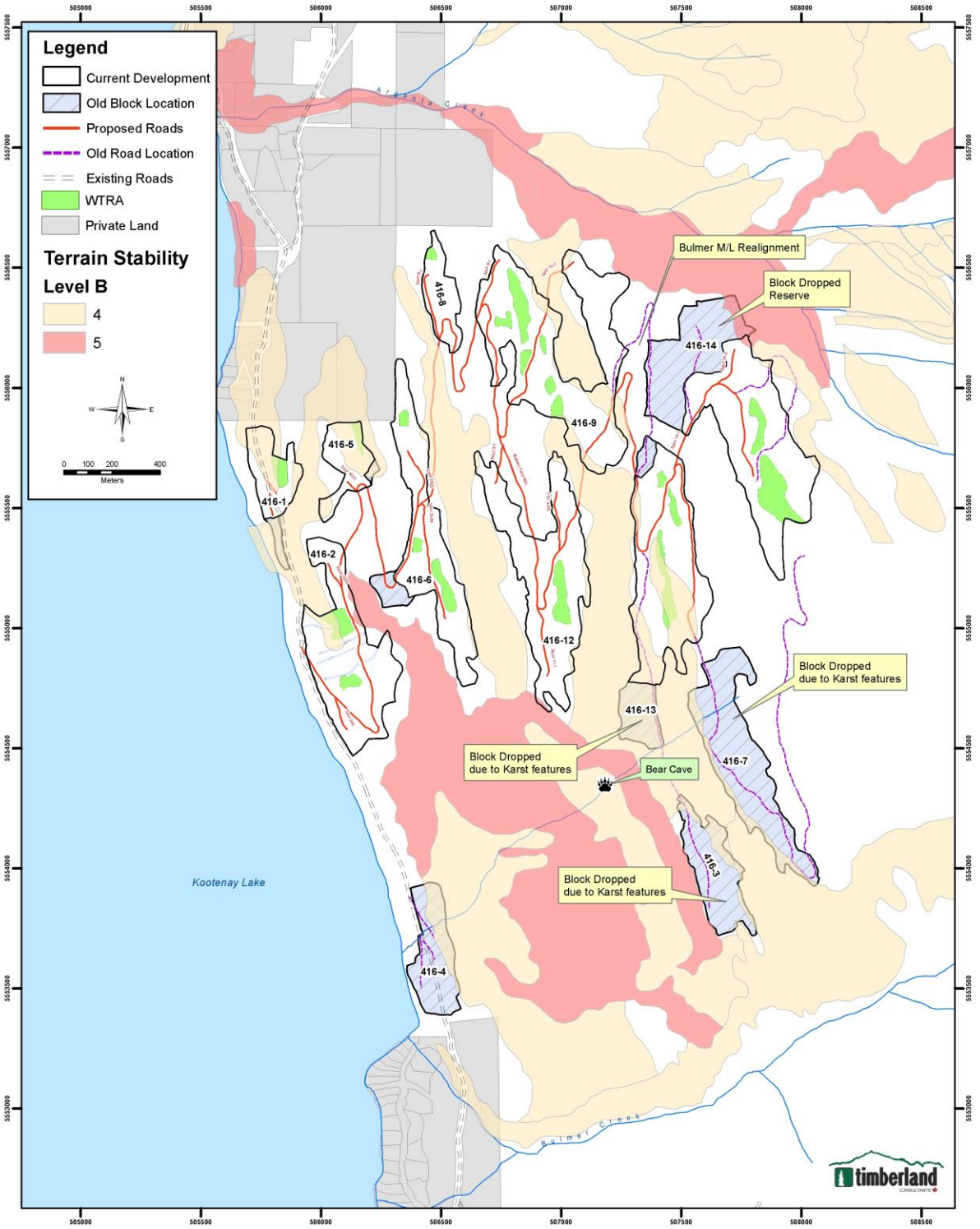
The development (figure #1), situated between 760m asl and 1520 m asl on Argenta Face, consists of a series of proposed cut blocks, roads, and spurs. The blocks are located on benches and sub-parallel draws. The benches or draws are separated by steeper rock-controlled slopes which correlate with the mapped terrain stability Class IV polygons. Surface slope drainage is controlled by these sub-parallel north-south trending draws, ridges, and benches (geology defined glacial scour) resulting in few definable watercourses. The Class V polygon mapped in the south part of the area outlines a large rock slump and headscarp. The slump was not assessed in detail, but it is assumed to be dormant. This failure is associated with karst features adjacent and upslope of the main headscarp.

Instability noted in the development area includes the very large dormant rock slump, small scale slumping along the toe of the dormant slump, small slides within the displaced material of the slump and scattered rock fall/topple throughout the rest of the area.

To meet Cooper Creek Cedar's management strategy of avoiding areas of Karst, delete blocks 416-3, 416-7 and remove southern portion of 416-13 from harvesting, place a reserve in the northwest portion of 416- 14, realign the portion of the proposed road below block 416-14, and delete spurs 1-16, 14-1, 15 from the proposal (figure #1).

To avoid impacts on the dormant rock slump, development should not occur upslope of the headscarp (blocks 416-3 and 7; spur 1-16 and portions of the mainline) or on the toe (block 416-4) until more detail evaluations of the slump and associated karst features are conducted.

COOPER CREEK CEDAR Ltd. **Figure #1** **CP 416 Argenta Face**



2. Introduction

On July 24, 2020, Mr. Bill Kestell RPF of Cooper Creek Cedar Ltd, sent an email with preliminary development plans on Argenta Face to Apex Geoscience Consulting Ltd. requesting a terrain stability site review and, although there are no government designated Karst potential areas within the proposed development, identification of Karst features. The Karst management for this assessment is to isolate the Karst terrain from the proposed harvesting and road construction.

The proposed development was field assessed in late fall of 2020 and early summer of 2021.

3. Methods, Limitations and Reliability

Google earth imagery, Bing maps satellite imagery, historical air photos, previous risk assessment for Bulmer fan, Karst Potential maps, WSC hydrographs for various creeks, regional geology maps, previous DTSFA's, and other reports were reviewed.

The proposed development was field assessed by W. Halleran P. Geo P. L. Eng. from October 22 to 24th 2020; June 17th (with Bill Kestell) and June 22, 2021. 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. A Samsung android tablet with the Avenza maps program with the imported hill shade and development maps was used for navigation and note taking.

The terrain stability site review was focused in areas mapped as Class IV or V to determine if the slopes are sensitive to alterations of upslope drainage patterns; and at locations where proposed roads and spurs crossed these steps.

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

Karst identification is based on geological expertise, and ministry guidelines (LMH 66 Ch. 11 and Karst Management Handbook 2003). Management recommendations are based on CCC management objectives.

This review assumes road good construction and timber harvest 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.

3.2 Likelihood of Landslide Determination

Field observations are used to determine the age, cause, distribution, type, size, and materials of both natural and development related landslides.

For purposes of this report, the age of the natural landslide is assumed to be equal to the annual exceedance probability 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, with an annual probability (Pa) of 0.002%. This assumption 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 appear fresh (i.e., exposed mineral soil, broken and/or scarred timber). 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 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 soil horizons). These areas are thought to have a low annual likelihood of landslides.

Climate change model project an increase in extreme climatic events. It is believed that the estimation of annual exceedance probability applied in this report is sufficiently precautionary to incorporate the projected increases over the period of concern.

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

The following formula is used to estimate the likelihood of an exceedance 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 timespan of concern and Px is the probability during the assessed period of time.

For this report, the likelihood of an event occurring during the time period (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 Partial Risk Methodology

For this report, Partial Risk is a function of the likelihood of a landslide occurrence and the likelihood that the slide can impact the considered elements.

The elements considered in this assessment are:

1. Water quality at the intakes on Argenta Creek,
2. Private Property along the lower slopes.
3. Argenta-Johnsons Landing Road

The relative rating for landslides effecting the considered elements is shown in Table 3.3.1.

Table 3.3.1. Likelihood of a Debris slide/ Debris Avalanche or Sediment Reaching or Effecting Argenta Creek, Argenta-Johnsons Landing Road or Private Land.

Relative Rating of a Landslide Effecting the elements assessed for Risk	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly effect Argenta Creek, Argenta-Johnsons Landing Road, or Private Land.
Moderate	There is a run-out slope of <20^{o} (36%) gradient and <200 m in length, or another terrain configuration which could intercept or dissipate a potential landslide debris and/or sediment from erosion (e.g., irregular, or benched rock-controlled terrain) between the development and the elements assessed for risk. Some secondary transport of suspended sediment and small wood debris by accompanying water runoff may reach the considered elements.
Low	Landslide debris and/or sediment from soil erosion is unlikely to reach or effect the elements assessed for risk at the time of an event. There is a run-out slope of <20^{o} gradient for >200 m, or another terrain configuration which would intercept or dissipate sediment or landslide (e.g., irregular or bench rock-controlled terrain), below and between the development the considered elements.
Negligible	Landslide deposition will not impact the considered elements.

Partial Risk 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 Partial Risk, P (HA).

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Effect the considered elements 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

4. General Observations:

4.1 Geology:

The proposed development is predominately underlain by an interbedded sequence of Phyllite, Schist, Quartzite and Limestone of the Lardeau Formation rocks with a ~170^{o} strike (roughly parallel with the slope) and ~80^{o} westerly dip.

4.2 Karst Features:

During the assessment karst related features were noted in two distinct areas.

Karst features including sinkholes, hillocks, ridges, and at least one cave (Bear) are directly upslope and adjacent to the head scarp of a large dormant rock slump/slide (downslope and within blocks 416-3, 416-7 and 416-13). The density and size of the features increase towards in the vicinity of the rock slump. The features appear to terminate or are offset by the large rock slump headscarp. Bear cave was not visited during this assessment, the location has been previously noted via BCFS cave inventory.

In the northwest portion of block 416-14 here is an apparent collapse feature which may be related to some emergent springs and travertine mound below the block. The travertine mound with springs is located at the toe of a slope slightly offset from the collapse feature, this spring and additional springs flow out and across a large flat precipitating tufa across the flat.

4.3 Terrain stability:

Isolated rock fall and topple occur along steep rock faces within the development area. Some of the rock topple appears to be caused by trees levering rocks as they fall.

North of Bulmer Creek there is a very large dormant rock slump, the toe of the displaced material is partially cut by the Argenta-Johnson's Landing Road. Small "recent" (Pa=.002?) slumps and some shallow sloughs (Pa=0.02) occur just upslope of the road along this toe. Widely scattered small sloughs/slides (Pa = 0.02) occur on the displaced material.

4.4 Surficial Geology:

Between 700m asl and 900m asl the slope is mostly underlain by loose sandy gravel to gravelly sand with small rock shelves, likely a Kame terrace deposit.

Upslope of the Kame Terrace the slope is predominately underlain by loose sandy gravel to variably dense silty sandy gravel (ablation Till) with significant areas of silty rubble colluvium. The rubble colluvium is often associated with short steep rock steps (usually quartzite). Blocky colluvial aprons occur at the toe of most of the larger rock faces.

Down slope of the Kame deposits the slope is typified by rock steps and faces interspersed with sandy gravel (likely glaciofluvial gravels).

