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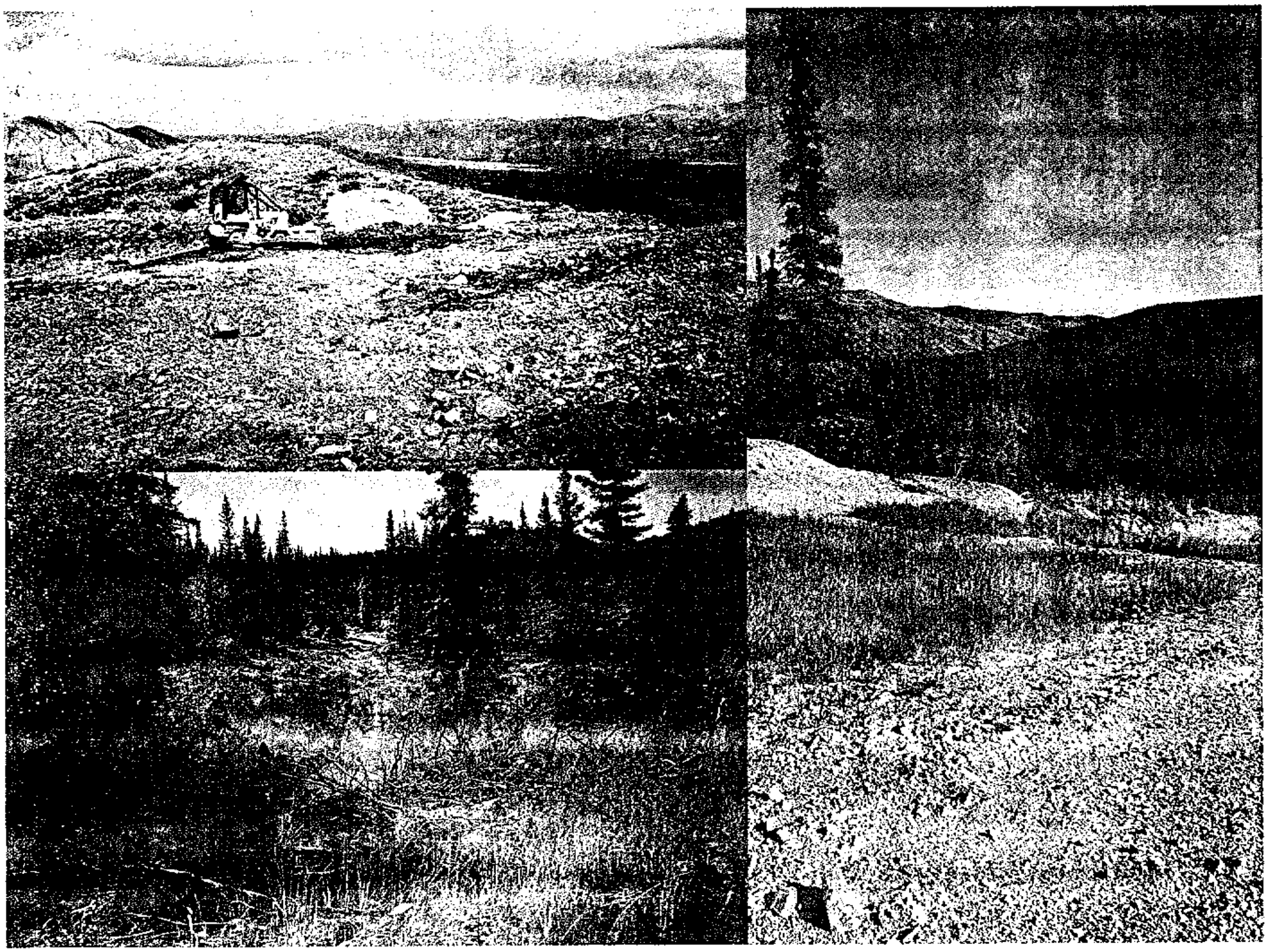
Mineral Resources Directorate, Yukon

RECLAMATION PRACTICES AND RESEARCH

ON MINERAL EXPLORATION PROPERTIES IN THE YUKON TERRITORY



By

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Cover photos:
Upper left: Bulldozer finishing infilling trench, INAC test site, Red Ridge property, Whitehorse area.
Lower left: Reclaimed trench on Cash Resources' Division Coal property, near Braeburn, Lake Laberge area.
Right: Reclaimed trench, INAC test site, Nucleus property, Carmacks area.

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Reclamation Practices and Research on Mineral Exploration Properties in the Yukon Territory

By

D.B. Craig and J.E. Craig (Consultants),
K. Pelletier, D. Emond, and H. Copland (INAC)

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Reclamation Practices and Research on Mineral Exploration Properties in the Yukon Territory

ABSTRACT

Recent legislative changes in the Yukon mining regime authorize the formulation of mining land use regulations which include reclamation requirements on mineral claims. Reclamation research was thus carried out to guide the development of policy and general operating conditions for the mining industry and government regulators.

Reclamation testing was carried out on three mineral exploration sites in Yukon: an alpine site at the Red Ridge property in the Whitehorse area, and two subalpine sites, a boreal forest site at the Nucleus property in the Carmacks area, and a site in moist permafrost at the Hawk property in the Dawson City area. Old exploration trenches were filled in and re-contoured with a small bulldozer and five plots were constructed on each new surface. A control plot was neither seeded, nor fertilized. The other four plots were seeded and fertilized, with one plot using a mulch blanket base, another using a topsoil blanket, and the two others only on the substrate present. A nitrogen-fixing bacterial culture termed inoculant (mycorrhizia), blended with the seed was also tested on three of these plots to evaluate its success.

Results generally show that growth on back filled trenches is mostly a function of climate, availability of moisture, and substrate grain size. As expected, the alpine site at Red Ridge had the least vegetative growth due to location being at a higher elevation, cooler and drier climate, and rockier surface material. Fine grained soil is more efficient for retaining moisture at the surface, thus when trenching is being carried out, the surface layer should be stripped and stockpiled separately from the rest of the overburden, and then replaced as the top layer following back filling. Microsites, such as grouser bar indentations on the Red Ridge site, seemed to promote growth, by trapping fines, seed and moisture. A few passes with a tracked vehicle, leaving the grouser bar indentations are recommended for ground preparation.

The planted grasses seem to inhibit growth of indigenous species in the first years after seeding at the Hawk site. However, the grass forms a compost layer which may nurse future growth of native species. Greater growth at the higher end of each plot at the Hawk site is ascribed to the greater snow depth and thus increased moisture content.

Growth was not significantly enhanced on plots with imported topsoil and mulch. Topsoil, in fact, had the negative effect of introducing foreign weed seed in the form of barley foxtail to the vegetation on the Nucleus and to a lesser extent on the Hawk site, and thus it is not recommended to apply imported topsoil. The mulch blanket was useful at the Nucleus site in limiting the vulnerability to erosion, and may be recommended in trenches where slope erosion is problematic. The nitrogen fixing inoculant did not appear to enhance growth.

Seeding of graminoids are recommended for promoting rapid revegetation in order to stabilize slopes subject to erosion. Special consideration should be given to obtaining native graminoid seeds for these works, such as reedgrass (Calamagrostis sp.), bluegrass (Poa sp.), fescues (Festuca sp.), and other native graminoids which are hardy and widespread, as well as nutritious forage for ungulates.

Although Mining Land Use Regulations requiring reclamation on mineral claims have not yet come into force, many examples of reclamation activities can be found throughout the Yukon, to the credit of the mining industry. Continued monitoring of reclaimed land disturbances, both seeded and not, will add to the data base of general operating conditions in the Territory.

Pratiques de remise en état de terrains d'exploration minérale du Yukon et recherche sur ce sujet

RÉSUMÉ

Des modifications récentes à la législation du Yukon concernant le régime d'exploitation minière autorisent l'élaboration de règlements sur l'utilisation des terrains miniers qui comportent des dispositions sur la remise en état du terrain des concessions minières. Des recherches sur la remise en état des terrains ont donc été entreprises afin d'orienter l'élaboration de politiques et de conditions générales d'exploitation à l'intention de l'industrie minière et des organismes de réglementation du gouvernement.

Des essais de remise en état ont été menés dans trois sites d'exploration minérale du Yukon, plus précisément dans un site de l'étage alpin situé dans la concession de Red Ridge, près de Whitehorse, et dans deux sites de l'étage subalpin, l'un dans la concession de Nucleus, dans la région de Carmacks, et l'autre dans un pergélisol mouillé, dans la concession de Hawk, près de Dawson City. D'anciennes tranchées d'exploration ont été remblayées et reconfigurées à l'aide d'un petit bouteur, et cinq placettes ont été établies à chaque nouvel endroit. Une placette témoin n'a été ni ensemencée ni fertilisée. Les quatre autres placettes ont été ensemencées et fertilisées, l'une avec paillis, la seconde sur terre végétale et les deux autres directement sur le substrat présent. Dans trois de ces placettes, on a également mis à l'essai une culture bactérienne fixatrice d'azote appelée inoculant (mycorhizes) mélangée aux semences afin d'évaluer les résultats procurés par cette technique.

