FARO MINE SITE RE-VEGETATION STUDY: WASTE ROCK DUMPS AND TAILINGS IMPOUNDMENT

PREPARED FOR:

DELOITTE AND TOUCHE INC.

SUITE 1900, 79 WELLINGTON STREET WEST, TD CENTRE

TORONTO, ON, M5K 1B9

PREPARED BY:

C. JACOBSEN, M. SETTERINGTON AND P. TOBLER

EDI ENVIRONMENTAL DYNAMICS INC.

402 HAWKINS ST

WHITEHORSE, YT, Y1A 1X8

D. POLSTER

POLSTER ENVIRONMENTAL SERVICES LTD.

5953 DEUCHARS DRIVE

DUNCAN, BC, V9L 1L5

J. STRAKER

C.E. JONES AND ASSOCIATES

UNIT 11, 2042 MILLS ROAD WEST

SIDNEY, BC, V8L 5X4

EDI PROJECT NO.: 07-YC-0026

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1 INTRODUCTION

The Anvil Range Mine was a base metal (zinc-lead-silver) open pit and underground mine located in central Yukon Territory. The mine operated under various owners from 1968 to 1998, eventually expanding to a footprint of approximately 25 km^2 including three open pits, water treatment facilities, numerous waste rock dumps, a tailings impoundment, ore processing facilities and related buildings. Since 1998 the mine has been in a "care and maintenance state" under the management of Deloitte & Touche Inc. In January 2003, the federal and territorial governments formally recognized that Anvil Range Mine was no longer economically viable and would not be operated again. In collaboration with local First Nations, the governments committed to jointly develop a Final Closure and Reclamation Plan for the mine property.

As one component of a series of reclamation studies, Deloitte & Touche Inc. retained the services of EDI Environmental Dynamics Inc. (EDI) to complete a Waste Rock Dumps and Tailings Impoundment Re-vegetation Study for the Faro Mine site, in association with Polster Environmental Services and C.E. Jones and Associates Ltd. The Re-vegetation Study is one of many technical studies completed as part of the Faro Mine Closure and Remediation planning process. At present, a number of proposed closure and reclamation options are under review by the Faro Mine Closure Project Oversight Committee, which includes representatives of the Ross River Dena Council and Selkirk First Nation, the Yukon public, and the Government of Canada. Regardless of the final scenario selected, long term re-vegetation of the tailings area (with or without tailings) and waste rock will be an essential component of the mine reclamation process. This Re-vegetation Study recommends re-vegetation prescriptions that will be applicable to each of the closure options under consideration for the Faro Mine site. As one component of these prescriptions, the Study identifies suitable sources of borrow materials that can be used as surface growth media and estimates the volumes of these materials on-site. As a second component of the re-vegetation prescriptions, the Study outlines important surface preparation considerations that need to be incorporated into reclamation plans to ensure successful, long term re-vegetation of the Faro Mine site. Native species suitable for reclamation, and re-vegetation methods amenable to successional reclamation, are also recommended.

1.1 PROJECT OBJECTIVES

The ultimate objective of the Re-vegetation Study was to develop prescriptions for the long term re-vegetation and reclamation of the Faro Mine site. Vegetation and soil conditions were the primary components considered in the development of these prescriptions. The Project Team also considered the implications of the re-vegetation prescriptions on wildlife and wildlife movement patterns through the mine site to adjacent key wildlife habitat areas. To facilitate the development of reclamation prescriptions, an intermediary objective of the project was to initiate an operational trial to test site preparation and re-vegetation prescriptions. The Project Team also attempted to identify opportunities to incorporate local employment and training into the re-vegetation implementation plan.

1.2 OVERALL APPROACH

The Re-vegetation Study followed a successional approach to reclamation, which involves utilizing processes of natural vegetation succession to facilitate the reclamation of disturbed sites, with the long term goal of restoring ecosystem function. Site investigations were conducted to identify the factors that inhibit vegetation growth, as well as the natural conditions under which vegetation is establishing on the disturbed site. After gaining an understanding of the response of vegetation to the environmental gradients occurring on the site, reclamation prescriptions were designed to foster the conditions under which natural processes of vegetation succession will occur (Luttmerding et al., 1990; Polster, 1991).

1.3 BACKGROUND

A literature review was completed to provide a baseline for the re-vegetation study. Background information was obtained on vegetation, soils and wildlife in the Faro Mine site and surrounding area, as well as additional information on mining reclamation and re-vegetation in the Yukon and northern Canada. An annotated bibliography was prepared, summarizing the relevant documents obtained through the literature review (EDI, 2007).

The literature review revealed a paucity of vegetation information specific to the Faro Mine site. With the exception of a limited inventory of vegetation in the area of the Grum deposits (Montreal Engineering Company Ltd., 1976), no other baseline vegetation studies of the Faro Mine site were obtained. A 1998 vegetation classification for nearby Sheep Mountain, as well as a broader scale classification of vegetation communities in the Carmacks-Ross River area, provided some vegetation information for the region (Oswald, 1983; Staniforth, 1998).

A series of reports completed by SRK Consulting Ltd. (2006a-d, 2004, 2003) on soil characteristics and cover materials at the mine site proved useful in understanding the materials available for re-vegetation, and in designing the soil sampling component of this Re-vegetation Study.

Baseline information on wildlife use of the mine site and the surrounding area was limited. There have been no Faro Mine site-specific wildlife surveys or inventory projects other than work on Dall's (fannin) sheep (e.g., McLeod 1981), and much of the literature is from regional government surveys or research projects unassociated with the mine. Most of the literature focused on the life history and migration routes of the fannin sheep population in the area (e.g. McLeod, 1981; Loehr, 2002). There were attempts to redirect sheep migration around mine operations on the Vangorda plateau area, but the sheep continued to migrate through the mine site following traditional trails (Gartner Lee Ltd. 2002). General information on other wildlife use of the area, such as that by moose, grizzly and black bears and furbearers was summarized by Montreal Engineering Company Ltd. (1976) and updated by Gartner Lee Ltd. (2002).

There was one previous re-vegetation project at the mine site on the dewatered freshwater reservoir (Laberge 2006). That project consisted primarily of a grass-seeding program as an immediate measure to reduce erosion potential and reflected a different approach than the successional reclamation methods applied in this study. Review of additional literature on mine reclamation in the Yukon and northern Canada yielded several relevant resources on successional approaches to re-vegetation (e.g. Withers, 1999; Wilson et al., 1996).

In summary, the literature reviewed revealed gaps in baseline information on vegetation communities and wildlife at the Faro Mine site and surrounding area. In this situation, the advantage of a successionally-based reclamation program is that it enables better understanding of the relationships between natural vegetation communities in the vicinity of the mine site, and vegetation communities in various stages of recovery from mining disturbance. This information allows us to predict future trends in vegetation development in sites disturbed by mining, and to design re-vegetation prescriptions to further facilitate this natural recovery process. The implications of vegetation succession on wildlife habitat and movement patterns can also be considered.

1.4 CONTENTS OF REPORT

The central components of the Study — vegetation and soils — are the primary focus of this report. Wildlife habitat and movement considerations, and the re-vegetation trials initiated in 2007, are also discussed. The report is organized as follows: Section 2.0 summarizes the methods used to sample vegetation communities and surface materials, to document wildlife habitat and movement considerations and to initiate re-vegetation trials. Section 3.0 presents the results of each component of this Study. Section 4.0 discusses the implications of the results on future re-vegetation of the mine site, and on the selection and surface preparation of capping materials. Section 5.0 provides recommended re-vegetation prescriptions for the Faro Mine site.

2 METHODS

2.1 STUDY DESIGN

The re-vegetation study consisted of two central components: 1) Developing a vegetation classification and subsequent restoration prescriptions; and 2) Determining the suitability of potential borrow materials for use as growth media. The methods employed in these vegetation and soils components are described in depth in sections 2.3 and 2.4, respectively. A secondary component of the study included consideration for re-vegetation as it may affect wildlife use of the mine site or movement through the site to adjacent key wildlife areas (described in further detail in Section 2.5). Field work for the vegetation, soils and wildlife components was completed concurrently between July 20 and 24, 2007. A third component of the study included a small re-vegetation trial, which was initiated in September, 2007 (described further in Section 2.6).

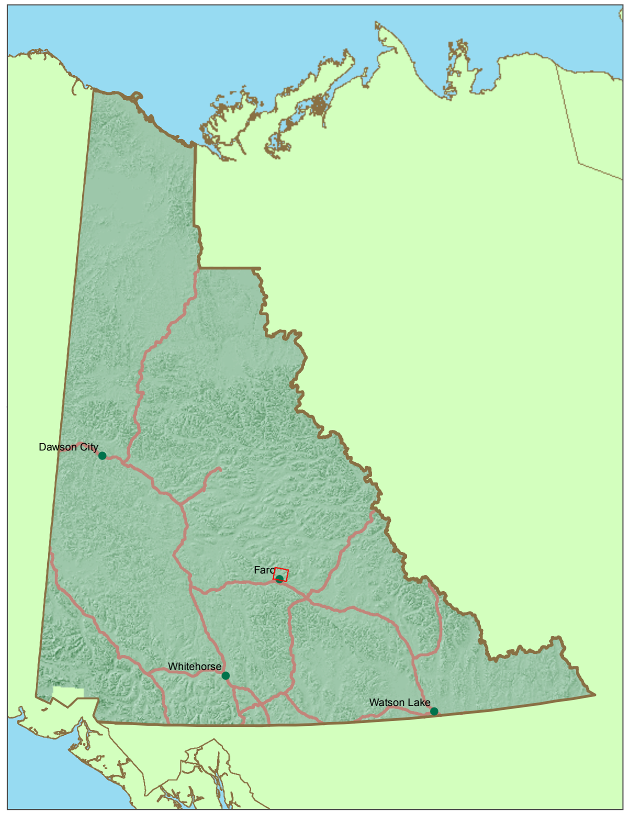
2.2 STUDY AREA

The study area encompassed the Faro Mine site which is located within the Yukon Plateau-North ecoregion (Smith et al., 2004). The 450 km long Tintina Trench forms a defining landscape feature, traversing the ecoregion from the northwest to the southeast. The trench is an important migration corridor for large numbers of Sandhill Crane and waterfowl breeding in Alaska (Yukon Ecoregions Working Group 2004). The Pelly, Ross, Macmillan, Stewart, Hess, McQuesten and Klondike River valleys all traverse the ecoregion. The region consists of relatively rolling highlands with an east-west orientation. Permafrost is discontinuous but widespread in this region, although less extensive near Faro (Yukon Ecoregions Working Group 2004). The climate of the Faro Mine site is cool with moderate precipitation. The mean annual temperature of the Faro site is -3.4^{o}C (1967–1980 data). July is the warmest month with a mean daily temperature of 11.5^{o}C, while January is the coldest month with a mean daily temperature of -29.4^{o}C. The mean annual precipitation at the Faro airport is 304.7 mm (1971–2001 data; Gartner Lee, 2002). Vegetation and humus layer thickness are controlled by forest fire history (Yukon Ecoregions Working Group 2004). Vegetation ranges from boreal forest to alpine. Boreal forest vegetation, consisting of open black spruce (*Picea mariana*) with a moist moss or drier lichen understory is the dominant forest type. White spruce (*Picea glauca*), occasionally with trembling aspen (*Populus tremuloides*) or lodgepole pine (*Pinus contorta*), occurs on warmer, better drained soils; mixed canopy forests are common due to frequent fires, and trembling aspen and balsam poplar are commonly found on disturbed sites. Higher alpine vegetation is characterized by shrub and lichen tundra (Yukon Ecoregions Working Group 2004). The ecoregion supports populations of most of the Yukon's typical boreal forest mammals including moose, woodland caribou, stone sheep, grizzly bear, black bear, wolverine, and marten. Many forest birds reach their northern limit of breeding in the ecoregion (Yukon Ecoregions Working Group 2004).

The Faro Mine area encompasses 25 km^2 of land in the Rose Creek Valley and the Vangorda Plateau, 15 km north of Faro, Yukon, on the southern slopes of the Anvil Range. The mine site includes three main areas: the Faro Mine and the Rose Creek Tailings area (both in the western portion of the site) and the

Vangorda/Grum area (in the eastern portion of the site). A 13 km haul road connects the eastern and western portions of the mine (Figure 1).

The Faro pit is a 1.06 km^2 pit surrounded by over 250 million tonnes of waste rock, with Faro Creek diverted around the northeastern edge of the pit and flowing through a rock drain under the haul road to the Vangorda/Grum area. The Rose Creek Tailings area encompasses 55 million tonnes of material held by three dams, with Rose Creek flowing through a diversion channel to the south of the tailings. The Vangorda Plateau includes the Vangorda and Grum pits, surrounded by 16 million tonnes and 100 million tonnes of waste rock, respectively. The Faro and Vangorda Plateau areas are situated at an elevation of approximately 1200 m ASL, while the tailings are situated at approximately 1000 m ASL (Faro Mine Closure Office, 2007).



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Checked By:	M. Setterington
Date:	28 January 2008
EDI Project Number:	07-YC-0026
Map Projection:	NAD 1983 UTM Zone 8

0 0.5 1 2 3 4 5

Kilometres

Digital Data Sources:

- Orthophoto: August 2003, Orthoshop, Calgary AB
- Base Map Files: NTDB Canada 1: 50,000, www.geogratis.ca
- Landsat: CTIS CanImage, www.geogratis.ca

Inset Mapping Source:
- Base Files: NTDB Canada 1: 2,000,000 www.geogratis.ca

Figure 1. Overview Map

Faro Mine Closure Project: Waste Rock Dumps and Tailings Re-vegetation Study

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2.3 VEGETATION ASSESSMENT

A vegetation classification was developed for the Faro Mine site based on 70 plots that were established on and adjacent to the mine site. Vegetation plots were established at sites that represented the range of conditions in evidence at the mine (Figure 2 to Figure 4). A variety of disturbed and undisturbed sites were sampled to provide an indication of the changes in vegetation at different sites over time. Plots were established following the methodology outlined in Luttmerding et al. (1990). Plot sizes varied according to the vegetation being sampled, but in all cases plot sizes represented at least twice the minimal area for the vegetation being sampled (Mueller-Dombois and Ellenberg, 1974). Sample sites were selected to represent homogeneous stands of vegetation of the specific type being sampled.

Figure 2. C. Jacobsen and D. Polster documenting species occurrence and cover in a vegetation plot.

At each sample site (relevé), a complete list of the plant species occurrences was compiled. For each species that occurred at greater than 5% cover, an estimate was made of its percent cover to the nearest percent. For those species present, yet comprising less than 5% cover, abundance was coded as R for rare (one to only several occurrences), '+' for species with several occurrences but less than 1% cumulative cover, and '1' for species with one to many individuals and less than 1% cumulative cover (Table 1).

Table 1. Cover and abundance scale used to classify plant cover where cover was less than five percent for the Faro Mine re-vegetation study.

Cover / Abundance Scale	Interpretation
R = 0.1	Rare — one to several individuals found with a cover significantly less than one percent
+ = 0.5	Several individuals with a cover less than one percent
1	One to many individuals with a total cover of less than one percent

Standard phytosociological methods were applied to the analysis of the floristic data (Mueller-Dombois and Ellenberg, 1974). This analysis seeks to find species-relevé groups by a simultaneous sorting of a table consisting of species down one side and plots across the top (relevés) ('Q and R' analysis). This sorting groups the species that occur together and the plots with similar species compositions. The species – relevé groups that are generated were then used to define vegetation types. The vegetation types that are defined using this method provide clues to the underlying ecological conditions of the vegetation being sampled, and in this case, the recovery following mining and the relationship between the recovering vegetation and natural communities in the surrounding area. This is the basic method that has been applied to the definition of Biogeoclimatic Ecosystem Classification (BEC) units throughout British Columbia and provides an excellent means of identifying the relationships between the impacted sites and the adjacent un-impacted vegetation.[1]

[1] See http://www.for.gov.bc.ca/hre/becweb/

Sample Sites - Revegetation Study

- ....Soil Plot
- ....Vegetation Plot
- ....Potential Borrow
- ....Organics

Data Input/Drawn by: M. Setterington, M. Power
Checked By: M. Setterington
Date: 28 January 2008
EDI Project Number: 07-YC-0026

Map Projection: NAD 1983 UTM Zone 8

250 125 0 250 500 750 1,000
Metres

Digital Data Sources:

- Orthophoto: August 2003, Orthoshop, Calgary AB
- Base Map Files: NTDB Canada 1: 50,000, www.geogratis.ca
- Landsat: CTIS CanImage, www.geogratis.ca
- Borrow Locations adapted from SRK Consulting (2002)
- Organic Soil Locations adapted from Bond (2001)

Inset Mapping Source:
- Base Files: NTDB Canada 1: 2,000,000 www.geogratis.ca

Figure 3.

Vegetation and Soil Sample Plots in the Western Portion of the Faro Mine Re-vegetation Study Area.

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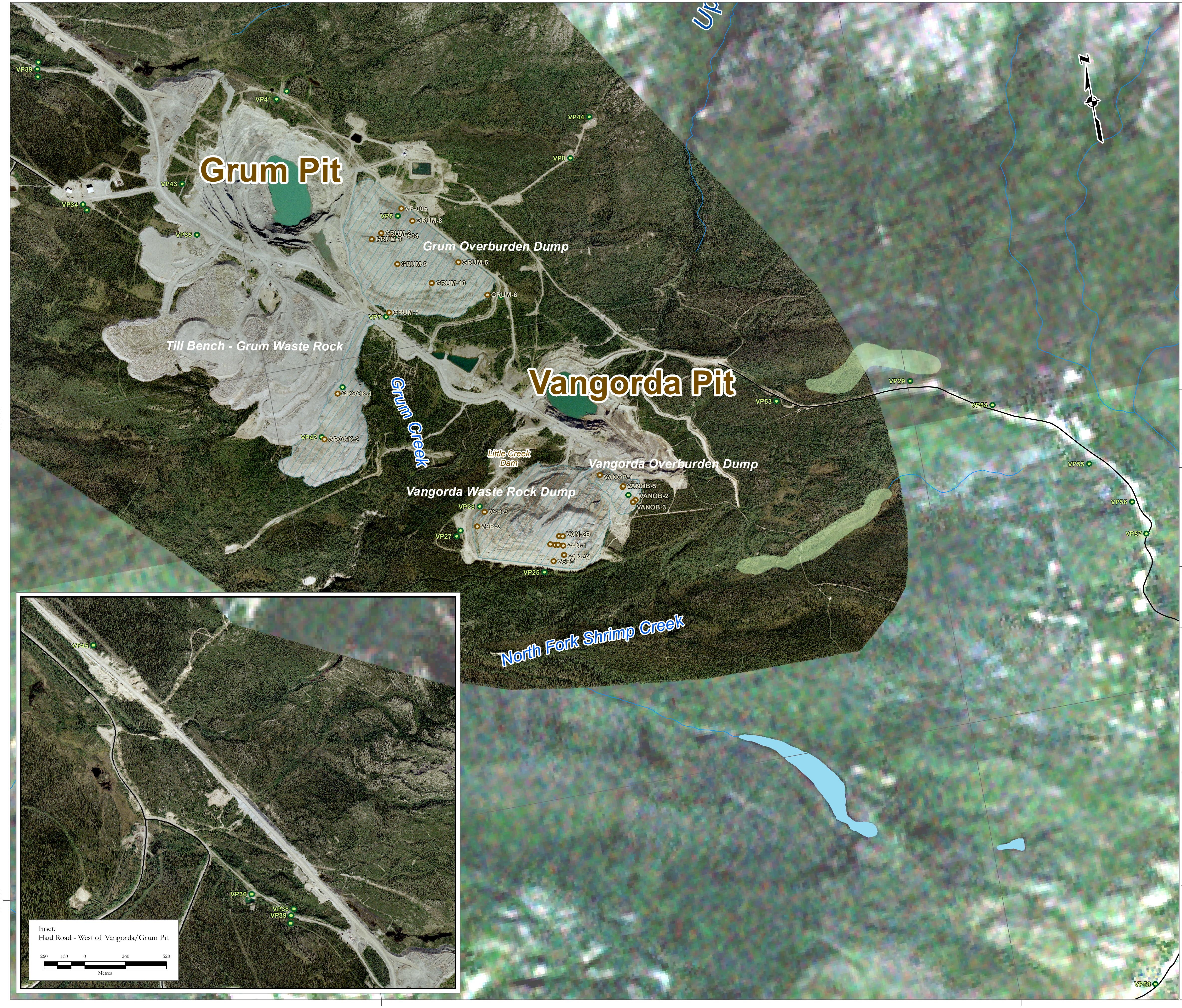

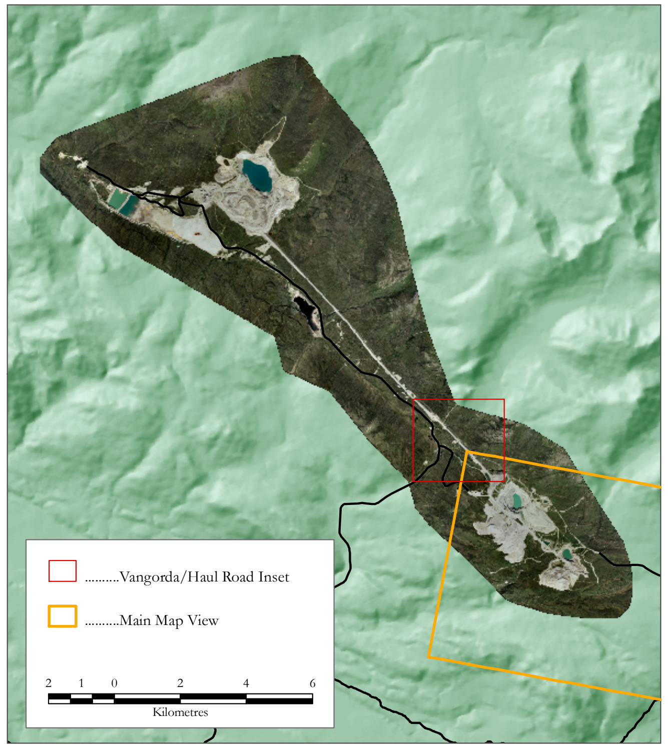

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Figure 4.

Vegetation and Soil Sample Plots in the Eastern Portion of the Faro Mine Re-vegetation Study Area.

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2.4 SOILS ASSESSMENT

2.4.1 FIELD METHODS

The primary objective of the soils component of the Re-vegetation Study was to characterize identified, potential borrow materials for their suitability for use as surface growth media in the Faro re-vegetation program. Prior to the field investigations, a review was conducted of the extensive, existing work on surficial materials and capping sources on the Anvil Range Mine complex. Reviewed work included a number of reports by SRK Consulting (2006a-d, 2004, 2003), as well as a report on quaternary geology in the vicinity of the Faro Mine (Bond 2001).

A field soils sampling plan was developed based on review of the above information. Sampling locations were based on SRK's categorization of potential borrow sources. A primary objective in selection of sampling sites was to co-locate with SRK's previous Phase 2 survey excavations (SRK 2003), so that information from surface samples collected in this study could be correlated to the engineering characterization and testing results contained in SRK's reports. Based on data provided by SRK (2003), sampling was restricted to those deposits having physical properties suitable as a vegetation growth substrate (*i.e.* sufficient soil fine-fraction [< 2 mm] content). Additional sampling sites were added opportunistically during the field sampling event.

Table 2 presents sample numbers collected by borrow source location during the 2007 sampling program. Locations of all observation/sample sites are shown in Figure 3 and Figure 4 and provided in Appendix C.

Table 2. Summary of soil sampling areas and sampling effort for the Faro Mine re-vegetation study.