4.5 Slope Drainage:

Glacial scouring of the slope selectively removed the phyllite (recessive) leaving small benches/draws (swales) separated by steeper rock slopes or ridges (Quartzite and to a lesser degree Limestone) sub-parallel to the contours. This topography controls the surface slope drainage on the face. Except for the noted springs and karst emergent streams in and below block 14 there is little evidence of streams or surface flows. Surface drainage patterns approximated from the DEM file using SWAT drainage delineation program (figure 2) show a “parallel” drainage pattern.

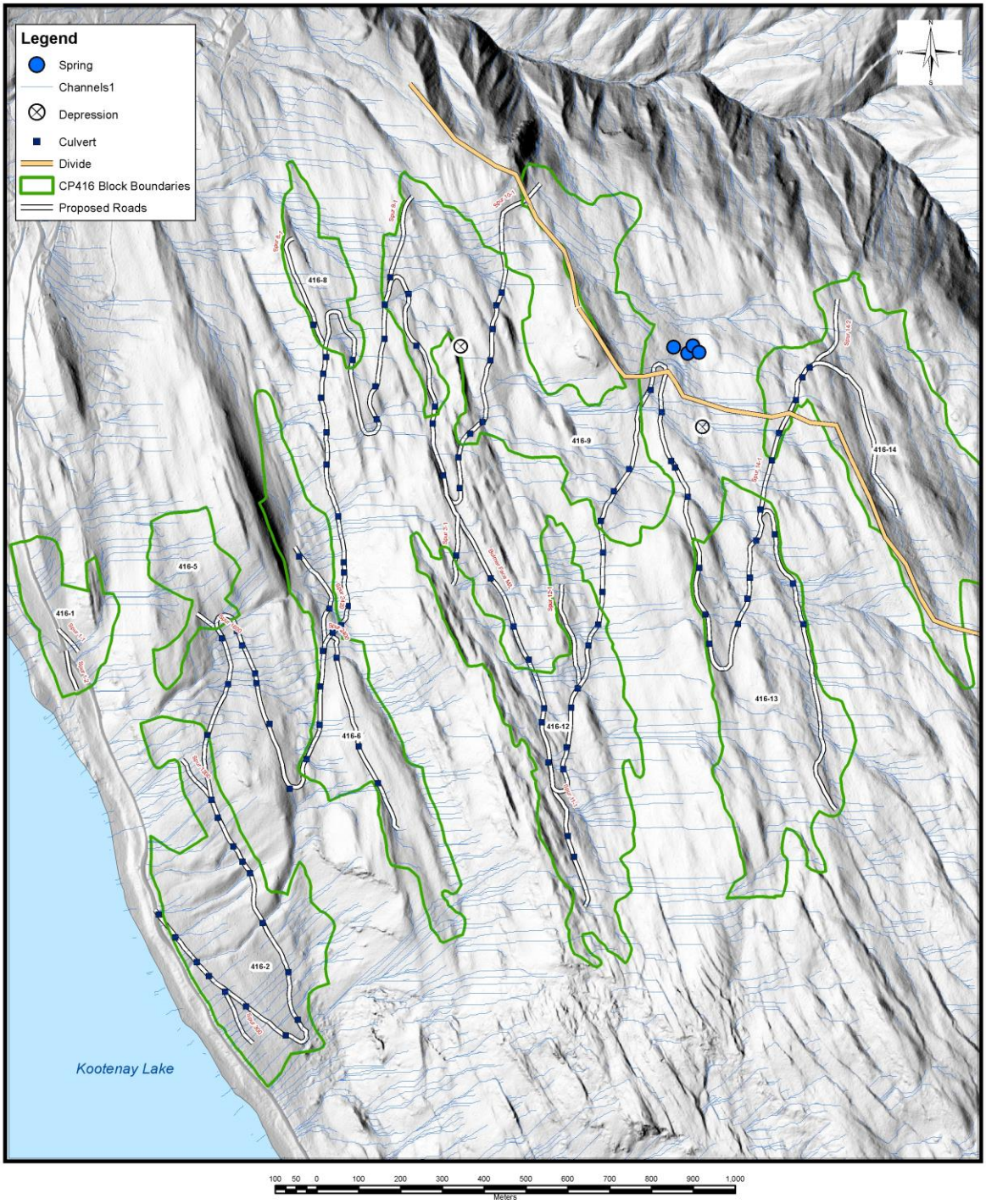
Quartzite units likely act as aquitards to downward flowing groundwater. Some of the swales/draws maybe underlain by dissolved or collapsed limestone. Subsurface drainage patterns are likely controlled by stratigraphy (i.e., along dissolution features confined within limestone units bounded by aquitards).

Springs occur along the toe of the large dormant rock slump along and just upslope of Argenta-Johnson’s landing road, water is likely flowing along the slip plane and through fractured rock.

4.6 Argenta Creek Drainage:

Compared to adjacent streams, the Water Survey of Canada (WSC) discharge data for Argenta creek shows a significant muted seasonal variation, delayed peak flow and a low per unit discharge. The hydrograph suggests that the stream is losing water (influent stream).

Figure #2
DEM Derived Drainage



Usually, the base flow of a stream is supplied by groundwater. In Argenta Creek, although slightly elevated, the low flow (base flow) varies from year to year and

decreases throughout the low flow period (Sept-May) unlike adjacent streams, which do not have yearly variations and have constant low flow volumes (base flow) throughout the low flow period (August to April).

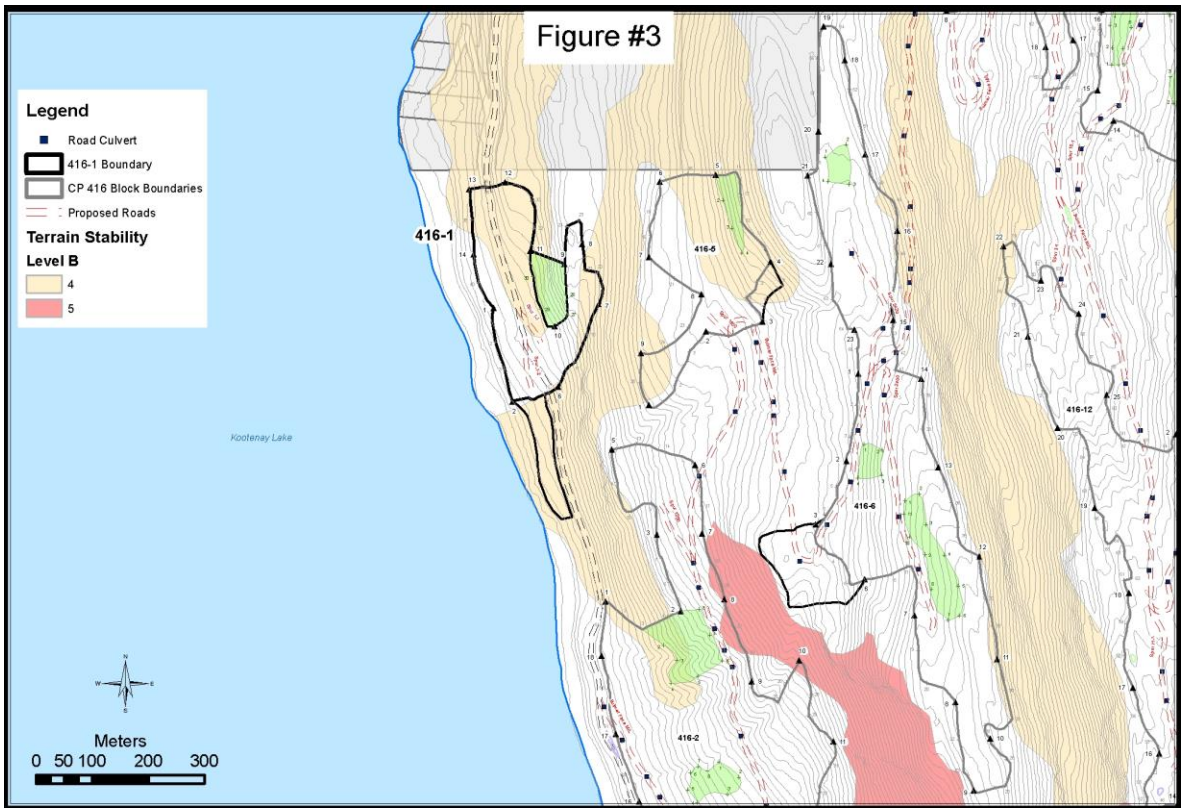
The RDCK Watershed Governance Initiative (WGI) website states “Argenta Creek is known to be partially supplied by water from subsurface karst, which can provide water all year-long for fire protection”. The WGI website does not attribute this statement to any verifiable source. However, if Argenta Creek was supplied by appreciable “subsurface Karst” water (Effluent stream) in addition to the surface runoff from the catchment, the per unit discharge should be greater relative to adjacent streams. The low flows (base) should not vary from year to year. It seems more likely, rather than being supplied by emergent springs, Argenta creek supplies water to the underground drainage. A survey of the hydraulic geometry of the channel along the length of the channel would provide information as to where water is lost or gained, specifically where the water is leaving the system. A conductivity survey of the stream would help determine the percentage of ground water contribution to the flow regime.

5. Detailed Observations

Proposed blocks:

Block 416-1

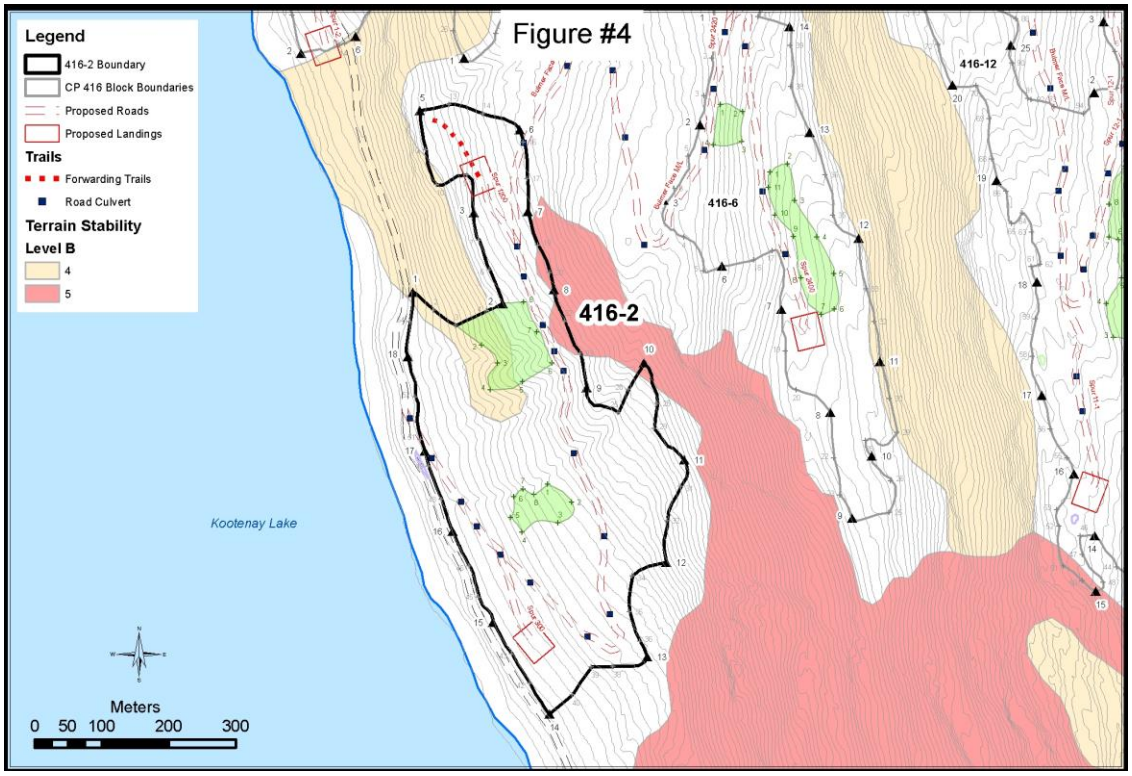
The proposed block partially straddles the Argenta-Johnson Landing Road directly upslope of Kootenay Lake (Figure #3) . Most of the lower boundary is along a small road that leads to abandoned mine shafts and old workings in the southern portion. The block lies partially within terrain mapped as potentially unstable (Class IV). The polygon underlying the north portion of the block has a 50% slope gradient and is shallow to rock, there is a small area of 85% gradient slope underlain by rubble and outcrop that within in a WTP. Below the block there is a 100% gradient slope underlain by sandy gravels with old ravelling. The southern portion of the block, that overlies a terrain polygon, is underlain by rock steps and low gradient slopes. There is no sign of instability within the proposed block.