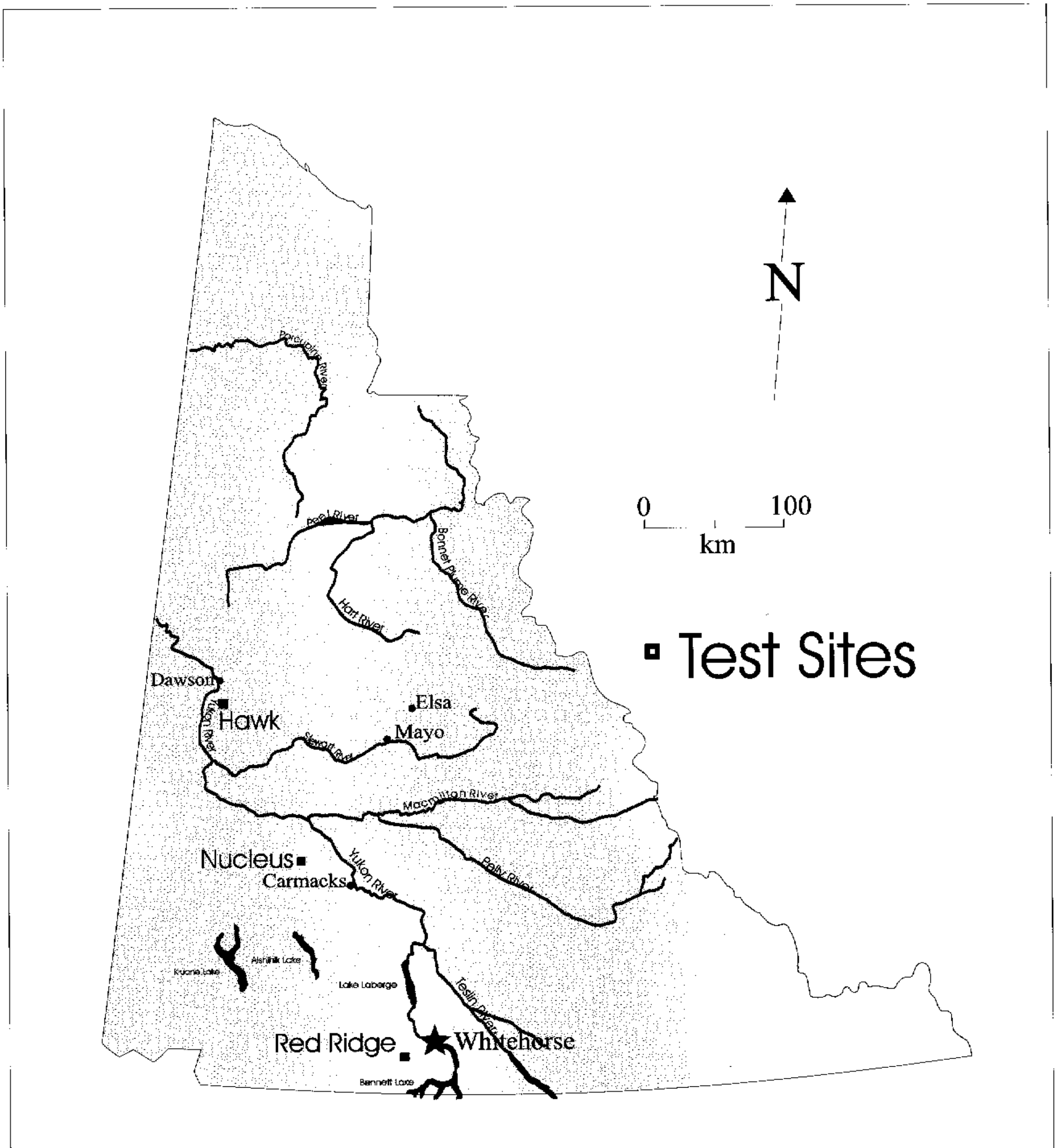
En règle générale, les résultats montrent que la croissance de la végétation sur les tranchées remblayées est surtout fonction du climat, de la disponibilité de l'eau dans le sol et de la granulométrie du substrat. Comme prévu, la végétation du site de l'étage alpin de Red Ridge avait le taux de croissance le plus faible en raison de l'altitude plus élevée, du climat plus frais et plus sec et de sa surface plus rocailleuse. Un sol à grain fin réussit à mieux conserver l'humidité en surface de sorte que, lors de l'excavation des tranchées, la couche superficielle devrait être décapée et mise dans des tas différents des morts-terrains pour ensuite être remise en place après le remblayage. Les microstations, comme les creux laissés par les bandes métalliques dans le site de Red Ridge, semblent favoriser la croissance, car elles emprisonnent les fractions fines, les graines et l'eau du sol. Pour préparer le terrain, il est recommander d'y faire circuler à quelques reprises un véhicule à chenilles dont les bandes ferrées laisseront des empreintes.

Au cours des premières années suivant l'ensemencement, les graminées plantées semblaient empêcher la croissance des espèces indigènes. Toutefois, les graminées forment une couche de compost qui pourrait servir d'abri aux espèces indigènes qui s'y développeront. Le taux de croissance supérieur relevé à l'extrémité la plus élevée de chaque parcelle du site de Hawk a été attribué à la présence d'un manteau nival plus épais et, par conséquent, à une augmentation de la teneur en eau du sol.

La terre végétale et le paillis qui ont été rajoutés n'ont pas considérablement amélioré la croissance. En fait, la terre végétale a eu le désavantage d'introduire des graines de mauvaises herbes exotiques, plus précisément d'orge queue d'écureuil, sur le site de Nucleus et, dans une moindre mesure, sur le site de Hawk. Il n'est donc pas recommandé d'étendre une couche de terre végétale venant d'ailleurs. Dans le site de Nucleus, le paillis a permis de limiter l'érosion et son utilisation pourrait être recommandée dans les tranchées où l'érosion des versants cause des problèmes. L'inoculant fixateur d'azote n'a pas semblé améliorer la croissance.

Pour promouvoir une revégétalisation rapide et ainsi stabiliser les versants sensibles à l'érosion, il est recommander de semer des espèces graminoïdes. Lors de tels travaux, il faudrait notamment s'efforcer d'utiliser des graines d'espèces graminoïdes indigènes, comme des calamagrostides (*Calamagrostis* sp.), des pâturins (*Poa* sp.), des fétuques (*Festuca* sp.) et d'autres espèces graminoïdes indigènes qui sont rustiques et répandues et qui constituent un fourrage nutritif pour les ongulés.

Même si la réglementation sur l'utilisation des terrains miniers exigeant la remise en état des terrains des concessions minérales n'est pas encore entrée en vigueur, on peut trouver au Yukon de nombreux exemples d'activités de remise en état qui sont tout à l'honneur de l'industrie minière. Le maintien d'une surveillance des perturbations des terrains remis en état, qu'ils aient été ou non ensemencés, permettra d'étoffer la base de données sur les conditions générales d'exploitation au Yukon.



1. Location map for three sites in Yukon reclaimed by INAC in 1995

INTRODUCTION

Background

Currently, in early 1998, there are no legislative requirements to carry out reclamation practices on mineral exploration properties in the Yukon Territory. The Canadian Environmental Assessment Act (CEAA) legislates that development activities requiring federal permits be assessed through environmental screening, and environmental impacts be mitigated with existing technology. However, mineral exploration does not require a permit, and since Section 3(3) of the Territorial Lands Act exempts the Yukon Quartz Mining and Yukon Placer Mining Acts from its jurisdiction, there is no trigger to conduct a screening.

Recent amendments (November, 1996) of the Yukon Quartz and Placer Mining Acts have allowed for the formulation of Mining Land Use Regulations. These regulations are currently undergoing final legal drafting by the Department of Justice. Once the regulations come into force, likely later this year (1998), prospectors, and exploration and mining companies will require a mining land use permit to carry out exploration, and land reclamation will be a requirement. Indian and Northern Affairs Canada (INAC) will then be responsible for carrying out an environmental assessment on each application, as per CEAA, and also for formulation of reclamation objectives.

Information on terrestrial reclamation associated with mineral exploration in Yukon has not been previously documented systematically. Little reclamation has been carried out particularly on lode exploration properties in Yukon, due to the lack of a regulatory requirement. However, exploration companies seem to be making increasing efforts at initiating reclamation on active and inactive properties. This work is sometimes documented in mineral assessment reports and can qualify for credit under the current Schedule of Representation, pursuant to the Yukon mining acts.

Starting in 1993, Mineral Resources, INAC initiated a brief study carried out in the Mt. Nansen area (E.B.A. Engineering Consultants) in preparation for formulation of reclamation objectives for the Territory. Three other areas in Yukon were then chosen for the current study: the Hawk showing, in the Dawson area; the Nucleus Property, in the Carmacks area; and the Red Ridge Property, in the Whitehorse area (Figure 1). Initial gathering of baseline data on the terrain on these three lode exploration properties was carried out in 1994 (Mougeot Geoanalysis, 1996), including some recommendations for reclamation testing. Reclamation work was initiated in 1995 in the same three areas by Dr. D. B. Craig under contract to Mineral Resources, INAC. This work and its results are described below in addition to documentation of other examples of mine and exploration site reclamation in various parts of Yukon.

Objectives

The principal objective of this study is to test several reclamation procedures on each of three mineral exploration trench sites in different settings namely: alpine (Red Ridge), boreal forest (Nucleus) and moist permafrost (Hawk; Figure 1). A further purpose, basic to this project, is that seeded species will provide a cover or nurse crop, but not impede the encroachment of local, native species onto these sites.

A second objective of this study is to begin to document other reclamation activities taking place in the Territory. Several companies have been performing reclamation activities prior to them being required by legislation. Documenting these sites, and comparing the successes of various methods of reclamation will help broaden the environmental database that can be used by industry and government for planning reclamation activities which will be required in the near future.

Reclamation Methods

One trench on each of the three mineral properties was chosen to be reclaimed. Sites were chosen on the basis of the recommendations of the Mougeot Geoanalysis (1996) report, and were modified as necessary in the field by H. Copland and F. Pearson (INAC), and H. Coyne and Sons Ltd. During August and September of 1995, H. Coyne and Sons Ltd. carried out the infilling of trenches using a light bulldozer, a John Deere 450 (Figure 2). Geographic location of the sites is by map and Global Positioning System Instrument Motorola TRAXAR.

Doug, David and Joan Craig constructed test plots on all three properties (Figure 3). Five plots at each site were measured, flagged and staked. Steel stakes, 20 mm in diameter and 50 cm long, driven in 35 cm, define the corners of each plot. Numbered aluminum tags, wired to the steel stakes, are keyed to the field notes and this report, identifying the treatment or reclamation procedures for these plots. A rough screen analysis was made using a 2.5 cm mesh screen.

The treatment procedures essentially follow the guidelines in the Mougeot Geoanalysis (1996, p. 69) reclamation report, using the same numbering system.

Plot 1. Fertilizer, seed, inoculant, no mulch
Plot 2. Fertilizer, seed, inoculant, mulch blanket
Plot 3. Fertilizer, seed, inoculant, topsoil (8 cm)
Plot 4. Control, just bulldozed, no enhancement
Plot 5. Fertilizer, seed, no inoculant

A straw mulch blanket 2 cm thick was applied to Plot 2, impaled on the corner stakes and rock anchored with closely spaced cobbles around the perimeter.