Source Area	No. Observation Locations	No. Samples
Rose Creek West Pit Area	3	2
Rose Creek Haul Road	3	4
Tailings Borrow areas	7	8
Faro Rock Dumps, till deposits	2	2
Faro Dump Toe	1	1
Haul Road Borrow	3	3
Grum Overburden Dump	10	10
Grum Rock Dumps, till capping	2	2
Vangorda Overburden Dump	5	5
Vangorda Rock Dump/Starter Berm	10	10
Vangorda Plateau organics	1	0

Locations of selected SRK Phase 2 sampling points were determined by entering location data and navigating by GPS unit. All sample point locations were recorded on a hand-held GPS unit. Sample excavations were conducted manually, with a long-handled steel shovel. Once excavations were completed, additional material from the pit wall was exposed using a stainless-steel shovel, and placed in plastic bags for transport to the lab. At all sample points, samples of mineral surficial materials were collected from as deep an excavation as possible (with shovel), to represent parent material characteristics that will dominate eventual excavated capping materials, as opposed to *in-situ* surface soil layers exposed to weathering reactions and possibly to airborne elemental deposition. This objective was accomplished at Phase 2 survey sites by excavating within the previous excavation. In these cases, sampled material would have originally been excavated from depths of approximately 0–6 m. In excavations produced solely by hand, the maximum sample depth was approximately 1 m. In some cases, surface materials were intentionally collected, either to provide representation of surface organics or of surface rooting conditions. Approximately 0.5–1.0 kg of material was included in each sample. Samples were stored cold until they were shipped to the laboratory for preparation.

2.4.2 LAB METHODS

Soil metal analyses were completed by CANTEST Ltd. in Burnaby, B.C for elements listed in Table 3 below. Strong acid leachable metals analysis was used for all elements in soils; analysis was performed using British Columbia Ministry of Environment, Lands and Parks Method, Strong Acid Leachable Metals in Soil, Version 1.0 (Province of British Columbia 2001). This method involves drying the sample at 60°C, sieving using a 2 mm (10 mesh) sieve and digestion using a mixture of hydrochloric and nitric acids. Analysis was then performed using Inductively Coupled Argon Plasma Spectroscopy (ICAP) for all elements except silver, arsenic, cadmium, molybdenum, selenium, and thallium, which were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP/MS); and mercury, which was analyzed using Cold Vapour Atomic Fluorescence.

Soil particle size analysis and pH and electrical conductivity measurement was completed by Pacific Soil Analysis Inc. (PSAI) in Richmond, B.C. Soil pH was analyzed based on procedures described in the Manual on Soil Sampling and Methods of Analysis (Carter 1993). The test was performed using a deionized water leach with measurement by pH meter. Electrical conductivity was measured on a saturated paste extract according to the methods in Manual of Soil Sampling and Methods of Analysis (McKeague 1978). Particle size distribution was determined in accordance with the methods in McKeague (1978) and Soil Sampling and Methods of Analysis (Carter 1993) by standard dry sieve to determine gravel content, wet sieve to determine sand content, pipetting to determine silt and clay content, and reported on a percent by weight basis. Sedimentation times were determined using the Tanner and Jackson Nomograph I (Tanner and Jackson 1947). Particle size limits used to define size fractions were given according to the Canadian Soil Survey Committee classification scheme.

Table 3. Analytical parameters for soil and detection limits at CANTEST Laboratories in µg/g (ppm).

Element	Abbreviation	Reported Detection Limit (µg/g)
Aluminum	Al	10
Antimony	Sb	0.1
Arsenic	As	0.1
Barium	Ba	1
Beryllium	Be	1
Boron	B	1
Cadmium	Cd	0.2
Calcium	Ca	1
Chromium	Cr	2
Cobalt	Co	1
Copper	Cu	1
Iron	Fe	2
Lead	Pb	0.2
Magnesium	Mg	1
Manganese	Mn	1
Mercury	Hg	0.01
Molybdenum	Mo	0.1
Nickel	Ni	2
Phosphorus	PO_4	20
Potassium	K	10
Selenium	Se	0.2
Silver	Ag	0.1
Sodium	Na	5
Strontium	Sr	1
Tin	Sn	5
Thallium	Tl	0.1
Titanium	Ti	1
Vanadium	V	1
Zinc	Zn	1
Zirconium	Zr	1

2.5 WILDLIFE ASSESSMENT

The intent of the wildlife assessment was to identify site-specific wildlife habitat issues should they exist and the ways in which these potential site-specific issues may be accommodated in re-vegetation and reclamation planning. Consideration was given to the potential importance of the mine site in relation to key habitat features in the surrounding landscape, and the ways in which reclamation activities may enhance the overall habitat value of the reclaimed mine site. To gain this perspective, a ground-based reconnaissance of the mine site and adjacent area was conducted to verify previously documented wildlife information for the

Faro and Vangorda/Grum area mine facilities and to identify undocumented wildlife habitats and movement patterns. Gordon Etzel, a local resident and member of the Ross River Dena First Nation, who is knowledgeable of wildlife habitat and movement patterns, aided in the general identification of wildlife values. Focal species included Dall's (fannin) sheep, moose, caribou, and grizzly and black bear. All wildlife observations were documented and any significant patterns noted by the wildlife biologist or Mr. Etzel were recorded and, where relevant, are noted in the re-vegetation plan recommendations.

2.6 RE-VEGETATION TRIAL

A re-vegetation trial was initiated in September 2007 on a newly constructed 25 by 25 m lysimeter plot constructed by SRK in late summer 2007 on the Vangorda Waste Rock Dumps. The key elements of the trial included mechanical preparation of the till surface to achieve a rolling topography to provide suitable microsites for seed germination and growth, followed by seeding and staking of species native to the mine site and characteristic of Vegetation Types 5 and 6 (pioneering species on disturbed sites). The machine operator constructing the trial cover plot loosely placed the non-compacted till layer to achieve minimum depths of 0.5–1.0 m, to provide adequate rooting depths.

The re-vegetation included collection and broadcast seeding of alder seed, and collection and staking of willow and poplar cuttings. Alder seed was collected from an abundant roadside alder stand in the Grum area by two field crew members over a period 4 hours on September 12th, 2007 (Figure 5). The willow and poplar stakes were cut by the same two-person crew in the northeast corner of the mine site on September 11th. Stakes were approximately 1 m long and not less than 2 cm diameter. After cutting, the stakes were bundled and soaked in a pond on site before transplanting on September 24, 2007.

Figure 5. Gordon Etzel collecting alder cones near the Vangorda/Grum area of the Faro Mine site, September 2007.

The alder seed was processed by drying the cones indoors in paper bags until the cones opened and seed was released. The cones were then agitated vigorously inside the bag to expedite seed release. The seed was sifted to separate it from the cones and debris, weighed, and refrigerated. On September 24, two field crew members broadcast the alder seed on the 25 by 25 m trial cover plot, using a handheld rotary seeder and by hand broadcasting; a total of 14 g of seed was applied. This amount was double the desired seeding rate of 0.1 kg/hectare. However, it was not possible to successfully distribute only 7 g of seed throughout the plot due to the difficulty of handling such a small volume of seed.

In the same 25 by 25 m plot, a total of 100 poplar and willow cuttings were staked (roughly 50 cuttings of each species). The staking effort took the two-person crew three hours to complete. The stakes were planted so as to bury at least 0.5 m of each cutting, and trimmed to leave approximately 0.15–0.2 m aboveground (Figure 6).

Figure 6. Lysimeter plot, constructed by SRK in August 2007 on the Vangorda waste rock dumps, seeded with alder and planted with balsam poplar and willow stakes in September 2007.

3 RESULTS

3.1 VEGETATION

Five species-relevé groups (groups of plots with similar species composition) were defined during the analysis of the floristic data. These groups were combined to classify eight vegetation community types, defined by the presence or absence of the species–relevé groups (Table 4, Appendix A). The *Pleurozium* species-relevé group is composed of two lichens, a moss and subalpine fir. This group is representative of older mature forests. When combined with the *Ledum* species-relevé, the *Pleurozium-Ledum* group defines an older undisturbed forest vegetation type (Vegetation Type 1, Figure 7). The *Mertensia* species-relevé group is composed of forest-related species that are indicative of rich forests in a transitional state. The *Ledum* species-relevé group is composed of typical moist forest species such as Labrador tea, black crowberry, bog bilberry, mountain cranberry and dwarf birch, which provides the link between the undisturbed forests and the lightly disturbed sites around the mine area (Vegetation Type 4, Figure 8). The *Populus* species-relevé group represents the characteristic species of disturbed mineral soils, although where it overlaps with the *Ledum* species-relevé group, the *Ledum-Populus* group indicates a transition between disturbed mineral soil and disturbed organic soils with some mineral component (Vegetation Type 5, Figure 9). The *Shepherdia* species-relevé group is representative of dry forest stands, often where past forest fires have removed the mature spruce (Vegetation Type 7, Figure 10). A collection of un- grouped relevés was formed of plots from both disturbed sites and undisturbed sites (Vegetation Type 8, Figure 10).

A summary of the defining features of each vegetation type is provided in Table 5. The arrangement of the vegetation types across Table 5 indicates the dominant underlying characteristics of the vegetation communities, in this case, disturbance and moisture conditions. Vegetation types 1 through 4 (Figure 7 and Figure 8) represent a range of undisturbed or minimally disturbed forest communities that are late in the natural successional series operating in the mine area. Vegetation types 5 and 6 (Figure 9) represent the range of disturbed site vegetation that occurs in the mine area. The species that comprise these communities are adapted to colonizing disturbed sites and will provide the backbone of the species that should be used for reclamation at the mine. Vegetation type 7 (Figure 10) is representative of dry forests with open bald grassy areas. This vegetation type will develop from the early successional plantings associated with Vegetation type 6 as the sites mature.

Table 4. Vegetation type defining species-relevé groups found during the Faro re-vegetation study.

Vegetation Type	Defining Species-Relevé Groups
1	*Pleurozium - Ledum*
2	*Pleurozium - Mertensia - Ledum*
3	*Mertensia - Ledum*
4	*Ledum*
5	*Ledum - Populus*
6	*Populus*
7	*Shepherdia*
8	Ungrouped relevés

Figure 7. Vegetation types 1 (left) and 2 (right)

Figure 8. Vegetation types 3 (left) and 4 (right).

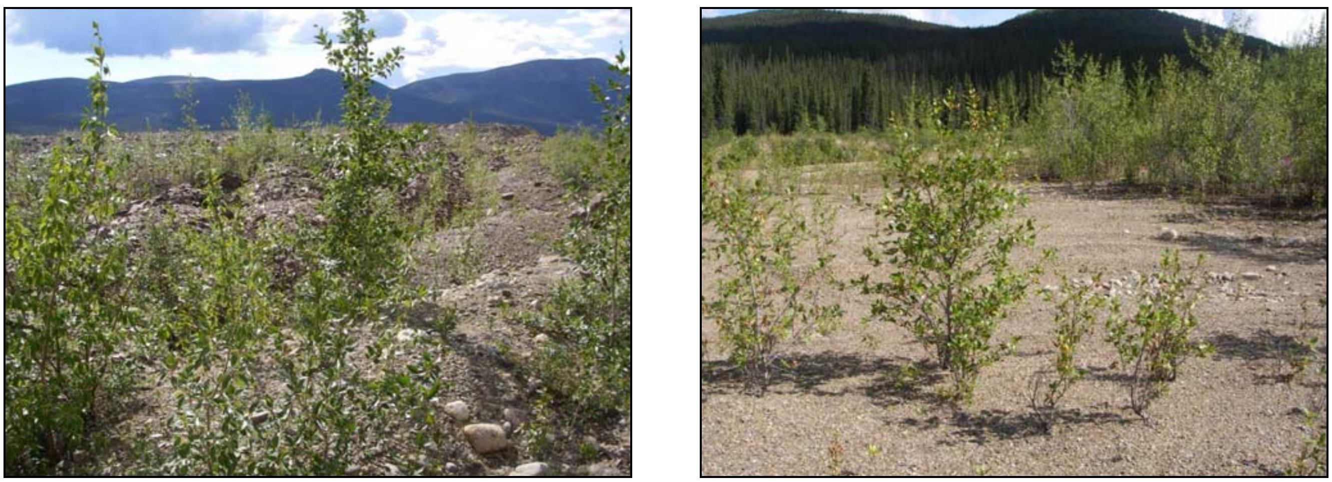


Figure 9. Vegetation types 5 (left) and 6 (right).

Figure 10. Vegetation types 7 (left) and 8 (right).

Table 5. Species-relevé groups, disturbance, and moisture characteristics of vegetation community types classified at the Faro Mine site

Vegetation Community Types	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Characteristics	**Cool, moist, undisturbed forest types**			**Slightly disturbed, moist forest**	**Disturbed sites**		**Warm, dry forest**	**Ungrouped sites**
Species-Relevé Group								
Pleurozium	■	■						
Mertensia		■	■					
Ledum	■	■	■	■	■			
Populus					■	■		
Shepherdia							■	
Average Number of Species	16.1	16.7	21.3	14.6	22.2	16.8	15.1	15.0
Dominant Substrate	Organic	Organic	Organic	Mixed	Mineral	Mineral	Mineral	Mixed
Disturbance	No	No	No	Yes	Yes	Yes	No	Mixed

3.2 SOILS

The full suite of analytical results is presented in Appendix C. Findings based on these results on the suitability of materials for use as reclamation growth media are summarized by borrow source area in Table 6, and discussed by borrow area, below. Findings on suitability were primarily based on soil chemical properties, as physically unsuitable materials were largely screened out of the sampling process, either through reference to SRK's Phase 2 survey or during field observations.

Chemical determination of material suitability for re-vegetation was primarily based on metals contents, although occasionally other chemical parameters (pH, electrical conductivity) were correlated with elevated metals concentrations. In making determinations of material suitability relative to metals concentrations, three references were used:

1. Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines (1999);
2. Yukon Contaminated Sites Regulation (CSR) soil standards (2002); and
3. Maximum local mineral soil concentrations not affected by airborne metals deposition, as reported in GLL's Terrestrial Effects Study (Gartner Lee, 2006).

Interpretation of the values in the above sources included the following assumptions:

- In CCME and Yukon CSR guidelines, the most stringent applicable guidelines were used. Often these values are under the "Agricultural" land use category. Although this is not anticipated as a post-closure land use for the Anvil Range mine site, these standards were utilized for interpretation as they: 1) provide conservative values for selection of suitable materials; and 2) reflect the pre-disturbance subsistence use of the land by local communities. For Yukon CSR "matrix" soil standards, selection of appropriate standards was based on the most conservative terrestrial use – "human intake of soil", "toxicity to soil invertebrates and plants", and "livestock ingesting soil and fodder" were variously used for different elements. Standards based on surface water or groundwater were not used.

- When observed local mineral soil concentrations (see no. 3, above) were in excess of either CCME or Yukon CSR standards, it was assumed that the maximum concentration observed in these samples represented an acceptable concentration resulting from natural mineralization of surficial materials and not from industrial activity. Similar concentrations would thus be tolerable/appropriate in the post-closure landscape. For example, the selected CCME soil quality guideline for arsenic is 12 µg/g, while the Yukon CSR standard is 25 µg/g. The maximum observed arsenic concentration in non-impacted mineral soils in the Anvil Range Terrestrial Effects study was 24 µg/g. Therefore, concentrations measured in samples from this study were interpreted primarily in reference to the local maximum of 24 µg/g, rather than the published guidelines/standards, as there is evidence of local natural arsenic enrichment.

Table 6. Re-vegetation suitability of borrow materials for surface capping at the Faro Mine site.

Source Area	Suitability	Issues/Comments	Estimated Volume (Mm^3)[2]
Rose Creek West Pit Area	Suitable	Some excessively coarse materials	0.18
Rose Creek Haul Road	Suitable	-	0.8
Tailings Borrow areas	Suitable, to be confirmed during excavation	Elevated Pb concentrations	1.7
Faro Dump Toe	Unsuitable	Elevated Zn concentrations	-
Haul Road Borrow	Suitable	Elevated Ni concentrations	0.72
Grum Overburden Dump	Suitable	Elevated Zn in surface samples	8.0
Vangorda Overburden Dump	Unsuitable	Extremely elevated metals concentrations; subsurface excavations required to confirm suitability	-
Vangorda Plateau organics	Suitable	Not recommended for salvage	
		Total Suitable Volume	**11.4**

[2] From SRK (2003).

Rose Creek West Pit

This material is of glaciofluvial origin located within the Rose Creek floodplain (represented by sample points B02-3, -5 and -6). Although this material is predominantly too coarse for use as upland capping material, SRK noted the presence of finer sediments and organics within the West Pit area, so it was included in sampling. Of the three observation locations, one was too coarse for sampling, consisting entirely of coarse sands and gravels. The other two locations had predominantly fine-textured materials, either dominantly sand or silt. There are no chemical limitations associated with this material. SRK (2003) estimated that there are approximately 0.18 million m^3 of suitable (fine-textured or organic) materials within this deposit. Although the volume of potentially suitable material from this source is small, it is a relatively desirable source to exploit (logistics aside), as it is already disturbed and will require re-vegetation.

Rose Creek Haul Road

This potential borrow area consists of sideslope forested upland glacial till deposits (represented by sample points B02-18, -22 and -25). Textures are loamy sands to loams with approximately 30-60 percent coarse fragments (> 2 mm). Samples excavated from point B02-22 have elevated arsenic concentrations (approximately 20-30 μg/g, in comparison to a local reference maximum of 24 μg/g, and CCME and Yukon CSR values of 12 and 25 μg/g, respectively). However, as discussed above, these concentrations are interpreted as being representative of natural mineralization in arsenic, and not of anthropogenic contamination. There are no other chemical limitations associated with this material. SRK (2003) has estimated that there are approximately 0.8 million m^3 of material within this deposit. From a re-vegetation perspective, development of this location as a borrow source is less desirable than some of the other sources, as such development would entail further disturbance and corresponding additional reclamation.

Tailings Borrow

These materials are forested sideslope tills similar to those in the Rose Creek Haul Road area, but have been subject to more influence from mining operations, both through partial clearing and access construction, and through airborne deposition of metals (represented by sample points B02-29, 30, 32, 33, 34, 35 and 36). Textures are sandy loams to silt loams with coarse fragment contents of approximately 5-55 percent. Four of the eight samples collected from these sites showed elevated lead concentrations (73.9–142 μg/g, versus a CCME guideline of 70 μg/g and a Yukon CSR standard of 350 μg/g). However, three of the samples had concentrations in the 70–90 μg/g range, similar to the local reference maximum mineral soil concentration of 61 μg/g. The sample with the highest lead concentration was collected from an area noted to be "impacted by dust" during the field sampling program. It is likely that surface soil materials from this area have elevated lead concentrations from airborne particulate deposition from the mine ore processing operations. These concentrations are likely not representative of the overall average of the potential materials in these deposits, as they will be substantially diluted by subsurface materials. However, should these materials be designated for use in surface capping of mine features, this premise of suitability through dilution should be tested by sampling and analysis of excavated materials. Other than the issue of elevated lead levels, there are no other chemical limitations to the use of these materials. SRK (2003) has estimated that there are approximately 1.7 million m^3 of material within this deposit. From a re-vegetation perspective this is a relatively desirable borrow source, as there are limited intact ecosystems established in these areas, and complete disturbance and re-vegetation of these sites might be more desirable than leaving them in their current condition.

Faro Dump Toe

This area was not identified during the Phase 2 survey, but is located downslope of a portion of the Faro waste rock dumps that will likely require re-sloping during decommissioning (represented by sample point VP-009). As this re-sloping would cover current undisturbed soils, these soils were evaluated for suitability for salvage and re-vegetation. The mineral soil collected for analysis from this site had an elevated zinc concentration (283 μg/g, in comparison to CCME/Yukon CSR levels of 200 μg/g, and a local reference maximum of 270 μg/g). This observation of elevated zinc content may be attributable to particulate deposition or natural mineralization, or both. However, since the potential volume available for salvage in this area is relatively small and difficult to access, and since the most valuable materials here are the intact (biologically active) surface soils that are most susceptible to contamination from dusting, these materials are not recommended for salvage. In the event that salvage of these materials is considered for surface capping, evaluations of average material metals concentrations should be undertaken.

Haul Road Borrow

This area is located on tills to the southwest of the Faro-Grum haul road and southeast of the North Fork Rose Creek rock drain (represented by sample points B02-38, -40 and -41). Textures are sandy loams to loams with approximately 40-60 percent coarse fragments. The only chemical limitation identified by lab analysis was elevated nickel concentrations of approximately 40–80 μg/g, in comparison to a local reference maximum of 40 μg/g and CCME and Yukon CSR standards of 50 and 100 μg/g, respectively. However, the Anvil Range Terrestrial Effects study (Gartner Lee, 2006) concluded that there was no evidence that nickel contents were related to industrial activity as opposed to natural mineralization. Therefore, the elevated nickel concentrations observed at this location were not interpreted as a limitation to use in surface capping during reclamation. SRK (2003) has estimated that there are approximately 0.72 million m^3 of material within this deposit. From a re-vegetation perspective, development of this location as a borrow source is less desirable than some of the other sources, as such development would entail further disturbance and corresponding additional reclamation.

Grum Overburden Dump

This location is a single large overburden dump predominantly consisting of glacial till materials originally overlying the Grum pit (represented by sample points Grum-2, -3, and -5 to -10; and VP-004 and -005). Textures of these materials, as sampled, range from sandy loams to loams with coarse fragment contents of approximately 15–75 percent. There are no substantial chemical limitations to use of this material as surface capping. Samples from points VP-005 and Grum 8 (on the northeast side of the dump) have elevated zinc concentrations (609 and 278 μg/g, respectively, in comparison to a local reference maximum of 270 μg/g and a CCME/Yukon CSR value of 200 μg/g). VP-005 also has a lead concentration of 312 μg/g, in comparison to a local reference maximum of 61 μg/g, and CCME/Yukon CSR levels of 70 and 350 μg/g, respectively).

It is not clear whether these elevated metals concentrations are the result of airborne particulate deposition or natural mineralization of the till, or both. However, they are not representative of the majority of samples obtained from this site — the average lead concentration in the 10 samples from the Grum overburden dump is 51 μg/g, while the average zinc concentration is 152 μg/g. Thus it is assumed that the average lead and zinc concentrations of mixed materials transported and distributed for use as capping will remain below maximum acceptable levels. Sample Grum-7 also showed an "elevated" arsenic concentration of 26.6 μg/g; however, as discussed above, concentrations of this magnitude are interpreted as being representative of natural local mineralization in arsenic, rather than of contaminated materials.

SRK (2003) estimated that there are approximately 8.0 million m^3 of material within this deposit. Given the size of this capping source and its relatively high potential for heterogeneity (being an excavated-and-dumped structure, as opposed to in-situ till), it will be important to have qualified personnel on-site during excavation to continuously evaluate the suitability of the entire deposit for use as capping material, as it is exposed. From a re-vegetation perspective, this is the most favourable borrow source on site, as it represents a large deposit (approximately 70% of the identified suitable borrow volume), the exploitation of which will require no disturbance of established ecosystems.