Block 416-2:

The proposed block is just upslope of the Argenta -Johnson Landing Road and immediately downslope of terrain mapped as Unstable (Class V) (Figure #4), which in this area, is underlain by benched gravelly sand, coarse colluvium, and rock outcrops with no evidence of instability.

The proposed block is underlain by bands of angular colluvium and outcrops interspersed with gravelly sand. The slope gradient is 50% or less (60% in the wtp). There is no evidence of instability within the proposed block.



Block 416-3:

Block 3 straddles a large bench immediately upslope of the main headscarp of a large dormant rock slump, Karst features occur along this slope.

Block 416-4:

This block is underlain by coarse to fine colluvium on the 55 to 70% slope gradient toe of the large dormant rock slump noted in this area. There are scattered wet areas and springs. There are small scale slump/slide features off the steeper pitches.

Block 416-5:

The upper portion of the block impinges on a Class IV terrain polygon (Figure #3) which except for the eastern most portion, is a 20% to 50% gradient slope underlain by gravel and colluvium. The eastern most portion (within a wtp) is a short 75% gradient slope underlain by rock and colluvium. There is a broad bench and old road at the base of this slope. Below the block, the terrain polygon is overlying a 45% gradient slope underlain by gravel with large erratic boulders. There is no evidence of instability.

Block 416-6:

This block is located immediately west of a large class IV polygon (Figure #3). The north end of the block spans a deep rock draw. The western boundary is at the base of a 90% gradient rock face on short 70% gradient blocky colluvium apron just up from 25% gradient slope in the draw. The eastern boundary is 15m up from the flats on 60% gradient blocky colluvium apron. The southern portion of the block is typified by broad rock benches and northerly pitching draws. There is no evidence of instability.

Block 416-7:

Block #7 was not field assessed; it is located directly upslope of block #3 and the dormant rock slump.

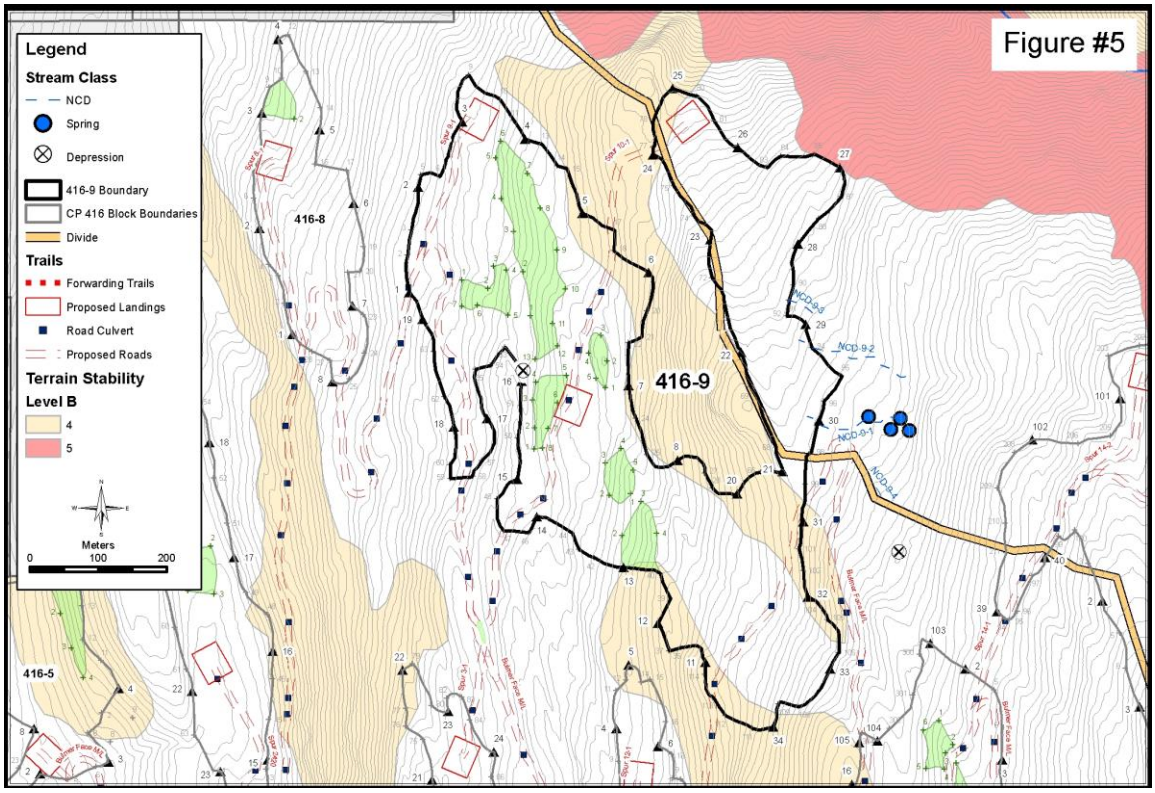
Block 416-8:

This block is located on “flats”, a small draw discharges onto these flats about where the Argent Face Main switches up through the block (Figure #5). There is no evidence of instability.

Block 416-9:

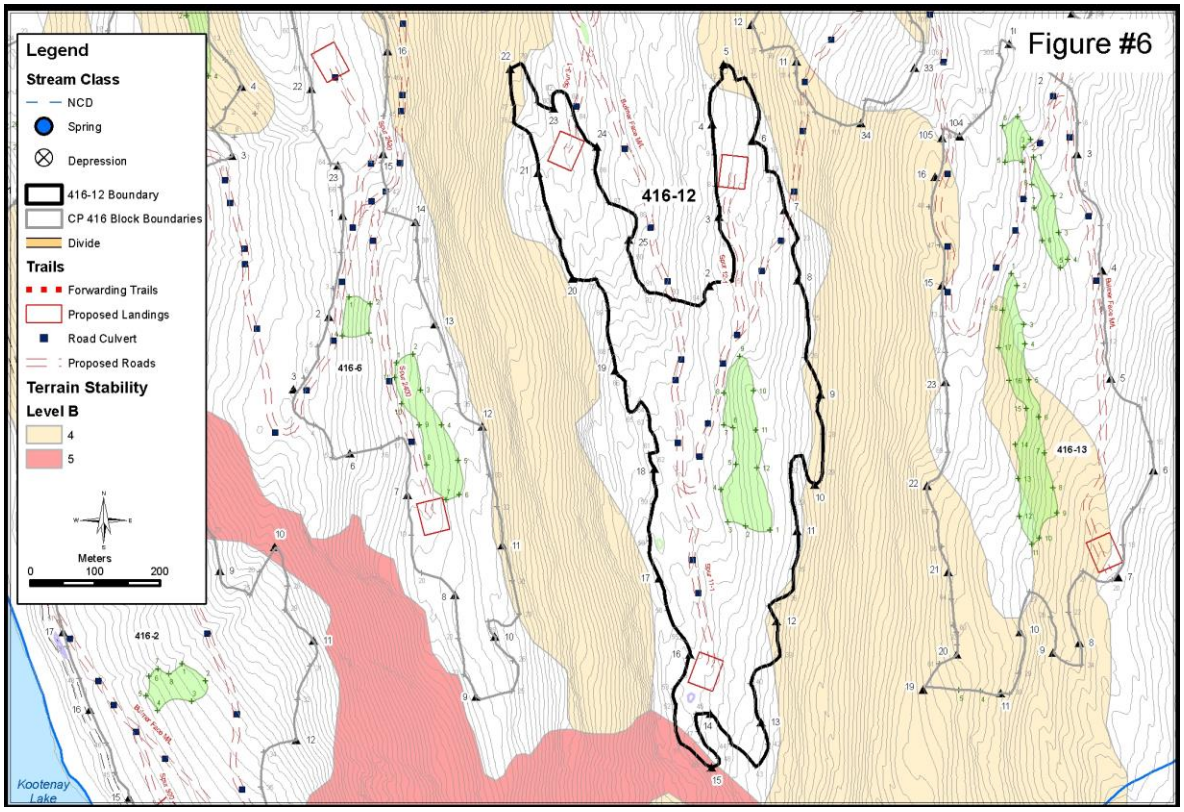
The proposed block is situated between, and impinges on, two class IV polygons (Figure #5).

The lower portion of the block is underlain by a series of broad north pitching draws/benches separated by short sharp (razor back) ridges and rock shelves. In places the boundary is located just up from a bench on the steep side slope (75%) of a ridge. The upper portion of the block is located on 45% slope gradient immediatlely below a 65% gradient slope underlain by coarse colluvium and rock. Except for possible rock fall from upslope there is no evidence of instability.



Block 416-12:

The block is situated on two broad benches underlain by silty gravel separated by a short 45% gradient slope of coarse colluvium and scattered outcrops. The block is "upslope" of a Class IV polygon (Figure #6) which delineates a series of bluffs and blocky colluvium aprons. Except for minor rockfall there is no evidence of instability.

