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PROJECT MEMORANDUM

To:	**Faro Mine Closure Planning Office**	**Fax No.:**	**Via e-mail**
Attention:	**John Brodie**	**CC:**	**Rock Drain Working Group**
From:	**Selina Tribe, Gerry Ferris**	**Date:**	**July 7, 2006**
Subject:	**Natural Hazard Terrain Assessment – NFRC and South Slope RCDC**		
No. of Pages (including this page):	**14 + Figures & Appendices**	**Project No:**	**0257-031-01**

1.0 INTRODUCTION

This memorandum provides a summary of the natural hazard terrain assessment performed for the North Fork Rose Creek (NFRC) basin and the natural slopes above the Rose Creek Diversion Canal (RCDC). In this study, only those natural hazards visible on airphotos within these two specific areas are addressed. There was no site reconnaissance carried out in conjunction with this phase of the assessment. This assessment of past performance (via historical airphotos) is thought to give an indication of the future performance within these two areas. This study does not provide a landslide hazard map for the basin (TBR 1996) nor address the various potential man made hazards within these basins (such as those from the canals, dikes, waste rock dumps, roads, dams etc). Although not comprehensibly assessed in this study some concerns related to the man made hazards are briefly assessed. Man made structures at the Faro Mine site, either in their current condition or future closure configuration, may pose additional hazards if they are not addressed as part of the closure planning. These man made structures and the potential hazards presented by them are outside the scope of the current study.

This study originally consisted only of the NFRC area upstream of the rock drain since it was initiated as part of the 2005 rock drain study. The original scope of work related only to the possibility of increased sedimentation upstream of the rock drain. Later this study was extended to include the area upslope of the Rose Creek Diversion Canal (RCDC).

Several editions of air photos covering the Faro Mine area and NFRC watershed were examined for evidence of landslides (active and relict), debris flows, solifluction and other natural geohazards. River and stream courses were examined for signs of erosion and changing course. This natural hazard terrain assessment in the NFRC watershed was extended to include the Faro Creek watershed, as it is diverted into the NFRC.

2.0 APPROACH

Air photos were purchased for this project to complement the existing air photo library (which only covered the area of historic mining activity) of the Faro Area. Historical air photos were reviewed to check for evidence of past activity and to determine general geomorphic characteristics of the valleys. A summary of the air photos reviewed for this study is included in Table 1.

Table 1 - Air Photo Summary

Roll Number	Photo Numbers	Scale	Date
A12245	149, 150, 151, 152, 153, 154	1:40,000	1949/08/25
A12203	395, 396, 397, 398	1:40,000	1949/08/25
A12282	181, 182, 183, 184, 186, 188, 189	1:40,000	1949/08/26
A21286	319, 320, 321	1:25,000	1969/08/28
NW 69877	131, 132, 136	1:30,000	1969
A22406	21, 22, 23, 24, 25, 26, 27, 28, 29, 30	1:25,000	1971/07/27
A22406	53, 54, 55, 56, 57, 58, 59, 60, 61	1:25,000	1971/07/27
A22406	31, 32, 33	1:25,000	1971/07/27
NW 50879	52, 53, 54, 55, 56, 57	1:8,500	1979
NW 100981	1, 2, 3, 4, 5, 6, 7	1:16,000	1981
A27522	78, 80, 83	1:50,000	1989/08/02
A27522	94, 96	1:50,000	1989/08/02
OS 9009015-1	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	1:10,000	1990
OS 9009015-2	52, 53, 54, 55, 56	1:10,000	1990
A27833	255, 256, 257, 258	1:50,000	1992/07/02
G0307052-1	1, 2, 3, 4, 5, 6, 7, 8	1:20,000	2003/07/25
G0307052-2	20, 21, 22, 23, 24	1:20,000	2003/07/25
G0307052-2	68, 69, 70, 71, 72, 73, 74, 75, 76, 77	1:10,000	2003/07/25
G0307052-3	44, 45, 46, 47, 48, 49, 50	1:20,000	2003/07/25
G0307052-3	95, 96, 97, 98, 99, 100, 101, 102, 103, 104	1:10,000	2003/07/25

3.0 NORTH FORK ROSE CREEK VALLEY

3.1. General Terrain Conditions

The North Fork Rose Creek Valley has moderate to high relief, comprising the mountains of the Anvil Range and an upland plateau (Figure 1). The upland plateau has been deeply incised by glacial erosion, rivers and streams. Numerous glacial cirques interrupt the rolling plateau surface to form biscuit-board topography[1]. Most of the higher elevations are dominated by bedrock with a patchy veneer of till. Weathered, frost-shattered rock is expected to exist at the bedrock surface. An overview of the North Rose Creek valley is shown on Figure 2, which was taken from the top of the waste rock dump looking toward Mt. Mye.

[1] A glacial landscape characterized by a rolling upland on the sides of which are cirques that resemble the bites made by a biscuit cutter in the edge of a slab of dough.

Middle and low elevations are blanketed by till and glaciofluvial deposits made of sand, gravel, and silt. Numerous winding and sub-parallel glacial meltwater channels line the middle and lower hill slopes. These channels indicate the approximate boundary of the glacial deposition during the last glaciation. An ice flow map (Open File 1999-14) of the study area is attached in Appendix A. Also attached in Appendix A are copies of the surficial geology mapping of the study area undertaken by Yukon Geology (Open File 1999-9 and Open File 1999-10) in 1998/1999.

Thick glacial deposits are observed on the valley floor of NFRC (Figures 1 and Appendix A). These deposits are composed of till, glaciofluvial sands and gravels, and glaciolacustrine silts, with the possibility of some clay. The glaciolacustrine materials are confined to the headwater of NFRC and one valley on the slopes of Mount Mye (Open File 1999-9).

Solifluction occurs on many of the upper slopes within the watershed, typically resulting in the deposition of a layer of poorly-sorted silty colluvium on top of glacial deposits. Areas in which slopes were observed to exhibit the most noticeable solifluction within the study area are indicated in Figure 1. Soliflucted terrain is identified by the presence of downslope-trending lineations that resemble melting ice cream (Figure 3). The areas dominated by sand and gravel within the glacial meltwater channels do not suffer the same amount of solifluction, possibly indicating a higher degree of thaw stability. The solifluction within the study area is not particularly intense as evidenced by the appearance of erosion channels formed during the last glacial advance (Open File 1999-9). Table 2 summarizes the general characteristics of the areas exhibiting solifluction within the North Fork Rose Creek Watershed Boundary.

Table 2 – General Characteristics of Solifluction Areas

Aspect	Slope Angle	Terrain Type*
North West	10	Till veneer <1 m thick Till blanket >1 m thick
South East	11	Till veneer <1 m thick Till blanket >1 m thick
North East	17	Colluvium veneer <1 m thick
South West	17	Colluvium veneer <1 m thick
South	21	Till blanket >1 m thick Colluvium veneer <1 m thick
South West	10	Till blanket >1 m thick Colluvium veneer <1 m thick
South East	13	Colluvium veneer <1 m thick Till veneer <1 m thick
North East	20	Colluvium veneer <1 m thick Till veneer <1 m thick
North West	19	Colluvium veneer <1 m thick Till veneer <1 m thick

*Bond (1999)

Numerous areas along ridge tops and at high elevations exhibit well-formed sorted stripes and circles, which indicates active frost churning and the development of an active layer over permafrost.

Alpine areas will have lichen-dominated vegetation and are devoid of trees. Lower elevation areas, especially valley floors and lower-middle valley slopes, support a sparse forest that is dominated by Black Spruce.

3.2. Hazards in the Basin

The locations of the active and inactive geomorphic processes in NFRC basin are shown by polygons and symbols on an overview map (Figure 1). Terrain symbols used are given in Table 3.

Table 3 - Geomorphic Processes

Terrain Symbol	Geomorphic Process
Rd	debris flow track
Rb	rock fall
A	avalanche track
Fu	soil slump
Fu^I	inactive soil slump

A group of at least four (4) debris flows (Rd) were observed on the 1971 photos which appear immediately adjacent to road cuts on steep slopes just east of the open pit. They are mapped on air photo A22406 #60 and the area is indicated on Figure 1 above the Faro Pit. Recent air photos (2003) do not show instability in that area. Also, no instability was noted in the air photos dating from 1949 (A12203 #395 and 396). It is likely that these debris flows were a direct result of the exploration roads that were cut in the mountain side. A few additional debris flows were identified elsewhere in the basin on steep valley slopes.

One active slump (Fu) was identified on the west slope of the North Fork Rose Creek on the photos dated from 1971. It is mapped on air photo A22406 #23 (Figure 4). As no recent photo set covers this area, it is not possible to determine whether the slump is still active. To determine if the slumps are still active, ground inspection of the area is recommended. The vegetation and small features indicate that the failures were small and moved only a small distance.

Several inactive soil slumps (Fu^I) were also identified on the banks of North Fork Rose Creek in the general vicinity of the active slump on the photos dating from 1971 (Figure 4). No recent air photo set covered this area, however, given their muted features and overgrown vegetation, these slumps were considered inactive. It is not evident from these photos whether the failures were caused by recent river erosion or an older event. The slumps may have been formed during deglaciation when the course of the North Fork Rose Creek was re-established and incised through the glacial sediments deposited within the valley. The soil slumps suggest the presence of clay and silts which are likely glaciolacustrine in origin. This area is mapped (Open File 1999-10) as being a glaciofluvial complex; composed of deposits of outwash, glaciolacustrine and minor till deposited in an ice contact environment.

Snow avalanche tracks occur throughout the study area, especially in regions of steep relief and snow accumulation zones. Many avalanche tracks do not reach the valley floor. The location of the avalanche tracks are noted on Figure 5.