Vangorda Overburden Dump

As with the Grum overburden dump, this deposit consists of materials removed during stripping of the Vangorda pit (represented by sample points VanOB-1 through -5). The size of this stockpile is far smaller than the Grum overburden dump, and from the appearance of materials exposed at the surface it seems to be substantially more heterogeneous, consisting of waste rock and other mineralized materials as well as the glacial till overburden. In addition, there may have been some processing or screening activities conducted on the upper platform of this site (John Brodie, Daryl Hockley, pers. comm.). Of the five samples taken from the Vangorda overburden dump in this study, two (VanOB-2 and -5) were obviously mineralized, and had elevated levels of arsenic, copper, lead and zinc (as well as other elements). VanOB-2 had arsenic and lead concentrations of 1080 and 13000 μg/g, respectively, while VanOB-5 had a zinc concentration of 3240 μg/g. Even samples of till materials from this location had elevated arsenic, chromium, lead and zinc concentrations. The elevated metals concentrations in these materials not only pose a direct problem for re-vegetation due to the potential for plant metal uptake and animal ingestion of plant and soil material, but are also associated with other chemical issues such as extremely high acidity and electrical conductivity, which can limit or prohibit plant growth. For these reasons, material from the Vangorda overburden dump is not recommended for use in surface capping and re-vegetation at the Faro Mine site. Use of this material could only be contemplated in conjunction with a more thorough evaluation of the complete deposit.

Vangorda Plateau Organics

Bond (2001) identified organic, surficial materials to the northwest of the Faro Mine area, and to the southeast of the Vangorda mine area. These latter materials were evaluated in the field for their potential use as amendments in the surface capping and re-vegetation program for the Anvil Range Mine complex. Organic materials could provide a valuable source of nutrients, water retention capacity, and biological inocula for reclaimed areas, and thus ameliorate limitations of the predominant till capping material. However, the organics at both locations identified by Bond are in currently undisturbed locations which would require road development to allow access and salvage. This further disturbance would then also necessitate additional reclamation. Because reclamation objectives can be accomplished without salvage of these materials, and because it is counter-productive to introduce further disturbance into the reclamation program, these materials are not recommended for salvage and use in the surface capping program.

3.2.1 OPPORTUNISTIC SAMPLING

Although not previously identified as potential borrow sources, a number of additional locations were investigated and sampled for reclamation soil quality in this study. These are discussed by area, below.

Till Bench, Grum Waste Rock Dumps

On the south side of the Grum waste rock dump, there is a till bench that was investigated, as it has begun to re-vegetate naturally without any apparent intervention (represented by sample locations GRock-1 and -2; Figure 11). The properties of the rooting zone materials at this location were therefore of interest. Textures at this location are loams to silt loams, with approximately 40 percent coarse fragments – thus physically similar to the potential till capping materials evaluated in this study. There are no chemical limitations to plant growth associated with this material. In terms of material quality and surface preparation, this site represents a template for re-vegetation of the remainder of the mine site.

Till Free-Dumps, Faro Waste Rock Dumps

In a few locations on the Faro waste rock dumps, till materials have been free-dumped in isolated, small areas. Many of these areas have naturally re-vegetated, and two were investigated during this study (represented by sample locations VP-023 and VP-024; Figure 11). These materials have been able to successfully sustain some vegetative colonization, despite coarser textures (higher coarse fragment contents and sand contents) than the majority of till materials evaluated in 2007. However, these materials also show elevated metals concentrations, with lead concentrations from 333–847 μg/g, and zinc concentrations from 775-1280 μg/g. Whether these elevated levels are the result of pre-existing mineralization or airborne enrichment is not clear, but it is undesirable to have similar materials exposed at surface as rooting media in the final post-closure landscape. Observations from this site highlight the importance of thorough evaluation of any materials contemplated for use in surface capping that have not been investigated through this or any other study, particularly if these materials have been exposed at surface in locations likely exposed to historical dusting from ore processing operations.

Figure 11. Naturally re-vegetating till bench on south side of Grum waste rock dump.

Figure 12. Natural re-vegetation on free-dumped till at Faro waste rock dumps (VP-023).

Vangorda Trial Areas and Starter Berm

Because of the research undertaken to date on the Vangorda waste rock dumps, and because of the potential to use unvegetated portions of the till Vangorda starter berm for operation-scale reclamation demonstration/trials, a number of till-capped locations in this area were investigated (represented by sample points Van-1, 2a, 2b, 3a, 3b, 4, Van-94, and VSB-1 through 3).

Samples Van-2 through 4 represent samples from SRK test plots on relatively recently capped areas. The source of the till for these plots is not known. Of the five samples from these plots, four represent benign materials with adequate physical properties and no chemical limitations. The fifth, from Van-4, showed elevated elemental levels, with arsenic and zinc concentrations of 495 and 489 μg/g, respectively.

Samples Van-1 and Van-94 are located on the original 1994 till cover, the former on the SRK test plot on this cover, and the latter below the test plot locations. These samples also have elevated metals levels (lead concentrations of 278-748 μg/g). Elevated metals concentrations of this magnitude have not been shown to restrict vegetation growth elsewhere on the site, yet this site remains largely devoid of vegetation despite being in place for more than a decade and being directly adjacent to undisturbed seed sources. This is likely due to the state of the surface of the till at placement (insufficient micro-topography, which encourages surface erosion and limits seed "catch"), and to the tendency following placement of these high-pH tills toward cementation, which further limits seed catch and seedling root penetration. This observation has implications (discussed below) for the future re-vegetation program at the Anvil Range Mine site.

Samples VSB-1 through 3 are located on the lower slopes of the Vangorda waste rock dump, on till material placed as the "starter berm" for this dump. During the 2007 field program, use of this in-place till material for establishment of reclamation demonstration trials was discussed, and so soil quality was investigated through sampling. Till samples from this area have adequate physical properties, but highly elevated metals levels, including arsenic concentrations as high as 545 μg/g and lead concentrations as high as 5570 μg/g.

Findings from investigation of the Vangorda trial areas and starter berm indicate the following:

- The source of the till for the starter berm, 1994 cover, and subsequent test plot till caps should be determined, as all of these areas included samples with undesirably high metals levels. Determining the borrow source with certainty would allow evaluation of implications for future capping efforts.
- The Vangorda starter berm, in its current configuration, is not a suitable location for establishment of reclamation areas. This site will require capping with "cleaner" (lower metals concentrations) materials prior to reclamation. This should either be done prior to establishment of reclamation areas, or other areas should be chosen for reclamation demonstration trials.
- Surface preparation will be critical to successful reclamation, particularly in encouraging establishment of naturally or anthropogenically seeded propagules. This requirement is discussed further in Section 4, Discussion.

3.3 WILDLIFE

Wildlife observations on site were limited, but the frequency and variety of observations were consistent with previously documented use of the area. There were several observations of Dall's sheep in the Vangorda Plateau area on the waste rock/till piles immediately south of the Grum Pit on the Haul Road, confirming their continued use of that general area as a seasonal movement corridor. The primary movement corridor from the south generally appears to be traversed from Sheep Mountain to the confluence of the Shrimp and Van Gorder creeks, then the Grum creek channel to the haul road, the Sheep Pad Pond area to the Grum overburden dump/water treatment plant, and eventually to Mount Mye north of the Vangorda Plateau (GLL 2002). This movement corridor generally matches the movement corridor based on survey data identified in the Wildlife Key Areas (WKA) database (Yukon Department of Environment 2007, Figure 13). The area was confirmed by Mr. Etzel as a sheep movement corridor. The movement corridor identified by local knowledge in the WKA database that goes around the west side of the Grum Pit was also suggested as an alternative route by Mr. Etzel. There was no discussion with Mr. Etzel about the movement corridor from the eastern edge of Sheep Mountain westward to north of the Vangorda Pit identified in the WKA database, and there were no site visits to that area (Figure 13).

A cow and calf moose were observed foraging in remnant vegetation at the edge of a drainage pond at the base of the Vangorda waste rock dump (Little Creek Dam, -133.196, 62.247). This area has a remnant patch of wetland-associated foraging habitat. Generally, there was sign of moose use at the periphery of the mine footprint. Overall moose use of the mine footprint is expected to be minimal and habitat quality nil. Additional to the observation of the moose, a Say's Phoebe was observed nesting in the pump house building on Little Creek Dam.

No caribou were observed within the footprint of the mine. Mr. Etzel noted that hills north and east of the Vangorda Plateau area of the mine often contain caribou, and that he has observed little use of the mine footprint by caribou. Habitat quality of the mine footprint is nil with no existing caribou habitat features.

There were no Grizzly or Black bear sightings during the site visit, but bears have been observed on the property (cited in GLL 2002). Habitat quality of the mine footprint is nil with no evident forage or escape cover.

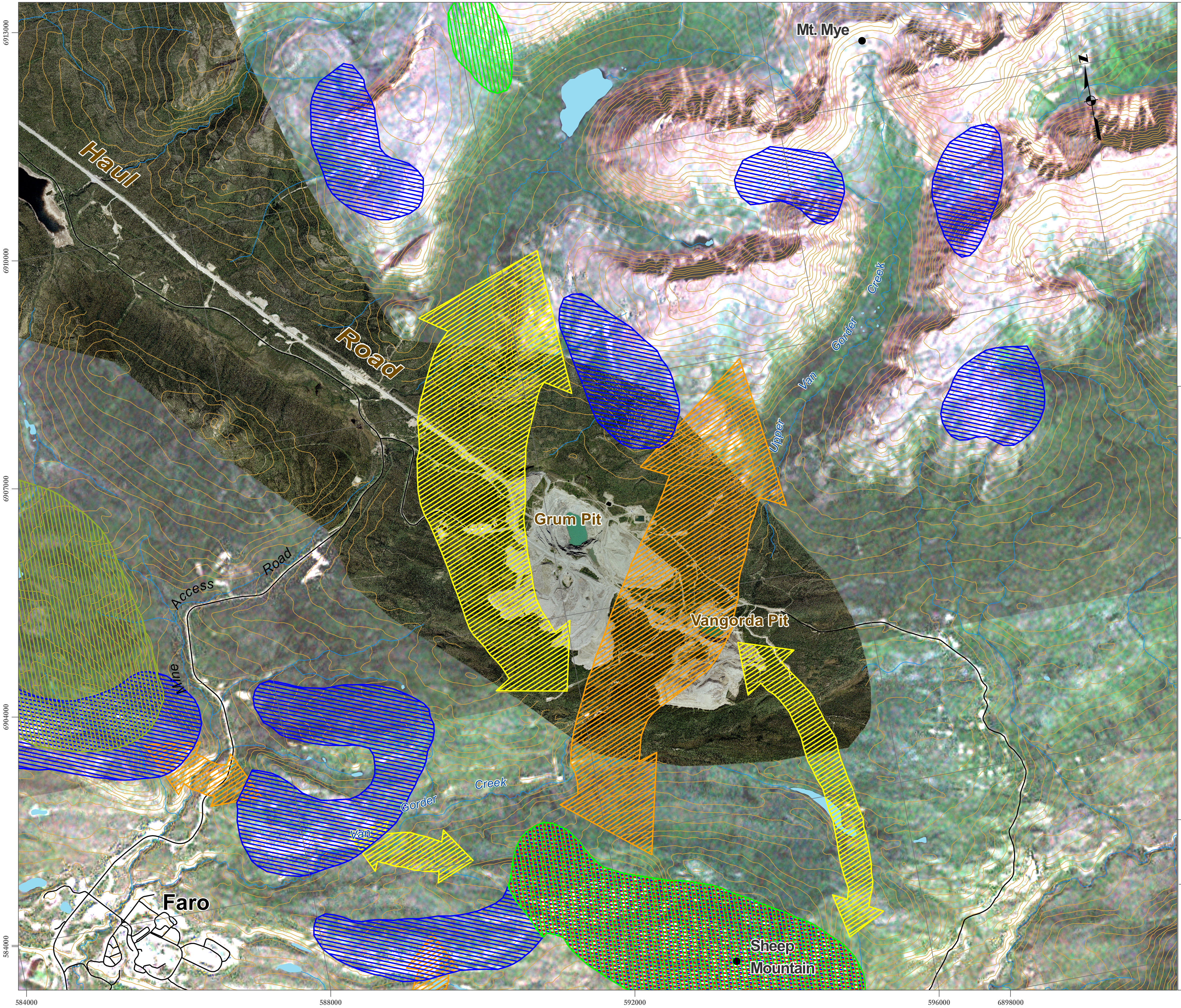
3.4 RE-VEGETATION TRIAL

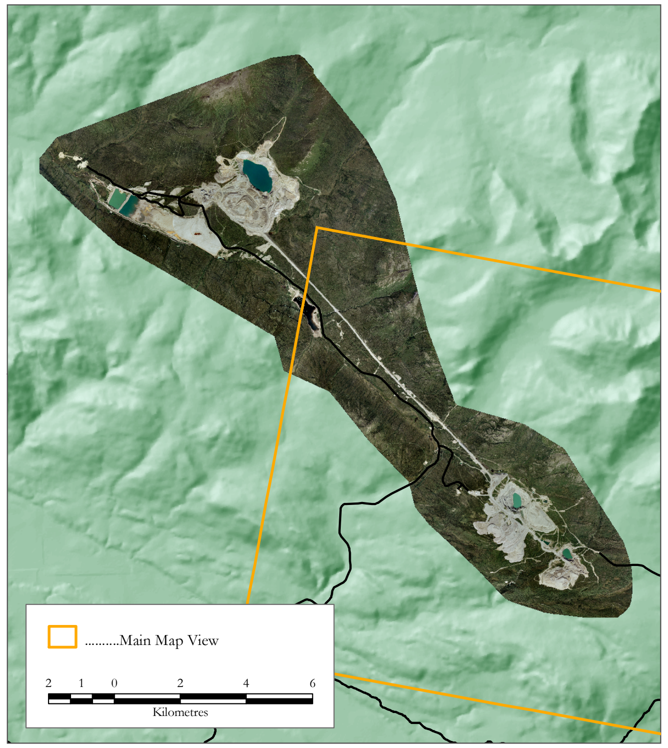
Results of the re-vegetation trial, in terms of alder seed sprouting rates and willow/poplar stake survival rates, will not be observed until the summer of 2008 or later. Monitoring of survival and growth rates will be important to determine the success of the re-vegetation trial.

The initial trial served to test the practicality of the methods applied. The surface preparation carried out by the machine operator constructing the cover trial plot was reasonably successful at achieving a till cover with the desired range of depths, suitable micro-topography and a non-compact state. However, one difficulty was encountered with the till depths. Points within the trial cover where only the minimum till depth (0.25 m) was achieved were too shallow for the willow and poplar stakes to be planted. The field crew was, however, able to plant the stakes in deeper pockets of till (0.5-1.0 m). This experience underscores the importance of micro-topographic variation in the planting surface and of achieving a minimum average till depth of 0.75 m. The surface preparation treatment must result in enough points with depths of 0.5 m or greater to achieve desired staking densities of 900 stems/hectare.

The alder seed collection was a straightforward task due to the abundant source of easily accessible, mature alder seed on the mine site. All of the seed collected during the trial collection period was processed and weighed to assess the efficiency of seed collection for larger scale application. With 8 person hours of manual collection effort[3] (picking cones), a total weight of 732 seed was collected – enough to broadcast seed 7.3 hectares of the mine site.

[3] Does not include the time to extract the seed.





Thinhorn Sheep Key Areas

- spring lambing - survey data
- spring lambing - local knowledge
- early winter rut - survey data
- early winter rut - local knowledge
- winter range - survey data
- winter range - local knowledge
- winter range - historic
- movement corridor - survey data
- movement corridor - local knowledge
- Mineral Lick

Data Input/Drawn by:	M. Setterington, M. Power
Checked By:	M. Setterington
Date:	28 January 2008
EDI Project Number:	07-YC-0026
Map Projection:	NAD 1983 UTM Zone 8

500 250 0 500 1,000 1,500 2,000
Metres

Digital Data Sources:

- *Orthophoto: August 2003, Orthoshop, Calgary AB*
- *Base Map Files: NTDB 1: 50,000, www.geogratis.ca*
- *Landsat: CTIS CanImage, www.geogratis.ca*
- *Wildlife Key Areas, Yukon Department of Environment. 2007-May-31. Yukon Wildlife Key Area Inventory. Digital database and software produced by Habitat and Regional Management Section, Fish and Wildlife Branch, Department of Environment, Government of Yukon, Whitehorse.*

Wildlife Key Areas (WKA) are compiled by the Yukon Department of Environment WKA Inventory Program (2005), against 1:250,000 NTDB from various data sources. Key Areas are based on observed locations of wildlife at key times of year, not on habitat assessment. With new information, boundaries and designations of Key Areas can change and additional Key Areas can be identified. Furthermore, Key Areas are not the only sites important for wildlife. Other information sources can identify other sites important for wildlife for reasons outside the scope of the WKA Inventory Program. Updates to Key Areas occur only periodically. For the most current information, please consult with the Regional Biologist for your area of interest. If you have questions or would like to contribute to the WKA database, please contact the WKA Inventory Program (wka@gov.yk.ca).

Figure 13.
Key wildlife considerations for the Faro Mine Closure Project Waste Rock Dumps and Tailings Re-vegetation Study

EDI ENVIRONMENTAL DYNAMICS INC.
Natural Resource Consultants

4 DISCUSSION AND CONCLUSIONS

4.1 VEGETATION RESTORATION CONSIDERATIONS

Ecological restoration is defined by the Society for Ecological Restoration International as the process of assisting in the recovery of ecosystems that have been damaged, degraded or destroyed (SERI, 2004). The key element in this definition is that what is done merely assists in the recovery of the damaged ecosystem. This recognition that we cannot fix damaged ecosystems any more than we can 'fix' a cut finger is paramount. For a cut finger, we can put on antiseptic and bandages and even stitch together the skin if the cut is severe enough, but it is the body that heals the cut. For ecosystems it is the same; we can provide treatments that will help establish vegetation, but it is really the natural processes of ecosystem healing that restore the damage. This concept is essential to the following discussion on restoration of the damaged sites.

Natural successional processes offer the most effective reclamation option for the Faro Mine (Polster, 1989). By re-establishing the natural successional trajectories on the mining disturbances, the long term health of the vegetation communities will be assured. There is a great temptation to establish a dense cover of seeded grasses and legumes, such as has been done at the old water storage pond. In this case, seeding was used to achieve short term erosion and sediment control objectives adjacent to Rose Creek. To achieve long term reclamation objectives, seeding of grasses and legumes should be avoided as it will only serve to slow the natural processes of re-vegetation. The dense grass cover will impede or slow the natural colonization of woody species for many years. Instead, planting pioneering species such as alder, willows and balsam poplar will ensure the appropriate conditions are available for the establishment of later successional conifers in the future (Figure 14). This approach will essentially jump start natural succession function. In situations where short term erosion control is of paramount importance, a treatment that includes light seeding with native grasses combined with seeding of alder and live staking of pioneering species can be applied to achieve erosion control objectives.

Lessons learned from previously completed re-vegetation and bioengineering projects in various locations throughout the Yukon support this approach. Previous re-vegetation monitoring reports were reviewed to identify the successes and challenges associated with past approaches to re-vegetating disturbed sites, including reclaimed mining landscapes and sites where significant erosion had occurred. The complete review is presented in Appendix D.

Several lessons learned from these projects are relevant to re-vegetation of the Faro Mine site. First, seeding with agronomic mixes of grasses and legumes has been found to impede colonization of native vegetation at other reclaimed mine sites in the Yukon (Mougeot Geoanalysis and S.P. Withers Consulting Services, 2000). In contrast, transplanting the native grass, *Deschampsia caespitosa,* into tailings has shown promise in facilitating colonization of native vegetation (Clark and Hutchinson, 2005). Second, rough loose microtopography has been found to assist colonization of native vegetation, by creating microsites amenable to the invasion and survival of seeds and plant propagules (Mougeot Geoanalysis and S.P. Withers Consulting Services, 2000). Third, success with planting cuttings of native shrub species, such as willows and poplars, has been achieved at riparian sites such as Noname Creek (near Carmacks) and Gold Run Creek (near Dawson City) (Laberge Environmental Services, 2007; Withers, 2003 and 2006).

In contrast, a small willow staking trial involving twenty cuttings planted in each of three trial plots was not successful at the dry, steeper sites at the Brewery Creek mine. Trembling aspen root cuttings, however, showed relatively good survival at the Brewery Creek mine, as did transplants of a number of shrub species. At the Faro freshwater dam, willow cutting survival was good near Rose Creek, but poorer in the upper reaches of the two tributaries to Rose Creek (Laberge Environmental Services, 2006). Willow cuttings planted at Noname Creek also showed good survival closer to the creek than on steeper, and presumably drier, gully walls (Withers, 2006). It should be noted that the methods used for these projects (including time of year, size of cuttings, soaking, planting depth) was limited. These are all important considerations in the use of live stakes in bioengineering and re-vegetation treatments. Without this information, it is not possible to fully understand the success of willow staking in the Yukon, especially in upland areas.

The lessons learned from review of past re-vegetation projects support the use of live-staking with native shrub species. The mixed results reported in past projects with willow staking in upslope areas highlight the value of using a variety of shrub species suited to a range of site conditions in re-vegetation treatments. The limited available research on live-staking of shrub species in upland areas of the Yukon also points to the need for additional, larger scale trials of these methods. Depending on results of the trials there may be a need to adjust the methods slightly. A higher stocking rate of cuttings could be used if survival is not as high as desired. Alternatively, the staking could be supplemented by planting rooted stock (grown in a greenhouse) or transplanting of small willow and balsam poplar from nearby areas.

With these considerations in mind, six different vegetation treatments are envisioned for the Faro property. These treatments have been designed for the expected range of microclimatic and topographic conditions (following surface re-contouring) at the mine site, and to meet anticipated riparian management and erosion control objectives. Table 7 presents the salient features of these treatments. The following paragraphs provide a discussion of the details associated with each treatment.

Table 7. Proposed generalized re-vegetation treatments for Faro Mine reclamation.

Treatment Type	Description
Primary Treatment	A mix of green alder seeding and live staking will be used to establish early seral vegetation on most of the disturbed areas.
Primary Treatment with Conifers	Same as Primary Treatment except density of alder seeding and staking will be reduced and conifer seedlings will be planted. This prescription can be used in cases where accelerated succession is desired (i.e. for aesthetic reasons).

Treatment Type	Description
Xeric (Dry) Vegetation Communities	Seeding with native bunch forming grasses and planting with appropriate shrubs will be used to create wildlife habitat on drier south and southwest facing slopes.
Hygric/Wetland Communities	Planting with native sedges and rushes will be used to establish wetlands in appropriate areas.
Riparian	Seeding of alder and live staking of other shrubs will be used in combination with conifers to re-establish riparian vegetation. This prescription would be appropriate where fish values would benefit from accelerated succession. A mature conifer forest can provide significant benefits (i.e. allows for light penetration for primary production) to fish and fish habitat compared to a more dense deciduous forest.
Erosion Controlling Treatment	Light seeding with native grasses in combination with green alder seeding and live staking will be used in situations where erosion potential is high and a cover of grasses is required for short term erosion control.

The **Primary Treatment** for reclamation at the Faro Mine will consist of creating a rough and loose condition in the substrate to minimize erosion and to provide suitable micro-site conditions to trap seeds and provide an appropriate seedbed for germination and early growth. Detailed soil capping and surface preparation requirements are described in Sections 4.2.1 and 4.2.2 of this report. Green alder (*Alnus crispa* (Drylander *ex* Ait.) Pursh ssp. *crispa*) seed will be collected locally and applied to the reclamation areas at a rate of 0.1 kg/ha. This will provide approximately one pure live seed per square meter and should result in adequate stocking. The alder will be supplemented with willow (*Salix* spp.) and balsam poplar (*Populus balsamifera* L. ssp. *balsamifera*) cuttings used as live stakes (refer to Appendix E for specific methods). Ideally, a pioneering woody species stocking rate of 2,500 to 3,000 stems/ha should be achieved. The balance between the willow and the balsam poplar should be adjusted to provide a diversity of cover characteristics so stands dominated by willow are interspersed with stands dominated by balsam poplar.

Figure 14. Dave Polster pointing to a spruce tree establishing under a tall canopy of willow and balsam poplar on an older, disturbed site at the Faro Mine.