2. John Deere 450 bulldozer backfilling trenches, Red Ridge property.

3. Construction of reclamation test plots at Hawk property. Mulch blanket plot in foreground and topsoil plot in background

Since Plots 1, 2 and 3 were inoculated with nitrogen fixing bacterial cultures (M. Keen, Appendix A), a fifth plot was established at each site with seed and fertilizer, but no bacterial culture, to test this further variable in this particular environment.

Fertilizer type and application followed Kennedy (1993) for planting of disturbed sites in the Yukon - highway shoulders, pipeline right of ways, etc. Approximately 1 kg per plot of 34-0-0 (ammonium nitrate) and 1.5 kg per plot of 8-24-24 (Nitrogen - Phosphorous - Potassium) were applied on plots 1, 2, 3 and 5. Seeding was in accordance with the recommendations of Tony Hill of Yukon Agriculture and Randy Lewis of Decora Landscaping. The seed mixture was provided by Prairie Seeds Inc. The Red Ridge Mixture was different from the Nucleus and Hawk sites, as detailed in the site field work descriptions. Seed was hand broadcast and raked into the top surface except where precluded by coarse rock. Rate of seed application was 300 gm/plot (75 kg/ha).

The Craigs also monitored the sites to evaluate seed growth during the 1996 and 1997 growing seasons.

The following section of this report, "Test Sites", includes a description of each of the three INAC test sites, including the field work carried out (construction of test plots) and observations, followed by a comparison of the three sites, and then conclusions and recommendations from the study. Specific vegetation data from each site is located in the Appendices B, C and D as identified by Joan Craig.

Several other exploration sites in Yukon were investigated in the 1997 field season by Karen Pelletier, Mineral Resources, INAC to determine the recent successes of previous reclamation and to provide some comparison to the INAC test sites. These sites are described and shown on a location map in the third part of this report - "Pre-Regulatory Reclamation in Yukon".

TEST SITES

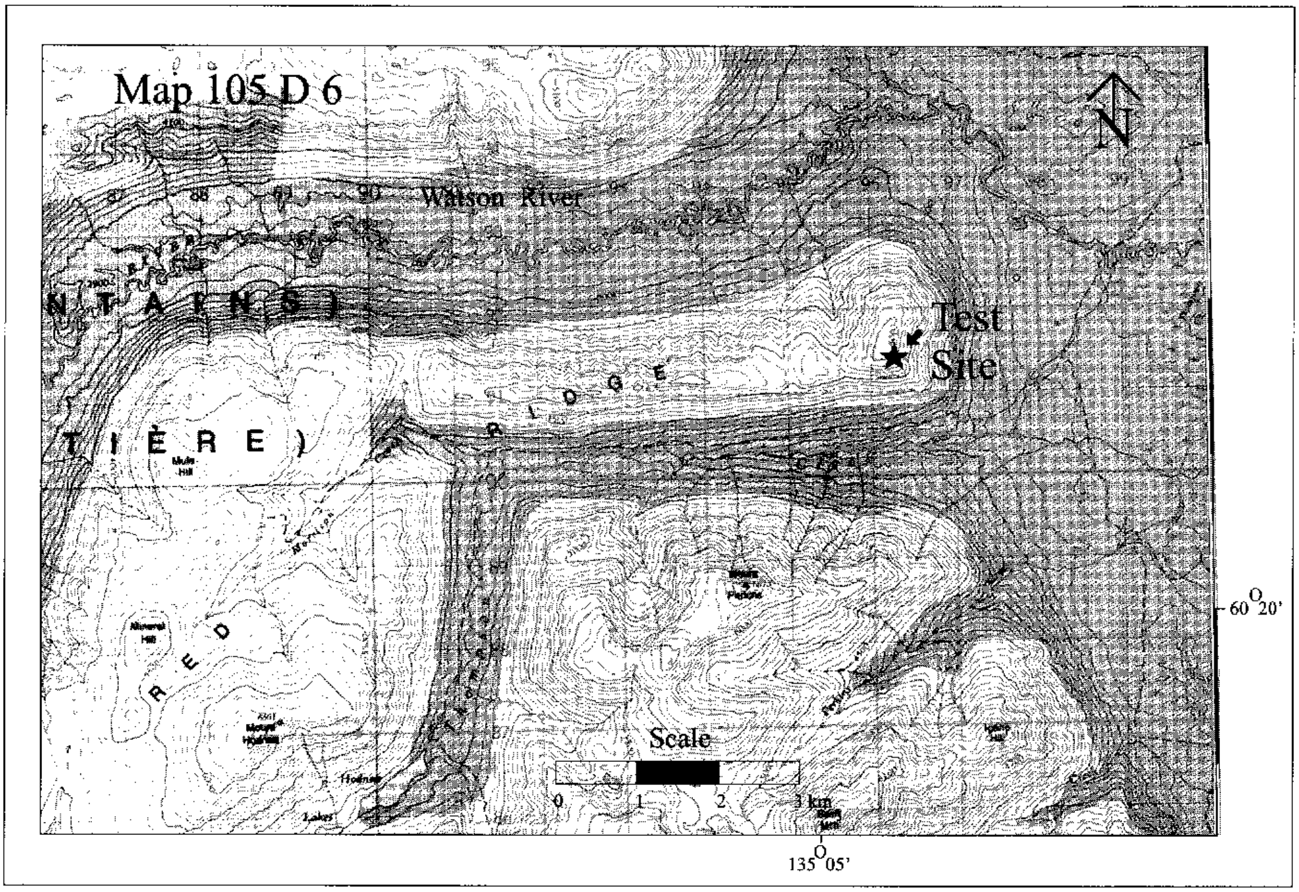
Red Ridge

Location and Access

The Red Ridge site (National Topographic System (NTS)105 D 6, Latitude 60° 21' 52.58" North, Longitude 135° 04' 12.14" West, Elevation 1504 metres) is five kilometres northwest of Annie Lake in the Alligator Lake 1:50,000 scale map area (Figure 4), on the eastern edge of the Coast Mountain physiographic subdivision (Bostock, 1948). It is accessible from Whitehorse, 65 kilometres by road via the South Klondike Highway, the Annie Lake Road and a mining road leading to the property. The last three kilometres of maintained road require a 4x4 vehicle to an old drilling camp. The old mining road up to the site which has not been maintained since exploration is driveable for the adventuresome, or a one hour hike. Exploration history is documented in the Mougeot Geoanalysis (1996) report, but mineral claims in the area of the site have since lapsed.

Aspect, Physical Characteristics and Geology

The trench selected for reclamation is located on the east end of Red Ridge, at the crest (Figure 5 and 6), trends north-northwest (335 degrees) and slopes gently (2 - 4 degrees) in that direction. The terrain drops off sharply to the east, the slope being 25 - 30 degrees. Thus, although the trench is on nearly level ground some of the excavated material is spilled over the edge and lies at the angle of repose of 35 degrees. Rock types consist of hornblende diorite (Wheeler, 1961, Unit 8d) and fine grained grey volcanic rock, probably basalt dyke material. Rocks are moderately weathered and oxidized, at least part of the trench being in a gossan zone, hence the name Red Ridge. Excavated material consists of approximately 50 percent minus 2.5 cm yellowish brown decomposed bedrock, including considerable sand and silt-sized material. Coarse material includes fairly fresh, broken rock up to 20 centimetres in longest dimension. Some parts of the site, particularly Plots 1 and 5 at the northwest end, have less fines, approximately 20 to 25 percent, and a preponderance of broken rock. No permafrost features are recognized.



4. Location map, Red Ridge site

5. Scenic view of Red Ridge, test site is on top of ridge, right side

The natural flora of the immediately adjacent undisturbed area are listed in Appendix B, a total of 34 species. The trench, cut in 1988, experienced little revegetation in the ensuing seven years. Growth in the trench was restricted to tiny fireweed, starwort and pioneering mosses.

The site was chosen to test revegetation techniques and procedures on disturbed sites above timberline.

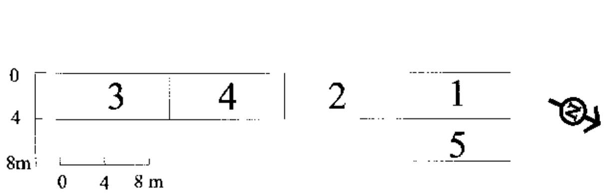
Field Work

The trench was backfilled with material originally excavated, forming a strip of reclaimed terrain 50 metres along the trench and 15 metres across, taking 14 hours to complete the bulldozer work. The transverse dimension naturally represents the width of the original trench and the excavated material piled on each side.

Plots were measured on the reclamation site as shown (Figure 7), each 10 metres along the trench and 4 metres across.

The grass seed mixture on the Red Ridge site contained the following varieties and proportions:

Alsike Clover	15%
Alpine Bluegrass	15%
Creeping Red Fescue	30%
Sheep Fescue	10%
Meadow Foxtail	15%
Timothy	15%



7. Test Plots, Red Ridge, plots are numbered as indicated in the "Field Observations" below.

6. View of trench before reclamation, Red Ridge

Field Observations

The Red Ridge site was visited on August 31, 1996 and July 23, 1997 (Figure 8). The following is a description of results.

Plot 1. Fertilizer, seed, inoculant. Sporadic growth was present in 1996, with about 15 percent of the plot covered, the growth being concentrated in depressions made by the bulldozer grouser bars. The growth was stunted, the grass being approximately 10 cm tall. The coverage in 1997 was slightly greater and the grass taller, to a maximum of 25 cm in height. Inflorescence (seed heads) of timothy and bluegrass were present.

Plot 2. Fertilizer, seed, inoculant, straw mulch. Growth in 1996 was to 20 percent coverage, and height to 12 cm. There was very little inflorescence of these grasses. There was about the same coverage in 1997, up to 15 cm high with rare or sparse inflorescence. (Figure 8)

Plot 3. Fertilizer, seed, inoculant, topsoil. Growth in 1996 was 20 percent coverage, and height to 12 cm (similar to Plot 2), with negligible inflorescence (Figure 9). There was similar coverage in 1997, with up to 20 cm height, and slightly more robust growth than Plot 2 (mulch). Rare or sparse inflorescence present. Caribou faecal material is near the plot. Rare scorpion weed, fireweed, and northern wormwood are also present.