In the mid 1980's a slope failure occurred within the waste rock dump adjacent to the causeway fill (the rock drain). The failure consisted of lateral displacement of the toe by a few metres with relatively minor vertical displacement at the crest. The upper part of the fill slope was regraded. In 1990 it was concluded that this portion of the waste dump was in a stable arrangement (Golder 1991).

Subsequently annual inspection visits have revealed minor movements at the toe of the slope and almost no movements at the crest.

3.3. Stream Processes in the Basin

North Fork Rose Creek is a sinuous stream flowing westward and southward from headwaters in the Anvil Range. Near the headwater region, the stream is sluggish with a beaded morphology indicative of permafrost-dominated terrain with massive ground ice. In the upper reach it is under fit for the broad glaciated valley it flows in.

Farther downstream and mid-course, North Fork Rose Creek is a sinuous, single channel stream, however is does contain a few vegetated islands around which the stream anastomoses. The stream has incised into a relatively thick blanket of glacial deposits in the valley floor. The stream is no longer under fit and appears adjusted in size to the relatively narrow valley floor.

3.4. Landslide Dam

As noted in Section 3.2, several inactive slumps were noted in the North Fork Rose Creek Valley above the Rock Drain. The following evaluation looks at the possible formation of a landslide dam due to the re-activation of these slumps. Re-activation could arise as a result of climate change, seismic activity or undercutting of the toe of the slump. The slumps were located within a unit mapped as a glaciofluvial complex; consisting of till, sand, gravel, and minor amounts of silt and clay.

Past movements in this area, the slumps as shown on Figure 4, did not result in the formation of a landslide dam. The airphoto review indicates that the slumping areas appear to have undergone only small movements. Given this evidence and the valley shape, it is considered unlikely that a landslide dam would form in this valley. Despite the apparent low likelihood of a landslide dam forming, critical structures may remain further downstream of these slumping areas, which would be adversely affected by the breaching of a landslide dam (i.e. the RCDC). In order to gain further understanding of the effect that a landslide dam would have, the following paragraphs estimate the possible flood event size if a landslide dam did form and subsequently fail by overtopping.

At the location of the slumps, the valley is broad and U-shaped. The maximum extent of the slumps was approximately 200 m from the edge of the creek on the east and 100 m in the west. The elevation difference between the creek level and the headscarp of the slumps is approximately 5.5 m (based on the 1:50,000 NTS map sheet with 30.5 m [100 foot] contour intervals).

The maximum height the landslide dam formed from this slump is the entire elevation difference between the headscarp and the creek, 5.5 m. A more realistic value would likely be half or one quarter the height. The lesser height would lower the volumes and peak discharge created by the dam. In order to produce a conservative estimate of the flood resulting from a breached landslide dam a range of heights was used, 3 and 5.5 m. A reservoir with a total surface area of 400 / 900 m^2 would be created for a 3 / 5.5 m high landslide dam, at the location of the previously noted slumps. From Clague and Evans (1994), the Potential Energy (PE) of the impounded water can be determined (Eqn. 1).

(1) Potential Energy (joules) = Dam Height (m) x Reservoir Volume (m^3) x Specific Weight of Water (9800 N/m^3)

The potential energy of the impounded water would therefore be between 17,640,000 and 133,402,500 J respectively for a 3 and 5.5 m high landslide dam. An empirical equation relating potential energy to peak discharge (Q) was presented by Costa and Shuster (1988) based on correlations obtained from failed landslide dams (Eqn. 2). Equation two was termed the threshold equation (Costa and Shuster 1988) as it represents the upper estimate of floods produced from all possible sources.

$$(2) \qquad Q = 0.063 \times PE^{0.42}$$

Using equation two and PE values between 17,640,000 and 133,402,500 J, the peak discharge from a failing landslide dam was calculated to between 70 and 163 m^3/s. Such an outburst flood from a failing landslide dam could impact downstream facilities, such as the RCDC. At this time the inflow design flood for the RCDC is understood to be on the order of 670 m^3/s. The peak flood discharge associated with a potential landslide dam is significantly smaller than the inflow design flood (IDF) for the RCDC, and consequently is not considered to pose an incremental risk to the RCDC.

Should a landslide dam form and subsequently breach, there would be sediment disturbed along NFRC. Some of this could reach the inlet of the RCDC and would necessitate additional maintenance activities.

3.5. Future Concerns

The natural hazard terrain assessment of the NFRC basin revealed the following hazards; one rockfall near the headwater of the creek, an area with relict debris flows, soil slumping in a glaciofluvial complex some 4 or 5 km upstream of the rock drain location and areas exhibiting solifluction. If conditions similar to those experienced in the past continue to be prevalent, similar scale of hazards would be expected.

If air and ground temperatures increase over the next few years or decades, the depth of the active layer thaw will increase. This increased thaw depth will melt (if present) the near surface ice within the permafrost. This is also true if forest fires occur and destroy the vegetative cover over the permafrost (Burn 1998).

The melting of the permafrost can cause slope instability (slides and flows) to develop, either by saturation of the upper soils, or if the conditions are right, the generation of excess pore pressures. These effects are generally thought to be most prevalent in ice rich soils (Couture et al. 2003) of glaciolacustrine origin. The terrain mapping of the study area (Open Files 1999-9 and -10) showed a general lack of glaciolacustrine deposits, although there were some materials associated with the glaciofluvial complexes which have already shown their unstable nature. A detailed study of the Surprise Rapids Landslide (Ward et al. 1992) showed that local fine-grained soil with high ice content within an otherwise stable coarse-grained environment could lead to the development of a large landslide complex, if disturbed.

Increased thaw depths, associated with either forest fires or warming, will lead to increased sediment amounts within NFRC due to soil movement within the valley however the significance of this increase is difficult to predict. The fluvial complex which contained past instability, Figure 4, will likely prove to be the most active in terms of landslide activity if depth of melting is increased.

Based on the past evidence of landslide activity, geometry of the basin and material types within the basin, the formation of landslide dams within the NFRC basin appears to be a remote possibility. If a landslide dam does form within the basin, the expected flood produced by the breaching of the landslide dam is considerably less than IDF for the downstream RCDC.

Angle of repose waste dumps typically exhibit significant movement and settlement immediately post construction (Williams 2000) which do not necessarily indicate instability. Instability of a waste rock dump is normally preceded by increasing rates of movement at the crest of the slope (Campbell 2000).

If left at the current angle of repose, saturation of the toe area, and potentially liquefaction of the underlying foundation (in the Zone II outflow area) could move the waste dumps into an unstable arrangement. It is understood that the waste sumps will be flattened to 3H:1V, which should result in stable slopes for the long term. Consideration of liquefaction of the soils in the Zone II area should be made as part of the final design for the dump slopes.

4.0 ROSE CREEK VALLEY WALL ABOVE RCDC

The available airphotos listed in Table 1 covered the study area upslope of the RCDC, Figure 6. This study followed the same procedure as the study of the NFRC basin. No comments are made in relation to landslide activity of the thermal protection berm or the dike crest, some comments related to the man made structures are contained in a recent report on the RCDC (BGC 2005). These hazards related to the constructed RCDC and others should be considered as part of the closure assessment.

4.1. General Terrain Conditions

The site has moderate to high relief, comprising the mountains of the Anvil Range (Figure 6). Most of the higher elevations are dominated by bedrock with a patchy veneer of till. Weathered, frost-shattered rock is expected to exist at the bedrock surface.

Middle and low elevations are blanketed by till, colluvium, and glaciofluvial deposits made of sand, gravel, and silt indicating the presence of a glacial meltwater channel. Attached in Appendix A are copies of the surficial geology mapping of the study area undertaken by Yukon Geology (Open File 1999-10) in 1998/1999.

Thick alluvial deposits are observed on the valley floor of Rose Creek downstream of the current dam locations (Figure 7 and Appendix A). These deposits are composed of interbedded sands and silts, with the possibility of some gravels and clay.

Solifluction does not appear to occur on the slopes above the RCDC, however the topographic relief causes minor slope wash[2] resulting in the deposition of a layer of poorly-sorted silty colluvium on top of glacial deposits.

Much of the ridge line to the south of the RCDC was not visible in the 2003 set of air photos; however, several peaks in the western edge of the study area near the Cross Valley Dam were visible within the photos. These peaks appeared to be dominated by bedrock with a few small patches of till veneer.

Alpine areas will have lichen-dominated vegetation and are devoid of trees. Lower elevation areas, especially valley floors and lower-middle valley slopes, support a sparse forest that is dominated by Black Spruce.

4.2. Hazards along the Valley Wall

The locations of the alluvial fans along the valley wall are shown by polygons and symbols on an overview map (Figures 7 and 8). Terrain symbols used are given in Table 4

Table 4 - Terrain Unit Symbols

Terrain Symbol	Terrain Unit
Af	alluvial fan
Ap	alluvial terrace
Cv	colluvium
Tb	till blanket
Tv	till veneer

At least four (4) alluvial fans (Af) were observed on the 2003 air photos which appear immediately downstream of the Cross Valley Dam. The weir section of the RCDC appears to have been constructed on two coalescing fans that originate on the south valley wall. They are mapped on air photo G0307052-1-003 (Figure 8) and indicated on the surficial geology map (Appendix A). A review of the historical air photos (1979 and 2003) indicates that the alluvial fans have not increased in size and thickness during this period. A borehole (BGC05-021) drilled during a 2005 site investigation (BGC 2005) confirms the presence of fine-grained interbedded sediments with organic materials along distinct horizons. A few additional alluvial fans were identified elsewhere along the valley wall (Figure 7) in the vicinity of the RCDC, however, these fans were small and poorly developed.