The **Primary Treatment with Conifers** will be similar to the Primary Treatment although the stocking rate of the final pioneering species stands (alder, willow and balsam poplar) will be reduced to between 1,500 and 2,000 stems/ha so that white spruce (*Picea glauca* (Moench) Voss) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) can be planted at a rate of 750 stems/ha. The conifers should be grown specifically for the Faro Mine reclamation project from seed that has been collected locally. Collecting seed for conifers locally will provide plants that are adapted to the local conditions. The Yukon Government, Forest Management Branch, has conifer seed collected from most areas in the Yukon in storage, some of which may be available for the project. As with the willows and balsam poplar, the mix between spruce and fir should be varied to create a diversity of plant communities on the reclaimed mine. The subalpine fir should be planted more heavily in the upper areas of the reclaimed mine while concentrations of spruce should be greater at lower elevations. This treatment will be applied in areas where a rapid re-establishment of conifers is desired for riparian and/or wildlife reasons.

Re-vegetation treatment for the **Xeric Vegetation Communities** will entail seeding in a light cover of native grasses and planting suitable trees and shrubs. Table 8 provides a listing of the native grasses that are currently commercially available. These should be tested at the mine to determine the species that will be most effective for inclusion in seed mixes that are developed for the mine. Specific designs for seed mixes for both this treatment and the erosion controlling treatment will need to be developed once the results of the trials are known. Trees and shrubs that can be used for the Xeric Vegetation Communities include aspen (*Populus tremuloides* Michx.), soapberry (*Shepherdia canadensis* (L.) Nutt.), prickly rose (*Rosa acicularis* Lindl.), kinnikinnick (*Arctostaphylos uva ursi* (L.) Spreng.), mountain juniper (*Juniperus communis* L.) and bush-cranberry (*Viburnum edule* (Michx.) Raf.).

The **Hygric Wetland Communities** can be established by planting either transplants of the appropriate sedges and rushes or planting container-grown stock. Since many of the species that are suitable for these sites are difficult to germinate and grow, it is suggested that donor stock be obtained from natural wetlands in the area. Removal of up to 10 percent of the cover in natural wetlands in a disbursed manner will not significantly impact the donor areas as the rhizomatous nature of these species will quickly fill in the voids. Number 2 (2 gal) nursery pots should be used for collection of stock as filling this size pot will ensure that ample root material is collected. In addition, by using material from local wetlands, the genetic compatibility with the area can be assured.

The **Riparian** areas offer the opportunity to establish a diversity of vegetation. Willows (*Salix* spp.) and balsam poplar (*Populus balsamifera* L. ssp. *balsamifera*) cuttings can be used as live stakes along the reclaimed riparian areas. Native white spruce (*Picea glauca* (Moench) can be planted in scattered locations to mimic the natural patterns found along the riparian areas. In addition, a mix of grey alder[4] (*Alnus incana* (L.) Moench ssp. *teunifolia* (Nutt.) Breitung) and green alder (*Alnus crispa* (Drylander *ex* Ait.) Pursh ssp. *crispa*) seed can be seeded on the riparian areas to increase the species diversity and provide nitrogen for both the riparian area and the stream.

The **Erosion Controlling Treatment** will consist of the Primary Treatment with a light seeding of native grasses. Table 8 provides a listing of commercially available native grasses that can be tested at the mine to determine the constituents of a suitable seed mix. Care should be taken to avoid establishment of a dense cover of grasses as this will slow the establishment of a woody species cover.

The re-vegetation design for the Faro Mine has been developed so that local materials can be used as much as possible. In addition, these materials can be obtained and applied by local personnel, thereby providing

[4] We have not identified a source for this species; however, it is likely found in riparian areas around the mine site or in nearby areas (i.e. Pelly River).

an opportunity to gain skills that can be used elsewhere in the Yukon. By using local, adapted species, the re-vegetation that is completed will re-integrate the site with the surrounding terrain. The re-vegetation program has also been designed to minimize the need for post-treatment maintenance. By initiating the natural successional processes at the mine, the cover of vegetation can be assured well into the future, although it is recognized that this initial cover will change over time.

Table 8. Commercially available native grasses suitable for re-vegetation at the Faro Mine site.

Common Name	Scientific Name[5]
Slender Wheatgrass	*Elymus trachycaulus* (Link) Gould ex Shinners ssp. *Trachycaulus*
Awned Wheatgrass	*Elymus trachycaulus* (Link) Gould ex Shinners ssp. *subsecundus* (Link) Gould
Broad-glumed Wheatgrass	*Elymus trachycaulus* (Link) Gould ex Shinners ssp. *subsecundus* (Link) Gould
Ticklegrass	*Agrostis scabra* Willd.
Polargrass	*Arctagrostis latifolia* (R.Br.) Griseb. s.l.
Fringed Bromegrass	*Bromus ciliatus* L.
Blue-joint	*Calamagrostis canadensis* (Michx.) Beauv.
Slim-stemmed Reedgrass	*Calamagrostis stricta* (Timm) Koeler ssp *stricta*
Tufted Hairgrass	*Deschampsia caespitosa* (L.) Beauv.
Hairy Wildrye	*Leymus innovatus* (Beal) Pilger
Rocky Mountain Fescue	*Festuca saximontana* Rydb.
June Grass	*Koeleria macrantha* (Ledeb.) Schultes
Alpine Timothy	*Phleum alpinum* (L.)
Alpine Bluegrass	*Poa alpina* L.
Glaucous Bluegrass	*Poa glauca* Vahl
Fowl Bluegrass	*Poa palustris* L.
Nuttall's Alkali Grass	*Puccinellia nuttalliana* (Schult.) Hitchc.
Spangletop	*Scolochloa festucacea* (Willd.) Link
Needle and Thread	*Stipa comata* Trin. & Rupr.
Spike Trisetum	*Trisetum spicatum* (L,) Richt.

[5] Scientific names follow Cody (2000).

4.2 SOILS

4.2.1 VOLUME REQUIREMENTS

The following discussion is based on soil volume requirements for providing an adequate rooting zone for the re-vegetation treatments described in Section 4.1 of this report. Capping volume requirements for other purposes (such as compacted layers for limiting infiltration) are outside the scope of this study.

Successful re-vegetation of the Faro Mine site will require placement of a **minimum** depth of un-compacted, adequate-quality material of 50 cm. Depths less than this value will overly restrict the volume of soil available for root occupation, and will limit vegetation growth by restricting available water during the growing-season. For re-vegetation purposes, no more than 1 m of un-compacted, adequate-quality material is required, on average. Depth of material placement and post-placement surface micro-topography will influence each other, as discussed below.

Volume estimates provided in Table 6 (adapted from SRK, 2003) indicate that there are approximately 11.4 million m^3 of materials suitable for reclamation at the Faro site, with 70% of these materials currently located in the Grum overburden dump. Of the potential borrow sources, use of materials from the Grum overburden, Rose Creek West Pit and Tailings borrow areas is most desirable from the re-vegetation point of view, as their use either entails no disturbance of established ecosystems, or involves disturbance of already severely altered ecosystems which might benefit from further reclamation efforts.

Table 9 provides estimated volumes required for average capping depths of 50, 75 and 100 cm for the major features in the Anvil Range mine complex, based on areas reported by SRK (2003). A comparison of this information to estimated volumes presented in Table 6 indicates that there is sufficient volume of suitable borrow material for all capping depth scenarios, given no other demands for till borrow materials for other uses. In reality, there are a number of other demands on these limited resources, and thus final selection of surface re-vegetation capping depths will involve balancing re-vegetation goals and requirements with other reclamation objectives.

Final availability of surface capping materials will also depend on actual excavated volumes of surface materials, as opposed to estimated volumes presented in this and other reports.

Table 9. Estimated volume requirements under various capping scenarios.

Site	Area (ha)	Volume required (M m^3)		
		50 cm depth	75 cm depth	100 cm depth
Rose Creek Tailings	234	1.2	1.8	2.3
Faro Waste Dumps	407	2.0	3.1	4.1
Vangorda Waste Dumps	51	0.3	0.4	0.5
Grum Waste Dumps	153	0.8	1.1	1.5
Total	**845**	**4.2**	**6.3**	**8.5**

4.2.2 SURFACE PREPARATION

As discussed in Section 3.2.1, there are portions of the Faro Mine site where suitable quality till materials similar to those identified in this report for use as surface reclamation capping have failed to re-vegetate, despite prolonged exposure. This observation indicates the importance of deliberate design and production of the final re-vegetation-ready surface.

The key to effective reclamation at the Faro Mine will be covering reactive wastes with sufficient till to prevent the movement of moisture and oxygen into the underlying waste rock, while providing a rooting medium that is sufficiently deep to allow all of the local species to grow freely. Final surfaces need to be non-compact, and should be left with sufficient microtopography to discourage small-scale surface erosion, to encourage ease and diversity of vegetation establishment, and to be similar to conditions in undisturbed local ecosystems.

In practice, this requirement amounts to high-frequency microtopographic relief on the order of 0.25–0.5 m, although smaller relief could be considered if it accomplishes the above objectives. The most effective natural recovery has occurred in areas of the mine site where free dumped till has been left in loose piles, indicating that the surface layer should be left as loose and rough as possible in reclamation treatments. There are a variety of ways of producing this variation through the use of agricultural or typical placement implements (e.g. breaking discs, heavy-duty harrows, multiple ripping shanks, excavator mounding).

The desired surface preparation and microtopography need to be considered in conjunction with minimum placement depths in order to determine average required volumes. For instance, if techniques capable of producing microtopographic relief of ± 0.25 m are used, and a minimum depth of 0.5 m is specified, then an average capping volume based on 0.75 m depths will be required to ensure minimum depths are achieved in furrows following surface preparation.

It will be necessary to synchronize placement and preparation activities with re-vegetation so that prepared areas receive re-vegetation treatments as rapidly as possible following placement, and do not have time for substantial cementation to occur. By creating an amenable substrate and establishing pioneering vegetation, the reclamation of the Faro Mine should be accomplished effectively.

4.3 WILDLIFE HABITAT AND MOVEMENT CONSIDERATIONS

All re-vegetation of the waste rock dumps and tailings will be an overall regional net benefit to wildlife. Habitat values of the existing mine site are negligible due to the lack of vegetation as both a food resource and source of cover. All re-vegetation will provide both forage and cover for a variety of species in both the short and long-term. Given the abundance of habitat in the surrounding areas, no wildlife-specific re-vegetation recommendations are proposed at this time.

The continued use of the site by Dall's sheep reflects their pattern of continued use of traditional trails and movement corridors. The area cleared for mining activities did not appear to create a barrier to sheep movement. To ensure continued seasonal movement of Dall's sheep through the site, the migration route through the Vangorda Plateau area of the mine noted above should not be significantly changed by landform design. Areas considered a barrier to movement include unsuitable habitats such as open water, wetlands, thick forests, and other areas without grass understory (Naturserve 2007). Should the landform and reclamation design be considering these options in the Vangorda Plateau area, site-specific recommendations can be made to ensure that sheep migration is not affected.

4.4 RE-VEGETATION TRIAL

The re-vegetation trial served as a small scale pilot project to test the application of the primary re-vegetation treatment discussed in Section 4.1. Unfortunately, the area available for this initial re-vegetation trial was extremely limited. Monitoring the trial site over the next few years may yield useful information on the efficacy of the primary treatment. However, it is advisable to conduct additional trials, since an enlarged re-vegetation trial study area is more likely to yield useful results, and will also allow further testing of the range of prescribed re-vegetation treatments.

5 RECOMMENDATIONS

The overall objective of this project was to develop re-vegetation prescriptions for reclamation of the Faro Mine site. As discussed at length in Section 4 of this report, the prescriptions developed by the Study Team include recommended placement depths of un-compacted till, soil surface preparation techniques, borrow sources, and re-vegetation treatments tailored to the range of anticipated landform positions in the re-contoured landscape. The critical components of the Study Team's recommended re-vegetation prescriptions are described in Section 5.1, and summarized in Table 10.

5.1 RECOMMENDED RE-VEGETATION PRESCRIPTIONS

The Study Team's recommended re-vegetation prescriptions include the following core components:

1. A minimum capping depth of 0.5 m of non-compacted till, combined with 0.25–0.5 m of topographic relief. This equates to a minimum average till depth of 0.75 m. If possible, a minimum average till depth of 1.0 m is desired to provide additional rooting material and microtopography. The absolute minimum depth of 0.5 m is recommended based on rooting depth requirements of native vegetation, and is in addition to compacted materials placed to meet other reclamation objectives.

2. Mechanical preparation of the till surface to achieve micro-topographic relief of 0.25–0.5 m through the use of agricultural or typical placement implements (e.g. breaking discs, heavy-duty harrows, multiple ripping shanks, excavator mounding). The most successful examples of natural regeneration in disturbed areas of the mine were documented in sites with micro-topographic variation of this relief and greater.

3. Use of materials from the Grum overburden, Rose Creek West Pit and Tailings borrow areas as capping materials. Of the previously-identified potential borrow sources, these materials are most desirable for use as growth media, offering suitable physical properties and metal concentrations within Yukon CSR and/or CCME guidelines. The use of these materials is also desirable because their excavation either entails no disturbance of established ecosystems, or involves disturbance of already severely altered ecosystems which might benefit from further reclamation efforts.

4. Use of approximately 4.2–8.5 M m^3 of the identified borrow source materials to achieve the recommended loose till capping depths of 50–100 cm throughout the reclaimed surface of the mine site. This estimate is within the total estimated volume of available borrow materials (11.4 M m^3) from these sources (based on SRK's 2003 estimates). Actual availability will depend on final excavated volumes of borrow materials. Ongoing evaluation of the chemical and physical suitability of these materials is recommended during excavation.

5. Following surface preparation, application of the recommended re-vegetation treatments outlined in Table 10, using native pioneering species characteristic of the disturbed vegetation communities at the

mine site to initiate the process of natural vegetation succession in the reclaimed and re-contoured landscape.

6. Tailoring the re-vegetation prescriptions to suit the landform positions in the reclaimed landscape, as described in Table 10. The recommended re-vegetation treatments are based on a primary treatment that combines green alder seeding and live staking of poplars and willows, similar to the re-vegetation trial initiated during this Study. This primary treatment will be suitable for the majority of landforms (e.g. capped dump slopes, platforms, rehabilitated roads). Variations on this primary treatment are proposed to meet riparian management and erosion-control objectives, and to suit hygric (wetland) sites or xeric (dry) sites.

7. Generating opportunities for local employment in materials placement and surface preparation, and alder seed collection, as well as collection and staking of live willow and poplar stakes.

Natural variability will be observed in re-vegetation patterns regardless of the re-vegetation treatment applied. Later successional species, including conifers, additional understory shrubs, mosses and lichens, will follow the establishment of the pioneering vegetation introduced through the re-vegetation treatments. Over the long term, the vegetation communities we can expect to see established on the mine site will reflect the underlying soil and moisture conditions in the reclaimed and re-contoured landscape, as defined in the vegetation classification presented in Section 3.1 and Appendix B. On warmer, drier sites (south and southwest-facing slopes) underlain by mineral soils, we can expect species characteristic of Vegetation Type 7 to establish. On cool, moist sites underlain by mixed organic and mineral soils, we can expect species characteristic of Vegetation Type 4 to follow the pioneering vegetation. On cool, moist sites underlain by organic soil, we can expect later successional species characteristic of Vegetation Types 1 to 3.

Table 10. Recommended soil capping and re-vegetation treatments for Faro Mine reclamation.

Treatment Type	Example Landform Positions	Soil Capping Requirements	Re-vegetation Treatments
Primary Treatment	Most landform positions, including capped dump slopes and platforms and rehabilitated roads.	Minimum 50 cm depth; average to accommodate minimum requirement and desired topographic relief, as per Section 4.2.2	A mix of green alder seeding and live staking will be used to establish early seral vegetation on most of the disturbed areas.
Primary Treatment with Conifers	As above, but particularly to meet aquatic (riparian) or wildlife (thermal cover) considerations.	Minimum 50 cm depth; average to accommodate minimum requirement and desired topographic relief, as per Section 4.2.2	Same as Primary Treatment except density of alder seeding and staking will be reduced and conifer seedlings will be planted.
Xeric Vegetation Communities	High elevation ridges, such as on the upper Faro dumps; south-facing slopes, particularly in crest positions.	Minimum 30 cm depth; average 30-40 cm. Topographic relief may have to be reduced to allow a thinner overall cover. Subject to geotechnical/geochemical considerations.	Seeding with native bunch forming grasses and planting with appropriate shrubs will be used to create wildlife habitat on drier south and southwest facing slopes.
Hygric/Wetland Sites	Topographic depressions underlain by low-conductivity material (e.g. compacted till).	Minimum 50 cm depth; topographic relief to achieve desired variability relative to water level or moisture regime. Subject to geotechnical/geochemical considerations.	Planting with native sedges and rushes will be used to establish wetlands in appropriate areas.
Riparian	Edges of aquatic features (e.g. rehabilitated Rose Creek drainage).	Will depend on specific feature, but average minimum 50-cm depth. Potential for use of coarser glaciofluvial materials.	Live staking, grey alder and other shrubs will be used in combination with conifers to re-establish riparian vegetation.
Erosion-controlling Treatment	Lower portions of longer planar slopes; areas adjacent to watercourses (may intersect with Riparian category).	Minimum 50 cm depth; average to accommodate minimum requirement and desired topographic relief, as per Section 4.2.2. Avoid capping these areas primarily with finer-textured sediments from the Rose Creek West borrow area.	Light seeding with native grasses in combination with green alder and live staking will be used in situations where erosion potential is high and a cover of grasses is required for erosion control.

5.2 RECOMMENDED NEXT STEPS

At this time, re-vegetation prescriptions have been developed for the general range of landform positions anticipated in the final reclamation landscape. The recommended prescriptions have been developed to be compatible with the three primary closure and reclamation options under consideration at this time. However, once the final reclamation plan and landform contouring plan is in place, detailed site-specific re-vegetation prescriptions will be required. We therefore recommend that development of detailed re-vegetation prescriptions be carried out in conjunction with the upcoming and final stages of reclamation planning.

The results from the lysimeter trials should be monitored over the next few years. Details on establishment rates from seed and live staking should be collected. In addition, any colonization of by other species should also be collected.

There has been discussion regarding operational trials which would involve the reclamation of large[6] areas around the mine site. Operational trials use techniques that would be used for normal reclamation and are of a size that will provide for the reclamation of the site being treated. These trials would be an excellent opportunity to test all aspects of reclamation including capping / cover design, landform engineering and re-vegetation. Optimally a location would be selected that will not be disturbed during future works at the site. Operational trails of the methods presented in this report will provide people (including stakeholders) with the opportunity to see what the early results of re-vegetation works. Future prescriptions can address any issues that may become apparent from the trials.

[6] Ultimately an area would be large enough to allow for variability of topography, aspect and moisture conditions such that is representative of the whole mine (as possible). An area should be a minimum of 1 ha but preferably around 5 ha in size. Several smaller areas (1-2 ha) with different conditions could be used instead of one large area.

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Appendix A. Vegetation Table

Community Types: 1

No.	Field Designation	VP 017	VP 025	VP 027	VP 033	VP 037	VP 063	VP 040	VP 044	VP 069	VP 053	VP 055	VP 062	VP 038	VP 032
		Nat For above pit	Nat For	Nat For	Nat For	Nat For dry forest	Nat For	Nat For Dry forest Grum	Nat For	Nat For	Cut For Old burn spruce cut	Nat For Old Burn	Nat For Old Burn Swim Lake	Nat For 0 deg exp 15 deg slope	Nat For
	TOTAL VEGETATION	**85**	**99**	**95**	**99**	**80**	**99**	**95**	**80**	**95**	**90**	**95**	**95**	**99**	**99**
139	**NUMBER OF SPECIES**	**12**	**18**	**13**	**12**	**11**	**14**	**9**	**17**	**12**	**15**	**18**	**15**	**23**	**13**
22	**Pleurozium** shreberi	5	10	5	60		80	40	25	80	10	30	50	40	60
21	Abies lasiocarpa	30		0.1	15	10	40	5	5		5	10		1	
13	Peltigera sp	1	5	20	10	15	1		5	5	5	10	1		10
16	Cladina mitis			30	15	30	10	30	10		10	20	40	20	20
25	**Mertensia** paniculata						1							1	0.5
22	Potentilla fruticosa														0.5
20	Salix myrtillifolia														
13	Salix reticulata													10	
7	Carex scirpoidea														
37	**Ledum** groenlandicum	0.5	15	20	10	10	15	20	5	60	10	10	40	15	20
35	Empetrum nigrum	1	20	10	5	10	1	10	15		20	15	15	10	30
34	Vaccinium vitis-idaea	1	10	5	5	5	1	5	1	5	1	5	5	5	10
30	Vaccinium uliginosum	1	0.5	5	1	1	5	1	5		10	5	5	5	10
24	Arctostaphylos rubra									0.5	1	1	1	10	1
40	Betula glandulosa	10		10	40	30	15	15	25		40	10	30	40	60
27	**Populus** balsamifera														
24	Salix arbusculoides	5									1				
16	Salix bebbiana														
15	Agrostis scabra														
39	Salix planifolia	5	10	5			1			5	5		5	1	5
15	**Shepherdia** canadensis		1.0												
12	Linnaea borealis		0.5				0.5							0.1	
12	Pinus contorta		30	10	0.1						1	5			
9	Geocaulon lividum									1					
7	Calamagrostis inexpansa														
55	Picea glauca	10	10	10		5	15	10		5	1	1	5	5	5
54	Salix glauca				0.5	0.5		0.5	10	10	5	5	5	5	10
44	Epilobium angustifolium		1				0.5					0.1			0.1
31	Arctagrostis latifolia														
30	Festuca altaica	0.5			1	1	0.5		1			1	0.1	5	1
24	Populus tremuloides								0.1	5	5				

Community Types: 2

No.	Field Designation	VP 045	VP 048	VP 056
		Nat For	Nat For Old spruce for	Nat For boggy wetland
	TOTAL VEGETATION	**98**	**90**	**95**
139	**NUMBER OF SPECIES**	**13**	**13**	**24**
22	**Pleurozium** shreberi	40	30	40
21	Abies lasiocarpa	5		5
13	Peltigera sp	5		
16	Cladina mitis	20	10	
25	**Mertensia** paniculata	0.5	1	0.1
22	Potentilla fruticosa	0.1	5	5
20	Salix myrtillifolia			5
13	Salix reticulata		1	5
7	Carex scirpoidea	0.5	1	1
37	**Ledum** groenlandicum	10	20	10
35	Empetrum nigrum	45	10	5
34	Vaccinium vitis-idaea	5	5	1
30	Vaccinium uliginosum	5	40	
24	Arctostaphylos rubra	5	10	5
40	Betula glandulosa	15	10	20
27	**Populus** balsamifera			
24	Salix arbusculoides			
16	Salix bebbiana			
15	Agrostis scabra			
39	Salix planifolia			
15	**Shepherdia** canadensis			
12	Linnaea borealis			
12	Pinus contorta			
9	Geocaulon lividum			
7	Calamagrostis inexpansa			
55	Picea glauca	5	10	10
54	Salix glauca	10	10	10
44	Epilobium angustifolium			
31	Arctagrostis latifolia			1
30	Festuca altaica	1	1	1
24	Populus tremuloides			