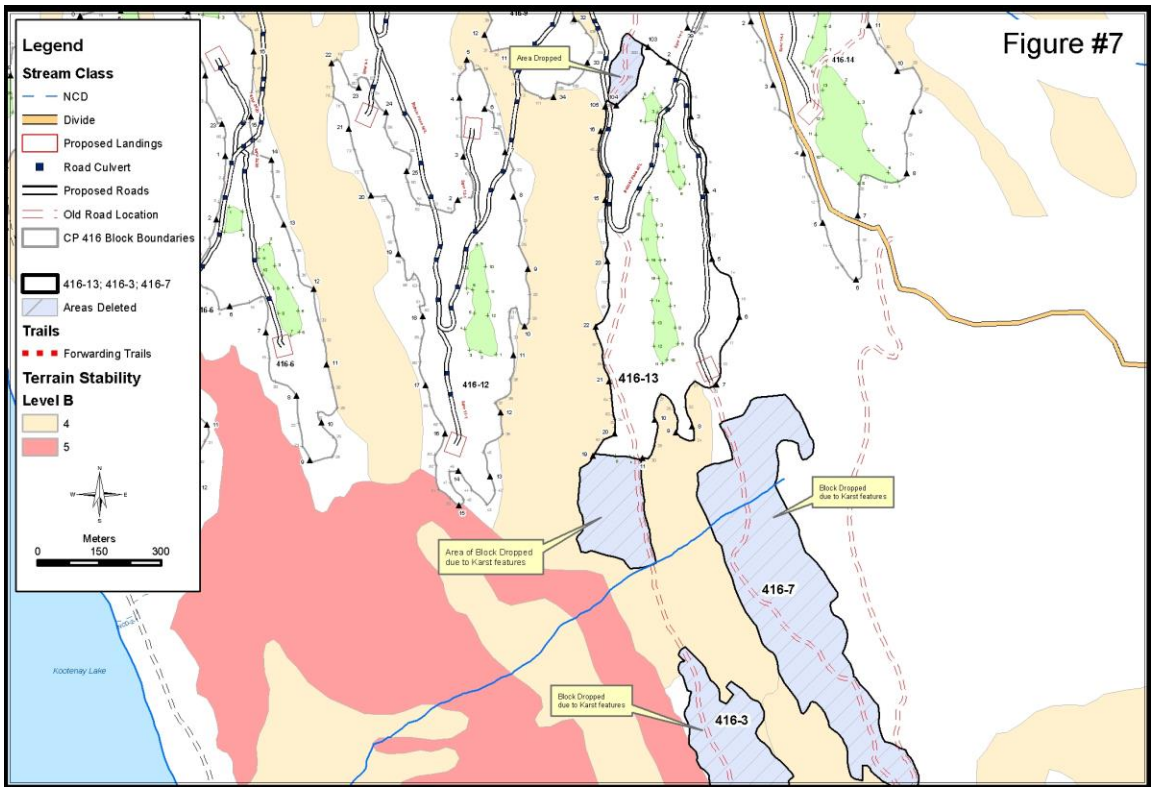


Block 416-13:

The proposed block (Figure #7) impinges on and is upslope of a terrain Class IV polygon. The northwest corner of the block extends onto a short 65% gradient slope underlain by silty sandy angular colluvium. The polygon below the block has 65% to 85% gradient slopes underlain by coarse colluvium with steep (90%) rock faces and small rock shelves. Within the block, the polygon is typified by short colluvial 55% gradient slopes and rock shelves.

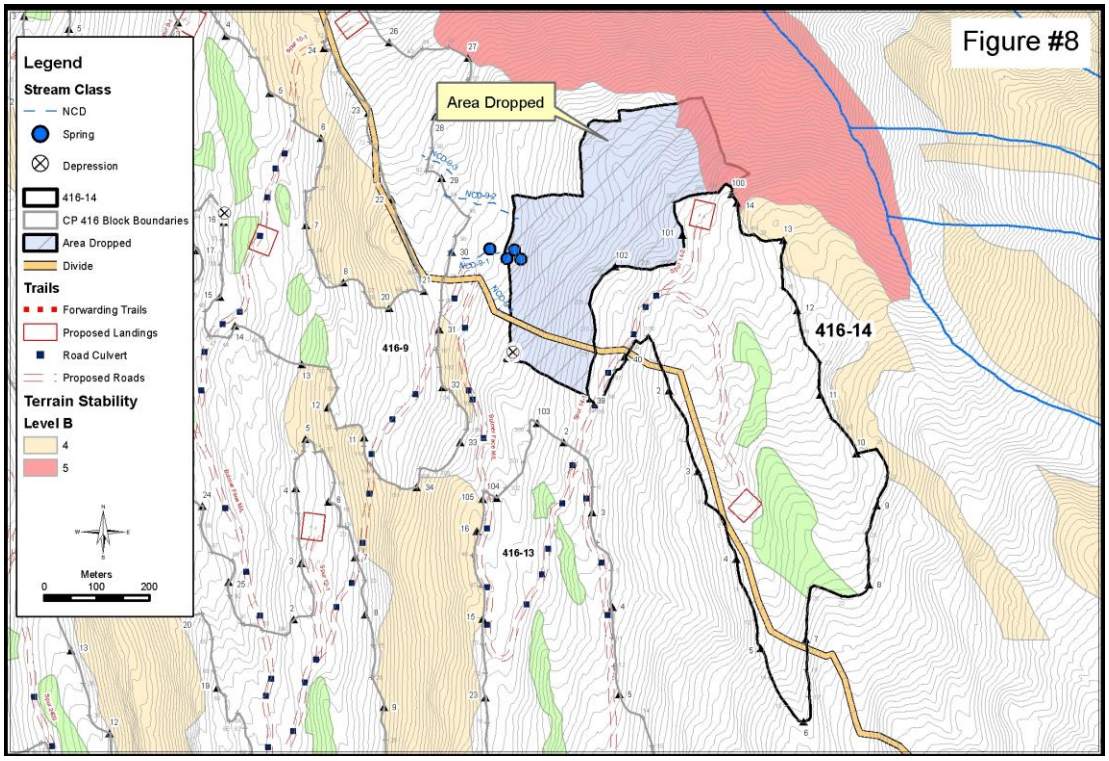
There are significant karst features, including sinkholes, hillocks, and ridges in the southern portion of block 416-13. This portion of the block is adjacent to, and upslope of slump scarps associated with the large dormant rock slump just north of Bulmer Creek (Class V and IV polygons).

Apart from the dormant rock slump and isolated rock topple/fall from the steep rock faces there is no evidence of instability within or below the block.



Block 416-14:

The upper portion of the block is situated on moderate gradient slopes just downslope of a snow avalanche runout zone (Figure #8). Wet and brushy areas at the termination of the avalanche zone are likely areas of accumulation of avalanche deposits that retain snow late into the spring melt. The lower portion of the block straddles a small steep rock bowl that may be a collapse feature, there are emergent streams and associated fans of loose and porous tufa (calcium carbonate precipitate) below and within the lower portion of the block. There is also a spring associated with a travertine mound deposit on the slope below the block.



Bulmer Mainline and Spurs:

Much of the proposed road and most of the spurs are situated on moderate to gentle gradient slopes. Culverts and cross-drains are well located and will maintain natural drainage patterns.

Observations reported below are restricted to areas mapped as IV or other areas of interest.

Bulmer Main Hubs 136 to 188:

This portion of the road (figure #9) crosses terrain mapped as Class IV which has a slope gradient greater than 60% and is underlain by short rock bluffs and steep blocky talus slopes. The only instability noted was scattered rock topple.

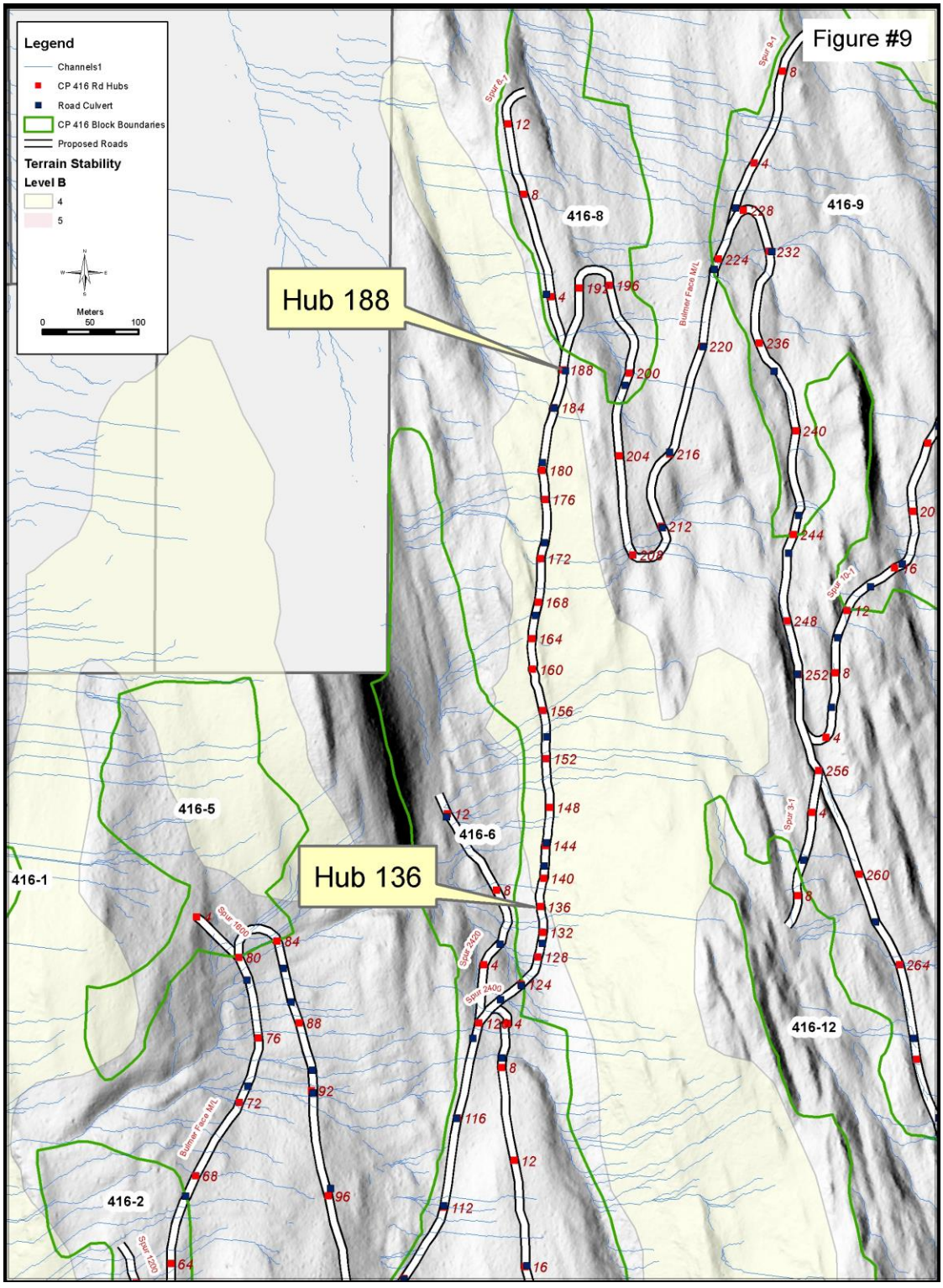
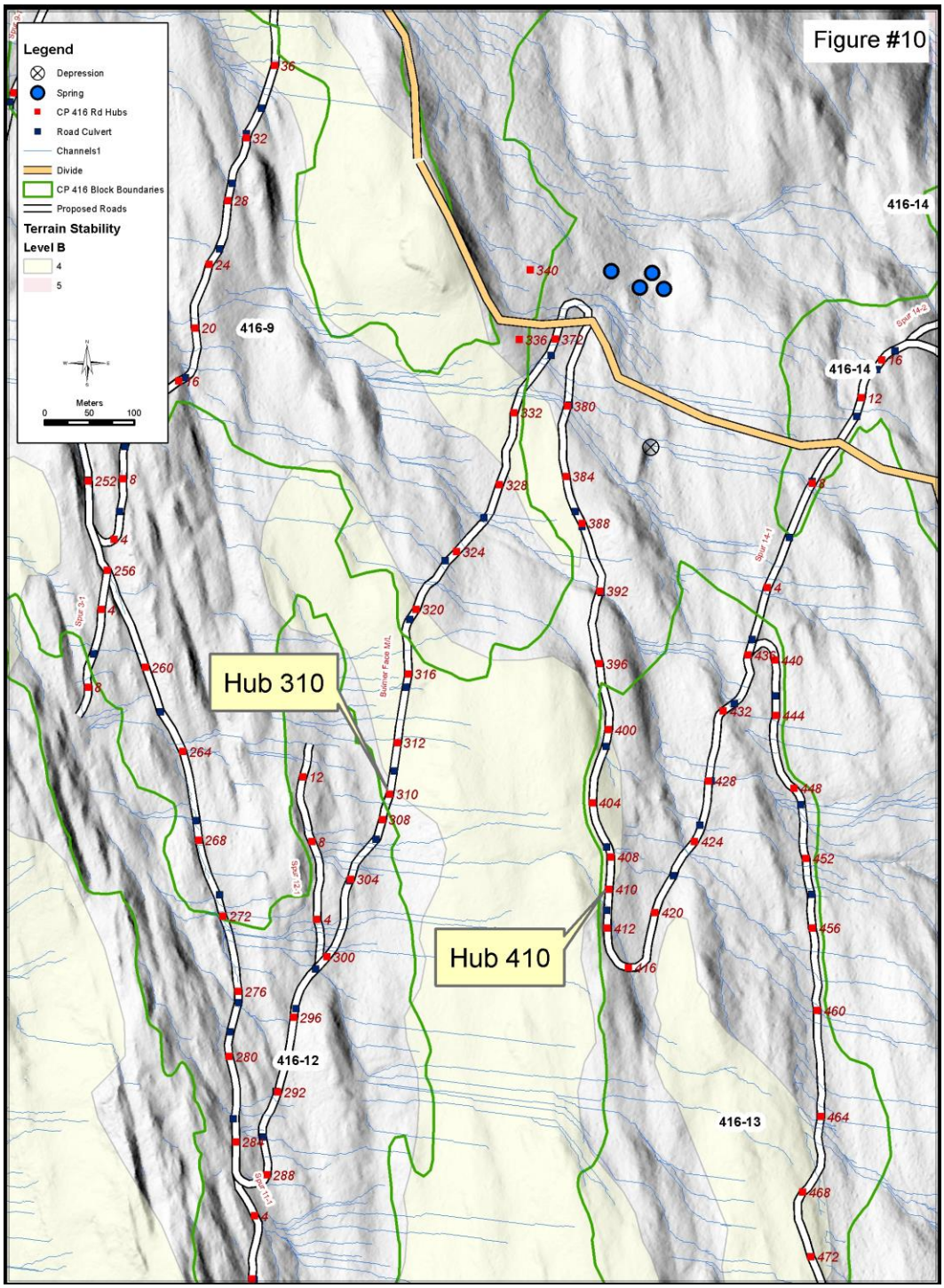