No avalanche tracks were encountered in this study area.

[2] The process of soil and rock material moving down a slope predominately under the influence of gravity assisted by running water that is not confined to channels.

4.3. Stream Processes in the Valley

Adjacent to the tailings impoundments Rose Creek has been diverted into the RCDC. The canal is maintained year round by site staff. Historical photos and observed stream morphology downstream of the mine site indicate that Rose Creek is a sinuous stream flowing westward. The stream meanders but there was no evidence of slumping along the stream bank. The stream does take several sharp turns at the locations of the alluvial fans.

4.4. Future Concerns

The only natural hazard revealed in this natural hazard terrain assessment of the slope above the RCDC was the alluvial fans which have developed near the western limit of the study area. If conditions similar to those experienced in the past continue to be prevalent, similar scale of hazards would be expected.

The upslope area between the pumphouse pond and the diversion berm appears to be affected by ground ice (BGC 2005). Elsewhere only minor occurrences of ground ice were encountered upslope of the RCDC (BGC 2005). If air and ground temperatures increase over the next few years or decades, the depth of the active layer thaw will increase. This increased thaw depth will melt (if present) the near surface ice within the permafrost. This is also true if forest fires occur and destroy the vegetative cover over the permafrost.

Melting of permafrost can cause local slope instability (slides and flows) to develop, either by saturation of the upper soils, or if the conditions are right the generation of excess pore pressures. However, the slope above the pumphouse pond is gentle and ground ice melting is not expected to create large-scale slope instability given the generally granular (thaw stable) nature of the soils encountered in the area.

The alluvial fans which deposit into the Rose Creek do not appear to be controlled by ground ice, but rather by precipitation and local flow patterns. The alluvial fans will continue to be active and affected by variations in rainfall and the resulting inundation with fine-grained sediment from the hill slope.

5.0 SUMMARY

A natural hazard terrain assessment has been conducted for two areas surrounding the Faro Mine site: the North Fork of Rose Creek basin upstream of the North Fork Rock Drain and the south valley wall of the Rose Creek valley above the RCDC. This study was conducted by examining air photographs (listed in Table 1) and categorizing the hazards seen on the photos.

In the North Fork of Rose Creek basin the following natural geohazards were identified:

1. one rockfall near the headwater of the creek,
2. an area with relict debris flows,

3. soil slumping in a glaciofluvial complex some 4 or 5 km upstream of the rock drain location, and
4. areas exhibiting solifluction.

Based on past performance within the basin, landslide dams are not thought to be likely. Given the potential significance of a breaching landslide dam, the size of an outflow flood was estimated and found to be less than the IDF for the RCDC located downstream.

In the slope above the RCDC the coalescing alluvial fans were identified as being a geohazard.

The geohazards identified on the air photographs represents the historical performance within these two study areas. This historical performance gives an indication of the future performance, if the climate conditions continue to be similar to that in the past. Increases in either temperature or rainfall will likely result in increased activity of the hazards in the basins and increased amounts of sediment carried by the creeks.

It is important to note that other than a localized zone of solifluction associated with an access road cut and the localized instability of a waste rock dump, there is no evidence that mining activities have changed the future potential for geohazards across the two study areas, relative to pre-mining conditions seen on historical air photos.

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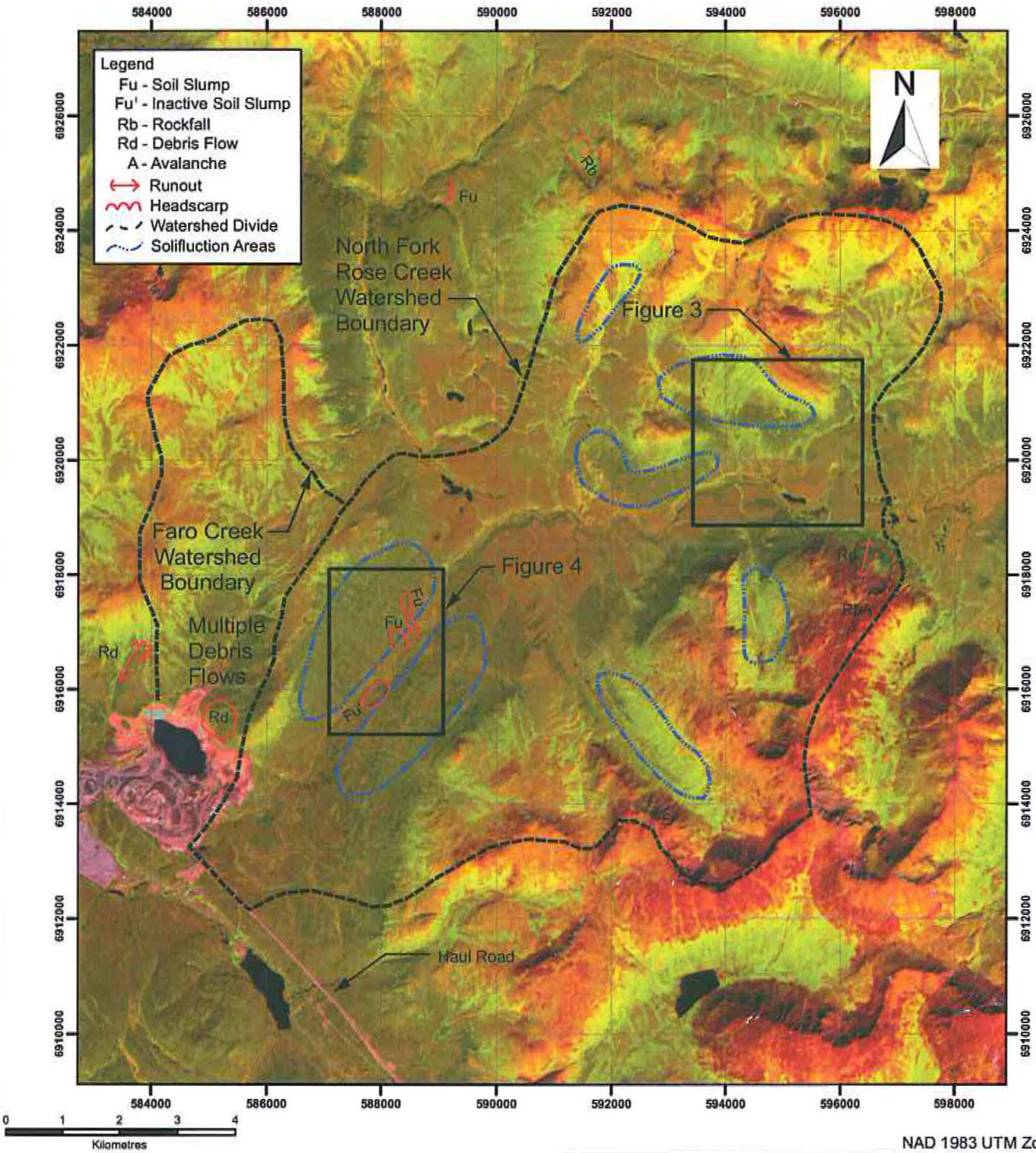
FIGURES



NAD 1983 UTM Zone 8N

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DATE:	MAY 2006	CHECKED:	GWF
DRAWN:	GEJ	APPROVED:	

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PROJECT
NATURAL HAZARD TERRAIN ASSESSMENT
NFRC AND SOUTH SLOPE RCDC

TITLE
NORTH FORK
HAZARD INVENTORY AND WATERSHED MAP

CLIENT: Deloitte & Touche

PROJECT No.	FIG No.	REV.
0257-031-01	1	0

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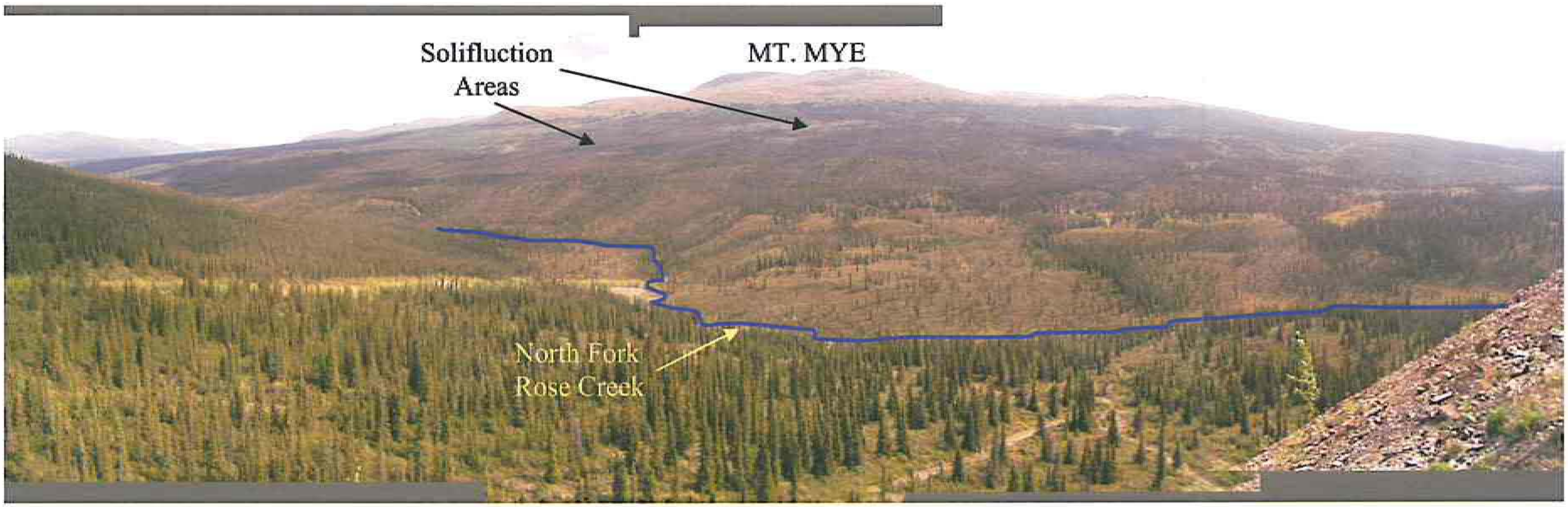