Community Types: 3

No.	Field Designation	VP 009	VP 010	VP 016	VP 052	VP 054	VP 006	VP 001	VP 029	VP 015
		Nat For	Nat For	Nat For above Faro Pit interceptor ditch	Nat For	Nat For boggy	Shrubland	Nat For	Nat For	Nat For cleared in winter
	TOTAL VEGETATION	**95**	**99**	**90**	**85**	**85**	**85**	**99**	**90**	**75**
139	**NUMBER OF SPECIES**	**18**	**13**	**13**	**14**	**37**	**27**	**17**	**31**	**22**
22	**Pleurozium** shreberi							60		
21	Abies lasiocarpa						0.5			
13	Peltigera sp									
16	Cladina mitis								10	
25	**Mertensia** paniculata	0.5	5	0.5			1	1	1	1
22	Potentilla fruticosa	5	5	0.5	1	10	5	10	1	1
20	Salix myrtillifolia	10	10	20	5	1	10	5	5	15
13	Salix reticulata	1	20		5	5	0.1		1	5
7	Carex scirpoidea		0.5				1			5.0
37	**Ledum** groenlandicum	5	10	1	5	5	1		15	1
35	Empetrum nigrum	1	10	5	1	1			10	5
34	Vaccinium vitis-idaea	1	1	5	5	1			1	1
30	Vaccinium uliginosum		15	5	5	1	5	0.1	5	5
24	Arctostaphylos rubra	1.0	1.0	1.0	1	5	5.0	1.0	5.0	0.5
40	Betula glandulosa	5	10	30	15	10	5	40	15	15
27	**Populus** balsamifera									
24	Salix arbusculoides									5
16	Salix bebbiana							15		
15	Agrostis scabra						1			
39	Salix planifolia	10							5	10
15	**Shepherdia** canadensis									
12	Linnaea borealis									
12	Pinus contorta									
9	Geocaulon lividum									
7	Calamagrostis inexpansa									
55	Picea glauca	10	15	10	5	1	0.5	10	1	1
54	Salix glauca		10	15	10	5		1	10	10
44	Epilobium angustifolium	1				0.1			1	0.5
31	Arctagrostis latifolia			1.0	1	1	1.0	1.0	1.0	1.0
30	Festuca altaica	5	1	1	1			5	1	5
24	Populus tremuloides						0.5			0.1

Community Types: 4

No.	Field Designation	VP 018	VP 014	VP 060	VP 043	VP 050
		Nat For	Tail pond breach	Nat For high bench	Nat For cleared in winter	Nat For Rose Cr riparian
	TOTAL VEGETATION	**99**	**10**	**90**	**85**	**90**
139	**NUMBER OF SPECIES**	**16**	**11**	**20**	**10**	**16**
22	**Pleurozium** shreberi					
21	Abies lasiocarpa	20	0.1		10	
13	Peltigera sp					
16	Cladina mitis					
25	**Mertensia** paniculata					
22	Potentilla fruticosa					1
20	Salix myrtillifolia			5	0.1	
13	Salix reticulata					
7	Carex scirpoidea					
37	**Ledum** groenlandicum	20	1	15	15	5
35	Empetrum nigrum	20	1	0.5	30	
34	Vaccinium vitis-idaea	1	0.5	5	5	
30	Vaccinium uliginosum	1	1			0.5
24	Arctostaphylos rubra			1		
40	Betula glandulosa	30	5		60	30
27	**Populus** balsamifera					
24	Salix arbusculoides			0.5		
16	Salix bebbiana					
15	Agrostis scabra					
39	Salix planifolia	1				
15	**Shepherdia** canadensis			5		
12	Linnaea borealis	0.5				
12	Pinus contorta					
9	Geocaulon lividum			1		
7	Calamagrostis inexpansa					
55	Picea glauca	5	1	10		10
54	Salix glauca		0.5	40	10	1
44	Epilobium angustifolium			1	1	
31	Arctagrostis latifolia	0.5	0.5			
30	Festuca altaica	0.5			0.5	5
24	Populus tremuloides					0.1

Community Types: 5

No.	Field Designation	VP 008	VP 021	VP 034	VP 028	VP 041	VP 024
		Disturbed	Disturbed	Disturbed	Disturbed below VanGorda Starter berm	Disturbed under powerlines	Disturbed till on dump
	TOTAL VEGETATION	**25**	**30**	**65**	**90**	**85**	**25**
139	**NUMBER OF SPECIES**	**16**	**20**	**19**	**32**	**26**	**20**
22	**Pleurozium** shreberi						
21	Abies lasiocarpa	0.5		1		0.5	
13	Peltigera sp						
16	Cladina mitis						
25	**Mertensia** paniculata				1		0.5
22	Potentilla fruticosa						1
20	Salix myrtillifolia	5					
13	Salix reticulata		0.5			5	
7	Carex scirpoidea						
37	**Ledum** groenlandicum	1	1	0.5	5		0.1
35	Empetrum nigrum	1	1	0.5	1	5	0.1
34	Vaccinium vitis-idaea		0.5	0.5	0.5		
30	Vaccinium uliginosum	1	1		0.5	1	
24	Arctostaphylos rubra		1.0				
40	Betula glandulosa	0.1		1	5	5	0.1
27	**Populus** balsamifera	1	10	5	10		10
24	Salix arbusculoides		5	1	5	0.1	1
16	Salix bebbiana		0.5	5	5	0.5	1
15	Agrostis scabra	1		1			0.5
39	Salix planifolia	10	5		10	10	1
15	**Shepherdia** canadensis		0.5				
12	Linnaea borealis						
12	Pinus contorta				0.1		
9	Geocaulon lividum						
7	Calamagrostis inexpansa						
55	Picea glauca	1	1		0.5		5
54	Salix glauca		5	10	10	10	5
44	Epilobium angustifolium		1	10	10	10	
31	Arctagrostis latifolia	0.5	0.5	1	1.0		1.0
30	Festuca altaica			0.5			
24	Populus tremuloides	0.1	0.5	0.5	0.5		

Community Types: 6

No.	Field Designation	VP 003	VP 011	VP 035	VP 012	VP 020	VP 030	VP 005	VP 019	VP 023	VP 026	VP 042	VP 031	VP 022	VP 039	VP 036	VP 047	VP 007	VP 013
		Disturbed Gravel pit	Disturbed Gravel pit	Disturbed till piles	Disturbed roadside	Disturbed top of Faro Pit	Disturbed top of VanGorda till pile	Disturbed till area	Disturbed top of Faro diversion on overburden	Disturbed Vege pockets on top of old dumps	Disturbed roadside	Disturbed Grum waste dump till bench	Disturbed	Disturbed top of Faro waste rock - poor rock	Disturbed old roads and shoulders	Disturbed old quarry	Disturbed old willow stand	Disturbed	Disturbed willow disturbed area below tailings dam
	TOTAL VEGETATION	**15**	**70**	**20**	**95**	**20**	**10**	**15**	**15**	**75**	**35**	**25**	**10**	**5**	**30**	**35**	**85**	**30**	**85**
139	**NUMBER OF SPECIES**	**23**	**31**	**16**	**17**	**13**	**19**	**12**	**18**	**15**	**17**	**21**	**21**	**13**	**17**	**15**	**9**	**14**	**11**
22	**Pleurozium** shreberi																		
21	Abies lasiocarpa								0.5							0.5			
13	Peltigera sp																		
16	Cladina mitis																		
25	**Mertensia** paniculata				15					1					0.5				
22	Potentilla fruticosa	0.5	0.5	0.1	0.5	0.5													
20	Salix myrtillifolia	0.5						1	0.5									1	
13	Salix reticulata																	0.5	
7	Carex scirpoidea							0.1											
37	**Ledum** groenlandicum																		
35	Empetrum nigrum								0.5										
34	Vaccinium vitis-idaea																		
30	Vaccinium uliginosum																		
24	Arctostaphylos rubra																		
40	Betula glandulosa	1	0.5			0.1									0.1		1		
27	**Populus** balsamifera	10	10	1	15	10	1	1	5	20	20	5	1	5	1	1	10	10	10
24	Salix arbusculoides		5	1	10				0.5	5	10	0.1	0.5	0.1	0.5	0.5	1	0.1	40
16	Salix bebbiana	0.1	5	1	10		0.5	0.5		5	0.5			1					
15	Agrostis scabra	5	5	1		1	1	5	0.5			5	1		1				
39	Salix planifolia		10	5	5	5	1	1	1	10	5	5	1		10	25	1	10	1
15	**Shepherdia** canadensis		0.5						0.1		0.1								
12	Linnaea borealis																		
12	Pinus contorta	0.1									1								
9	Geocaulon lividum																		
7	Calamagrostis inexpansa																		
55	Picea glauca	1	1			0.1	0.1	0.5	1	5		0.1	0.5	0.5			10	0.5	1
54	Salix glauca	0.1	10	5	10	5	1	1	1	10	10	5	1	1			60	10	30
44	Epilobium angustifolium	1	5	1	30	0.5	1		1	10	5	10	5		0.5	1	0.5	1	1
31	Arctagrostis latifolia	1.0	5.0	1		0.5	0.5	1.0	0.5	1.0	1.0	0.5	0.1			0.1		1.0	
30	Festuca altaica	1	0.1			0.5													
24	Populus tremuloides	0.5	5									0.1	0.5	0.1			0.5		

Community Types: 7

No.	Field Designation	VP 058	VP 070	VP 065	VP 066	VP 067	VP 068	VP 059	VP 057
		Nat For dry old burn	Nat For dry slope	Nat For Spruce Sheph	Nat For Low elev Pot trem clone	Nat For old burn Sheep outlook	Nat For old burn 1969?	Nat For 30 deg slope 168 deg exp	Nat For old burn
	TOTAL VEGETATION	**70**	**85**	**95**	**85**	**60**	**80**	**60**	**85**
139	**NUMBER OF SPECIES**	**12**	**18**	**12**	**10**	**14**	**14**	**17**	**24**
22	**Pleurozium** shreberi			70			30		
21	Abies lasiocarpa								
13	Peltigera sp								
16	Cladina mitis								
25	**Mertensia** paniculata	1					1		1
22	Potentilla fruticosa								
20	Salix myrtillifolia		1						
13	Salix reticulata								
7	Carex scirpoidea								
37	**Ledum** groenlandicum		1						1
35	Empetrum nigrum								0.1
34	Vaccinium vitis-idaea		5			1			
30	Vaccinium uliginosum								
24	Arctostaphylos rubra			1					10
40	Betula glandulosa								
27	**Populus** balsamifera		1				10		
24	Salix arbusculoides								
16	Salix bebbiana	5							
15	Agrostis scabra								
39	Salix planifolia		15	10					
15	**Shepherdia** canadensis	30	0.1	20	5	5	0.5	15	1
12	Linnaea borealis	1		1	1	1	5		1
12	Pinus contorta	10	5				20	0.5	
9	Geocaulon lividum	5	1	1			1		5
7	Calamagrostis inexpansa		0.5		20	5	10	10	1
55	Picea glauca		10	30		10	10		5
54	Salix glauca		5			15	15		10
44	Epilobium angustifolium	1	1	1	1	1	1		1
31	Arctagrostis latifolia								
30	Festuca altaica								5
24	Populus tremuloides	10	5		30	5	5	5	20

Community Types: 8

No.	Field Designation	VP 061	VP 046	VP 002	VP 004	VP 049	VP 051	VP 064
		Nat For low bench spruce	Nat For 200 deg Exp 35 deg slope	Disturbed 2004 test pit	Disturbed Grum overburden pile	Disturbed early seral on alluvium	Nat For lower Rose Creek	Nat For Old Spruce forest
	TOTAL VEGETATION	**90**	**85**	**50**	**20**	**75**	**75**	**99**
139	**NUMBER OF SPECIES**	**20**	**14**	**21**	**19**	**14**	**8**	**9**
22	**Pleurozium** shreberi	1					25	80
21	Abies lasiocarpa							
13	Peltigera sp							
16	Cladina mitis						15	10
25	**Mertensia** paniculata		1	10			0.5	1
22	Potentilla fruticosa			5			0.1	
20	Salix myrtillifolia			10	0.5			
13	Salix reticulata							
7	Carex scirpoidea							
37	**Ledum** groenlandicum							
35	Empetrum nigrum							
34	Vaccinium vitis-idaea						5	
30	Vaccinium uliginosum							
24	Arctostaphylos rubra	0.1				0.5		
40	Betula glandulosa			10			50	
27	**Populus** balsamifera				0.5	40		
24	Salix arbusculoides	10						
16	Salix bebbiana							
15	Agrostis scabra			1				
39	Salix planifolia				0.5	5		1
15	**Shepherdia** canadensis					0.1		
12	Linnaea borealis	5	5					
12	Pinus contorta							
9	Geocaulon lividum	1						5
7	Calamagrostis inexpansa		5					
55	Picea glauca	25	20			10	5	30
54	Salix glauca	10	10		1	20	0.5	
44	Epilobium angustifolium	1	1	0.5	1	1	0.5	0.5
31	Arctagrostis latifolia			1.0	1.0		1	
30	Festuca altaica		1	10			1	
24	Populus tremuloides		10					

		VP 017	VP 025	VP 027	VP 033	VP 037	VP 063	VP 040	VP 044	VP 069	VP 053	VP 055	VP 062	VP 038	VP 032	VP 045	VP 048	VP 056	VP 009	VP 010	VP 016	VP 052	VP 054	VP 006	VP 001	VP 029	VP 015	VP 018	VP 014	VP 060	VP 043	VP 050	VP 008	VP 021	VP 034	VP 028	VP 041	VP 024	VP 003	VP 011	VP 035	VP 012	VP 020	VP 030	VP 005	VP 019	VP 023	VP 026	VP 042	VP 031	VP 022	VP 039	VP 036	VP 047	VP 007	VP 013	VP 058	VP 070	VP 065	VP 066	VP 067	VP 068	VP 059	VP 057	VP 061	VP 046	VP 002	VP 004	VP 049	VP 051	VP 064
23	Equisetum arvense																0.5	1	1		10		1	1	0.5	1	0.5	0.5						0.5			5	0.5			1	15		1		0.5	10		1	0.5						1									20			1			
19	Achillea millifolium																								0.5							0.5			1	1			1	1		1		1	0.5			1		1		1	1		5					1			1		0.5		1	1			
19	Rosa acicularis	1	1				0.5			1					0.1											0.5				1						1		0.5						0.5													1	1	0.5	30			10	1	5	1					1
18	Erigeron acris																							0.5			1						0.5		1	0.5		1	0.5	0.5	1		1		0.5	1	0.5			1	0.5	1	1		1																
17	Epilobium latifolium																							1									5	1.0		0.5		1.0	1	0.5	0.5					1	1.0		1	1.0	0.5	1	1														1	0.5			
17	Cornus canadensis	1	30	0.1	1		1	1	1		0.5	1	0.1					1					1			1		1							0.5	5												1																							
16	Betula neoalaskana									10		0.1				0.1								0.5		0.1	0.1		1			1										0.1			0.1						0.1					0.5		5						0.1					1		15
14	Arctostaphylos uva-ursi																		1.0					1.0						10				5.0					0.1	5.0																	25	5			5	10	1	30		5	0.5				
13	Hedysarum mackenzii																					1	0.1		0.5							0.5							0.5	0.5		5										5	5							5				0.5	1				1		
13	Lupinus arcticus								1			1	1	5			1		1				0.5							1																												1			10	5			1	1					
13	Pedicularis labradorica					0.5			1					1				0.5					1				1					1				1	0.5													0.5								0.5						0.5	1						
13	Solidago multiradiata														0.5					0.5			0.5	1		0.5	1.0													1.0		1.0	0.5														1						1			1	1				
12	Senecio paupercaulus																						0.5	0.1	0.1	0.5										0.5	1			0.5						0.5				1		0.5	0.5											0.5							
11	Hordeum jubratum																																						0.5	1	5			1	10				20	5	0.5				1												0.5	10			
11	Petasites frigidus													0.5		1		0.5	0.5							1	0.5	1								0.5	1										0.5							1																	
11	Taraxacum officinale																							0.1										0.5	1	1				1		1		1				5	0.5			0.5			0.5																
10	Elymus trachycaulus																																		5				1	5			0.1	1				1				15	10		5													1			
10	Parnassia palustre																	1	1				1	5		1						0.5					1					1										0.5												0.5							
10	Pyrola secunda		0.5							1																					0.1																									1		1	1					0.5	0.5				0.5		1
10	Trisetum spicatum																						0.1								1					1					0.1		1			0.5			1		1																0.5	1			
9	Alnus crispa		0.5																					0.5												0.1		0.1		0.1						5		0.5													0.1										10
9	Salix barclayi									1								5												5		10					20			10									0.1												0.5	1									
8	Carex rossii																																			0.5		0.1	0.1																				0.5		1		1	1			1				
8	Ledum decumbens																		0.5	10	1			1		10	1	5	1																																										
8	Oxytropis deflexa																								1											1			1	1												15	15														1		5		
8	Poa palustris																							1														1	0.5							0.5			0.5	0.5	0.5																0.5				
7	Carex aquatilis																	1				10	5			1			0.5			30					0.5																																		
7	Crepis elegans																																					0.5	0.5					0.5					1	1					0.1													0.5			
7	Polytrichum juniperinum			5	5	10	5		10				1									5																																																	
7	Stellaria longipes																																0.1				0.5							0.5	0.1				1																		0.1	1			
6	Carex phaeocephala																		1																	1				0.5										0.5	0.1																1				
6	Gentiana propinqua													1													0.5													0.1		0.5						0.5																1							
6	Lycopodium annotinum			1	0.5				0.5			1	1																		0.1																																								
6	Rubus arcticus																	1								0.5				0.1							5																												5		0.5				
5	Descurainia sophia																			0.5																								0.5						1					0.1													1			
5	Mosses & Lichens, other										40							90					20							30																															20										
5	Platanthera hyperborea																						0.5	1																													0.1			0.1													1		
5	Poa alpina																																1						1	0.1	0.5												0.5																		
5	Pyrola asarifolia																	1					0.1														0.1																			1									1						
5	Pyrola chlorantha		0.5																						1					0.1						1											0.1																								
5	Viburnum edule																																																								5		1					10	5	1					
4	Artemesia norvegica								1																										0.5															0.1													5								
4	Calamagrostis canadensis																													15		15					30					1																													
4	Carex mertensii													0.1									0.5																								0.5																					0.5			
4	Cladonia rangiferina			1	5							5		20																																																									
4	Equisetum sylvaticum																									1										1	5											5																							
4	Erigeron humilis																0.1	0.1																								0.1																									1				
4	Luzula parviflora																		1													0.5	5				1																																		
4	Lycopodium complanaum		0.5	1					0.5			1																																																											
4	Stereocaulon	5				10		10	5																																																														
4	Tofieldia pusilla																	0.5					1	1																																												0.1			
3	Aconitum delphinifolium																								0.5																																										1			0.1	
3	Agoseris glauca													0.5				0.1					0.1																																																
3	Brayea ???													0.5		1	0.1																																																						
3	Carex atrata																				0.5	1			1																																														
3	Dryas drummondii																																					0.1			1					0.5																									
3	Juniperus communis																																	0.5																														10		5					
3	Monesus uniflora																			0.5																1																													1						
3	Oxytropis campestris																																																			0.5	5										1								
3	Poa pratensis																																				5										0.5																					1			
3	Polygonum viviparum																						1	1													1																																		
3	Rubus chamaemorus																						1			0.5		1																																											
3	Sphagnum																						50			20		80																																											
3	Vaccinium oxycoccus																	1					1			1																																													
2	Anemone multifida													1																																																	1								
2	Bromus pumpillianus																													5																														5											

		VP 017	VP 025	VP 027	VP 033	VP 037	VP 063	VP 040	VP 044	VP 069	VP 053	VP 055	VP 062	VP 038	VP 032	VP 045	VP 048	VP 056
2	Calamagrostis rubescens																	
2	Carex aeneta															0.1		
2	Carex black & green																	
2	Carex capillaris													0.5				
2	Dodecatheon frigidum													1				
2	Eriophorum vaginatum																	0.1
2	Fragaria glauca																	
2	Galium boreale																	
2	Kalmia polifolia																	
2	Lycopodium clavatum										0.5	1						
2	Poa arctica																	
2	Puccinellia nuttalliana																	
2	Rubus idaeus																	
1	Agrostis alba																	
1	Anemone parviflora																	
1	Arabis hirsuta																	
1	Arabis holboellii																	
1	Aster sibiricus																	
1	Boutellia ???																	
1	Carex rostrata																	
1	Cassiope mertensii													15				
1	Cerastium beeringianum																	
1	Cladina stellaris																	
1	Cornus stolonifera																	
1	Cypripedium ???																	
1	Dicranum																	
1	Elymus glauca																	
1	Erigeron peregrinus																	
1	Geum macrophyllum																	
1	Goodyera repens		0.1															
1	Helictotrichon hookeri								1									
1	Hieracium gracile (yellow)																	
1	Hylocomium splendens		10															
1	Lycopodum selago																	
1	Pedicularis bracteosa																	
1	Penstamon gormanii																	
1	Picea mariana												10					
1	Poa glauca																	
1	Polemonium pulcherrinum																	
1	Polypogon moss						1											
1	Potentilla biennis																	
1	Potentilla norvegica																	
1	Potentilla nivea																	
1	Ranunculus aquatilis																	
1	Ribes lacuste																	
1	Rumex arcticus																	
1	Salix polaris																	
1	Salix scouleriana																	
1	Senecio triangularis																	
1	Spiranthes romanzoffiana																	
1	Vernonica wormskoldsii																	

		VP 009	VP 010	VP 016	VP 052	VP 054	VP 006	VP 001	VP 029	VP 015	VP 018	VP 014	VP 060	VP 043	VP 050	VP 008	VP 021	VP 034	VP 028	VP 041	VP 024
2	Calamagrostis rubescens																				
2	Carex aeneta					0.5															
2	Carex black & green	0.5						1													
2	Carex capillaris					5															
2	Dodecatheon frigidum						0.5														
2	Eriophorum vaginatum								0.1												
2	Fragaria glauca																				
2	Galium boreale																				
2	Kalmia polifolia					1	0.1														
2	Lycopodium clavatum																				
2	Poa arctica																				
2	Puccinellia nuttalliana																				
2	Rubus idaeus						0.1														
1	Agrostis alba																				
1	Anemone parviflora						1.0														
1	Arabis hirsuta																				
1	Arabis holboellii																				
1	Aster sibiricus																				
1	Boutellia ???																				
1	Carex rostrata					1															
1	Cassiope mertensii																				
1	Cerastium beeringianum																				
1	Cladina stellaris								1												
1	Cornus stolonifera																				
1	Cypripedium ???																				
1	Dicranum								10												
1	Elymus glauca																				
1	Erigeron peregrinus																				
1	Geum macrophyllum																				
1	Goodyera repens																				
1	Helictotrichon hookeri																				
1	Hieracium gracile (yellow)																				
1	Hylocomium splendens																				
1	Lycopodum selago					0.1															
1	Pedicularis bracteosa															0.5					
1	Penstamon gormanii																				
1	Picea mariana																				
1	Poa glauca																				
1	Polemonium pulcherrinum																			0.5	
1	Polypogon moss																				
1	Potentilla biennis																				
1	Potentilla norvegica																				
1	Potentilla nivea																				
1	Ranunculus aquatilis																			0.1	
1	Ribes lacuste												0.5								
1	Rumex arcticus								0.5												
1	Salix polaris																				
1	Salix scouleriana																				
1	Senecio triangularis																			1	
1	Spiranthes romanzoffiana					0.5															
1	Vernonica wormskoldsii					0.5															