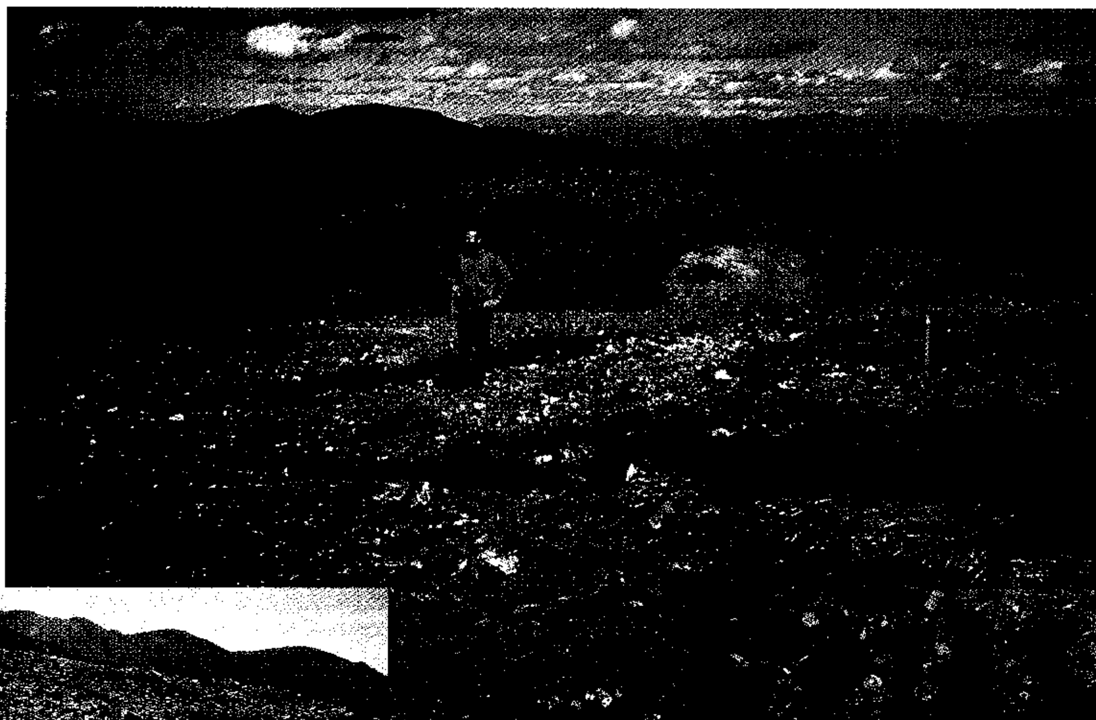
Plot 4. Control. No enhancement. Growth was negligible in 1996. A few bluegrass plants were present in 1997, presumably seeded accidently from the adjacent plot.

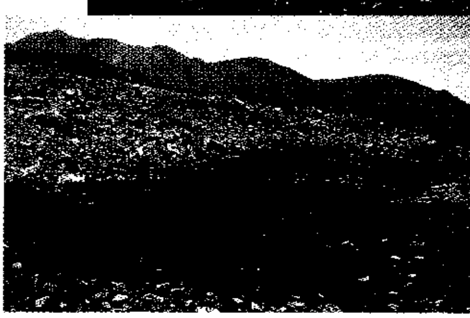
Plot 5. Fertilizer, seed, no inoculant. Growth in 1996 was comparable to, or slightly better than adjacent Plot 1. Growth was associated with linear depressions and moisture was recognizable in these depressions. There was modest inflorescence of timothy, to a height of 20 cm. There are slightly more fines on Plots 1 and 5. Plot 4, control, is particularly rocky (deficient on fines). There was fairly good inflorescence on Plot 5 in 1997, with heights up to 25 cm. Plots 1 and 5, with on site fine material, produced grass almost as well as Plot 3 with hauled in topsoil. Plot 5 growth was similar to, but slightly more robust than that on Plot 1 in density (percent of area showing growth), maximum height, average height and proportion of inflorescence. The concentration of growth in favourable microsites, here bulldozer grouser bar indentations, is striking (Figure 10).

Summary

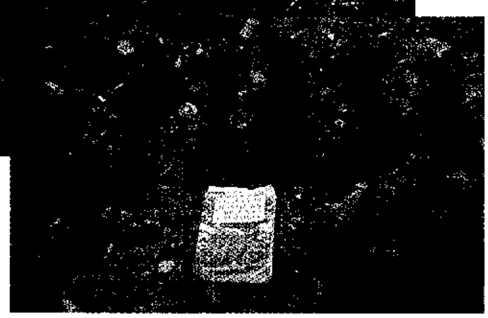
Plot 3 (topsoil) had slightly greater growth than Plot 2 (mulch; Figure 8 and 9). Plots 1 and 5 were similar with Plot 5 slightly greater and both showing moderately less growth than Plots 2 and 3. Further, growth was concentrated on Plots 1 and 5 in the small depressions produced by the grouser bars on the bulldozer track pads. Native revegetation, off the reclamation site by several metres, in the nine years since the original disturbance, shows a lush if discontinuous growth of goldenrod, saxifrage, willow, fescue and bluegrass.

8. Overview of test plots, Red Ridge; project manager Hugh Copland standing on Plot 4, Control, and Plot 2, Straw mulch in foreground, right side





9. Red Ridge, Plot 3, Topsoil



10. Red Ridge, growth in grouser bar depressions

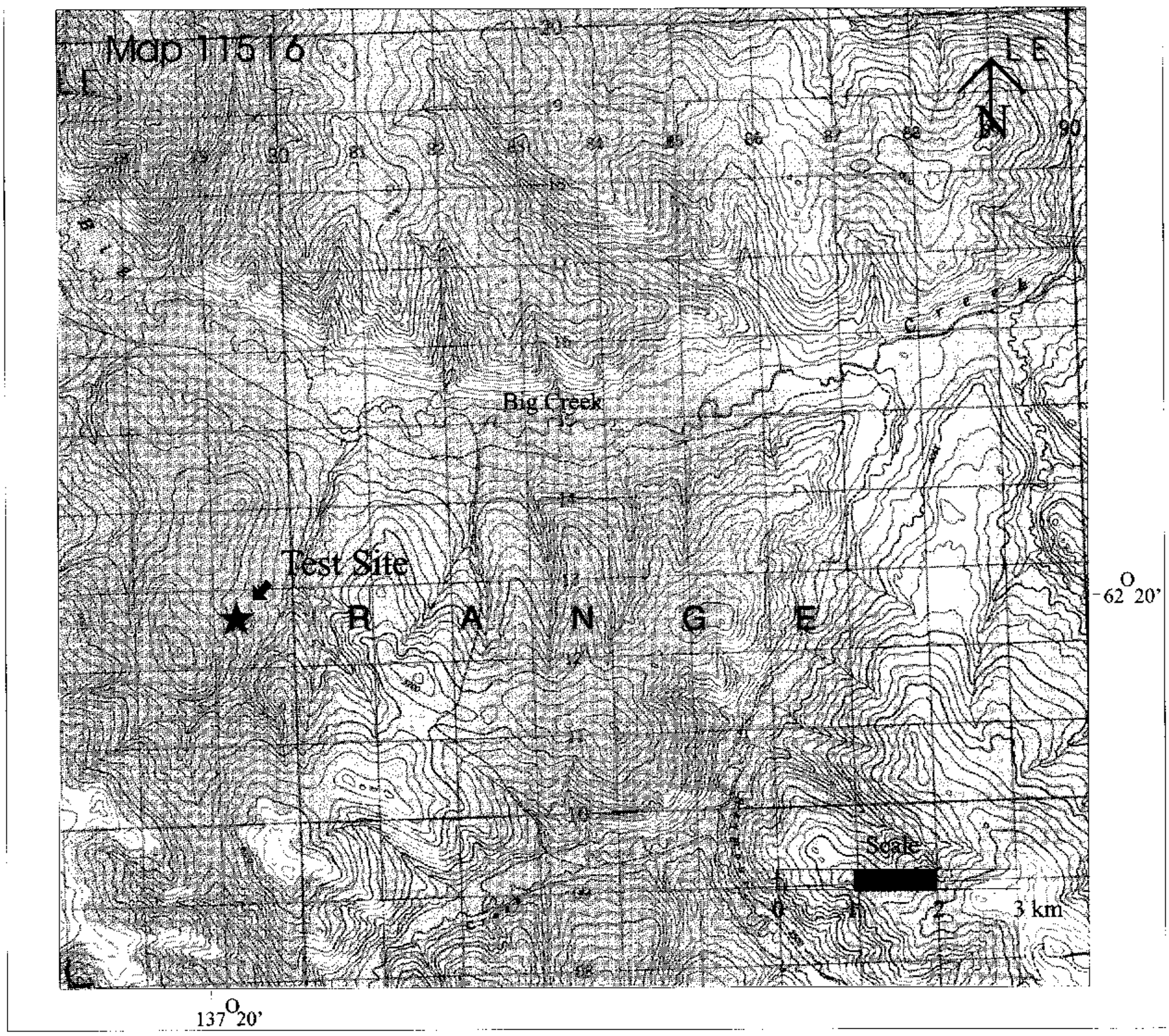
Location and Access

The Nucleus site (NTS 115 I 6, Latitude 62° 20' 3.15"N, Longitude 137°, 19' 38.47"W, Elevation 901 m) is at the headwaters of Big Creek in the Stoddart Creek 1:50,000 scale map area (Figure 11), on the eastern edge of the Dawson Range subdivision of the Yukon Plateau (Bostock, 1948). The site is accessible from Carmacks, 90 kilometres by road, on the Mt. Freegold Road and beyond to the Big Creek airstrip, then by three kilometres of rough bulldozed road up the hillside west of the airstrip. The property is owned by Archer, Cathro & Associates (1981) Ltd.