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Client: Deloitte & Touche

Project: GEOHAZARD REVIEW – FARO MINE

Title: VIEW OF NORTH FORK ROSE CREEK FROM ROCK DUMP

Project #:	Date:	Scale:	Drawn:	Approved:	Figure:
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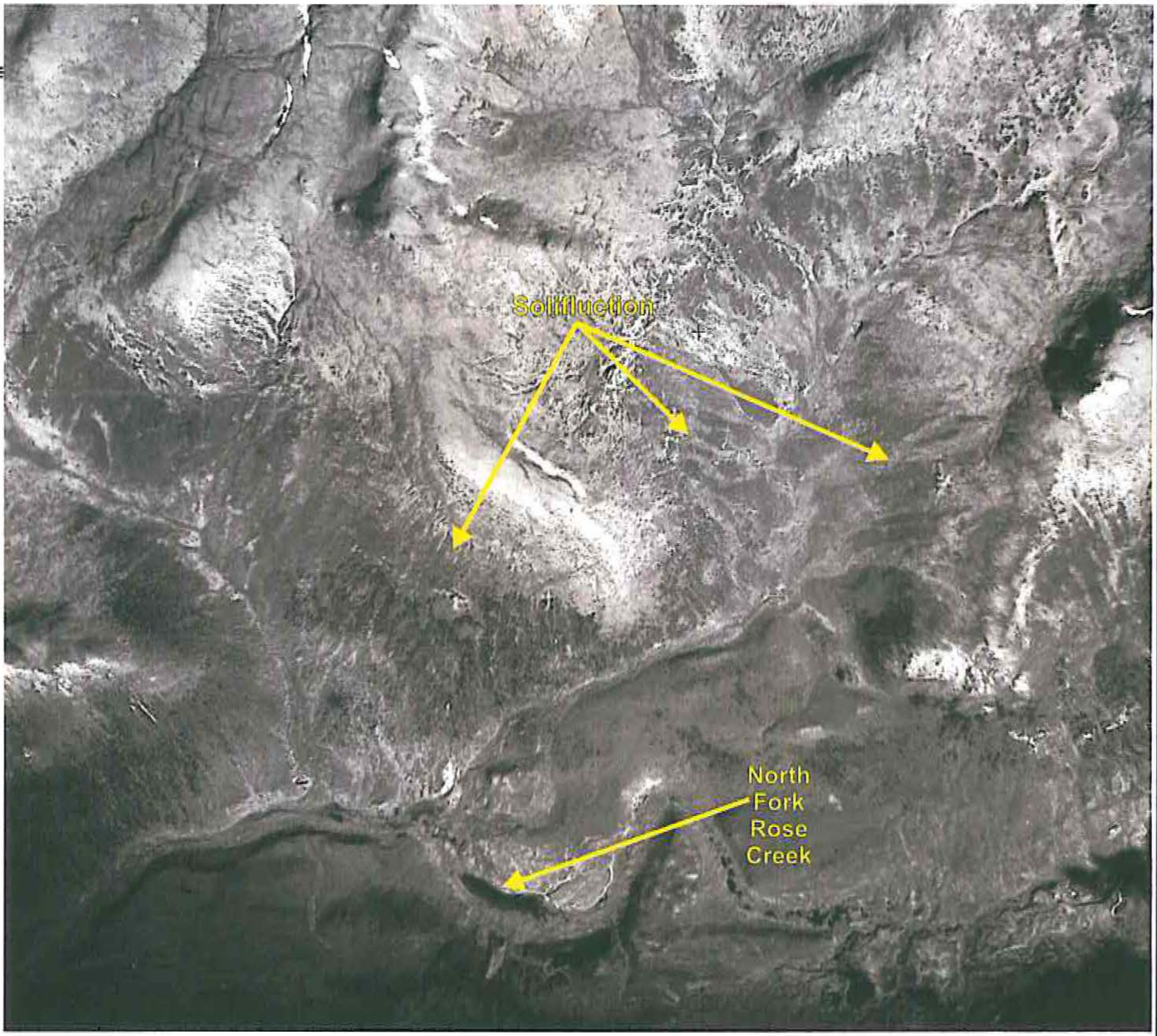

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CLIENT: Deloitte & Touche

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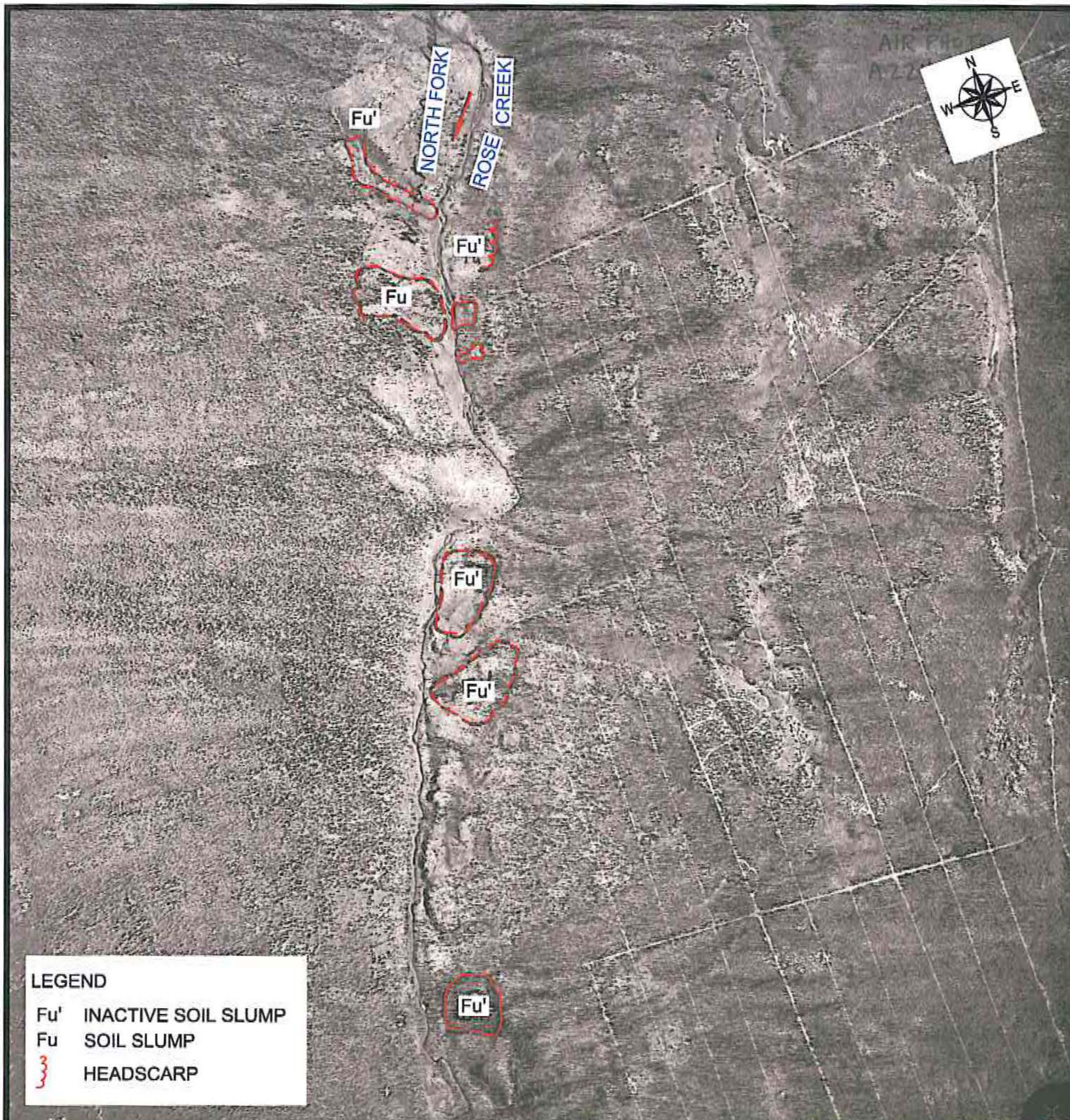
PROJECT: NATURAL HAZARD TERRAIN ASSESSMENT NFRC AND SOUTH SLOPE RCDC

TITLE: NORTH FORK SOLIFLUCTION CA. 1949

PROJECT No.	Figure No.	REV.
0257-031-01	3	0



AIRPHOTO A22406-23

200m 0 200m 400m 600m

Scale APPROX. 1:17000

SCALE:	AS SHOWN	DESIGNED:	ST
DATE:	MAY 2006	CHECKED:	GWF
DRAWN:	CJT	APPROVED:	