		VP 003	VP 011	VP 035	VP 012	VP 020	VP 030	VP 005	VP 019	VP 023	VP 026	VP 042	VP 031	VP 022	VP 039	VP 036	VP 047	VP 007	VP 013
2	Calamagrostis rubescens																		
2	Carex aeneta																		
2	Carex black & green																		
2	Carex capillaris																		
2	Dodecatheon frigidum																		
2	Eriophorum vaginatum																		
2	Fragaria glauca																		
2	Galium boreale																		
2	Kalmia polifolia																		
2	Lycopodium clavatum																		
2	Poa arctica						0.5								0.5				
2	Puccinellia nuttalliana			1								1							
2	Rubus idaeus										1								
1	Agrostis alba						1												
1	Anemone parviflora																		
1	Arabis hirsuta																		
1	Arabis holboellii																		
1	Aster sibiricus																		
1	Boutellia ???											0.1							
1	Carex rostrata																		
1	Cassiope mertensii																		
1	Cerastium beeringianum																		
1	Cladina stellaris																		
1	Cornus stolonifera																		
1	Cypripedium ???																		
1	Dicranum																		
1	Elymus glauca																		
1	Erigeron peregrinus																		
1	Geum macrophyllum				10														
1	Goodyera repens																		
1	Helictotrichon hookeri																		
1	Hieracium gracile (yellow)											0.5							
1	Hylocomium splendens																		
1	Lycopodum selago																		
1	Pedicularis bracteosa																		
1	Penstamon gormanii																		
1	Picea mariana																		
1	Poa glauca																		
1	Polemonium pulcherrinum																		
1	Polypogon moss																		
1	Potentilla biennis		1																
1	Potentilla norvegica																		
1	Potentilla nivea																		
1	Ranunculus aquatilis																		
1	Ribes lacuste																		
1	Rumex arcticus																		
1	Salix polaris		0.1																
1	Salix scouleriana																		
1	Senecio triangularis																		
1	Spiranthes romanzoffiana																		
1	Vernonica wormskoldsii																		

		VP 058	VP 070	VP 065	VP 066	VP 067	VP 068	VP 059	VP 057	VP 061	VP 046	VP 002	VP 004	VP 049	VP 051	VP 064
2	Calamagrostis rubescens			0.5												0.5
2	Carex aeneta															
2	Carex black & green															
2	Carex capillaris															
2	Dodecatheon frigidum															
2	Eriophorum vaginatum															
2	Fragaria glauca							1		1						
2	Galium boreale				1			1								
2	Kalmia polifolia															
2	Lycopodium clavatum															
2	Poa arctica															
2	Puccinellia nuttalliana															
2	Rubus idaeus															
1	Agrostis alba															
1	Anemone parviflora															
1	Arabis hirsuta												1.0			
1	Arabis holboellii												1.0			
1	Aster sibiricus						0.5									
1	Boutellia ???															
1	Carex rostrata															
1	Cassiope mertensii															
1	Cerastium beeringianum											1				
1	Cladina stellaris															
1	Cornus stolonifera									0.5						
1	Cypripedium ???													1		
1	Dicranum															
1	Elymus glauca												0.1			
1	Erigeron peregrinus										0.5					
1	Geum macrophyllum															
1	Goodyera repens															
1	Helictotrichon hookeri															
1	Hieracium gracile (yellow)															
1	Hylocomium splendens															
1	Lycopodum selago															
1	Pedicularis bracteosa															
1	Penstamon gormanii							0.5								
1	Picea mariana															
1	Poa glauca							1								
1	Polemonium pulcherrinum															
1	Polypogon moss															
1	Potentilla biennis															
1	Potentilla norvegica											1				
1	Potentilla nivea							0.1								
1	Ranunculus aquatilis															
1	Ribes lacuste															
1	Rumex arcticus															
1	Salix polaris															
1	Salix scouleriana	10														
1	Senecio triangularis															
1	Spiranthes romanzoffiana															
1	Vernonica wormskoldsii															

Appendix B. Photos of Vegetation Types


Photo 1. Plot VP032 – Vegetation Type 1


Photo 2. Plot VP025 – Vegetation Type 1


Photo 3. Plot VP033 – Vegetation Type 1


Photo 4. Plot VP038 – Vegetation Type 1


Photo 5. Plot VP044 – Vegetation Type 1


Photo 6. Plot VP062 – Vegetation Type 1

Photos 1-6. Examples of Vegetation Type 1, a cool, moist, undisturbed forest type.

Photo 7. Plot VP045 -- Vegetation Type 2

Photo 8. Plot VP056 – Vegetation Type 2

Photo 9. Plot VP048 – Vegetation Type 2

Photo 10. Plot VP001 – Vegetation Type 3

Photo 11. Plot VP052 – Vegetation Type 3

Photo 12. Plot VP009 – Vegetation Type 3

Photos 7-12. Examples of Vegetation Types 2 and 3, also cool, moist, older forest types.


Photo 13. Plot VP015 – Vegetation Type 3


Photo 14. Plot VP016 – Vegetation Type 3


Photo 15. Plot VP014 – Vegetation Type 4


Photo 16. Plot VP018 – Vegetation Type 4


Photo 17. Plot VP043 – Vegetation Type 4


Photo 18. Plot VP060 – Vegetation Type 4

Photos 13-18. Examples of Vegetation Types 3 and 4, a somewhat disturbed, moist forest type.


Photo 19. Plot VP008 – Vegetation Type 5


Photo 20. Plot VP021 – Vegetation Type 5


Photo 21. Plot VP024 – Vegetation Type 5


Photo 22. Plot VP028 – Vegetation Type 5


Photo 23. Plot VP003 – Vegetation Type 6.


Photo 24. Plot VP011 – Vegetation Type 6.

Photos 19-24. Examples of Vegetation Types 5 and 6, characteristic of disturbed sites.


Photo 25. Plot VP057 – Vegetation Type 7


Photo 26. Plot VP058 – Vegetation Type 7


Photo 27. Plot VP066 – Vegetation Type 7


Photo 28. Plot VP070 – Vegetation Type 7


Photo 29. Plot VP064 – Vegetation Type 8


Photo 30. Plot VP046 – Vegetation Type 8

Photos 25-30. Examples of Vegetation Type 7, characteristic of dry forests, and Type 8.

Appendix C. Soil Sampling Sites and Analytical Results

Tabulated Analytical Results

Sample	Plot Location		Gravel		Sand	Silt < 53 microns	Clay	pH	EC
	Lat.	Long.	>2 mm %	< 2 mm %	<2 mm %	%	<2 microns %	pH	mmhos/cm
BO2-18	-133.466	62.360	30.1	69.9	46.3	44.6	9.1	6.5	0.22
BO2-22	-133.457	62.358	48.0	52.0	67.6	25.5	6.9	7.2	0.24
BO2-22A	-133.457	62.358	59.6	40.4	81.2	15.0	3.8	7.5	0.26
BO2-25	-133.449	62.355	33.5	66.5	58.0	34.4	7.6	7.0	0.34
BO2-29	-133.417	62.348	41.7	58.3	43.3	44.8	11.9	7.0	0.32
BO2-3	-133.484	62.363		100.0	70.0	24.7	5.3	6.4	0.18
BO2-30	-133.412	62.347	6.9	93.1	23.4	58.2	18.4	5.7	0.68
BO2-30A	-133.412	62.347	16.5	83.5	27.7	51.0	21.3	6.2	0.84
BO2-32	-133.409	62.349	54.7	45.3	63.3	30.4	6.3	6.3	0.28
BO2-33	-133.409	62.348	35.2	64.8	49.6	41.9	8.5	7.6	0.26
BO2-34	-133.400	62.347	41.8	58.2	41.1	44.5	14.4	8.0	0.42
BO2-35	-133.388	62.343	29.9	70.1	44.7	45.9	9.4	7.5	0.28
BO2-36	-133.389	62.341	23.4	76.6	47.0	43.0	10.0	7.8	0.42
BO2-38	-133.358	62.335	57.0	43.0	57.0	36.3	6.7	8.1	0.30
BO2-40	-133.356	62.334	39.7	60.3	48.5	42.2	9.3	7.9	0.30
BO2-41	-133.360	62.337	40.8	59.2	46.6	42.9	10.5	7.8	0.30
BO2-5	-133.480	62.361	1.3	98.7	41.0	46.3	12.7	5.2	0.14
GROCK-1	-133.220	62.254	37.2	62.8	47.7	40.6	11.7	8.0	0.38
GROCK-2	-133.223	62.252	39.8	60.2	38.0	51.2	10.8	8.0	0.42
GRUM-10	-133.206	62.259	32.9	67.1	41.0	41.5	17.5	7.9	0.94
GRUM-2	-133.211	62.263	40.0	60.0	47.5	36.9	15.6	7.9	0.60
GRUM-3	-133.212	62.263	49.4	50.6	63.9	26.8	9.3	7.9	0.50
GRUM-5	-133.203	62.260	15.3	84.7	46.5	36.0	17.5	8.0	0.40
GRUM-6	-133.200	62.258	57.1	42.9	42.4	39.3	18.3	8.0	0.46
GRUM-7	-133.212	62.258	41.8	58.2	41.2	40.1	18.7	7.8	1.10
GRUM-8	-133.207	62.263	74.0	26.0	55.8	31.7	12.5	7.8	1.02
GRUM-9	-133.210	62.261	49.2	50.8	45.6	40.0	14.4	8.1	0.34
VA2-2B	-133.197	62.244	38.9	61.1	43.7	38.2	18.1	8.0	0.96
VAN-1	-133.197	62.243	41.2	58.8	36.8	40.9	22.3	8.0	1.38
VAN-2A	-133.198	62.244	42.9	57.1	43.6	38.1	18.3	8.0	0.88
VAN-3A	-133.198	62.243	55.3	44.7	85.1	11.5	3.4	7.3	0.88
VAN-3B	-133.198	62.243	55.2	44.8	83.7	12.5	3.8	7.8	0.68
VAN-4	-133.199	62.243	48.8	51.2	46.0	36.7	17.3	7.8	1.24
VAN-94	-133.197	62.243	40.9	59.1	37.6	42.2	20.2	8.0	0.88
VANOB-1	-133.191	62.247	34.4	65.6	34.2	44.7	21.1	8.2	0.30
VANOB-2	-133.187	62.245	44.6	55.4	59.1	30.1	10.8	2.1	16.00
VANOB-3	-133.188	62.245	38.1	61.9	31.8	40.4	27.8	7.7	3.16
VANOB-4	-133.189	62.246	50.5	49.5	38.5	47.4	14.1	7.8	1.82
VANOB-5	-133.189	62.246	30.4	69.6	48.1	41.4	10.5	7.2	12.80
VP-004	-133.210	62.263	44.6	55.4	47.2	35.4	17.4	7.8	0.58
VP-005	-133.208	62.264	33.8	66.2	41.5	43.7	14.8	7.6	1.08
VP-009	-133.358	62.344	6.3	93.7	69.9	23.9	6.2	5.4	0.80
VP-023 S	-133.366	62.343	90.1	9.9	58.5	32.3	9.2	7.5	0.56
VP-024 S	-133.380	62.346	78.9	21.1	62.6	29.7	7.7	5.6	0.30
VSB-1	-133.199	62.242	46.3	53.7	31.5	59.2	9.3	8.0	0.52
VSB-2	-133.207	62.245	56.4	43.6	59.8	32.3	7.9	2.4	11.00
VSB-3	-133.206	62.246	40.3	59.7	39.0	46.0	15.0	7.3	3.40

Sample	Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
BO2-18	0.6	9.5	163	< 1	0.3	39	14	36	21.7
BO2-22	0.6	29.4	125	< 1	0.3	32	12	25	20.5
BO2-22A	0.5	20.8	92	< 1	0.2	34	13	25	20.2
BO2-25	< 0.1	7.7	129	< 1	< 0.2	19	7	23	13.8
BO2-29	0.6	9.3	194	< 1	0.4	40	13	35	21.9
BO2-3	< 0.1	6.4	130	< 1	0.6	33	12	21	32.8
BO2-30	0.7	11.4	327	< 1	0.3	33	10	33	142
BO2-30A	0.5	9.2	355	< 1	0.6	38	13	40	17.3
BO2-32	< 0.1	7.9	220	< 1	< 0.2	43	15	26	86.2
BO2-33	0.5	8.2	184	< 1	0.3	38	12	31	13.5
BO2-34	0.7	9.5	215	< 1	0.4	43	13	34	75.8
BO2-35	< 0.1	7	175	< 1	< 0.2	38	12	27	18.9
BO2-36	0.6	8.3	205	< 1	0.4	31	12	31	73.9
BO2-38	0.7	23	144	< 1	0.4	53	18	41	12.2
BO2-40	< 0.1	11.8	205	< 1	0.4	46	20	45	14.9
BO2-41	0.5	8.3	199	< 1	0.3	38	14	33	14.4
BO2-5	< 0.1	6.2	155	< 1	0.6	40	11	19	39.5
GROCK-1	0.5	17.1	189	< 1	0.3	44	13	26	33.1
GROCK-2	0.8	9.4	260	< 1	0.6	38	15	31	39.5
GRUM-10	< 0.1	8.3	225	< 1	0.4	21	9	18	12.3
GRUM-2	< 0.1	10.4	199	< 1	0.4	29	12	23	20.3
GRUM-3	< 0.1	14.6	111	< 1	0.3	30	14	24	11.6
GRUM-5	< 0.1	8.6	216	< 1	0.3	21	8	16	28.6
GRUM-6	0.5	8.8	211	< 1	0.4	24	10	21	12.7
GRUM-7	0.6	26.6	211	< 1	0.5	33	15	31	20.2
GRUM-8	0.7	12.7	142	< 1	0.4	35	13	24	60.2
GRUM-9	< 0.1	9.2	103	< 1	< 0.2	38	11	24	16.2
VA2-2B	0.5	13.5	185	< 1	0.3	33	11	21	35.3
VAN-1	1.2	29.6	247	< 1	0.6	95	17	41	278
VAN-2A	0.6	14.4	213	< 1	0.5	31	11	23	47.9
VAN-3A	1	23.9	182	< 1	0.4	23	10	42	56
VAN-3B	< 0.1	8.9	123	< 1	0.3	20	8	19	29.4
VAN-4	1.8	495	304	< 1	1.2	29	18	34	207
VAN-94	1.9	36.7	305	< 1	1.1	105	18	47	748
VANOB-1	0.9	18.4	195	< 1	0.5	103	17	32	28
VANOB-2	53.3	1080	11	< 1	1.5	13	32	626	13000
VANOB-3	1.2	19.1	242	< 1	0.7	65	13	37	78.8
VANOB-4	2.1	54.4	330	< 1	1	35	12	84	404
VANOB-5	8.5	282	22	< 1	11.3	37	19	148	3000
VP-004	< 0.1	9	186	< 1	0.4	29	11	26	20.3
VP-005	1.9	36.9	279	< 1	1.1	35	14	41	312
VP-009	< 0.1	6.3	128	< 1	< 0.2	20	9	20	9.6
VP-023 S	1.1	23.2	140	< 1	1.2	27	17	95	847
VP-024 S	0.8	26.5	154	< 1	0.9	33	17	86	333
VSB-1	0.8	23.6	199	< 1	0.4	106	20	37	24.6
VSB-2	32.8	545	8	< 1	< 0.2	38	49	174	5570
VSB-3	6	133	59	< 1	0.7	72	21	90	1070

Sample	Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g
BO2-18	12900	< 1	5910	25300	7360	483	735	590
BO2-22	13400	< 1	5930	23200	6710	352	412	1080
BO2-22A	12800	< 1	5210	22200	7100	354	443	1040
BO2-25	9400	< 1	7650	15300	3620	216	439	882
BO2-29	13900	< 1	5430	24700	7260	405	912	1450
BO2-3	13100	< 1	3660	23500	5840	386	615	902
BO2-30	12900	< 1	8800	22900	5660	283	605	1200
BO2-30A	15700	< 1	8970	24500	6100	502	629	1420
BO2-32	20100	< 1	4500	28500	10200	512	259	1950
BO2-33	16300	< 1	7020	25600	7880	349	772	2050
BO2-34	13800	< 1	18300	25200	8370	379	594	1970
BO2-35	14800	< 1	4640	23800	6530	339	556	975
BO2-36	11600	< 1	11900	22800	5790	385	1100	1660
BO2-38	12700	< 1	12100	29100	6850	340	831	1810
BO2-40	17300	< 1	11700	31800	6950	454	764	2810
BO2-41	13500	< 1	9480	26500	6690	334	589	2220
BO2-5	17300	< 1	2380	26000	6690	355	723	869
GROCK-1	13200	< 1	7860	25500	9050	345	522	1500
GROCK-2	11700	< 1	6360	24200	7810	371	651	1200
GRUM-10	11600	< 1	7350	21100	5480	349	539	1520
GRUM-2	13200	< 1	7430	23900	6720	369	556	1610
GRUM-3	13800	< 1	6880	27300	8140	392	474	1110
GRUM-5	10500	< 1	6570	18300	5260	299	533	1340
GRUM-6	12200	< 1	7760	22300	5970	350	595	1530
GRUM-7	13600	< 1	13200	27100	8290	445	724	1580
GRUM-8	11500	< 1	11300	26700	8990	381	524	1190
GRUM-9	12800	< 1	6090	23500	7050	297	498	2300
VA2-2B	12400	< 1	7330	22400	6660	336	669	1500
VAN-1	13900	< 1	17100	27800	12600	408	583	1020
VAN-2A	11700	< 1	6760	23300	6500	349	534	1550
VAN-3A	9200	< 1	6180	19900	4030	293	537	1570
VAN-3B	8640	< 1	5540	17800	4320	262	484	1420
VAN-4	11500	< 1	6970	25400	6230	402	555	1460
VAN-94	14300	< 1	18200	31100	13100	454	637	1080
VANOB-1	13900	< 1	19000	26100	14200	425	601	1160
VANOB-2	2590	< 1	5860	94700	1310	61	161	890
VANOB-3	12500	< 1	17600	24100	10400	388	709	1290
VANOB-4	11500	< 1	7580	26300	7500	378	757	1080
VANOB-5	9000	< 1	12300	38100	9880	493	667	814
VP-004	13300	< 1	7200	25300	6940	385	572	1630
VP-005	12100	< 1	7230	29300	7620	463	624	1310
VP-009	9290	< 1	3740	19000	3720	266	523	986
VP-023 S	11200	< 1	8570	32000	6190	427	560	1700
VP-024 S	15200	< 1	3970	34200	6550	354	476	2320
VSB-1	14500	< 1	22600	29500	11800	466	571	1110
VSB-2	6230	< 1	10500	117000	3930	99	302	945
VSB-3	13100	< 1	16500	38900	9580	375	569	1030

Sample	Hg ug/g	Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g
BO2-18	0.03	0.8	36	0.6	< 0.1	0.1	< 5	38	79
BO2-22	0.02	0.7	35	0.6	0.1	0.2	< 5	33	66
BO2-22A	0.02	0.7	36	0.4	< 0.1	0.2	< 5	29	69
BO2-25	0.03	0.9	21	0.7	0.1	0.1	< 5	23	38
BO2-29	0.04	0.8	46	0.5	0.1	0.2	< 5	34	78
BO2-3	0.02	0.5	32	0.4	0.1	0.2	< 5	31	96
BO2-30	0.12	0.9	30	0.8	0.3	0.2	< 5	32	109
BO2-30A	0.05	1	47	1.1	0.1	0.2	< 5	39	95
BO2-32	0.05	0.6	42	0.4	< 0.1	0.3	< 5	38	133
BO2-33	0.03	1	39	0.5	0.1	0.2	< 5	36	72
BO2-34	0.09	1.1	47	0.7	0.2	0.2	< 5	34	109
BO2-35	0.03	1.1	36	0.5	< 0.1	0.2	< 5	33	63
BO2-36	0.06	1.1	35	0.5	0.2	0.2	< 5	30	137
BO2-38	0.02	5.2	80	1	0.1	0.3	< 5	50	72
BO2-40	0.04	2.5	78	1.8	0.2	0.4	< 5	62	78
BO2-41	0.04	1.3	45	0.5	0.1	0.2	< 5	39	71
BO2-5	0.03	0.8	30	0.4	0.2	0.2	< 5	39	120
GROCK-1	0.03	0.5	44	0.5	0.1	0.2	< 5	27	92
GROCK-2	0.06	0.8	45	0.7	0.1	0.2	< 5	31	121
GRUM-10	0.03	0.9	22	0.6	< 0.1	0.1	< 5	28	65
GRUM-2	0.03	0.5	31	0.5	< 0.1	0.1	< 5	30	115
GRUM-3	0.02	0.4	33	0.4	< 0.1	0.1	< 5	23	71
GRUM-5	0.05	0.5	22	0.5	< 0.1	0.1	< 5	26	72
GRUM-6	0.03	0.6	24	0.5	< 0.1	0.1	< 5	31	67
GRUM-7	0.04	0.7	40	0.8	0.1	0.1	< 5	31	86
GRUM-8	0.08	0.7	37	0.5	0.1	0.2	< 5	23	278
GRUM-9	0.01	0.3	32	0.3	< 0.1	0.2	< 5	24	71
VA2-2B	0.03	0.6	31	0.4	0.1	0.2	< 5	28	104
VAN-1	0.11	0.9	86	0.7	0.3	0.2	< 5	37	147
VAN-2A	0.06	0.6	32	0.5	0.1	0.2	< 5	27	164
VAN-3A	0.04	0.7	24	0.4	0.2	0.2	< 5	23	177
VAN-3B	0.02	0.6	21	0.4	0.1	0.2	< 5	23	93
VAN-4	0.13	0.9	33	0.6	0.3	0.4	< 5	27	489
VAN-94	0.14	1.2	88	0.8	0.6	0.2	< 5	38	378
VANOB-1	0.06	0.7	93	0.7	0.2	0.1	< 5	38	93
VANOB-2	19.4	7	9	1.9	46.6	4.8	< 5	12	1260
VANOB-3	0.14	1.2	61	1.5	0.3	0.2	< 5	38	112
VANOB-4	0.18	1.2	38	0.7	0.4	0.6	< 5	32	293
VANOB-5	1.48	1.8	49	0.9	3.6	0.9	< 5	31	3240
VP-004	0.03	0.6	29	0.5	0.1	0.2	< 5	28	84
VP-005	0.41	0.9	41	0.7	0.5	0.3	< 5	30	609
VP-009	0.02	0.8	23	0.4	0.1	0.1	< 5	25	283
VP-023 S	0.32	0.8	31	0.8	0.7	0.4	< 5	33	775
VP-024 S	0.23	0.9	33	0.6	0.4	0.4	< 5	35	1280
VSB-1	0.05	0.8	97	0.6	0.1	0.2	< 5	37	92
VSB-2	4.71	3	24	1.3	20.9	1	< 5	21	180
VSB-3	0.66	1.4	62	0.9	2.6	0.4	< 5	33	313

Sample	Na ug/g	Sr ug/g	Ti ug/g	Zr ug/g
BO2-18	170	31	176	2
BO2-22	256	35	241	2
BO2-22A	313	31	246	2
BO2-25	248	34	285	1
BO2-29	310	32	241	4
BO2-3	242	29	326	2
BO2-30	262	46	231	2
BO2-30A	265	41	373	1
BO2-32	367	30	436	3
BO2-33	375	39	379	4
BO2-34	216	59	207	5
BO2-35	349	29	290	2
BO2-36	233	49	255	3
BO2-38	165	45	217	4
BO2-40	407	52	330	5
BO2-41	161	44	335	2
BO2-5	93	18	251	< 1
GROCK-1	116	33	272	7
GROCK-2	99	31	278	7
GRUM-10	194	30	289	6
GRUM-2	152	30	301	7
GRUM-3	139	27	143	4
GRUM-5	166	28	274	6
GRUM-6	178	31	303	6
GRUM-7	149	52	176	5
GRUM-8	102	38	189	7
GRUM-9	87	30	326	7
VA2-2B	145	29	262	7
VAN-1	87	60	133	6
VAN-2A	136	29	225	7
VAN-3A	181	46	317	2
VAN-3B	157	38	246	2
VAN-4	143	33	208	7
VAN-94	91	60	151	6
VANOB-1	106	67	182	5
VANOB-2	146	18	126	4
VANOB-3	97	63	114	6
VANOB-4	134	35	231	6
VANOB-5	101	36	193	5
VP-004	182	30	266	5
VP-005	91	33	231	6
VP-009	147	26	251	2
VP-023 S	239	40	247	4
VP-024 S	340	27	412	3
VSB-1	73	71	138	5
VSB-2	87	36	132	5
VSB-3	82	54	134	6

Expanded Analytical Results

Table of Contents

Note: Coordinates provided are in UTM, aone 8V, datum NAD83. SRK plot coordinates and mapping has historically been in NAD27.