Aspect, Physical Characteristics and Geology

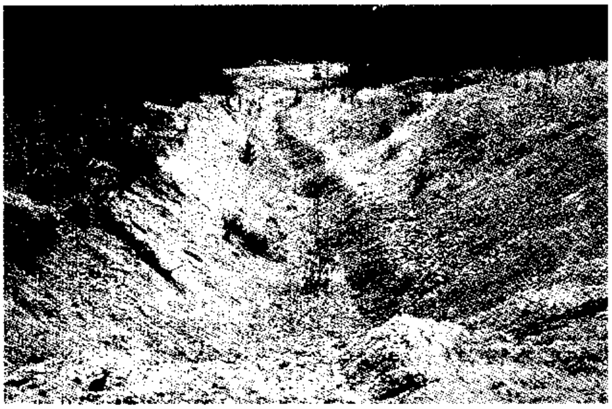
The reclamation test trench runs directly down slope on an east facing hillside (Figure 12), the slope being 12 degrees. Predominant rock type is an oxidized rhyolite associated with monzonite (Bostock, 1939, Unit 9). The material has an abundant clay fraction from weathered feldspars; any mafic minerals originally present have altered to limonite or other iron oxides. Some 75 percent of the material restored to the trench is minus 2.5 cm, much of this being in the sand-silt-clay sized fractions.

The down slope direction or orientation of the trench is regarded as the worst for instability for such an exploration cut, channelling run-off, and guaranteeing erosion of fine material. A depositional fan has formed at the lower end of this trench over the past six years from the fine material washed out of the upper part of the trench, including the short section in this reclamation test (Figure 13).



11. Location map, Nucleus property

12. Nucleus property area of trenching from the air. Reclaimed trench is in upper left of trenched area.

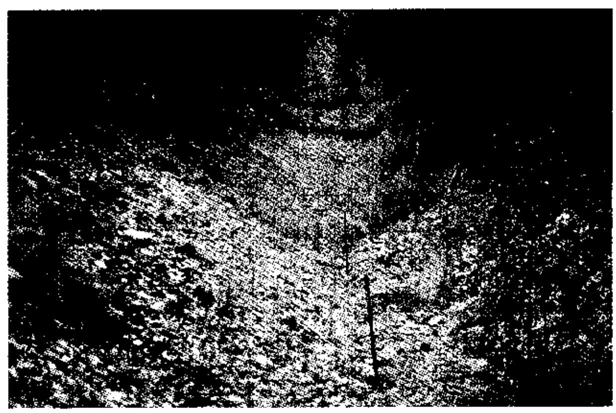


13. Nucleus trench showing depositional fan.

14. Nucleus trench, spruce seedling

The naturally occurring flora of the adjacent undisturbed area, regarded as the climax stage of plant succession, are listed in Appendix C, a total of 26 species recognized. The trench was cut in 1989. Revegetation in this trench cut by a backhoe is restricted to balsam poplar, black spruce and alder seedlings. Figure 14 shows a spruce seedling 15 cm tall at the Nucleus trench site. Alder grows more rapidly than does spruce in this environment (Figure 15), to greater than one metre in height, presumably in part because of nitrogen fixing bacteria hosted on their root systems.

Site selection was based on the abundance of exploration drill sites and trenches in the Dawson Range, and the appropriateness of testing revegetation response.



15. Nucleus trench, alder seedling.

Field Work

A section of trench was backfilled. The original excavated material was used to produce a reclaimed area 30 metres long by 20 metres wide, even though the trench itself is 3.5 to 4 metres wide. Machine time was 21 hours for the 600 square metres of site reclamation. Care was taken in the bulldozing, such that the bottom of the excavated material or spoil pile was replaced last, thus there is a maximum amount of fines on top, critical for revegetation. The rough screen test indicated approximately 75 percent minus 2.5 cm and much of this is fine material. Some coarser rock fragments, up to about 20 cm in diameter are present.

Test plots have a different orientation than at Red Ridge. The layout of the 4 m by 10 m plots is shown in Figure 16.

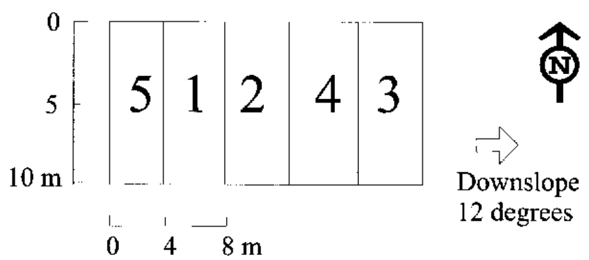
Since the disturbed area is wider than at Red Ridge, the 10 metre dimension was taken across the trench. The plot sequence is important at this site as erosion will readily move fine material downslope, confusing the effects. Accordingly, Plot 3, fertilizer, seed, inoculant and topsoil covering is placed furthest downslope. The importance of this was borne out during the field work.

Seeding was done 10 days after the topsoil was placed. Rain during the interval cut gullies several centimetres wide completely through the black topsoil blanket, exposing the yellow-brown mineral soil/decomposed bedrock backfill beneath; the effected black topsoil being moved farther downslope. Small logs were placed across the slope at the lower side of this plot as a barrier to transport of topsoil.

The seed mixture selected for the Nucleus site was:

Alsike Clover	15%
Fowl Bluegrass	5%
Creeping Red Fescue	30%
Meadow Foxtail	10%
Red Top	5%
Reed Canary Grass	10%
Timothy	15%
Slender Wheatgrass	10%

The site is understood to be in an area of extensive permafrost. However, this is not apparent in the rather dry, rocky trenches.



16. Test Plots, Nucleus, plots are numbered as indicated in the "Field Observations" below.

Field Observations

The Nucleus site was visited 3 September 1997. Growth was more abundant there and much taller than that at Red Ridge (Figure 17).

Plot 1. Fertilizer, seed, inoculant. Growth was considered modest to good with roughly 80 percent covered, with inflorescense heads 40 to 60 cm high. Alsike clover was present but not abundant (1%).

Plot 2. Fertilizer, seed, inoculant, straw mulch. There was good growth with 90 percent cover with timothy, red fescue and wheatgrass inflorescences greater than 50 cm in height. Alsike clover made up 20 percent of the vegetation (Figure 18) and rare fireweed plants were present.

Plot 3. Fertilizer, seed, inoculant, topsoil. Cover was 90 percent and where graminoids were not present, there was a fine pioneering moss. However, it is notable that barley foxtail (*Hordeum jubatum*) predominated the grasses (Figure 19). This species is normally considered a noxious weed, and it should be emphasized that it is present neither in the seed mixture nor indigenous to the surrounding area. Some tiny rose plants were present. The log barriers across the slope seemed to reduce the erosion.

Plot 4. Control. No enhancement. Some 10 percent germination of grasses took place as well as the growth of some rose and fireweed. Growth of the grasses was prominent in small erosional channels incised in the yellow-brown decomposed bedrock backfill.

Plot 5. Fertilizer, seed, no inoculant. Modest to good growth to 80 percent was observed. Growth is almost identical with that of Plot 1 except that alsike clover is not present on Plot 5, and a few fireweed plants are present on this plot.

Immediately downslope from the site, below Plot 3, erosional channels or gullies were cut to a depth of 15 cm in the trench backfill material. Barley foxtail, wheatgrass and timothy were all growing in these gullies. Obviously seed was transported from Plot 3 (topsoil) onto the non-seeded area.

Summary

Growth was robust on the four seeded plots, with Plots 1 and 5 being almost identical except for minor alsike clover on Plot 1 and a few fireweed plants starting to recolonize Plot 5. Plots 2 and 3, at 90 percent coverage, had slightly greater growth than Plots 1 and 5. Plot 2 (mulch) was characterized by alsike clover and Plot 3 (topsoil), surprisingly, was characterized by barley foxtail.

17. Nucleus trench, overview of reclaimed plots

18. Nucleus, Plot 2, straw mulch, alsike clover. Joan Craig, vegetation specialist

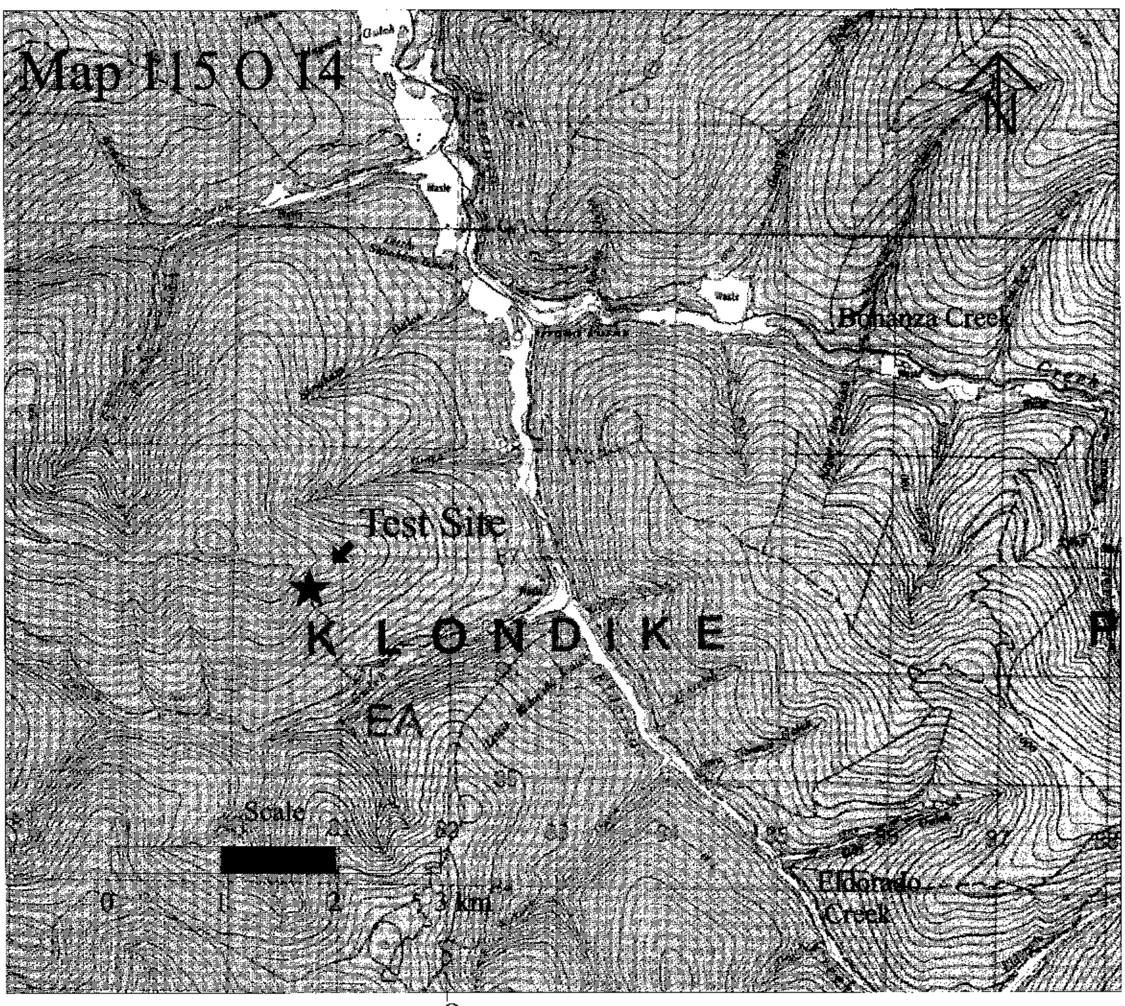
19. Nucleus, Plot 3, topsoil, barley foxtail. Joan Craig, vegetation specialist