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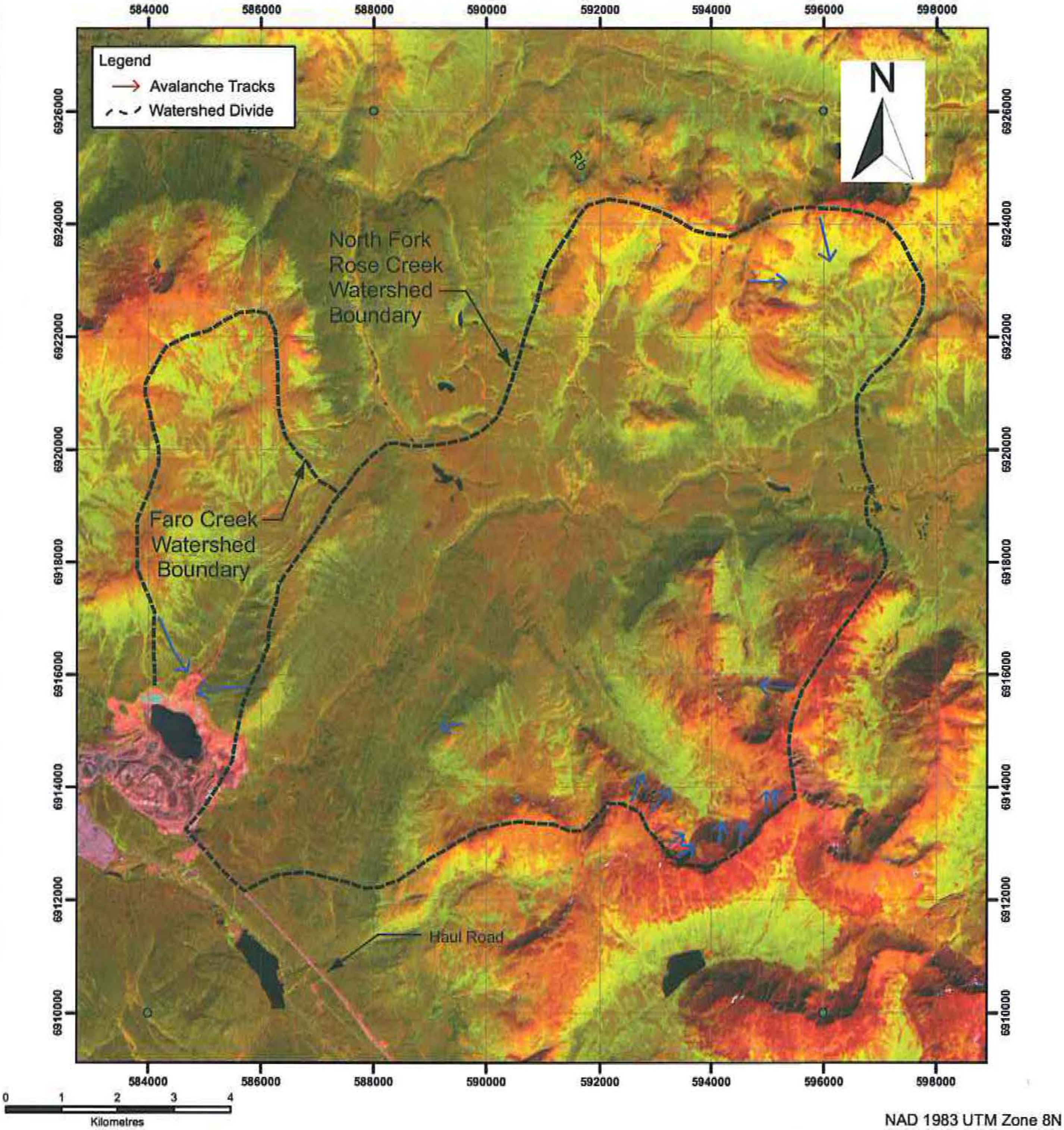
AN APPLIED EARTH SCIENCES COMPANY
Vancouver, BC
Phone: (604) 684 5900

PROJECT: NATURAL HAZARD TERRAIN ASSESSMENT NFRC AND SOUTH SLOPE RCDC

TITLE: VIEW OF LANDSLIDE ACTIVITY ON NORTH FORK ROSE CREEK (CA. 1971)

CLIENT: Deloitte & Touche

PROJECT No.	FIG No.	REV.
0257-031-01	4	0



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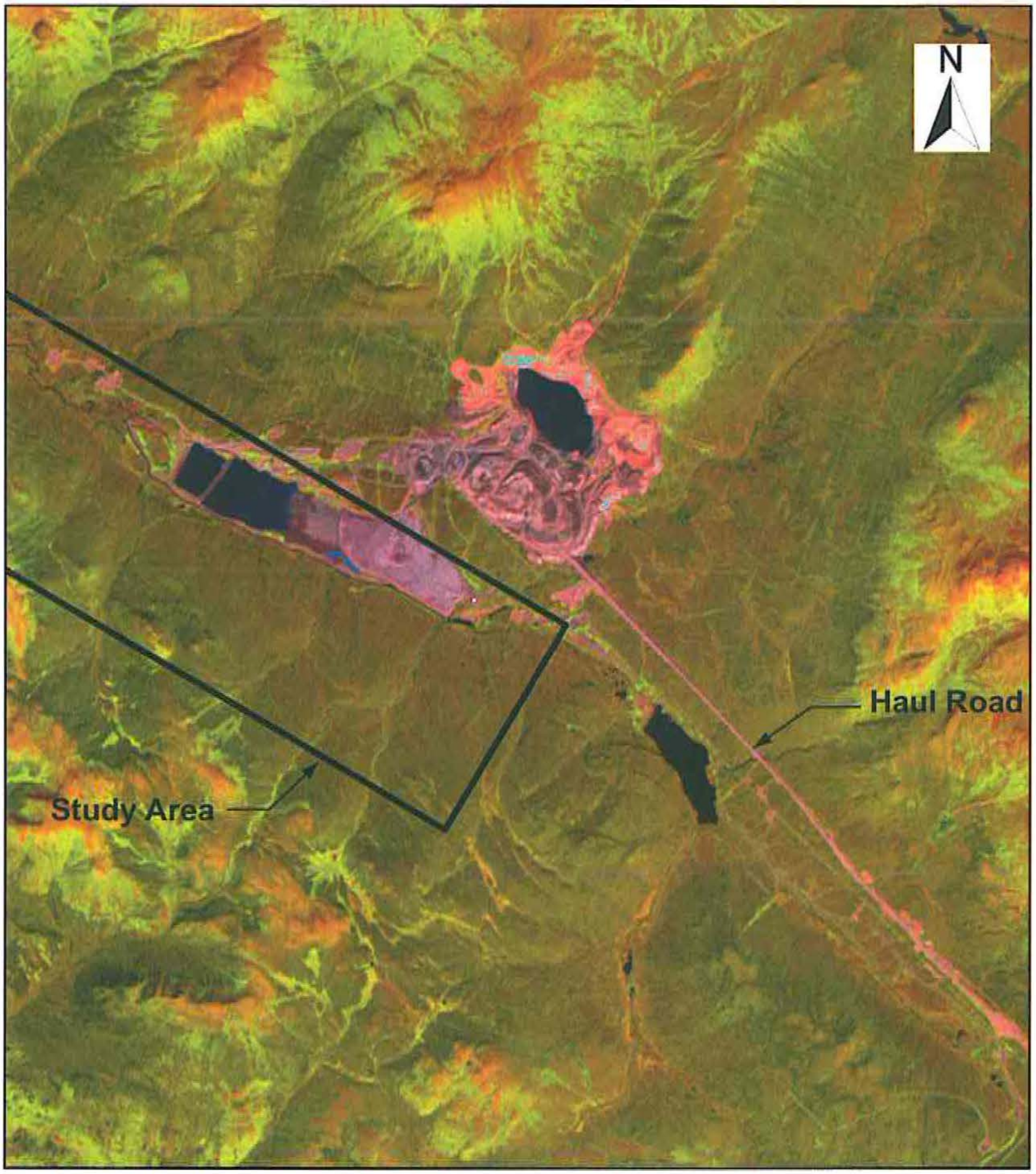
PROJECT: NATURAL HAZARD TERRAIN ASSESSMENT NFRC AND SOUTH SLOPE RCDC

TITLE: NORTH FORK GEOHAZARD INVENTORY AND WATERSHED MAP

CLIENT: Deloitte & Touche

PROJECT No.	FIG No.	REV.
0257-031-01	5	0

N:\BGC\Projects\0257 Deloitte & Touche\031 Rose Creek Hazards\mxd\0257031 Avalanche Activity.mxd



NAD 1983 UTM Zone 8N

SCALE:	AS SHOWN	DESIGNED:	ST
DATE:	MAY 2006	CHECKED:	GWF
DRAWN:	GEJ	APPROVED:	

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Vancouver, BC Phone: (604) 684 5900

PROJECT: NATURAL HAZARD TERRAIN ASSESSMENT NFRC AND SOUTH SLOPE RCDC

TITLE: SOUTH SLOPE RCDC STUDY AREA

CLIENT: Deloitte & Touche

PROJECT No.	FIG No.	REV.
0257-031-01	6	0

N:\BGC\Projects\0257 Deloitte & Touche\031 Rose Creek Hazards\mxd\0257031 watershed.mxd

Source: G0307052-1 Photo #003,005
Year: 2003

CLIENT:

Deloitte & Touche

Legend

Af	Alluvial Fan
Ap	Alluvial Plain
Cv	Colluvium
Cv/Mb	Colluvium over Till
Cv/R	Colluvium over Rock
Gf	Glaciofluvial Sands, Silts, & Gravel
Mb	Till
Mb/R	Till over Rock
R	Rock
(blue line)	Creek

REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED
	-	- -	-	-	-
-	-	- -	-	-	-
-	-	- -	-	-	-