Figure #9
Legend
Channels1
CP 416 Rd Hubs
Road Culvert
CP 416 Block Boundaries
Proposed Roads
Terrain Stability
Level B
4
5
Meters
0
50
100
Hub 188
Hub 136
416-1
416-2
416-5
416-6
416-8
416-9
416-12
Spur 6-1
Spur 9-1
Spur 10-1
Spur 3-1
Spur 1600
Spur 2420
Spur 2400
Spur 1200
Bulmer Face Mtl

Bulmer Main between Hubs 310 to 410: (Figure #10)



Between Hubs 310 to 321 the road crosses a Class IV polygon which in this area has a slope gradient of 60 to 65% and is underlain by coarse colluvium and small outcrops.

The slope along the road location within the northern polygon (hubs 329-369) does not exceed 45% and is coarse colluvium below a small rock lip. Just past hub 374 the original old road alignment switched on the broad bench with multiple NCD's/emergent springs, then along the base of a slope which contained a karst emergent spring and associated travertine deposit. The road was realigned to avoid this area. The new alignment of the road switches (hubs 374-375) in dry broad flat south of this area.

Between hubs 380 and 389 the road crosses the top of the polygon; the slope has a gradient of 55% to 65% and is underlain by coarse colluvium and small outcrops. At hubs 400-410 the road encroaches on to the top of a class IV polygon; in this area the slope does not exceed 55%.

Spur 8-1:

Spur 8-1 is located on top of the rock face heading out onto "flats". While there is no evidence of recent instability, the blocky talus slopes are likely formed by the accumulation of rock fall/topple.

Spur10-1:

Spur 10-1 accesses the western portion of the block 9, a portion of this spur crosses a Class IV polygon which in this location has a slope gradient of 65% or less and is underlain by mossy rock outcrops and coarse colluvium.

Spur 10-2:

The termination of this spur is just within Argenta Creek Watershed Catchment (figure #8).

6. Implications, Recommendation and Risk Analysis

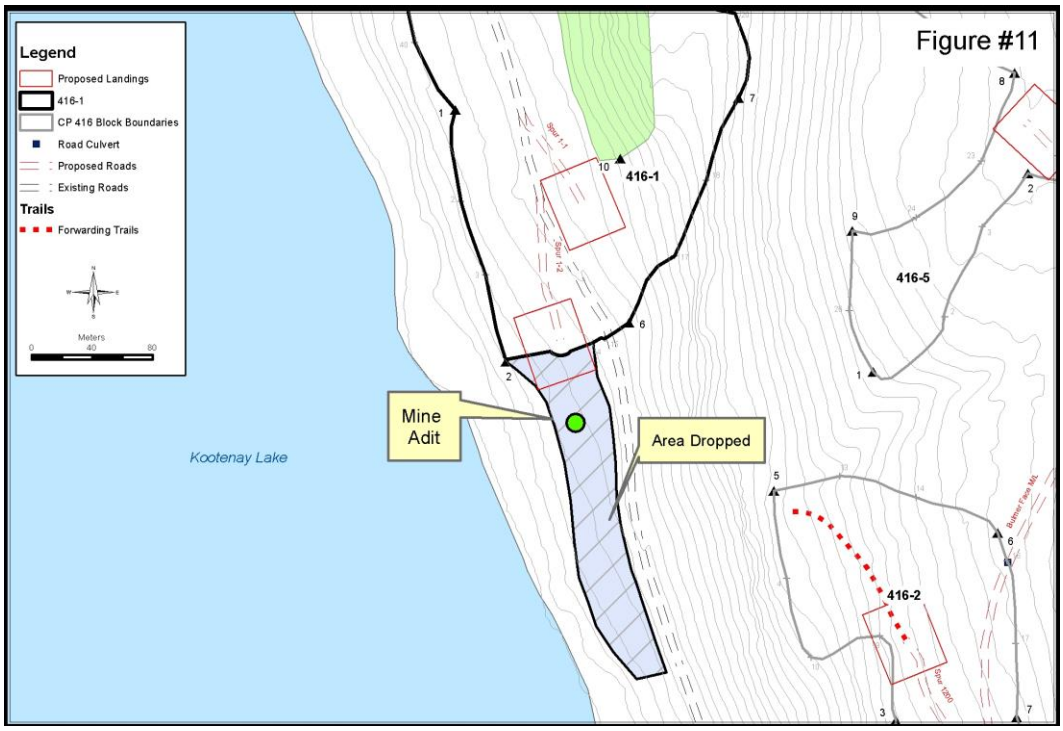
Except for rockfall/topple from the rock bluffs there is no evidence of instability within the proposed development area. The steeper slopes (mostly the Class IV polygons) are typically rock outcrop at the top with coarse colluvium aprons at the base, these slopes are insensitive to alterations of slope drainage.

Culvert locations (figure 3) as proposed during the road layout will maintain natural slope drainage.

Unless otherwise indicated the development as proposed will not significantly increase the low likelihood of landslide initiation.

6.1 Blocks:

Block 416-1: There are no terrain stability concerns for this block. Place a 5m no machine zone around the mine adit for worker safety (Figure #11).



Block 416-2: There are no terrain stability concerns for this block.

Block 416-3: To avoid karst terrain and any impact on the dormant rock slump remove this block and Spur 1-16 from the current proposal.

Block 416-4: To avoid harvesting on the toe of the dormant rock slump remove this block and spur 4-1 from the current proposal.

Block 416-5: Avoid trails on 75% gradient slope in the northeast portion (currently in wtp), trails can be constructed at the base of the slope to reach timber. Timber harvesting as recommended will not significantly increase the low likelihood of landslide initiation.

Block 416-6: There are no terrain concerns with this block.

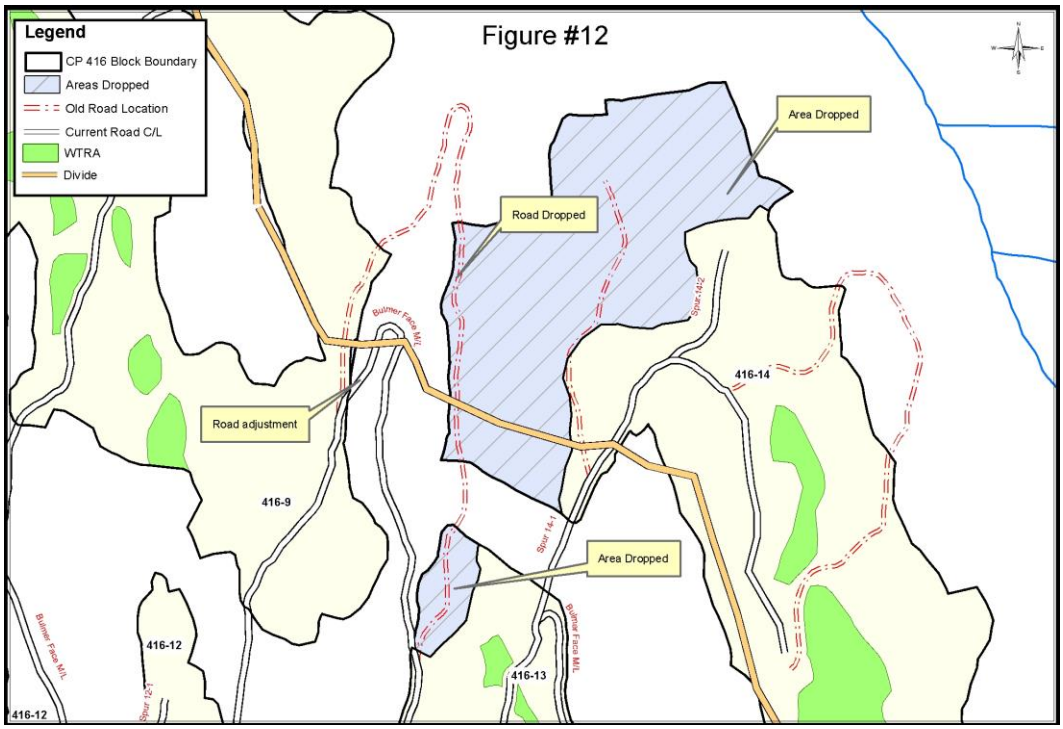
Block 416-7: To avoid Karst terrain and harvesting upslope of the rock slump remove this block and proposed road segment from the current development.