SITE BO2 – 3

Date Sampled: July 20, 2007

UTM: 578465 E 6915485 N

Description: test pit downstream on Rose Ck. Sampling of silty, organically enriched materials reported by SRK in Rose Pit West. Sample is surface sample (approx. 5-15 cm bgs).

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 63 microns %	< 4 microns %	pH	mmhos/cm
	100.0	70.0	24.7	5.3	6.4	0.18

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	6.4	130	< 1	0.6	33	12	21	32.8
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13100	< 1	3660	23500	5840	386	615	902	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.5	32	0.4	0.1	0.2	< 5	31	96	242
Sr ug/g	Ti ug/g	Zr ug/g						
29	326	2						

SITE BO2 – 5

Date Sampled: July 20, 2007

UTM: 578642 E 6915374 N

Description: test pit downstream on Rose Ck. Also in Rose Pit West. Sample is surface sample (approx. 5-20 cm bgs).

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
1.3	98.7	41.0	46.3	12.7	5.2	0.14

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	6.2	155	< 1	0.6	40	11	19	39.5
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
17300	< 1	2380	26000	6690	355	723	869	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	30	0.4	0.2	0.2	< 5	39	120	93
Sr ug/g	Ti ug/g	Zr ug/g						
18	251	< 1						

SITE BO2 – 6

Date Sampled: July 20, 2007

UTM: 578845 E 6915400 N

Description: test pit, granular F^G, not suitable – Rose Ck. Borrow

Photo:

Sample: not taken

SITE VP – 004

Date Sampled: July 20, 2007

UTM: 592949 E 6904715 N

Description: Sample from surface material on the Grum Overburden Dump. Sample is surface sample (approx. 0-20 cm bgs).

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
44.6	55.4	47.2	35.4	17.4	7.8	0.58

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	9	186	< 1	0.4	29	11	26	20.3
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13300	< 1	7200	25300	6940	385	572	1630	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.6	29	0.5	0.1	0.2	< 5	28	84	182
Sr ug/g	Ti ug/g	Zr ug/g						
30	266	5						

SITE GRUM – 2

Date Sampled: July 20, 2007

UTM: 592881 E 6904747 N

Description: Sample is from cutbank wall on Grum Overburden Dump to collect material from greater depth than on dump surface – collected at approx. 4 m below overall dump surface.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
40.0	60.0	47.5	36.9	15.6	7.9	0.60

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	10.4	199	< 1	0.4	29	12	23	20.3
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13200	< 1	7430	23900	6720	369	556	1610	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.5	31	0.5	< 0.1	0.1	< 5	30	115	152
Sr ug/g	Ti ug/g	Zr ug/g						
30	301	7						

SITE GRUM – 3

Date Sampled: July 20, 2007

UTM: 592816 E 6904720 N

Description: Sample from top 20 cm of brown, sandier till overlying the grey, finer-textured Grum overburden.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
49.4	50.6	63.9	26.8	9.3	7.9	0.50

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	14.6	111	< 1	0.3	30	14	24	11.6
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
< 1	6880	27300	8140	392	474	1110	< 1	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.4	33	0.4	< 0.1	0.1	< 5	23	71	139
Sr ug/g	Ti ug/g	Zr ug/g						
27	143	4						

SITE VP 005

Date Sampled: July 20, 2007

UTM: 593037 E 6904877 N

Description: seeded portion from E. Side of Grum dump, sample from 50 cm depth bgs. Typical grey, finer-textured till Grum overburden. This sample exceeds YTCSR for zinc – 600 ppm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
33.8	66.2	41.5	43.7	14.8	7.6	1.08

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
1.9	36.9	279	< 1	1.1	35	14	41	312
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12100	< 1	7230	29300	7620	463	624	1310	0.41
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	41	0.7	0.5	0.3	< 5	30	609	91
Sr ug/g	Ti ug/g	Zr ug/g						
33	231	6						

SITE GRUM 5

Date Sampled: July 20, 2007

UTM: 593330 E 6904476 N

Description: Sample from Grum Overburden Dump; like Grum-2, this sample collected from bank and eroding fan at base, to collect non-surface material.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
15.3	84.7	46.5	36.0	17.5	8.0	0.40

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	8.6	216	< 1	0.3	21	8	16	28.6
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
10500	< 1	6570	18300	5260	299	533	1340	0.05
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.5	22	0.5	< 0.1	0.1	< 5	26	72	166
Sr ug/g	Ti ug/g	Zr ug/g						
28	274	6						

SITE GRUM 6

<u>Date Sampled:</u> July 20, 2007

<u>UTM</u>: 593475 E 6904239 N

<u>Description:</u> Grum OB, grey clay till from exposed bank.

<u>Photo:</u>

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
57.1	42.9	42.4	39.3	18.3	8.0	0.46

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	8.8	211	< 1	0.4	24	10	21	12.7
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12200	< 1	7760	22300	5970	350	595	1530	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.6	24	0.5	< 0.1	0.1	< 5	31	67	178
Sr ug/g	Ti ug/g	Zr ug/g						
31	303	6						

SITE GRUM 7

Date Sampled: July 20, 2007

UTM: 592839 E 6904241 N

Description: Grum OB, grey clay till from exposed bank.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
41.8	58.2	41.2	40.1	18.7	7.8	1.10

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.6	26.6	211	< 1	0.5	33	15	31	20.2
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13600	< 1	13200	27100	8290	445	724	1580	0.04
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.7	40	0.8	0.1	0.1	< 5	31	86	149
Sr ug/g	Ti ug/g	Zr ug/g						
52	176	5						

SITE VP 009

Date Sampled: July 20, 2007

UTM: 585040 E 6913563 N

Description: toe of Faro Dump, could be salvaged during re-sloping, surface soil shows zinc concentrations in excess of CCME, but only marginally elevated wrt Swim Lake background. 25 cm of organic material over 30 cm of sandy loam, low coarse fragment till. Coarse fragment content increases drastically at 50 cm; rooting is no deeper than 50 cm. Sample from 30-45 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
6.3	93.7	69.9	23.9	6.2	5.4	0.80

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	6.3	128	< 1	< 0.2	20	9	20	9.6
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
9290	< 1	3740	19000	3720	266	523	986	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	23	0.4	0.1	0.1	< 5	25	283	147
Sr ug/g	Ti ug/g	Zr ug/g						
26	251	2						

SITE BO2 - 18

Date Sampled: July 21, 2007

UTM: 579383 E 6915239 N

Description: from till sideslope above Rose Ck. Haul Road. Sample from backfilled material on the site of SRK's test pit hoe excavation, to collect material at greater depths. Collected sample represents a mixture of materials from approx. 0-3 m depths.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
30.1	69.9	46.3	44.6	9.1	6.5	0.22

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.6	9.5	163	< 1	0.3	39	14	36	21.7
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12900	< 1	5910	25300	7360	483	735	590	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	36	0.6	< 0.1	0.1	< 5	38	79	170
Sr ug/g	Ti ug/g	Zr ug/g						
31	176	2						

SITE BO2 - 22

Date Sampled: July 21, 2007

UTM: 579888 E 6914977 N

Description: from till sideslope above Rose Ck. Haul Road. Sample is organically enriched surface material from adjacent to the SRK test pit excavation.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
48.0	52.0	67.6	25.5	6.9	7.2	0.24

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.6	29.4	125	< 1	0.3	32	12	25	20.5
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13400	< 1	5930	23200	6710	352	412	1080	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.7	35	0.6	0.1	0.2	< 5	33	66	256
Sr ug/g	Ti ug/g	Zr ug/g						
35	241	2						

SITE BO2 – 22A

Date Sampled: July 21, 2007

UTM: 579888 E 6914977 N

Description: from till sideslope above Rose Ck. Haul Road. Sample is subsurface till from SRK test pit hoe excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
59.6	40.4	81.2	15.0	3.8	7.5	0.26

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	20.8	92	< 1	0.2	34	13	25	20.2
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12800	< 1	5210	22200	7100	354	443	1040	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.7	36	0.4	< 0.1	0.2	< 5	29	69	313
Sr ug/g	Ti ug/g	Zr ug/g						
31	246	2						

SITE BO2 – 25

Date Sampled: July 21, 2007

UTM: 580306 E 6914685 N

Description: till above Rose Ck. Haul road further SE than previous. Sample is subsurface till from SRK test pit hoe excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths.

Photo:

Sample: from hoe excavation

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
33.5	66.5	58.0	34.4	7.6	7.0	0.34

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	7.7	129	< 1	< 0.2	19	7	23	13.8
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
9400	< 1	7650	15300	3620	216	439	882	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	21	0.7	0.1	0.1	< 5	23	38	248
Sr ug/g	Ti ug/g	Zr ug/g						
34	285	1						

SITE BO2 – 29

Date Sampled: July 21, 2007

UTM: 581940 E 6913910 N

Description: Sample area is previously disturbed area with willow cover. Sample is subsurface till from SRK test pit hoe excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
41.7	58.3	43.3	44.8	11.9	7.0	0.32

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.6	9.3	194	< 1	0.4	40	13	35	21.9
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13900	< 1	5430	24700	7260	405	912	1450	0.04
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	46	0.5	0.1	0.2	< 5	34	78	310
Sr ug/g	Ti ug/g	Zr ug/g						
32	241	4						

SITE BO2 – 30

Date Sampled: July 21, 2007

UTM: 582222 E 6913797 N

Description: semi-disturbed area impacted by dust. Two samples collected from backfilled material from SRK's test pit excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths. This sample exceeds CCME lead levels.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
6.9	93.1	23.4	58.2	18.4	5.7	0.68

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.7	11.4	327	< 1	0.3	33	10	33	142
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12900	< 1	8800	22900	5660	283	605	1200	0.12
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	30	0.8	0.3	0.2	< 5	32	109	262
Sr ug/g	Ti ug/g	Zr ug/g						
262	262	262						

SITE BO2 – 30A

Date Sampled: July 21, 2007

UTM: 582222 E 6913797 N

Description: as above: semi-disturbed area impacted by dust. Two samples collected from backfilled material from SRK's test pit excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
16.5	83.5	27.7	51.0	21.3	6.2	0.84

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	9.2	355	< 1	0.6	38	13	40	17.3
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
15700	< 1	8970	24500	6100	502	629	1420	0.05
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1	47	1.1	0.1	0.2	< 5	39	95	265
Sr ug/g	Ti ug/g	Zr ug/g						
41	373	1						

SITE BO2 – 32

Date Sampled: July 21, 2007

UTM: 582395 E 6914064 N

Description: older disturbed area revegetated with willow and poplar. Sample from approx. 5-20 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
54.7	45.3	63.3	30.4	6.3	6.3	0.28

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	7.9	220	< 1	< 0.2	43	15	26	86.2
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
20100	< 1	4500	28500	10200	512	259	1950	0.05
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.6	42	0.4	< 0.1	0.3	< 5	38	133	367
Sr ug/g	Ti ug/g	Zr ug/g						
30	436	3						

SITE BO2 -33

Date Sampled: July 21, 2007

UTM: 582400 E 6913930 N

Description: open trench approx. 1 m deep on older road, no longer in use. Sample excavated from trench bottom.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
35.2	64.8	49.6	41.9	8.5	7.6	0.26

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	8.2	184	< 1	0.3	38	12	31	13.5
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
16300	< 1	7020	25600	7880	349	772	2050	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1	39	0.5	0.1	0.2	< 5	36	72	375
Sr ug/g	Ti ug/g	Zr ug/g						
39	379	4						

SITE BO2 – 34

Date Sampled: July 21, 2007

UTM: 582855 E 6913811 N

Description: Sample is from area of SRK test pit excavation – material collected at 60 cm depth.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
41.8	58.2	41.1	44.5	14.4	8.0	0.42

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.7	9.5	215	< 1	0.4	43	13	34	75.8
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13800	< 1	18300	25200	8370	379	594	1970	0.09
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.1	47	0.7	0.2	0.2	< 5	34	109	216
Sr ug/g	Ti ug/g	Zr ug/g						
59	207	5						

SITE BO2 – 35

Date Sampled: July 21, 2007

UTM: 583473 E 6913402 N

Description: east of tailings area, brown clay till, sample from approx. 5-20 cm bgs.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
29.9	70.1	44.7	45.9	9.4	7.5	0.28

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	7	175	< 1	< 0.2	38	12	27	18.9
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
14800	< 1	4640	23800	6530	339	556	975	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.1	36	0.5	< 0.1	0.2	< 5	33	63	349
Sr ug/g	Ti ug/g	Zr ug/g						
29	290	2						

SITE BO2 – 36

Date Sampled: July 21, 2007

UTM: 583422 E 6913205 N

Description: east of tailings area, brown clay till, sample from approx. 5-20 cm bgs.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
23.4	76.6	47.0	43.0	10.0	7.8	0.42

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.6	8.3	205	< 1	0.4	31	12	31	73.9
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11600	< 1	11900	22800	5790	385	1100	1660	0.06
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.1	35	0.5	0.2	0.2	< 5	30	137	233
Sr ug/g	Ti ug/g	Zr ug/g						
49	255	3						

SITE BO2 – 41

Date Sampled: July 21, 2007

UTM: 584944 E 6912748 N

Description: south of Faro-G/V haul road. Sample is subsurface brown till from SRK test pit hoe excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
40.8	59.2	46.6	42.9	10.5	7.8	0.30

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	8.3	199	< 1	0.3	38	14	33	14.4
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13500	< 1	9480	26500	6690	334	589	2220	0.04
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.3	45	0.5	0.1	0.2	< 5	39	71	161
Sr ug/g	Ti ug/g	Zr ug/g						
44	335	2						

SITE BO2 – 38

Date Sampled: July 21, 2007

UTM: 585068 E 6912616 N

Description: intact ecosystem to the south of the Faro-G/V haul road. Sample is subsurface brown till from SRK test pit hoe excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths. Exceeds CCME for nickel.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
57.0	43.0	57.0	36.3	6.7	8.1	0.30

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.7	23	144	< 1	0.4	53	18	41	12.2
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12700	< 1	12100	29100	6850	340	831	1810	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
5.2	80	1	0.1	0.3	< 5	50	72	165
Sr ug/g	Ti ug/g	Zr ug/g						
45	217	4						

SITE BO2 – 40

Date Sampled: July 21, 2007

UTM: 585167 E 6912502 N

Description: intact ecosystem to the south of the Faro-G/V haul road. Sample is subsurface brown till from SRK test pit hoe excavation. Collected sample represents a mixture of materials from approx. 0-3 m depths. Exceeds CCME for nickel.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
39.7	60.3	48.5	42.2	9.3	7.9	0.30

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	11.8	205	< 1	0.4	46	20	45	14.9
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
17300	< 1	11700	31800	6950	454	764	2810	0.04
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
2.5	78	1.8	0.2	0.4	< 5	62	78	407
Sr ug/g	Ti ug/g	Zr ug/g						
52	330	5						

SITE VAN 2B

Date Sampled: July 22, 2007

UTM: 593667 E 6902640 N

Description: On SRK trials on the Vangorda waste rock dump. Surface is 0.75 m till capping, extremely compacted/cemented. Sample is from 0-7 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
38.9	61.1	43.7	38.2	18.1	8.0	0.96

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	13.5	185	< 1	0.3	33	11	21	35.3
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12400	< 1	7330	22400	6660	336	669	1500	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.6	31	0.4	0.1	0.2	< 5	28	104	145
Sr ug/g	Ti ug/g	Zr ug/g						
29	262	7						

SITE VAN 2A

Date Sampled: July 22, 2007

UTM: 593645 E 6902648 N

Description: On SRK trials on the Vangorda waste rock dump. Surface is till capping, extremely compacted/cemented. Sample is from approx. 0-10 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
42.9	57.1	43.6	38.1	18.3	8.0	0.88

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.6	14.4	213	< 1	0.5	31	11	23	47.9
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11700	< 1	6760	23300	6500	349	534	1550	0.06
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.6	32	0.5	0.1	0.2	< 5	27	164	136
Sr ug/g	Ti ug/g	Zr ug/g						
29	225	7						

SITE VAN 3A

Date Sampled: July 22, 2007

UTM: 593611 E 6902597 N

Description: On SRK trials on the Vangorda waste rock dump. Surface is the thinner glaciofluvial capping treatment – not compacted/cemented, but coarse textured with high coarse fragment contents. Sample is from approx. 0-10 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
55.3	44.7	85.1	11.5	3.4	7.3	0.88

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
1	23.9	182	< 1	0.4	23	10	42	56
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
9200	< 1	6180	19900	4030	293	537	1570	0.04
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.7	24	0.4	0.2	0.2	< 5	23	177	181
Sr ug/g	Ti ug/g	Zr ug/g						
46	317	2						

SITE VAN 3B

Date Sampled: July 22, 2007

UTM: 593629 E 6902593 N

Description: On SRK trials on the Vangorda waste rock dump. Surface is the thicker glaciofluvial capping treatment – not compacted/cemented, but coarse textured with high coarse fragment contents. Sample is from approx. 0-10 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
55.2	44.8	83.7	12.5	3.8	7.8	0.68

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	8.9	123	< 1	0.3	20	8	19	29.4
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
8640	< 1	5540	17800	4320	262	484	1420	0.02
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.6	21	0.4	0.1	0.2	< 5	23	93	157
Sr ug/g	Ti ug/g	Zr ug/g						
38	246	2						

SITE VAN 1

Date Sampled: July 22, 2007

UTM: 593659 E 6902583 N

Description: till test plot on '94 cover, extremely compacted/cemented. Sample is from approx. 0-10 cm. CCME exceedances for Cr, Pb and Ni.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
41.2	58.8	36.8	40.9	22.3	8.0	1.38

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
1.2	29.6	247	< 1	0.6	95	17	41	278
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13900	< 1	17100	27800	12600	408	583	1020	0.11
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	86	0.7	0.3	0.2	< 5	37	147	87
Sr ug/g	Ti ug/g	Zr ug/g						
60	133	6						

SITE VAN 4

Date Sampled: July 22, 2007

UTM: 593581 E 6902605 N

Description: below test plots on '94 cover, compacted/cemented. Sample is from approx. 0-10 cm. Extremely elevated As (495 ppm), and Zn also in YTG CSR exceedance.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
48.8	51.2	46.0	36.7	17.3	7.8	1.24

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
1.8	495	304	< 1	1.2	29	18	34	207
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11500	< 1	6970	25400	6230	402	555	1460	0.13
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	33	0.6	0.3	0.4	< 5	27	489	143
Sr ug/g	Ti ug/g	Zr ug/g						
33	208	7						

SITE VSB 1

Date Sampled: July 22, 2007

UTM: 593581 E 6902496 N

Description: starter berm area, still compacted/cemented till. Sample is from approx. 0-10 cm. YT CSR exceedance for Cr, CCME for Ni.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
46.3	53.7	31.5	59.2	9.3	8.0	0.52

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.8	23.6	199	< 1	0.4	106	20	37	24.6
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
14500	< 1	22600	29500	11800	466	571	1110	0.05
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	97	0.6	0.1	0.2	< 5	37	92	73
Sr ug/g	Ti ug/g	Zr ug/g						
71	138	5						

SITE VSB 2

Date Sampled: July 22, 2007

UTM: 593144 E 6902801 N

Description: starter berm area; looser or newer till. Sample is from approx. 0-10 cm. Extremely elevated As, and Pb (0.5%), YTG CSR exceedance for Cu.

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
56.4	43.6	59.8	32.3	7.9	2.4	11.00

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
32.8	545	8	< 1	< 0.2	38	49	174	5570
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
6230	< 1	10500	117000	3930	99	302	945	4.71
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
3	24	1.3	20.9	1	< 5	21	180	87
Sr ug/g	Ti ug/g	Zr ug/g						
36	132	5						

SITE VSB 3

Date Sampled: July 22, 2007

UTM: 593208 E 6902884 N

Description: starter berm area; looser or newer till. Sample is from approx. 0-10 cm. YTG CSR exceedances for As and Pb, CCME for Cr, Cu and Zn.