SCALE:	1:21,500
DATE:	JUNE 2006
DRAWN:	SLF
DESIGNED:	JMS
CHECKED:	JMS
APPROVED:	GWF

PROJECT NATURAL HAZARD TERRAIN ASSESSMENT NFRC AND SOUTH SLOPE RCDC

TITLE TERRAIN ANALYSIS UPSLOPE OF RCDC

PROJECT No.	FIGURE No.	REV.
0257-031-01	7	0

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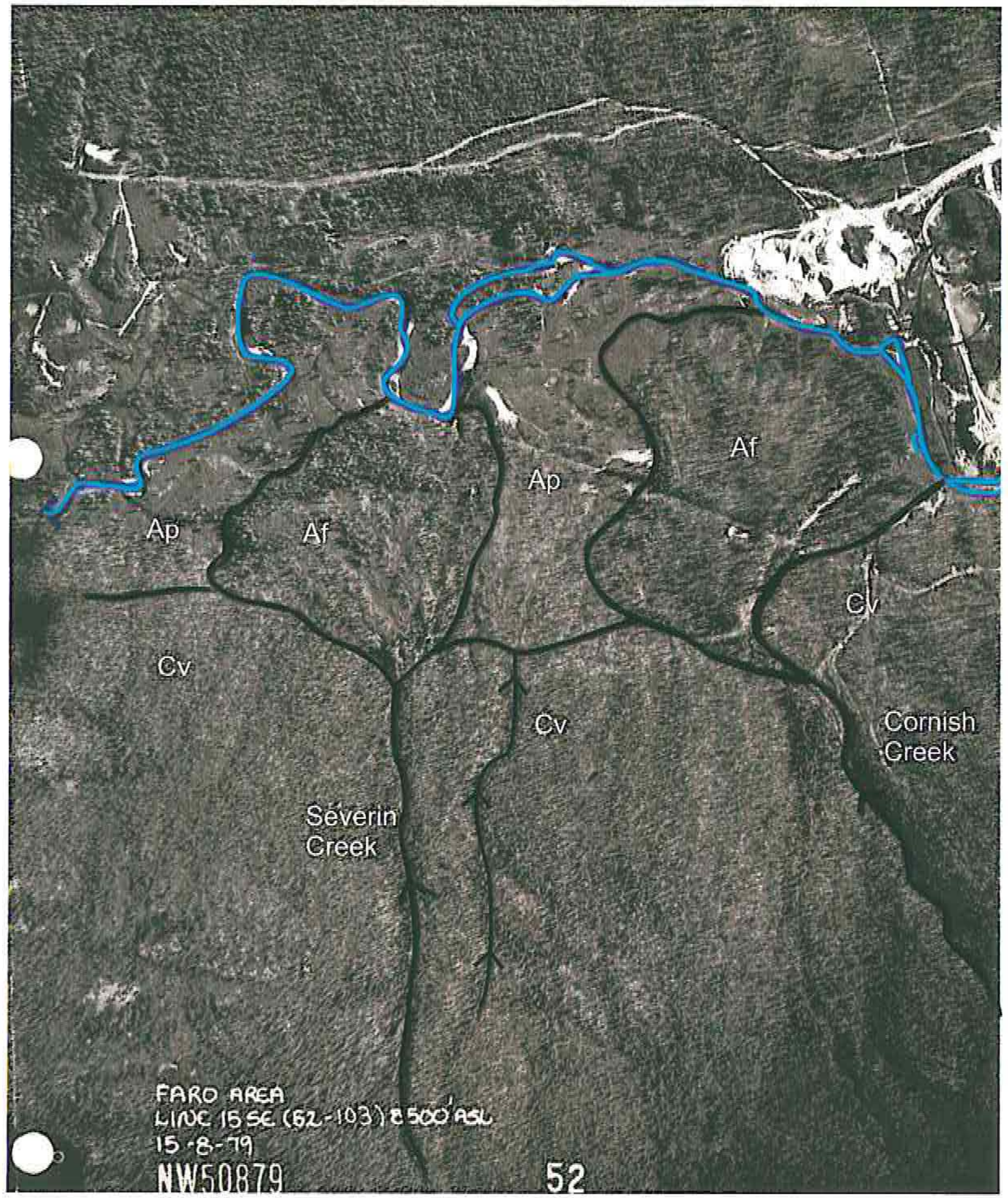

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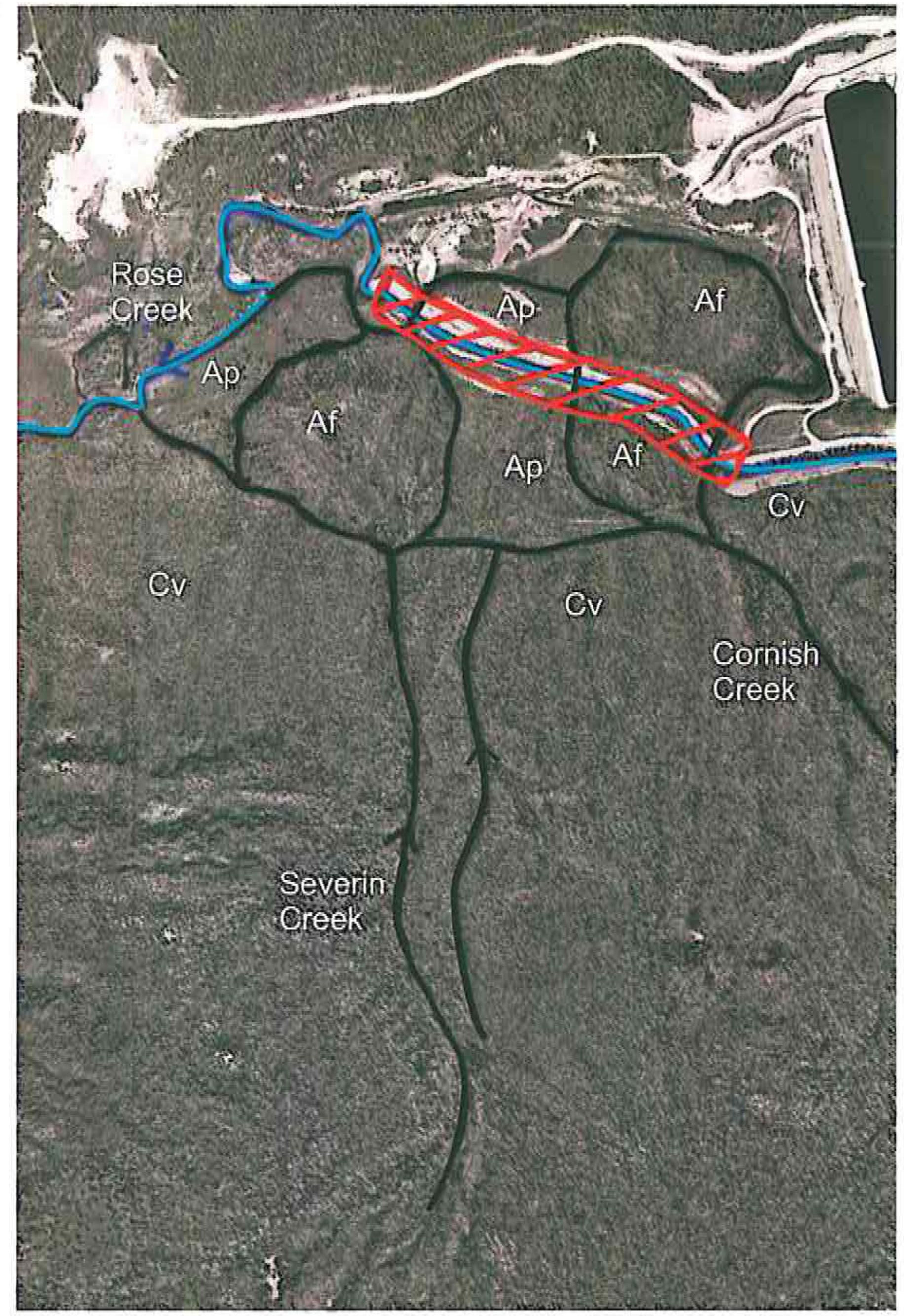
Year: 1979



Scale: 1:10,000
Source: G0307052-2 No. 070
Year: 2003

CLIENT:

Deloitte & Touche

Legend

Af Alluvial Fan
Ap Alluvial Plain
Cv Colluvium
Creek
Weir Section

REV.	DATE	REVISION NOTES	DRAWN	CHECKED	APPROVED
	-	- -	-	-	-
-	-	- -	-	-	-
-	-	- -	-	-	-

SCALE:	AS SHOWN
DATE:	MAY 2006
DRAWN:	SLF
DESIGNED:	JMS
CHECKED:	JMS
APPROVED:	GWF

PROJECT NATURAL HAZARD TERRAIN ASSESSMENT NFRC AND SOUTH SLOPE RCDC

TITLE ALLUVIAL FANS DOWNSTREAM OF CROSS VALLEY DAM

PROJECT No.	FIGURE No.	REV.
0257-031-01	8	0

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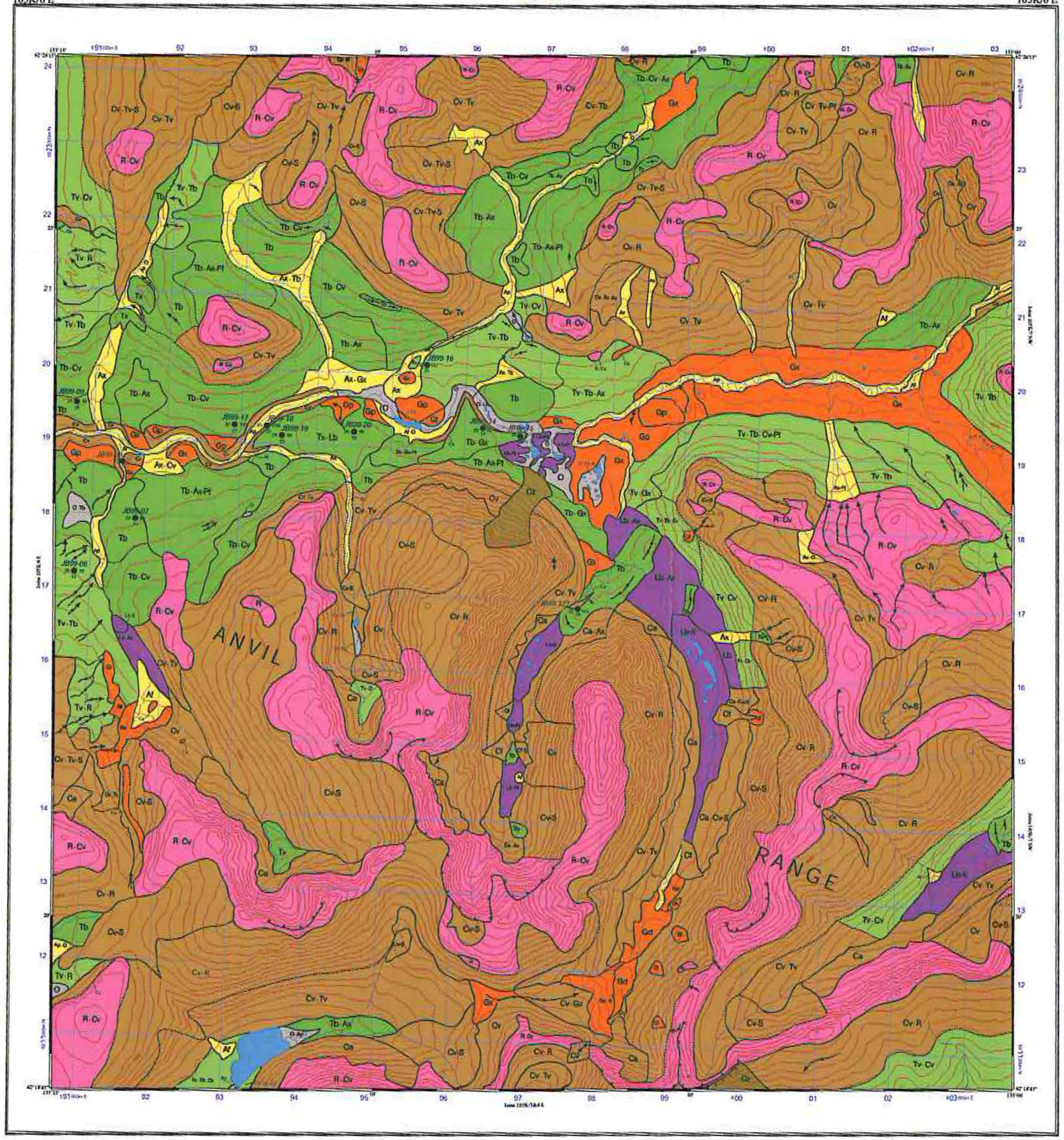
APPENDIX A



LEGEND

QUATERNARY
HOLOCENE

ORGANIC DEPOSITS

O : organic

ALLUVIAL DEPOSITS

Ap : alluvial plain
At : alluvial terrace
Af : alluvial fan
Ax : complexes of Ap and At undivided

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS

Cv : colluvium veneer
Cf : colluvial fan
Ca : colluvial apron
Cz : mass wasting

LATE PLEISTOCENE (WISCONSINAN) - McCONNELL GLACIATION

GLACIOLACUSTRINE DEPOSITS

Lb : glaciolacustrine blanket ; 1 - 40 m thick

GLACIOFLUVIAL DEPOSITS

Gp : glaciofluvial plain
Gt : glaciofluvial terrace
Gf : glaciofluvial fan
Gd : glaciofluvial delta
Gx : glaciofluvial complex

GLACIAL DEPOSITS (till)

Tv : till veneer
Tb : till blanket
Tx : till complex

LOWER CAMBRIAN TO CRETACEOUS

BEDROCK

R : bedrock : common on plateau summits and ridges of Anvil Range

COMBINED MAP UNITS

TERRAIN MODIFIERS

SUBARCTIC, ALPINE AND PERIGLACIAL PROCESSES

Pf : permafrost within 1 m of surface
K : thermokarst
S : solifluction

FLUVIAL PROCESSES

EROSIONAL PROCESSES

G : gullying : areas of rapid erosion

SYMBOLS

Geological boundary (defined, assumed)
Glacial meltwater channel
Moraine ridge
Cirque
Mass movement failure : slow to moderate (i.e., creeps or slumps)
Mass movement failure : moderate to fast (i.e., slides or avalanches)
Aligned landform
Till geochemistry sample (ppm)

Sample Number
Cu Zn
Pb

REFERENCES

JENNINGS, D.S. and JILSON, G.A., 1986. Geology and sulphide deposits of Anvil Range, Yukon. In: Mineral Deposits of Northern Cordillera, Proceedings of the Mineral Deposits of Northern Cordillera Symposium, MORIN, J.A. (ed.). Canadian Institute of Mining and Metallurgy, Special Volume 37, p. 319-361.

RECOMMENDED CITATION

LIPOVSKY, P.S. and BOND, J.D., 1999. Surficial geology map and till geochemistry of Mount Mye (105K/6 E), central Yukon (1:25 000 scale). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 1999-9.

Digital cartography and drafting by P.S. Lipovsky, Yukon Geology Program.

Any revisions or additional geological information known to the user would be welcomed by the Yukon Geology Program.

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Indian and Northern Affairs Canada
Exploration and Geological Services Division
Yukon Region

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SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE (105K/6 E), CENTRAL YUKON

by

P.S. Lipovsky and J.D. Bond
Yukon Geology Program

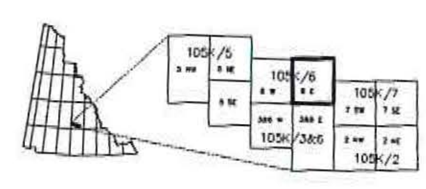
SURFICIAL GEOLOGY AND TILL GEOCHEMISTRY OF MOUNT MYE

(105K/6 E), CENTRAL YUKON

SCALE 1:25 000

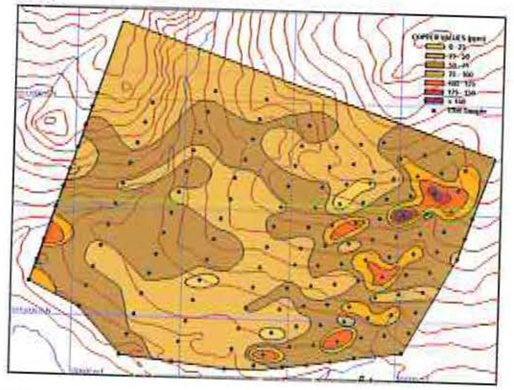
CONTOUR INTERVAL 100 FEET
North American Datum 1983
Transverse Mercator Projection

ONE THOUSAND METRE
Universal Transverse Mercator Grid
ZONE 8

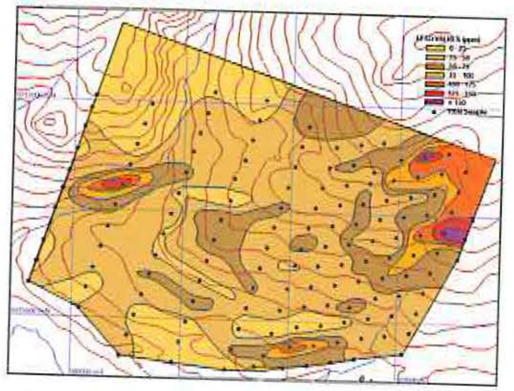


TILL GEOCHEMISTRY OF FARO GRID

COPPER



LEAD



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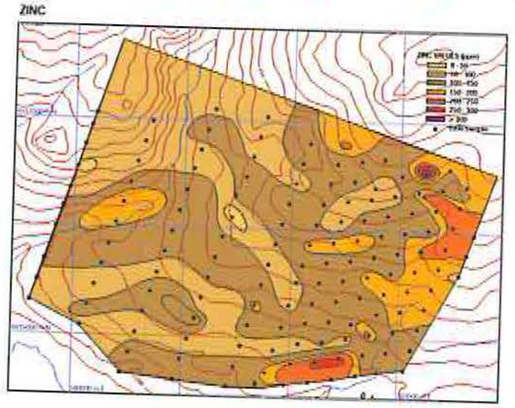