Block 416-8: There are no terrain stability concerns with this block.

Block 416-9: There are no terrain stability concerns with this block.

Block 416-12: There are no terrain stability concerns for this block.

Block 416-13: The northwest corner of the block is a short 65% shallow soil over rock slope, either reserve this section (as shown in figure #12) or harvest from the road (no trails). To avoid Karst features, remove the southern part of the block. Timber harvesting of the proposed block will not significantly increase the low likelihood of landslide initiation.



Block 416-14: To avoid any potential impacts on travertine deposits, emergent springs with tufa, and collapse features, reserve the southern part of the block as shown on figure #12. This exclusion area also effectively isolates the block from direct contact with the slope to Argenta Creek.

The rest of the block is mostly low to moderate gradient. An avalanche track terminates in the top southeastern portion of the block. It is likely that the melting of the avalanche

deposits in the spring produces a significant volume of water concentrated in a confined area, avoid diversions down skid trails.

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

6.2 Bulmer Main Line and Spurs:

There are no terrain stability concerns for much of the proposed road and most of the spurs. Culverts and cross-drains are well located and will maintain natural drainage patterns.

Unless otherwise noted, road construction utilizing standard road construction techniques will not significantly increase the low likelihood of landslide initiation.

Along the lower section of the road (600m asl to 900m asl) there are significant areas of sandy gravel to gravelly sand, through those sections the cut and fill slopes should not exceed 1.2:1.

To avoid possible impacts on Karst features, delete the portion of the road designed to access block 7, delete spurs 14, 15-2 and 16-1. (This has already been incorporated in the final development plan).

Between road hubs 374 and 375 the road has already been realigned to avoid Karst features.

Specific comments on sections of roads and spurs are tied into road hub stations as tabulated below and shown on figure #13.

Road prescription tables.

Table 6.2-1 Section #1

Hubs	Slope	Material	Recommendations	Residual likelihood of slide
145-162	65-85% (Small rock faces 100%)	Blocky colluvium and outcrop	Cut in rock 0.25:1, in talus 1.1:1, key in and place coarse colluvium 1:1, FB slopes greater than 80%	L
172	50-100		1:1 fill, try not to spill over side, move center line ~ 2m into hill.	L

Hubs	Slope	Material	Recommendations	Residual likelihood of slide
185-189	65 to 100%	Blocky colluvium and outcrop	rock 8m high on cut side, blocky coll 65% down with step 10 to 15m below, key in fill.	L

Table 6.2-2 Section #2

Hubs	Slope	Material	Recommendations	Residual likelihood of slide
309-321	45%-65%	Coarse colluvium and rock steps	key in fill, place coarse material at no more than 1:1. Cut 0.25:1 in rock, 1:1 in colluvium (1m)	L
319	60%	Coarse colluvium	culvert marked, move culvert north 20m to sta. 321.	L
321	45%	Coarse Colluvium	Move culvert from 319 to here.	L

Where Spur 10-1 crossed the class IV terrain polygon, which is underlain by coarse colluvium and rock and did not exceed 65% slope gradient, conventional construction is sufficient to maintain the low likelihood of landslide initiation.

Direct water off the back end of the landing at the end of Spur 10-2 to avoid diverting water out of Argenta Creek Catchment.

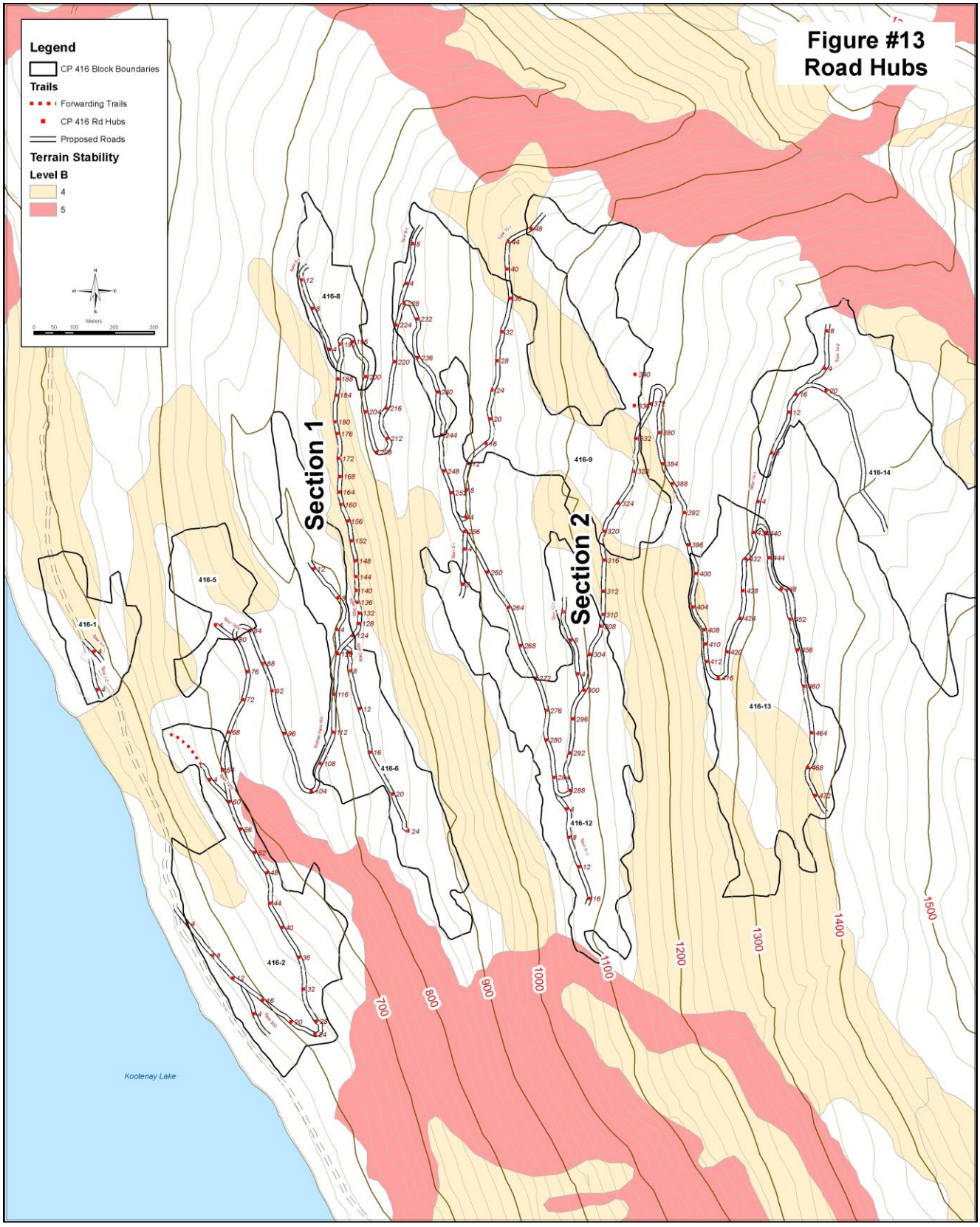


Figure #13
Road Hubs
Legend
CP 416 Block Boundaries
Trails
Forwarding Trails
CP 416 Rd Hubs
Proposed Roads
Terrain Stability
Level B
4
5
Section 1
Section 2
416-1
416-2
416-5
416-6
416-8
416-9
416-12
416-13
416-14
Kootenay Lake
700
800
900
1000
1100
1200
1300
1400
1500

6.3 Partial Risk:

Partial risk is an assessment of the likelihood of a landslide and the likelihood of the slide affecting the elements considered for risk. Partial risk does not include an estimation of consequence.

The overall slope configuration of short steep steps alternating with broad benches and or draws reduces the potential runout distances of any landslide, effectively eliminating the possibility that slides initiating anywhere but along the lower most slopes from impacting Argenta-Johnsons Landing Road, Argenta Creek, or Private Property.

Private Land:

Blocks 416-1, 416-2, 416-5 and 416-12 and most of the road alignment and spurs are not upslope of private land.

Table 6.3-1 Partial Risk Matrix

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Effect 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

Blocks 416- 9, 416- 13 and 416-14 and road section between Hubs 145 to 189 are separated from private land by sections of slope >200m <36% and/or slope configurations (benches, flutes, ridges) that will stop slides from reaching private land boundaries. Block 416-6 is separated from private land by a draw and is unlikely to impact the private land.

Table 6.3-2 Partial Risk Matrix

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Effect 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

Development of blocks 416-1, 416-2, 416-5, 416-6, 416-9, 416-12, 416-13, and 416-14 are deemed to pose a very low Partial Risk to private land.

Argenta-Johnsons Landing Road:

Blocks 416-1 and 416-2 are in proximity to this road, all other blocks are separated from the road by broken topography or low gradient sections and pose a very low risk. For blocks 416-1, 416-2 and associated roads:

Table 6.3-3: Partial Risk Matrix

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Effect 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

Although there is a low likelihood of landslide initiation and slide that did occur would reach the road, there is a moderate partial risk to Argenta-Johnsons Landing Road.

Argenta Creek:

As seen on figure #14 only portions of Blocks 416-9 and 416-14 are within the Argenta Catchment. The end of Spur 10-1 just enters the mapped boundary within block 416-9 and the switch just upslope of this block is also just within the catchment. There is a low likelihood of landslides (the slope gradient within the block is >45%), the boundary is set back from the slope to the creek which is this location is ~ 55%. The recommended excluded area in block 416-14 isolates the proposed harvesting from historic instability on the slope above Argenta Creek (visible on hillshade), the drainage within the block will not flow towards the noted instability. To the north, the block and in block spurs are separated from the slope to Argenta creek by a small rise. Both Blocks 416-9 and 416-14 are assessed as having a low likelihood of landslides, landslides that did initiated would not reach Argenta Creek, however due to the drainage patterns sediment may reach the stream.

Table 6.3-4 Likelihood of Debris slide/Avalanche or sediment reaching or effecting Argenta Creek.

Relative Rating of a Landslide Effecting the elements assessed for Risk	Description of Activity and/or Geomorphic Conditions
High	Landslide debris and/or sediment delivery would reach or directly effect Argenta Creek, Argenta-Johnsons Landing Road, Kootenay Lake, or Private Land.
Moderate	There is a run-out slope of<20^{o} (36%) gradient and <200 m in length, or another terrain configuration which could 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 the elements assessed for risk. 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 effect the elements assessed for risk at the time of an event. There is a run-out slope of <20^{o} gradient for >200 m, or another terrain configuration which would intercept or dissipate sediment or landslide (e.g., irregular or bench rock-controlled terrain), below and between the development the elements assessed for Risk.
Negligible	Landslide deposition will not impact the considered elements.