Location and Access

The Hawk site (NTS 115 O 14, Latitude 63° 53' 45.51"N, Longitude 139° 21' 07.23"W, Elevation 840 m) is on the left limit of French Gulch in the Grand Forks 1:50,000 scale map area (Figures 20 and 21). It is in the Klondike Plateau, part of the much larger Yukon Plateau subdivision of the Canadian Cordillera (Bostock, 1948). The site is accessible from Dawson City by way of Bonanza Creek Road to Grand Forks, up Eldorado Creek then up French Gulch, a total of 25 kilometres from Dawson City. A well defined bulldozer trail leads from the French Gulch road 700 metres to the site. The Hawk claims are held by Arbor Resources Ltd.

Aspect, Physical Characteristics and Geology

The Hawk trench is a contour cut in a south facing hillside (Figure 22) in a greenish grey, friable, quartz-muscovite-chlorite schist (Klondike Schist, Green, 1972, Unit B) containing lenses and pods of quartz. Foliation (schistosity) consistently strikes southeast 135 degrees and dips fairly steeply southwest at 55 degrees. The schist weathers to a grey-green chlorite and mica rich clay. The slope of the undisturbed hillside above and below the trench is 15 to 20 degrees. The trench is cut as a notch in the hillside with much of the excavated material pushed over the downhill side (Figure 23) .



63°55'

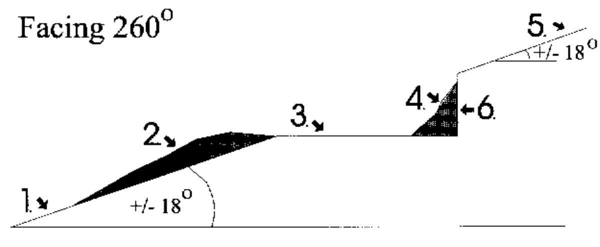
139°20'

20. Location Map, Hawk property

21. Typical Klondike terrain in the area of the Hawk showing

22. Hawk, view of trench prior to reclamation

24. Hawk, slumping effects direction of shrub growth



23. Cross Section, Hawk, trench before backfilling

1. Undisturbed downhill slope
2. Excavated material at an angle of repose of 35 degrees
3. Floor of trench, horizontal
4. Material slumped from trench high wall at angle of repose
5. Undisturbed uphill slope, 20 degrees
6. Schist high wall, subvertical

Since the trench was cut in 1983, material has slumped down the steep face onto the floor of the trench and rests at an angle of repose of approximately 35 degrees.

The naturally occurring flora in the undisturbed area adjacent to the trench is listed in Appendix D. A dense growth on the floor of the trench is dominated by alders, birch, willow and balsam poplar two to three metres in height. The fine material and the moisture retaining characteristics of the trench floor, essentially a horizontal terrace, presumably contribute to the lush growth. There is also ice rich permafrost adjacent to, and below the trench site. Ice rich organic soil is found only a few metres from the trench.

The cut face has little growth present, but shrubs are growing on slumped material. Instability is indicated by willows growing at a significant departure from vertical (Figure 24). More dramatic are small birches whose stems are almost horizontal then bent sharply toward the vertical. Such shapes are consistent with rotation of slumping material followed by a time interval of stability, allowing the plants to resume growing vertically.

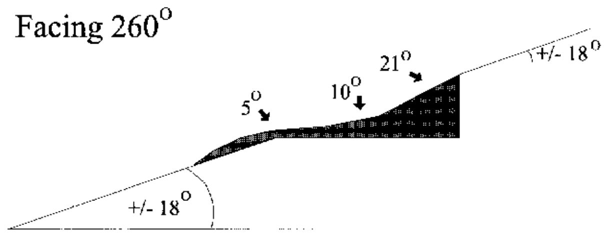
The excavated material pushed over the downhill side of the cut lies at an angle of repose of 35 degrees. The new growth, within the original tree cover, consists of the same species as those on the floor of the cut. The plants are, however, much smaller, from about 20 cm high to those identifiable only with a hand lens, rather than the three metre height of the new growth on the floor of the cut.

A rough screen analysis of the surface material from the reclaimed or backfilled trench indicates that roughly 90 percent is minus 2.5 cm and much of this is very fine.

The site was chosen as an example of revegetation of a trench in a moist permafrost area. The only part which is not revegetating fairly rapidly is the exposed schist bedrock in the high wall side of the cut.

Field Work

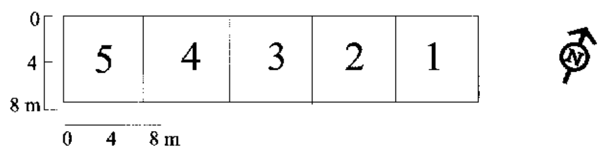
The bulldozing took a total of 24 hours, during which material was pushed from the original spoil pile across the floor of the trench and up against the cut face, producing a restored profile as indicated (Figure 25). The original trench can be divided into three zones: 1) the downslope, excavated material is reasonably stable; 2) the horizontal floor is stable and supports dense, robust vegetation; and 3) the uphill side or high wall of the cut is markedly unstable, as evidenced by slumping of rock debris, scarcity of vegetation and deformation of some plants which are growing on the slumping material (Figure 23). The excavated material, being cast to the downhill side, is recovered as backfill at considerable effort and expense, but is the only reasonable source of fill. An uphill source, for example, would disturb an otherwise pristine area which would then require reclamation. Thus the reclamation of the trench is one of compromise. The key replacement for stabilization is at the toe of the cut. Accordingly, material was pushed up to within 50 cm of the top of the cut in a profile which is concave upwards as illustrated (Figure 25).



25. Cross Section, Hawk, trench after backfilling

The measured slopes range from 21 degrees at the top to less than 10 degrees on the downhill side. Such slopes are regarded as being stable in this setting of fairly rapid growth. Further, any fine material that does move from the steeper part of the newly formed slope should deposit on the gentler part. The options are limited by the geometry of the original hillside - the average slope of any reclamation profile must average out at about 18 degrees.

The same seed mixture, fertilizer, mulch and topsoil were used at this site as at Nucleus (page 12, Figures 3 and 26).



26. Test Plots, Hawk, plots are numbered as indicated in the "Field Observations" below.

Field Observations

The Hawk site was visited 21 August 1996 and 10 September 1997. The plots are along the side hill as shown (Figure 22 and 25). Growth on the plots is greater on the high side than on the lower in both density of plants and height of individual plants (Figure 27).

Plot 1. Fertilizer, seed, inoculant. In 1996 there was perhaps 70 percent grass cover, but this was made up of 100 percent on the upper part and 60 percent on the lower part of the plot. By 1997 the coverage by timothy, fowl bluegrass, creeping red fescue and slender wheatgrass was estimated at 90 percent with the plants reaching heights of greater than one metre (Figure 28). A considerable mat from decay of 1996 growth appears to be largely fescue with some wheatgrass.

Plot 2. Fertilizer, seed, inoculant, straw mulch. In 1996 there was 100 percent cover including minor alsike clover. In 1997, there was 100 percent cover of slender wheatgrass, bluegrass, timothy and several alsike clover plants. Although there were no bare patches on Plot 2, a moose bed was observed. There was no significant difference in lushness or health of grasses between Plot 1 (no mulch) and Plot 2 (straw mulch).

Plot 3. Fertilizer, seed, inoculant, topsoil. In 1996, cover was about 80 percent with timothy, alsike clover and non-planted species - strawberry blite (*Chenopodium capitatum*), lamb's quarters (*Chenopodium album*) and hawkweed (*Hieracium umbellatum*). In 1997, cover was estimated to be 85 percent but growth was slightly less lush than on Plots 1 and 2. A mat of dead wheatgrass is composting down to form or add to the new substrate for successive growth. Scorpion weed (*Phacelia sericea*) and one barley foxtail (*Hordeum jubatum*) plant were noted.

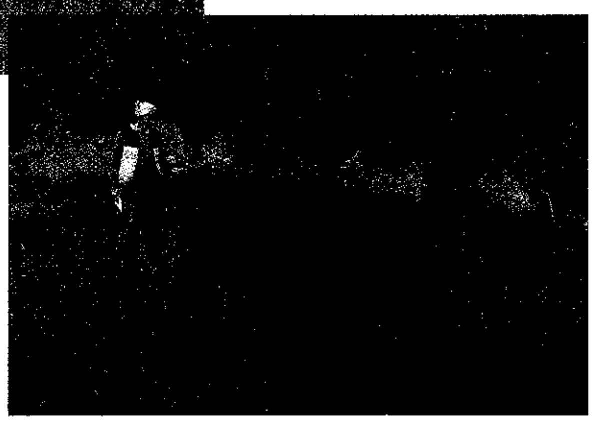
Plot 4. Control. No enhancement. Since no seeding was done the sparse vegetation observed in 1996 represents growth from material brought in by the bulldozer, animals or blown by wind. Rose, willow, fireweed and raspberry were identified. By 1997, coverage was estimated at 5 percent (Figure 29) and in addition to the species noted above bluebell, Jacob's ladder, hawkweed and milk vetch (*Astragalus sp.*) were growing.