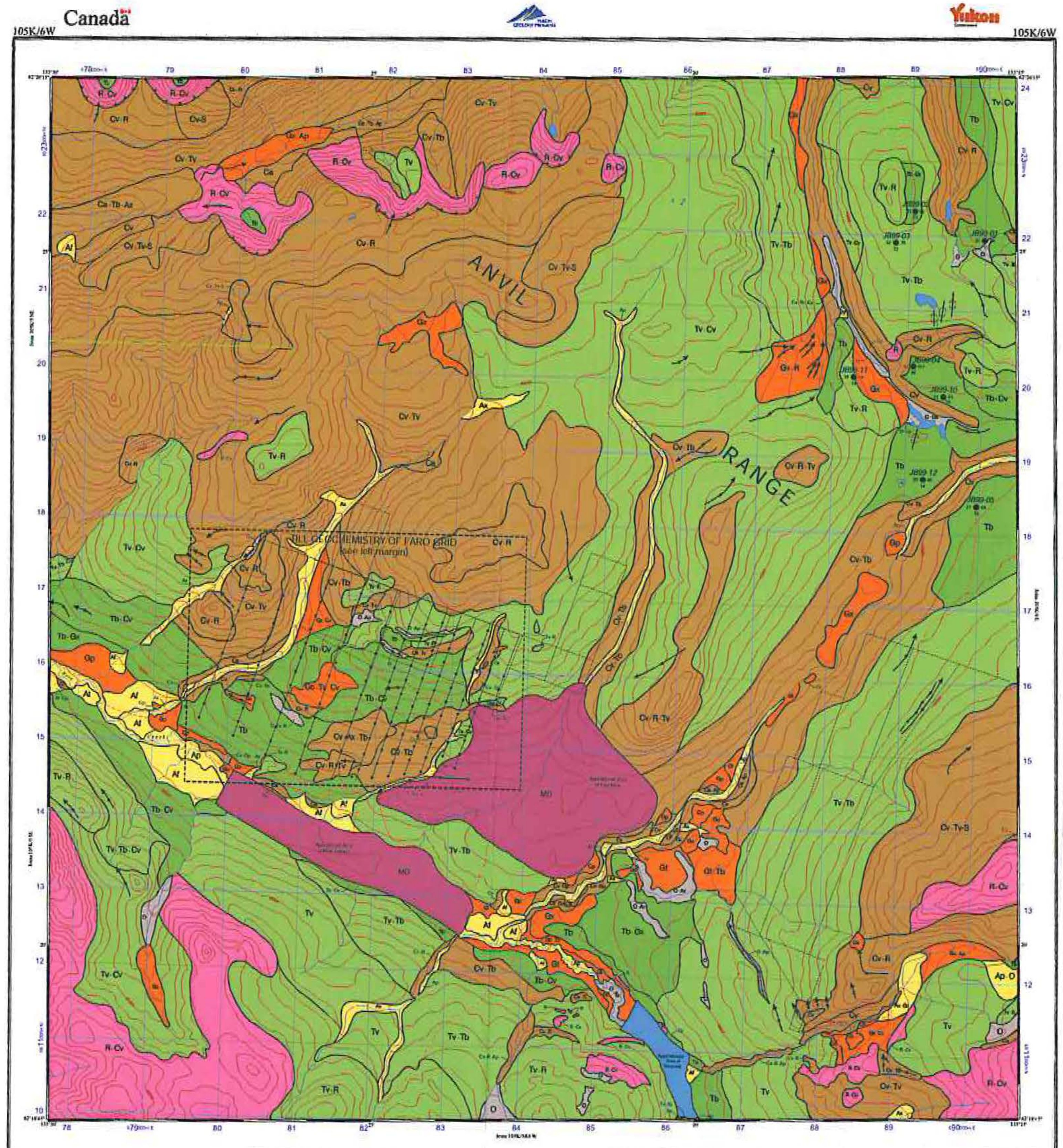

LEGEND

QUATERNARY

HOLOCENE

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

LATE PLEISTOCENE (WISCONSINAN) - McCONNELL GLACIATION

LOWER CAMBRIAN TO CRETACEOUS

COMBINED MAP UNITS

TERRAIN MODIFIERS

SYMBOLS

Sample Number

REFERENCES

RECOMMENDED CITATION

SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE

(105K/6 W), YUKON TERRITORY

SCALE 1:25 000

Indian and Northern Affairs Canada
Exploration and Geological Services Division
Yukon Region

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SURFICIAL GEOLOGY MAP AND TILL GEOCHEMISTRY OF MOUNT MYE (105K/6 W), CENTRAL YUKON

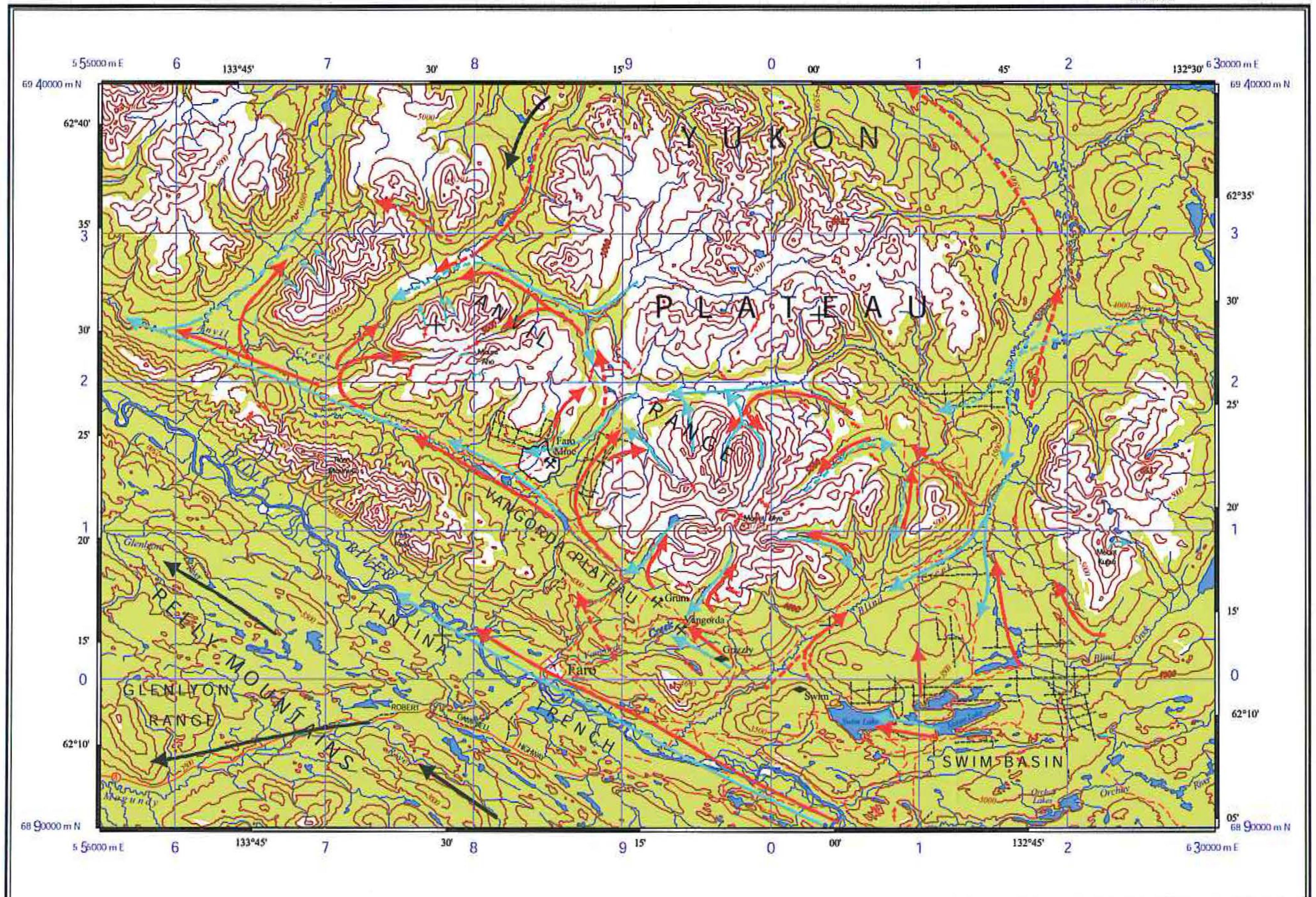
by

J.D. Bond
Yukon Geology Program
Geoscience Office

Canada

Yukon Geology Program

Yukon Government



LEGEND

McConnell glacial maximum ice flow (defined, inferred)

Late McConnell Pelly readvance phase (defined, inferred)

McConnell ice flow (Jackson, 1994)

Meltwater channel (glacial maximum, Pelly readvance)

Mine pit

Massive sulphide deposit, undeveloped

REFERENCES

JACKSON, L.E., Jr., 1994. Terrain inventory and Quaternary history of the Pelly River area, Yukon Territory; Geological Survey of Canada, Memoir 437, 41 p.

RECOMMENDED CITATION

BOND, J.D., 1999. McConnell ice-flow map of the Anvil District (105K), central Yukon (1:250,000 scale). Exploration and Geological Services Division, Yukon Region, Indian and Northern Affairs Canada, Open File 1999-14.

Digital cartography and drafting by P.S. Lipovsky, Yukon Geology Program.

Any revisions or additional geological information known to the user would be welcomed by the Yukon Geology Program.

Copies of this map may be purchased from Geoscience Information and Sales, c/o the Whitehorse Mining Recorder, Indian and Northern Affairs Canada, Room 102-300 Main St., Whitehorse, Yukon, Y1A 2B5, Ph 867-667-3266 Fax 867-667-3267.

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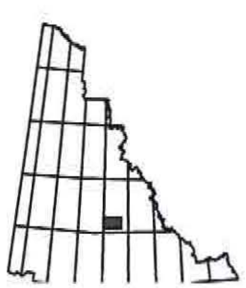
This map was released Nov. 1999.

McCONNELL ICE-FLOW MAP OF THE ANVIL DISTRICT

(105K), CENTRAL YUKON

SCALE 1:250 000



CONTOUR INTERVAL 500 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1983
Transverse Mercator Projection

10 0 10 20 30 Kilometres

Topographic base produced by SURVEYS AND MAPPING BRANCH, DEPARTMENT OF ENERGY, MINES AND RESOURCES.

ONE THOUSAND METRE
Universal Transverse Mercator Grid
ZONE 8

Indian and Northern Affairs Canada
Exploration and Geological Services Division
Yukon Region

Open File 1999-14

McCONNELL ICE-FLOW MAP OF THE ANVIL DISTRICT (105K), CENTRAL YUKON

by
J.D. Bond
Yukon Geology Program
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