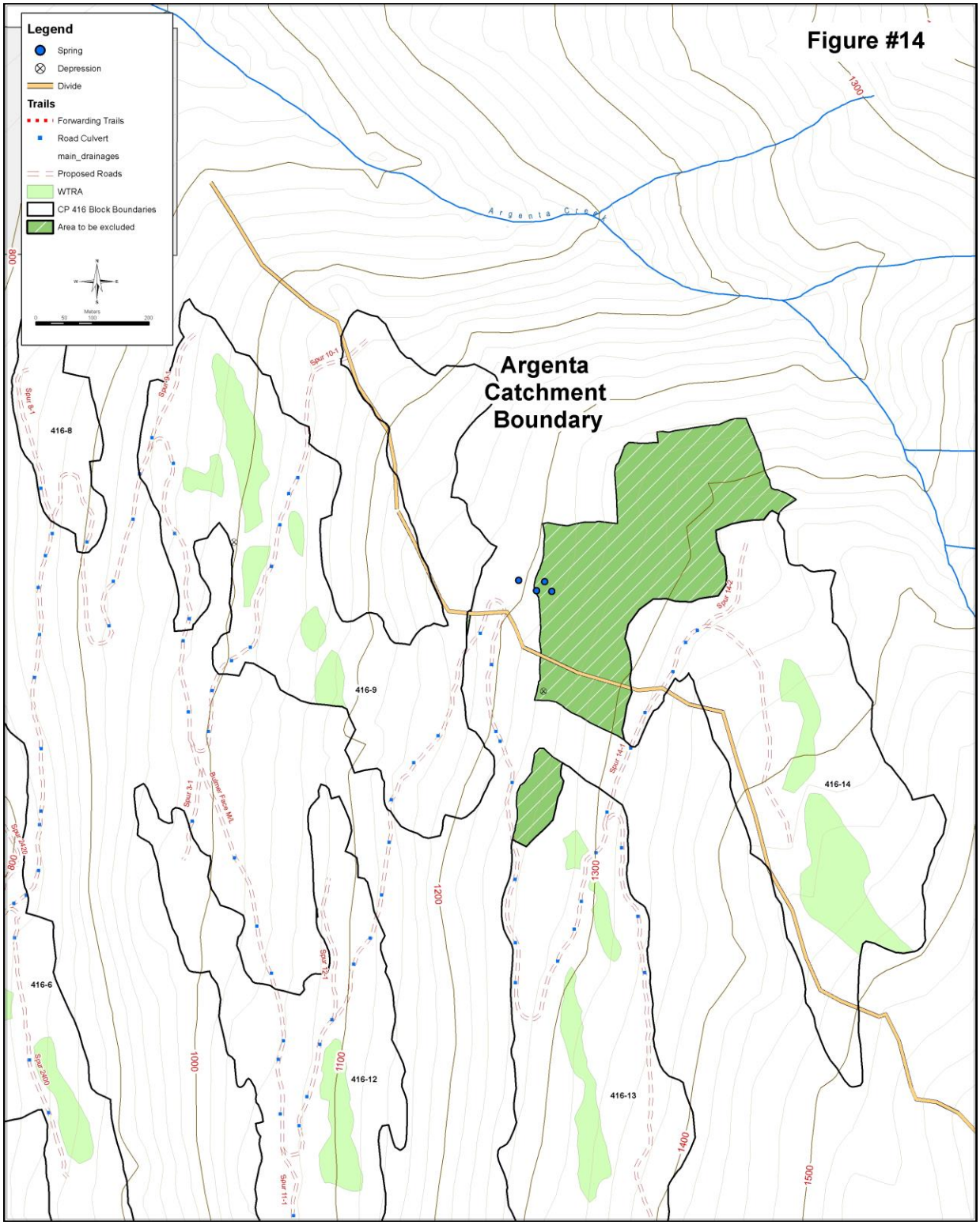


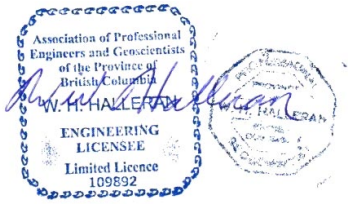
Figure #14
Legend
Spring
Depression
Divide
Trails
Forwarding Trails
Road Culvert
main_drainages
Proposed Roads
WTRA
CP 416 Block Boundaries
Area to be excluded
Argenta Creek
Argenta Catchment Boundary
416-8
416-9
416-14
416-6
416-12
416-13
Spur 8-1
Spur 10-1
Spur 14-2
Spur 14-1
Spur 3-1
Spur 2400
Spur 2-1
Spur 11-1
Palmer Face Mtl
800
900
1000
1100
1200
1300
1400
1500

Table 6.3-5 Partial Risk Matrix

		Likelihood that the Landslide and or Sediment Delivery Will Reach or Otherwise Effect 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

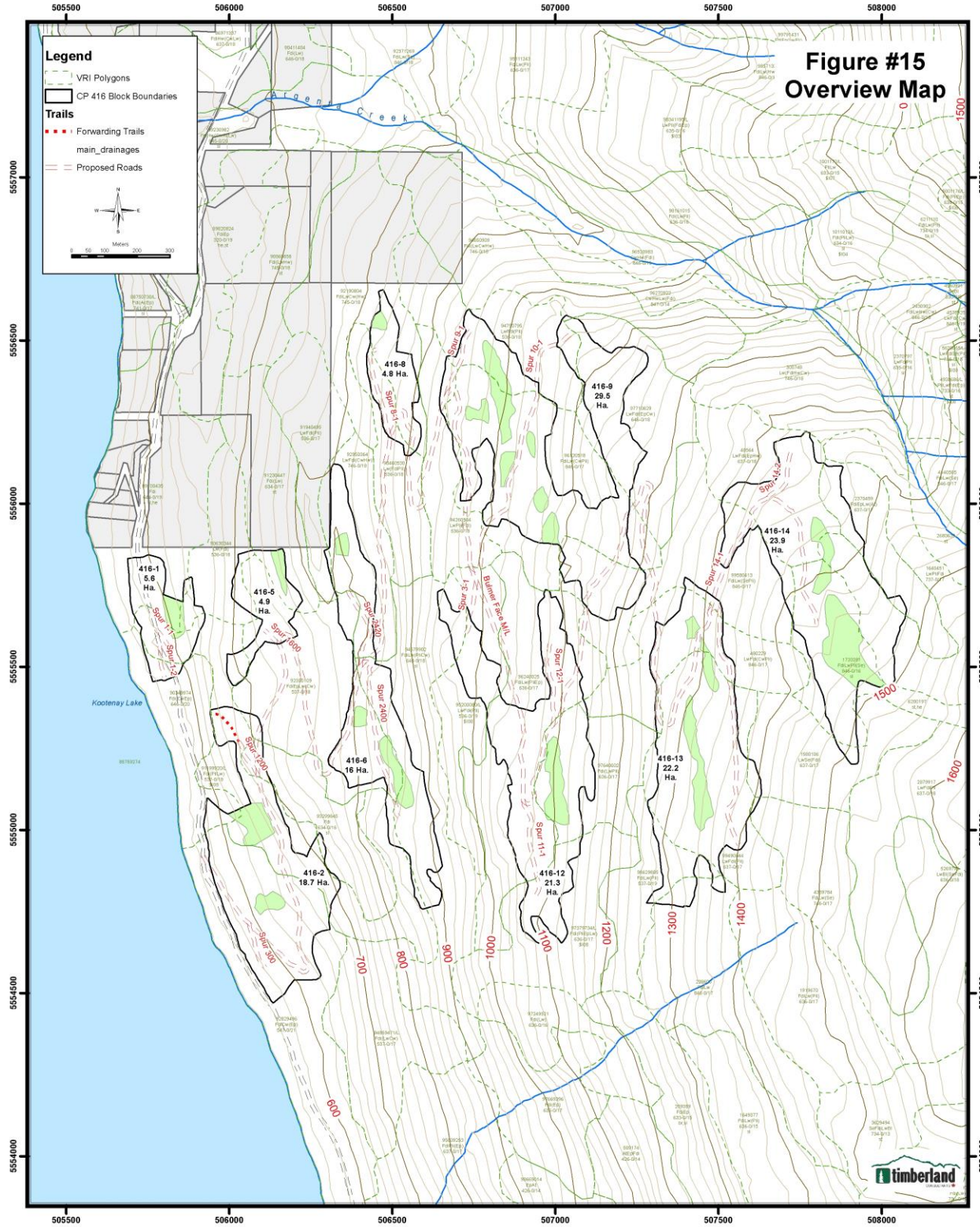
Blocks 416-9, 416-14 and associated roads and spurs pose a low Partial Risk to Argenta Creek.

Respectfully Submitted,
Apex Geoscience Consultants Ltd.



Will Halleran P.Geo. P.L.Eng..

Appendix I Final Layout 1



Appendix II Observation Site and notes 1

site	Description
b1	60% slope, gravelly sand, areas of moss overed rubble, steep slope in wtp, stable.
b 2	short steep sections are small quartzite outcrops, here mostly angular colluvium.
b 3	sta. 75, culvert, small dry swale, 50% slope. outcrop scattered on slope, larger outcrop upslope and down slope, in gravelly sand 1.2:1, when in angular rubble or rock, steeper is okay. rock sticking out in places so likely hit it in places.
b 4	40 to 45% slope, mostly angular material and small outcrops, spur heads down just upslope of rock face.
b 5	short slope, gravely sand and coarse colluvial slope, rock at rim in places.
b6	gravely sand occ silty areas, flat,
b7	still on large low gradient area, ablation till, head over to check poly.
b 8	short 50% slope, 85% angular frags, bench up and down, stable., head up
b 9	boundary up on short 75% slope, angular colluvium, trails on small bench below to avoid this slope, steeper up slope with rock at rim.
b 10	crossed moss covered talus long term angle, rock phyllitic quartzose at rim, here rounded rock on top 35%, pockets of sandy gravel, large flat or ridge just up, likely mantled with sandy gravel shallow to rock, stable. so polygon delineates broad benches with rock steps. top here mostly rock peaking out banded gtzite, small ridge on outside, deep draw to east.
b 11	90% rock slope to draw boundary at base of rock, lower grade to slope within reach trails on lower gradient, do not trail boundary.
b 12	bottom of 70% rubble slope, on 25% just up from flats, keep trail off steep slope, keep on 30%.
b13	landing in flats beside 2.5 m high small rock step to east, looks like another bench after that, here bench pitches draw pitches generally south, 20m wide. underlain by silt.
b 14	boundary 15m up 60% blocky colluvial slope, lst and quartzite, 80% upslope, 15m up rounded rock sticks out.
b 15	station 145, road culvert on 80% slope, blocky colluvium 3m high quartzite outcrop, talus at long term, cut in rock 0.25:1, in talus 1.1:1, may require full bench in places, stack coarse rock 1:1, keyed into slope, draw below good spoil. this poly is steep colluvium with rock faces. foliation dips into hill, favourable.
b 16	to here 75% or greater, likely hit rock, but mostly blocky colluvium, upslope about 20 meters steeper likely rock, small rock faces here, when slope exceeds 80%, fb, otherwise, key in stacked coarse colluvium.
b 17	sta 152, rock face, then shelf 4m up, heading onto shelf ahead, if fb here not much of a cut, 80% below.
b18	sta 154, onto rock shelf, 55% up, small shelf, ensure fill does don't spill over rock lip.
b 19	sta158, shelf just ended road on short -55%, 10 from 65%, cut side is jumble of blocks from rock step 4m high, key in coarse fill, cut will likely be in rock.
b 20	sta. 162, to here as before, here starting to cut through small rock face at edge of shelf, small shelf below, blocky colluvium here, key in and place coarse colluvium 1:1, cut in rock 0.25:1.