Plot 5. Fertilizer, seed, no inoculant. In 1996, growth was similar to but slightly less dense than on Plot 1, with coverage estimated at 70 percent. In 1997, coverage was estimated at 95 percent with lushness similar to Plot 1 (Figure 30).

27. Hawk, overview of reclaimed trench, notice greater growth on uphill portion. Bob Whittingham, Mineral Resources, INAC.

28. Hawk, Graminoids, one metre tall. Joan Craig, vegetation specialist

29. Hawk, Plot 4, control, native flora



30. Hawk, Plot 5, fertilizer and seed, robust growth.

Summary

After one year's growth Plots 2 (mulch) and 3 (topsoil) had greater coverage and more lush growth than Plots 1 and 5. However, after two years growth this difference had largely disappeared. Plot 3 (topsoil), in fact, had slightly less lush growth than Plots 1 and 5. From a modest distance, plot boundaries are indistinguishable and plots are similar. Moose tracks (calf and cow), faecal material and beds are present on and immediately adjacent to the plots.

Site Comparisons

Table 1 summarizes the physical characteristics of each of the three sites.

There was far more contrast from site to site than there was from plot to plot at a particular site. The plots at Red Ridge had less than 10 percent of the biomass of the plots at the Hawk site, whereas Nucleus had close to 50 percent of the biomass of that at the Hawk site.

Table 1. Site Characteristics

	RED RIDGE	NUCLEUS	HAWK
Date	1988	1989	1983
Latitude	60° 21'	62° 20'	63° 54'
Elevation	1500 m	900 m	800 m
Aspect	ridge top	East side hill	South side hill
Rock Type	hornblende diorite	rhyolite	schist
Percent Fines	less than 50	75	90
Moisture	dry	medium	moist
Wind	exposed	partly protected	protected (forest)
Grass Height	10-20 cm	40-60 cm	90-100 cm
Coverage - percent	20	80	90-100

CONCLUSIONS OF STUDY

1. Growth in back filled trenches appears to be largely a function of microclimate, especially the availability of moisture, and the substrate, especially the proportion of fine material in the top few centimetres. Growth appears to be much less sensitive to field applications of mulch or topsoil. Accordingly, the results to be expected at reclaimed trenches are going to be highly variable, based on the particular setting, not on the treatment applied.

2. Microsites are also important as illustrated by the disproportionate growth in the grouser bar indentations at Red Ridge. They may trap fines, seed or moisture or some combination of these three but it is suggested here that moisture retention is the most important.

3. Topsoil produced little in the way of benefits. Although there was modestly greater growth on the topsoil on Plot 3 at Nucleus, than on the seeded Plots 1 and 5 without topsoil, this improvement is not considered significant. Further, the stimulus may be only temporary as indicated at Hawk Plot 3, where after one year the growth was more lush than on the seeded Plots 1 and 5 without topsoil. However, by the end of the second year (1997) this difference had largely disappeared.

4. The dramatic, abundant growth of barley foxtail on Nucleus Plot 3 and one plant on Hawk Plot 3, with essentially no other source for this species than the topsoil itself, demonstrates that undesirable seeds can easily be brought in unintentionally. Barley foxtail is a hardy, aggressive, noxious plant which can be injurious when eaten by ungulates. It pierces the gums of the animals and these lesions can then become infected.

5. The control Plot 5 at the Hawk site with several species indigenous to the immediate surroundings and the absence of these on the grass plots show clearly that the presence of planted grasses can impede the encroachment of native species onto disturbed sites. This is in direct conflict with one of the purposes presented in the Introduction section of this report.

6. Grasses, growing luxuriantly on the Hawk site, are already forming a compost mat in which indigenous species may grow. This is the purpose of a cover or nurse crop and is being fulfilled.

7. The Nucleus site illustrated the vulnerability to erosion of a downslope trench. At this site the straw mulch seemed to check erosion and could well reduce it until further vegetation was abundant enough to stabilize the site.

8. The significantly greater growth at the top of each plot at the Hawk site, in contrast with the growth on the lower edge of the plot, in spite of the similar setting and treatment, is best ascribed to increased moisture due to greater snow depth and to greater depth of backfill containing finely divided mineral and organic material. With the southern exposure and forest downslope the lower part of the plots would get slightly less direct sunlight. However, abundant moisture and fill at the top seems to be the best explanation.

RECOMMENDATIONS

1. When trenching, the surface layer should be stripped and stockpiled separately from the bulk of the material excavated from the trench if possible. This is presently being done in the development of gravel borrow pits.

2. When the trench is being backfilled, this surface layer, with a higher proportion of fine material and containing any possible organic soil, seeds and rhizomes, should be replaced last.

3. The last few passes with a tracked vehicle could be made with the blade raised leaving grouser bar indentations which form attractive microsites for initial growth.

4. No topsoil should be brought in. On the basis of this study, little benefit was derived from the use of this particular topsoil. Further, it is essentially impossible to guarantee that undesirable plant material will not be brought in with the soil.

5. Careful consideration should be given to the planting of graminoids. If rapid revegetation is important to stabilize a slope subject to erosion then planting could be done. Typically, there is an abundance of seeds or other reproductive material from either or both the restored top layer or the immediate surroundings.

6. If graminoids are to be planted, some consideration should be given to obtaining seed such as reedgrass (*Calamagrostis sp.*), bluegrass (*Poa sp.*), fescues (*Festuca sp.*) and other native graminoids which are native to the area, hardy and wide spread, as well as being palatable and nutritious forage for ungulates.

7. A single application of inorganic fertilizer applied as recommended for agricultural land will stimulate growth.

8. Nitrogen fixing inoculant appears to be beneficial for clover growth on only Nucleus Plot 2. This project has not demonstrated significant benefits from the use of such inoculant. Local flora with nitrogen fixing nodules, gathered and appropriately prepared, would enhance growth of the corresponding plant species. (For example, mycorrhiza nodules from alder trees should be used to inoculate alder seedlings and clover nodules should be used to inoculate clover seeds as was done in this study).

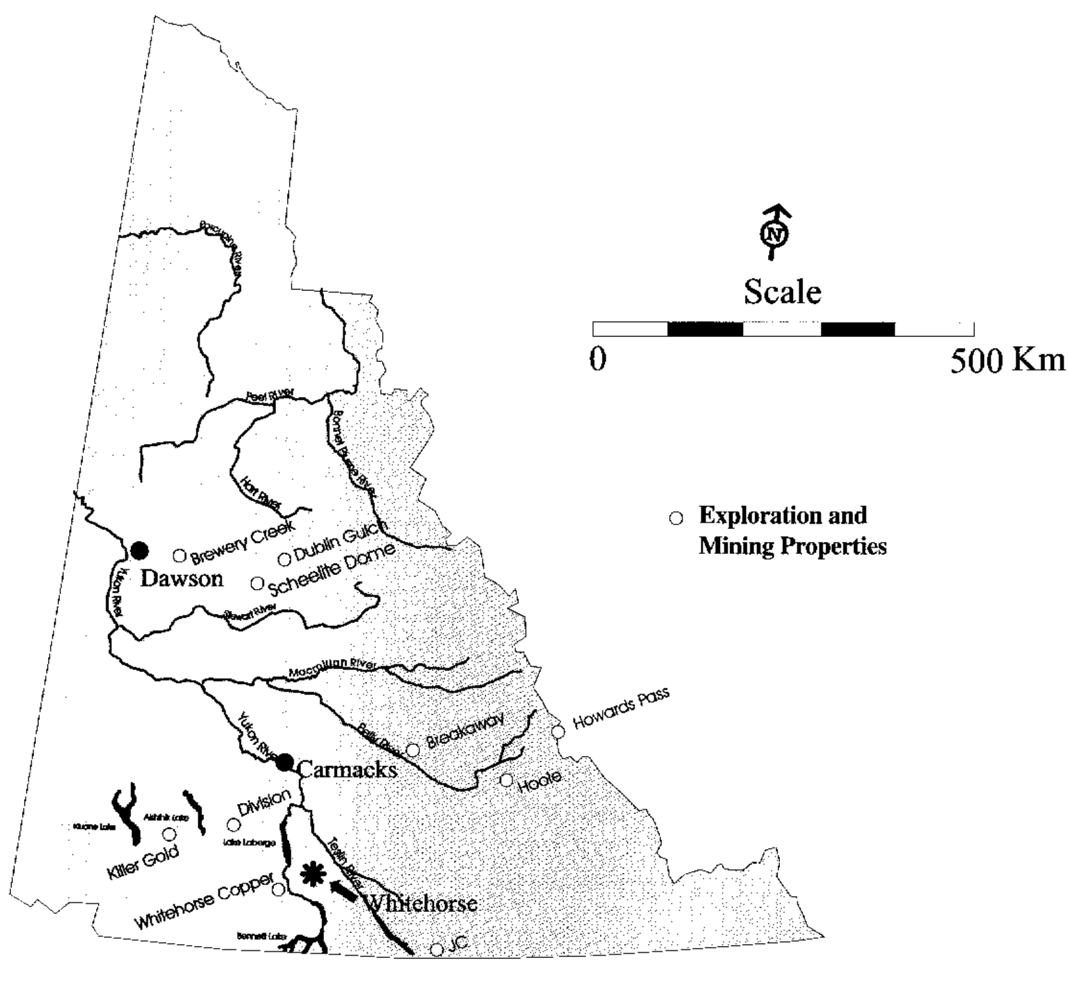
9. The sites should be examined for one or two more years, checking the same features as were assessed in 1997. Further, the transition from seeded to indigenous species should be monitored. This examination would be most valuable or at least best observed at the Hawk site where growth is rapid and numerous species are available in the immediate surroundings to colonize the disturbed site.

10. Some consideration should be given to an attempt to curb the growth of barley foxtail at Nucleus and Hawk. This should be done for the merit of arresting an environmentally negative or deleterious result of the project, however unintentionally caused, as well as for the scientific aspects of determining how successful such an attempt might be.