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
40.3	59.7	39.0	46.0	15.0	7.3	3.40

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
6	133	59	< 1	0.7	72	21	90	1070
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13100	< 1	16500	38900	9580	375	569	1030	0.66
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.4	62	0.9	2.6	0.4	< 5	33	313	82
Sr ug/g	Ti ug/g	Zr ug/g						
54	134	6						

SITE VANOB 1

Date Sampled: July 22, 2007

UTM: 593971 E 6902982 N

Description: Vangorda overburden stockpile, compacted grey till. Sample is from approx. 0-20 cm. YTG CSR exceedance for Cr.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
34.4	65.6	34.2	44.7	21.1	8.2	0.30

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.9	18.4	195	< 1	0.5	103	17	32	28
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13900	< 1	19000	26100	14200	425	601	1160	0.06
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.7	93	0.7	0.2	0.1	< 5	38	93	106
Sr ug/g	Ti ug/g	Zr ug/g						
67	182	5						

SITE VANOB 2

Date Sampled: July 22, 2007

UTM: 594164 E 6902786 N

Description: mineralized material on Vangorda OB stockpile. Sample is material underlying surface oxidized materials (approx. 10-20 cm depth). 1.3% Pb, most other metals in YTG CSR exceedance.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
44.6	55.4	59.1	30.1	10.8	2.1	16.00

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
53.3	1080	11	< 1	1.5	13	32	626	13000
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
2590	< 1	5860	94700	1310	61	161	890	19.4
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
7	9	1.9	46.6	4.8	< 5	12	1260	146
Sr ug/g	Ti ug/g	Zr ug/g						
18	126	4						

SITE VANOB 3

Date Sampled: July 22, 2007

UTM: 594146 E 6902773 N

Description: greyer till, more benign in appearance than previous sample. Cemented with fragmental, anglular aggregate. Sample is from approx. 0-10 cm. CCME exceedances for Cr, Pb and Ni.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
38.1	61.9	31.8	40.4	27.8	7.7	3.16

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
1.2	19.1	242	< 1	0.7	65	13	37	78.8
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12500	< 1	17600	24100	10400	388	709	1290	0.14
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.2	61	1.5	0.3	0.2	< 5	38	112	97
Sr ug/g	Ti ug/g	Zr ug/g						
63	114	6						

SITE VANOB 4

Date Sampled: July 22, 2007

UTM: 594098 E 6902880 N

Description: brown, vegetated free-dumped till. Sample is from approx. 0-20 cm. Exceeds CCME for Cu, Pb.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
50.5	49.5	38.5	47.4	14.1	7.8	1.82

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
2.1	54.4	330	< 1	1	35	12	84	404
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11500	< 1	7580	26300	7500	378	757	1080	0.18
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.2	38	0.7	0.4	0.6	< 5	32	293	134
Sr ug/g	Ti ug/g	Zr ug/g						
35	231	6						

SITE VANOB 5

Date Sampled: July 22, 2007

UTM: 594104 E 6902885 N

Description: salt-crusted, unvegetated, material adjacent to previous sample. Sample is from 0-5 cm. YTG CSR exceedances for As, Pb and Zn.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
30.4	69.6	48.1	41.4	10.5	7.2	12.80

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
8.5	282	22	< 1	11.3	37	19	148	3000
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
9000	< 1	12300	38100	9880	493	667	814	1.48
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
1.8	49	0.9	3.6	0.9	< 5	31	3240	101
Sr ug/g	Ti ug/g	Zr ug/g						
36	193	5						

SITE GROCK 1

Date Sampled: July 22, 2007

UTM: 592423 E 6903793 N

Description: till bench on Grum Dump, grey till. Sample is from approx. 0-20 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
37.2	62.8	47.7	40.6	11.7	8.0	0.38

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.5	17.1	189	< 1	0.3	44	13	26	33.1
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
13200	< 1	7860	25500	9050	345	522	1500	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.5	44	0.5	0.1	0.2	< 5	27	92	116
Sr ug/g	Ti ug/g	Zr ug/g						
33	272	7						

SITE GROCK 2

Date Sampled: July 22, 2007

UTM: 592289 E 6903523 N

Description: undulating, well-vegetated site at SW end of till benches on the Grum dumps. Rough surface (not levelled), but not free-dumped (bubble-dumped) and not loose – excavation by hand is possible only to approx. 10 cm, due to coarse fragments and high bulk density. Less compacted/cemented than the Vangorda Overburden sites. Sample is from approx. 0-20 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
39.8	60.2	38.0	51.2	10.8	8.0	0.42

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.8	9.4	260	< 1	0.6	38	15	31	39.5
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11700	< 1	6360	24200	7810	371	651	1200	0.06
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	45	0.7	0.1	0.2	< 5	31	121	99
Sr ug/g	Ti ug/g	Zr ug/g						
31	278	7						

SITE GRUM 8

Date Sampled: July 23, 2007

UTM: 593091 E 6904788 N

Description: Grum Overburden Dump, SE of VP-005 – more like waste rock than till (grey fines and non-competent schist), but very coarse. Sample is from approx. 5-20 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
74.0	26.0	55.8	31.7	12.5	7.8	1.02

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.7	12.7	142	< 1	0.4	35	13	24	60.2
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11500	< 1	11300	26700	8990	381	524	1190	0.08
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.7	37	0.5	0.1	0.2	< 5	23	278	102
Sr ug/g	Ti ug/g	Zr ug/g						
38	189	7						

SITE GRUM 9

Date Sampled: July 23, 2007

UTM: 592946 E 6904535 N

Description: free-dumped area on top of Grum OB stockpile. Grey till – very sparsely revegetated, despite age. Sample is from approx. 5-20 cm.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
49.2	50.8	45.6	40.0	14.4	8.1	0.34

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	9.2	103	< 1	< 0.2	38	11	24	16.2
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
12800	< 1	6090	23500	7050	297	498	2300	0.01
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.3	32	0.3	< 0.1	0.2	< 5	24	71	87
Sr ug/g	Ti ug/g	Zr ug/g						
30	326	7						

SITE GRUM 10

Date Sampled: July 23, 2007

UTM: 593142 E 6904376 N

Description: free-dumped till from edge of the Grum OB stockpile. Sample from 50-cm depth in loose free-dump pile.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
32.9	67.1	41.0	41.5	17.5	7.9	0.94

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
< 0.1	8.3	225	< 1	0.4	21	9	18	12.3
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11600	< 1	7350	21100	5480	349	539	1520	0.03
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	22	0.6	< 0.1	0.1	< 5	28	65	194
Sr ug/g	Ti ug/g	Zr ug/g						
30	289	6						

SITE VP023 S

Date Sampled: July 23, 2007

UTM: 584592 E 6913446 N

Description: Soil sample for VP-023 vegetation plot – location slightly adjusted to stay within vegetated area. Vegetated by poplar, willow, and spruce. Surface material is organically enriched brown till. Sample is from approx. 0-20 cm. Extremely enriched in Zn, possibly due to airborne particulate deposition.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
90.1	9.9	58.5	32.3	9.2	7.5	0.56

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
1.1	23.2	140	< 1	1.2	27	17	95	847
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
11200	< 1	8570	32000	6190	427	560	1700	0.32
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.8	31	0.8	0.7	0.4	< 5	33	775	239
Sr ug/g	Ti ug/g	Zr ug/g						
40	247	4						

SITE VP024 S

Date Sampled: July 23, 2007

UTM: 583881 E 6913809 N

Description: soil sample from vegetated free-dumped till (SW end) on top of Faro dumps. Ten year-old white spruce, kinnikinnick, willow, and poplar present. Surface material is organically enriched brown till. Sample is from approx. 0-20 cm. Zn extremely elevated.

Photo:

Laboratory Data:

Gravel		Sand	Silt	Clay		EC
>2 mm %	< 2 mm %	<2 mm %	< 53microns %	<2 microns %	pH	mmhos/cm
78.9	21.1	62.6	29.7	7.7	5.6	0.30

Sb ug/g	As ug/g	Ba ug/g	Be ug/g	Cd ug/g	Cr ug/g	Co ug/g	Cu ug/g	Pb ug/g
0.8	26.5	154	< 1	0.9	33	17	86	333
Al ug/g	B ug/g	Ca ug/g	Fe ug/g	Mg ug/g	Mn ug/g	P ug/g	K ug/g	Hg ug/g
15200	< 1	3970	34200	6550	354	476	2320	0.23
Mo ug/g	Ni ug/g	Se ug/g	Ag ug/g	Tl ug/g	Sn ug/g	V ug/g	Zn ug/g	Na ug/g
0.9	33	0.6	0.4	0.4	< 5	35	1280	340
Sr ug/g	Ti ug/g	Zr ug/g						
27	412	3						

Appendix D. Summary of Re-vegetation Projects in the Yukon

Summary of Re-vegetation Projects in the Yukon

Introduction

The following paragraphs present a brief review of monitoring reports from previously completed re-vegetation and bioengineering projects in various locations throughout the Yukon. The purpose of this review was to identify the documented successes and challenges associated with past approaches to re-vegetating disturbed sites, including reclaimed mining landscapes and sites where significant erosion had occurred. Particular emphasis was placed on examining projects involving planting of native shrub cuttings, because this is one of the primary treatments recommended in the Faro Mine Site Re-vegetation Study. The aim of this review is to glean lessons learned from past projects to support the recommendations for re-vegetation of the Faro mine site.

The majority of reports reviewed for this exercise were re-vegetation project reports and follow-up monitoring reports sponsored by the Mining and Petroleum Environment Research Group (MPERG). This series of reports documents the implementation and subsequent success of re-vegetation and bioengineering trials at the Brewery Creek mine site, Gold Run Creek, and Noname Creek. One report by Mougeot Geoanalysis and S.P. Withers Consulting Services (2000) evaluated re-vegetation success at multiple mining sites four years after re-vegetation treatments had been applied. Another report documented the results of experimental re-vegetation trials with a transplanted native grass (*Deschampsia caespitosa*) and various soil amendment treatments. In addition to the MPERG research report series, a Laberge Environmental Services (2006) monitoring report assessing the results of re-vegetation treatments in the dewatered freshwater reservoir at the Faro mine site was reviewed.

The following paragraphs provide descriptions of the various types of sites where re-vegetation projects were conducted and monitored, as well as a summary of the re-vegetation techniques applied and the results documented in follow-up monitoring studies. A brief discussion of the lessons that can be learned from these past projects concludes the review.

Yukon Re-vegetation and Bioengineering Projects

Brewery Creek Mine

Re-vegetation efforts at Brewery Creek mine site are documented in a series of MPERG reports from 2002, 2003 and 2007. The 2002 report by Stu Withers, *Experimental Reclamation Project: Shrub Trial Plots – Brewery Creek Mine*, describes the initial establishment of trial re-vegetation plots at three sites at this mine in September 2000. Trial plots were established at three disturbed sites: a steep well-drained south-facing slope (35 degrees) at an elevation of 805 m, a steep well-drained north-facing slope (30 degrees) at an elevation of 828 m, and a moderately-drained northwest slope (8 degrees) at an elevation of 769 m. These sites had previously been seeded with grasses and legumes. The plots were 2 m by 3 m. One half of each plot was cleared of existing vegetation prior to treatment. Eleven different shrub species were either transplanted or staked using stem or root cuttings. Planting densities of willow cuttings in the three sites ranged from 8 to 10 cuttings in each half plot. Trembling aspen root cuttings were also planted in one site at a density of eleven cuttings per half plot.

Monitoring in July/August, 2001 showed that virtually all of the willow cuttings had died. The transplanted shrubs fared better. The spring of 2001 was an unusually dry year, and this was suggested as a factor that may have hindered survival and growth of cuttings. A subsequent monitoring event was documented in the 2003 report by Stu Withers, *Follow-up Monitoring: Shrub Trial Plots at Brewery Creek Mine and Bioengineering Trials at Noname Creek*. Several conclusions were drawn at this time. Thick growth of seeded grasses and legumes was determined to be restricting natural shrub colonization, as well as the survival and growth of transplanted species. Alfalfa, in particular, was found to be choking shrubs. Willow staking was determined to be unsuccessful at Brewery Creek Mine. The study suggested that dry, well-drained sites like the trial sites may not be amenable to willow staking. Monitoring conducted again in 2006 was documented in: *Shrub Trial Plots - Brewery Creek Mine: 2006 Follow-up Monitoring Report,* by Laberge Environmental Services. Transplanted Alaska birch, trembling aspen and black spruce transplants all showed good survival rates. Trembling aspen root cuttings had survived and grew well. Although the willow cuttings had not survived, some volunteers had appeared.

Noname Creek

Bioengineering and re-vegetation efforts at Noname Creek are documented in a series of initial project reports and subsequent monitoring reports from 2002, 2003, 2005 and 2006 by Laberge Environmental Services and Stu Withers. The site is a northwest-facing, permafrost-rich slope along an unnamed tributary to Big Creek, west of Carmacks. The site was disturbed by road construction associated with placer mining activity in 1999 and 2000, resulting in slope failure and gullying. In September 2001, bioengineering structures were installed. The structures consisted of gully breaks comprising a lattice of 3-4 m long dormant willow cuttings, and pole drains. Dormant willow cuttings, approximately 40 cm long, were also inserted into the gully bottom and sidewalls. Cuttings were spaced about 0.5 m apart and planted so that three quarters of the length of the cuttings were buried with the distal ends up.

Follow up monitoring in 2002 showed good survival of willow cuttings. Upgrades were completed on the bioengineering structures in September 2003 and May 2004 to repair gully breaks that had been breached in narrower and steeper sections of the gully. At this time, the willow cuttings had survived and were found to be growing well. The few willow stakes that had not survived had been planted on the higher and drier sides of the gully. A fire burned the area in 2004. Monitoring conducted in 2005 showed new growth on the scorched willows, with those that had been staked earlier (2001) faring best. Dense colonization of grasses and forbs was evident in the erosion gully.

Gold Run Creek

The results of an erosion control project using bioengineering techniques at Gold Run Creek are presented in two initial project reports, entitled, *Reconnaissance Survey of Erosion Control Site at Gold Run Creek* (Laberge Environmental Services, 2004) and *Pilot Scale Erosion Control Using Bioengineering Techniques at Gold Run Creek, 2005* (Laberge Environmental Services, 2006), as well as a follow-up monitoring report, entitled, *Gold Run Creek Erosion Control Project: 2006 Follow-up Monitoring* (Laberge Environmental Services, 2007). A slope failure had occurred at a placer mining site on Gold Run Creek, near Dawson City in the early 1980's. Subsequent permafrost melting led to further slumping and erosion at the site, creating a large erosion channel 300 m long and 50 m deep. The runoff channel had eroded through a southwest-facing, sloped overburden stockpile, resulting in sedimentation of the creek during peak rainfall events.

In September, 2005, several bioengineering structures were installed in an effort to control erosion and revegetate this disturbance. These structures included an earth retaining wall placed at the eroding apex of the slope and a flume constructed of live willow cuttings to channel runoff. Additional willow cuttings harvested from the stockpile were planted in the slope.

Monitoring results one year later showed that the flume had collapsed and the erosion project failed as a result. However, the earth retaining wall had remained intact with significant growth of roots and shoots from live willow cuttings. Most willow cuttings staked upstream had also survived and showed new growth.

Evaluation of Yukon Re-vegetation Projects

A 2000 study, entitled *Assessment of Long-Term Vegetation and Site Conditions at Reclaimed Yukon Mineral and Coal Exploration Sites*, was completed by Mougeot Geoanalysis and S.P. Withers Consulting Services. This study reviewed several mining exploration and development reclamation sites above and below treeline in 1999. Four of these sites had been part of an experimental re-vegetation trial in 1995 and one had been re-vegetated in the early 1980s.

The reclaimed exploration sites included the Red Ridge trench, near Annie Lake in the Whitehorse area; the Nucleus trench, west of Carmacks; and the Hawk trench near Dawson City. The trenches had been revegetated with different seed and fertilizer mixes. Several coal trenches and drill pads west of Braeburn were also evaluated. Finally, Jason Knoll near McMillan Pass was evaluated to represent a drill pad/ coal trench site near treeline.

Monitoring results showed that the refilled and contoured trenches, with rough and loose surfaces, revegetated well. Replacement of original soil was determined to contribute significantly to the revegetation process, particularly at high elevation sites and sites in extreme climatic conditions. Seeded agronomic legumes were not found to survive long or contribute greatly to vegetative cover. Sod-forming species such as red fescue were found to inhibit colonization of native species. Agronomic species were not found to colonize undisturbed sites. Alpine sites were found to show poorer revegetation in contrast to nutrient-rich, lower elevation sites.

Several conclusions were drawn. First, dense seeding of agronomic species was determined not to be necessary or desirable in most cases, even though it may be desired for erosion control in steep slopes. Sites with loose and rugged topography were determined to foster colonization and growth of native species. Native species invade pockets with shade and moisture and without cover of seeded grasses. Replacement of tree debris was also noted as valuable for creation of habitat for small mammals, and for restoring ungulate corridors (by limiting visibility by predators).

Faro Mine Site: Re-vegetation of the Dewatered Freshwater Reservoir

Re-vegetation of the dewatered freshwater reservoir at the Faro mine site was conducted in 2003 and 2004, with follow-up monitoring described in the report entitled, *2006 Revegetation Assessment of the Dewatered Freshwater Reservoir South Fork of Rose Creek, Yukon,* by Laberge Environmental Services.

The dewatered reservoir was seeded in several phases with a mix of northern native grass species. Transplanting of stem cuttings of seven shrub and one tree species (*Salix pulchra, S. alaxensis, S. scouleriana, S. barclayi, Populus tremuloides, P. balsamifera, Shepherdia canadensis and Picea glauca*) was also carried out. Staking was done in September 2003 at the east end of reservoir. Willow stem cuttings were also staked in June 2004 on riparian area of the Rose Creek main channel. In September and October 2004, willow stem cuttings were staked along two main tributaries and floodplains adjacent to dam breach.

Monitoring results demonstrated 80% survival of staked willows in a 2006 assessment of the floodplains upstream and downstream of the dam breach (the most successful species were *Salix pulchra, S. alaxensis* and *Populus balsamifera*). Many staked willows died at the top but were sprouting at ground level. Willows in the Rose Creek riparian zone and tributaries demonstrated an 80% survival rate with *S. alaxensis* being most successful. A lower survival rate was found for willows in the upper reaches of the two tributaries (10-30%).

Experimental Re-vegetation with a Native Grass

A study exploring the potential for revegetation of mining disturbance with a native grass, *Deschampsia caespitosa*, is documented in the report, entitled, *Enhancing Natural Succession on Yukon Mine Tailings Sites: a low-input Management Approach: the potential for the native grass Deschampsia caespitosa in northern mine tailings revegetation*, by Alison Clark and Tom Hutchinson (2005). Tailings at three Yukon mine sites were included in the study: United Keno Hill, Mount Skukum, and Wellgreen. *D. caespitosa* was found colonizing all three low-nutrient sites with elevated levels of heavy metals. Seeds and transplants of this native grass were planted in test plots under different soil treatments at each mine site. Results showed that the grass grew in all types of sites even without soil amendment, and that the grass acted as a nurse crop, facilitating the colonization of other native species. Plants grown hydroponically in conditions with elevated metals levels also showed tolerance to heavy metals. The results showed promise for use of *D. caespitosa* in tailings revegetation.

Germaine Creek

Gravel bar staking of willow and installation of live palisades (balsam poplar) were completed by Polster and Associates on a side channel of the Klondike River in the fall of 2004. In 2006, a monitoring program to evaluate the success of the works was completed (M. Miles and Associates Ltd. and Polster Environmental Services Ltd. 2007). The cuttings within the gravel bar staking had a 69% survival rate with growth ranging from 48-77 mm in height. The stocking rate was sufficient to form a dense cover of willows. The live palisades had a success rate of only 14% and were subject to a fungal attack.

Conclusions

There are several lessons learned that can be drawn from the re-vegetation projects that have been initiated and monitored in the Yukon. First, seeding with agronomic mixes of grasses and legumes has been found to impede colonization of native vegetation. In contrast, transplanting the native grass *Deschampsia caespitosa* into tailings has been shown to facilitate colonization of native vegetation. Second, rough loose microtopography has been found to assist colonization of native vegetation, by creating microsites amenable to the invasion and survival of seeds and plant propagules.

Third, success with planting cuttings of native shrub species, such as willows and poplars, has been achieved at riparian sites such as Noname Creek and Gold Run Creek. Willow survival and growth has also been successful in erosion control structures erected at these locations. However, willow staking has been unsuccessful at the dry, steep sites at the Brewery Creek mine and the drier sides of the gully at Noname Creek. At the Faro freshwater dam, willow survival was also poorer in the upper reaches of the two tributaries to Rose Creek, in comparison with the downstream riparian areas.

One limitation of the abovementioned monitoring reports is that many do not outline the exact methods applied in the preparation and planting shrub cuttings. The reports do not state the diameter of the cuttings selected, whether the cuttings were prepared (soaked for a number of days prior to transplanting) and, with the exception of the Noname Creek project, to what depth the cuttings were planted. These are all important considerations in the use of live stakes in bioengineering and re-vegetation treatments. Without this information, it is not possible to evaluate whether the failure at Brewery Creek may have been related to the techniques applied in this early experiment with willow staking in the Yukon.

In addition, the area of the test plots at the Brewery Creek sites where cuttings failed was limited. Approximately 20 willow cuttings were planted in each 2 m by 3 m test plot at three different trial sites. This resulted in a rather limited total number of cuttings to monitor. It is difficult to draw a conclusive lesson from this limited study of live staking in the drier, sloped sites at Brewery Creek.

Review of monitoring reports for re-vegetation and bioengineering projects conducted throughout the Yukon suggests relatively improved success of willow staking at riparian sites and poorer results at drier and steeper sites. This outcome is worth consideration in the design and development of future re-vegetation trials using live staking of willows. Planting of a range of shrub species suited to different site conditions may help to ensure the survival and growth of cuttings. The limited, existing research also points to the need to conduct additional live-staking trials in non-riparian areas and on a larger scale than past studies.

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Appendix E. Live Staking: Summary and General Guidelines for Implementation

Live Staking: Summary and General Guidelines for Implementation.

Live staking is perhaps the simplest form of soil bioengineering. Live staking is a simple method of establishing pioneering woody vegetation. Cuttings are inserted into the soft materials in the fall[1] or spring and as the cuttings grow over the summer, the roots serve to bind the unstable materials.

Cuttings from various plant parts are widely used in the establishment of pioneering woody species, both as direct plantings and as materials for nursery growth of plants (Hartmann and Kester 1975; Institute for Land Rehabilitation 1978; Hardy BBT 1989; Haeussler and Coates 1986; Comeau et al 1989; Dick 1974; Marchant and Sherlock 1984). Direct use of cuttings eliminates the cost of developing rooted stock in nurseries. However, in some cases survival rates for cuttings are lower than survival of rooted stock. Where sites are dry, such as gravel bars, and cuttings can be buried deep enough to obtain water, survival of cuttings can be better than rooted stock. Cuttings are particularly useful in the re-establishment of pioneering woody species that are often favoured as browse for wildlife (Stanlake et al 1978).

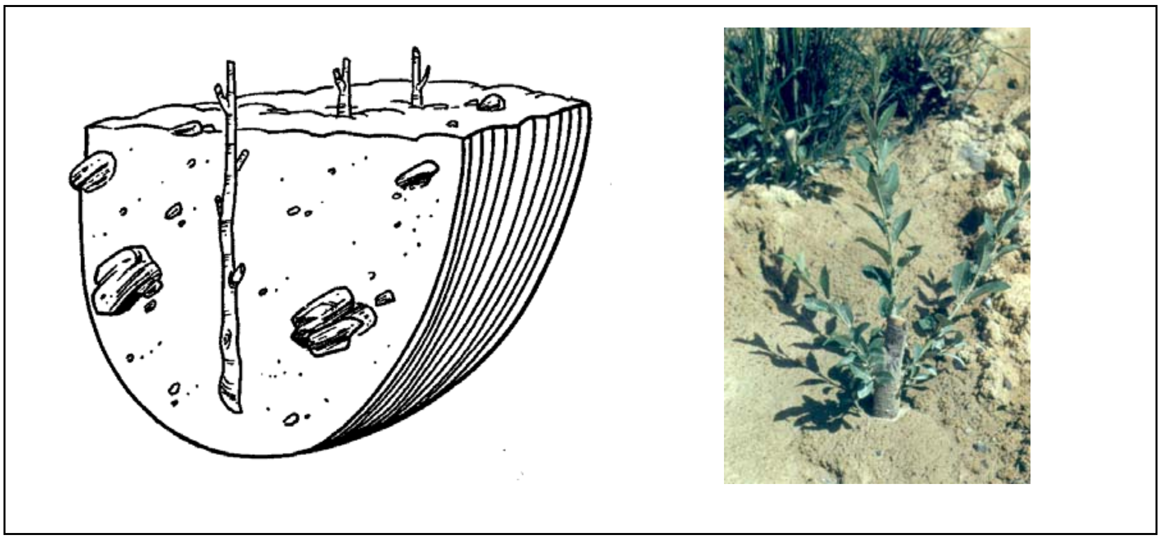

Figure 1. Diagram and picture of the live staking method (Polster 2008).

While simple to implement there are a number of key general guidelines that need to be followed. These are outlined below.

[1] In most cases, fall is most practical in the Yukon as in spring the ground typically remains frozen beyond the period of dormancy, but there may be problems with excessive drying of the cuttings over the winter with fall planting.

Harvesting:

- Harvesting of cuttings should be completed during the dormant period (from the time the leaves turn yellow to well before green up).
- Donor sites should be selected as nearby and in similar environments than the planting site. As a general rule donor sites should be within 300 m elevation and 100 km horizontal distance from the planting site.
- Harvest focus should be on straight vigorous growing stems.
- Cuttings should be trimmed of all branches smaller than 2 cm in diameter.
- The top end of the cuttings should be minimum diameter of 2 cm.
- Optimal lengths of cuttings are 1-2 m.
- Cuttings should be stored in low light, cool area until ready for planting or soaking.
- Soaking the cuttings in water for 10 days before planting improves rooting success.

Planting:

- Most (3/4 to 7/8) of the cutting should be underground to establish a balance between root and shoot growth.
- Stems should be planted with the shoot (small) end up.
- A dibble or a "pinch bar" with a pointed tip can be used to provide a pilot hole for the cuttings as long as the soil is packed firmly around the cutting once the cutting is in the ground.
- Where difficulty is encountered, cuttings may be trimmed to maintain the 3/4 or 7/8 burial, as long as the cutting is at least 50 cm long.
- Cuttings need not be planted vertically (as shown) but can be slipped into the soil diagonally, as long as the cutting will remain moist over most of its length.

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