site	Description
b 21	sta, 166, on shelf halfway to cutting up next slope, the rock was quartzite the hill is shelved because foliation a d structure dips into the hill at a good angle. blocky lst talus and small bluff upslope, broad shelf below, this shelf 7m wide, looks like low gradient to top bluffs, about 25m up.
b 22	to sta. 172, cut through short rock face, 50% colluvial slope up, shelf below became flute, lst?, will catch fill, here on edge of short face, small on short bench, partially gone then o it again, 1:1 fill, try not to spill over side, move into hill a bit.
b 23	back on a shelf, back key in fill, upslope is 60% rubble slope, can see ahead will cut up through another small rock face, slope is typified as shelved benched
b 24	to sta 180. cut through small rock face, 2 short rock shelves below then higher one, key in fill, now onto 50% colluvial slope. rock faces angling across slope north westerly, foliation now more vertical.
b 25	185 to 189 jct with spur, crossed bowl like feature with rock 8m high on cut side, blocky coll 65% down with step 10 to 15m below, key in fill ahead o to moderate slopes. spur follows top of rock face to flats,
b 26	outlet of draw on flats.
b27	to here 2 60% slopes with rock at rim, quartzite, colluvium no sign of instability, here bench boundary.
b 28	sharp ridge and steep sided draw-flute, 15m deep, sharp bottom, quartzose phyllite forms razor back, possible collapsed cave.
b 29	sta. 27 spur 10-1, to here short rock faces and up to 55% colluvial slopes, just up from bottom, rock was laminated lst, near top right here was foliated micaceous quartzose phyllite with large quartz veins. here on small mounded bench. follow spur to poly
b 30	sta. 32, to here crossed a couple quartzose rock controlled draws sub parallel to slope, here rounded draw comes from slope joins sub parallel rounded draw, rounded lst cobbles in soil, to here most fragments were a angular quartzose. outlet? also large subrounded boulders of grit.
b31	out of draw bench onto 45% slope, coarse colluvium lots of lst, small lst razorback just upslope, defines swale
b32	just starting on 65% slope, coarse colluvium, small outcrop just upslope, here - 50%.
b 33	to sta. 42, mostly moss covered laminated quartzite, slope did not exceed 65%, here up on 25% or less moss covered treed rock step, broken angular rock on top.
b 34	road flat bench, occasional boulders of quartz felspar intrusive, must be erratic, no terrain concerns.
b 35	+70%-30%, upslope coarse colluvium and small steps, downslope a small swale sub parallel and small rock ridge
b37	fc 6 boundary on+ 65%-60% slope, well up from bench (cannot see it , coarse colluvium, high bluff 25m upslope, at rim. no shallow failures but really steep for conventional, one designated trail, reclaim. don't think the ncds make it to the slope. long way to run skidder up the hill, can't turn too steep may not be safe. spur is where the run would have to start.
b 38	this is where the lst razorback is.
b39	in draw, laminated limestone on east, quartzose phyllite on west, lst shows lots of dissolution on fractures.

site	Description
b40	broken limestone face, possible karst feature.
b 41	short rock faces, between moderate slopes.
b42	couple of small bluffs and coarse colluvium with rounded cobbles, so start to mix sandy gravel ablation till.
b 43	in draw, rock on sides, bottom, tree churns show well rounded cobbles and gravel on small rock steps.
b 44	small rock faces 85% slope at top here mostly 65 or less, smaller outcrops, to here mostly angular colluvium, rounded cobbles increase as head down, no sign of instability
b 45	bench looks like an old road here, recent cut out, slope mostly less than 60%, small continuous benches.
b 46	+55-20 coarse colluvium mixed with sandy gravel, stepped.
b 47	passed a large granite erratic, still areas of small out crop and angular material, but now mostly gravelly sand to sandy gravel, 45% slope.
b 48	road shallow bench draw, sandy gravel
b 49	sta 23, 10m wide flat phyllite ridge top.
B 50	boundary at edge of rock rim, 1m back loose, keep machines 2m back from edge, sitting bench here old cut trail, 80% slope below, junipers.
b 51	boundary at base of 85% slope, mostly loose phyllite rubble, no evidence of springs or wet, here broad bench. lots of small mossy blocks on bench
b 52	50% slope to road, mossy rock at break.
b 53	road cut is massive quartzite, donot trail slope, rock.
b 54	lower boundary at edge of 35% bench along a road, road cut sandy gravel , slope below road 65%, with possible small rock step, here gravel.
b 55	bellow road 10m high 100% sandy gravel slope, drift logs old on flats below, now treed, show old high-water mark.
b 56	two sets of flags stay on upper, on 50% slope above old gravel scarp, no trails on 50.
b 57	end of high gravel scarp, slope 45%, more angular, ahead, small outcrops peak out, scarp below now 3m high partially rock, set back from lake by road, flat below likely rock.
b 58	from fc 2 onto rock shelf, old road cut through quartzite headed uphill slope 45%, here tailings and shaft looks like massive sulphides. Open shaft others caved, at least 10m deep.
b59	10% rock flat, 55% stepped rock to lake, boundary at break
b 60	rock to here.
b 61	from poc to here sta. 5 cross short up ?% slope below 55%, sandy colluvium, mostly small angular laminated quartzose, hard to side cast without hitting road, here still just 6m from steep road cut, likely rock, not a terrain concern but might be difficult, 55% slope up here.
b62	50% slope, occ outcrop, sandy silty colluvium, flatter up slope.
b 63	boundary 10m up on 70% slope coarse colluvium, below a out 50% blocky colluvium
b 64	60%, black crumbly phyllite, either a rock step upslope or old slump scarp, check.

site	Description
b65	partially rock sticking out but also looks like material slide off, wet here crown will be rock, check it, 70% slope here.
b 66	quartzite rock step, no cracks, look like small rock slumps but most likely just rock sticking out. no obvious stream.
b67	seep out of slope, couple of large cedars, mostly angular colluvium here , 65% slope,.
b 68	boundary about 15m up 65% slope from flats, do not run up slope here in wet area, flag it out.
b 69	70 45 break, boundary about 6m up, here coarse quartzite colluvium, so wet area a concern but not here, may just want to pull boundary down, no trails on greater than 45 here.
b70	50%, coarse colluvium, 50% to road, call it, not likley to slide but consider trails on this slope visible. i think my inclinometer broke.
b71	water on road cut seem s like rock slump deposit, jumbled
b72	strong spring out of rock here a out 2m down, by pole.
delete,	rock controlled small faces, coarse colluvium, 80%, mostly less except for rock, not sensitive

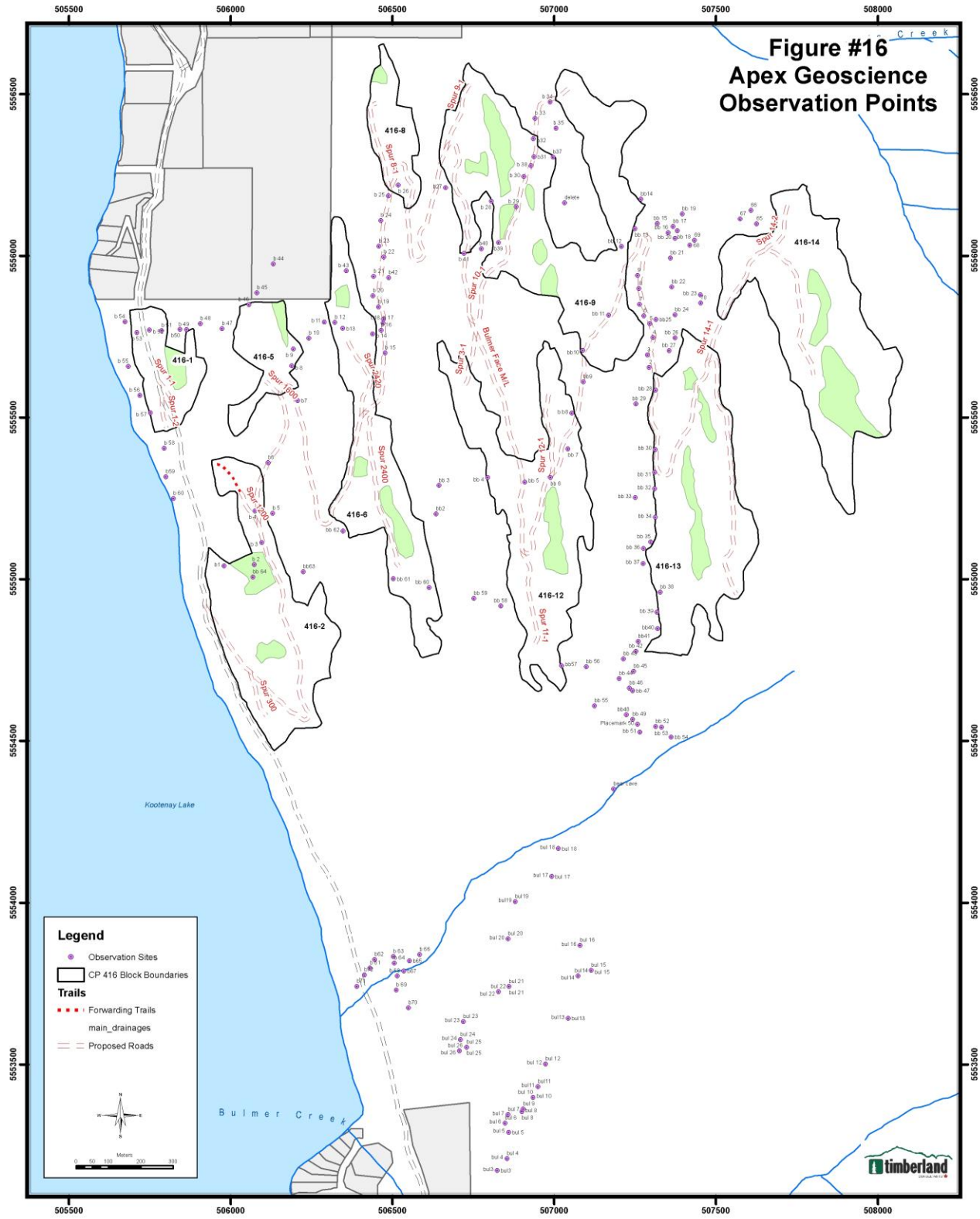


Figure #16
Apex Geoscience
Observation Points
505500
506000
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5555000
5554500
5554000
5553500
416-1
416-2
416-5
416-6
416-8
416-9
416-12
416-13
416-14
Spur 8-1
Spur 10
Spur 2-1
Spur 12-1
Spur 11-1
Spur 14-1
Spur 14-2
Spur 1-1
Spur 1-2
Spur 1200
Spur 1300
Spur 2400
Spur 300
Bulmer Face MTL
Kootenay Lake
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Observation Sites
CP 416 Block Boundaries
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main_drainages
Proposed Roads
Meters
timberland