PRE-REGULATORY RECLAMATION IN YUKON

Although terrestrial exploration and mining activities on claims remains largely unregulated in Yukon, several explorationists and miners operating in the Territory are nevertheless striving to conform with the environmental protocol followed by the mining industry in other parts of Canada and the U.S. This environmental awareness is demonstrated by the examples cited in the following. These examples are only representative of some projects of which Mineral Resources are aware, and undoubtably is not a complete picture of the reclamation activity occurring in the Yukon prior to 1998. Hopefully there are many more examples yet to be brought to our attention.

Lode exploration properties visited during 1997 by K. Pelletier, INAC are shown in Figure 31 and include Breakaway, Division Coal, Dublin Gulch, Howard's Pass, Killer Gold and Scheelite Dome. Reclamation work described on the Hoole, J.C. and Rusty Springs Properties are based on information provided by the companies doing the work. Mining properties visited where reclamation activity has occurred include Brewery Creek and Whitehorse Copper. The scope of reclamation work done on each of these properties varies and is described in the following.



31. Location map of reclamation properties

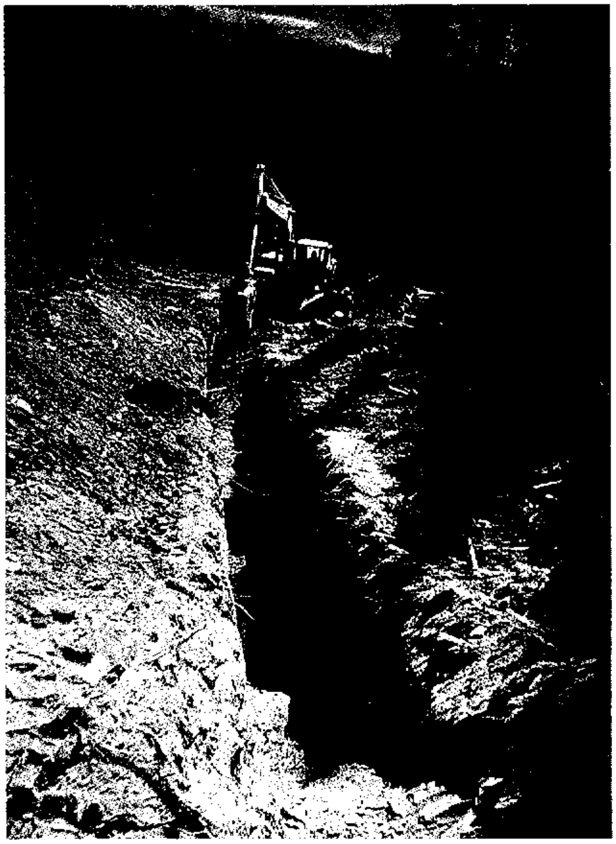
EXPLORATION PROPERTIES

Breakaway

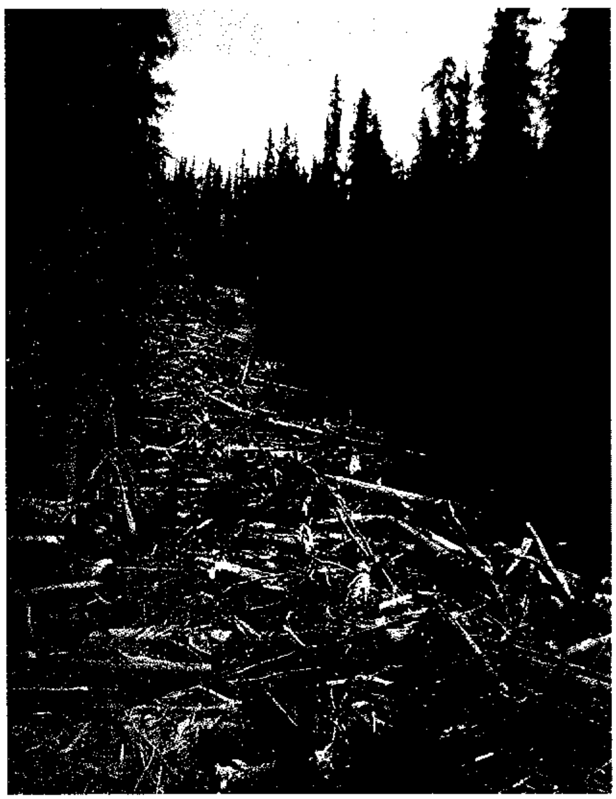
The Breakaway Pb-Zn prospect, located approximately 15 km northeast of Ross River, is accessible by bulldozer trail and winter road from the North Canol Road. The property was first explored by previous owners between 1975 and 1977, and again in 1981. The area was restaked by the current owners, Expatriate Resources Ltd., in 1995 and explored in 1996. The company made a notable effort to minimize the impact of those activities which resulted in land disturbance, such as trenching and mobilizing the backhoe.

During mobilization of the backhoe onto the claims (approximately 1.5 km), pre-existing cat trails and winter roads were used and the vegetation was disturbed as little as possible. The exploration work was planned for the spring to prevent any rutting or gouging along the access trail, and the type of excavator was selected for its low ground weight relative to other equipment alternatives. Natural revegetation is expected to occur rapidly because the area is gently sloping (average of 20°) and supports a moderately dense vegetative cover consisting mainly of buck brush and willow. Most of the 1981 cat trails on, or leading to the property are also partially to completely obliterated by overgrowth.

Material excavated from the exploration trenches was separated into two piles, with overburden placed on one side of the trench and the vegetative mat on the other (Figure 32). Following geological mapping and rock sampling in the trench, the excavated material was replaced (within three days) and the vegetative layer was restored to the surface. Trees which were cut down to clear the way for trench excavation were later spread over the buried trench in order to help prevent erosion and also to eventually provide nutrients to the soil as the material decomposes (Figure 33). Salvaged moss was carefully placed back on the surface to enhance re-growth and, as observed in 1997, has begun to reestablish itself on the reclaimed trench sites.



32. Excavation trenching at the Breakaway property in 1995

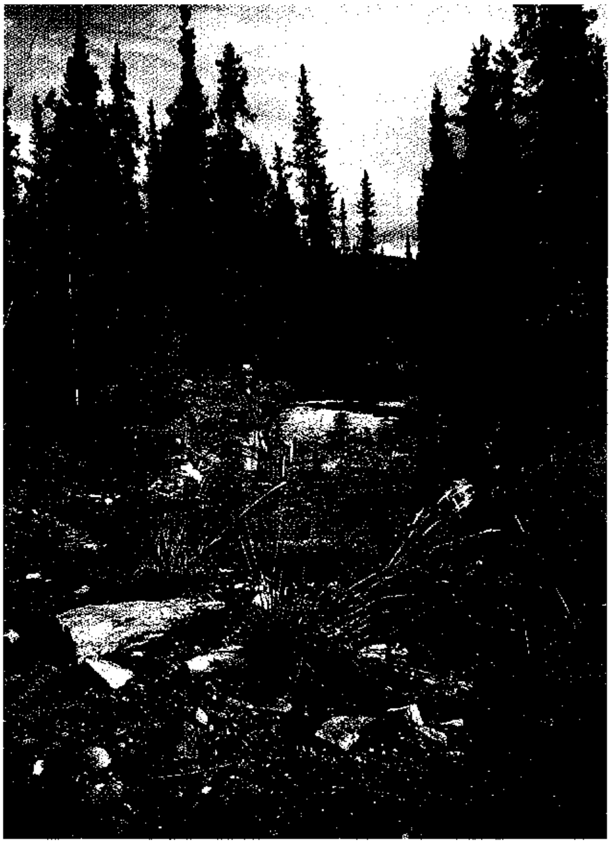


33. Refilled trench covered by slashed vegetation from the original clearing, Breakaway property.

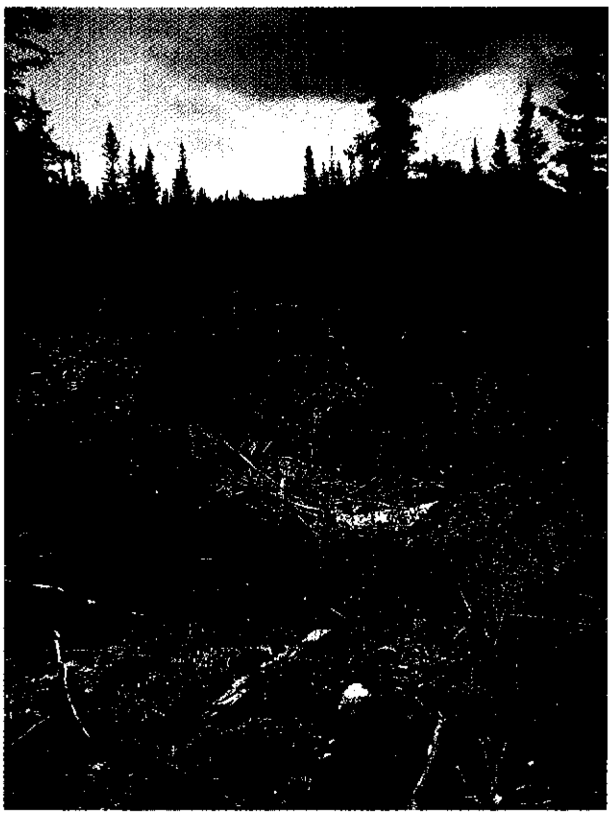
Division Coal

The Division Coal Property, located approximately 22 km west of Braeburn, north of Whitehorse, was first staked in 1902. The earliest exploration activities at the site occurred between 1970-72 and again in 1990-91 by previous owners. Cash Resources Ltd. acquired the coal leases in 1992, conducted further exploration as well as environmental baseline studies between 1993 and 1997, and are planning to continue exploration in 1998.

Coal leases in the Yukon, unlike mineral claims, are administered under the Territorial Lands Act (TLA). Land use activities on coal leases are permitted under the Territorial Land Use Regulations (TLUR), pursuant to the TLA,



34. Non-reclaimed 1972 trench at the Division Coal property (August, 1997)



35. Reclaimed 1994 trench at the Division Coal property (August, 1997)

and require reclamation for any disturbed terrestrial sites. The Division Coal property, therefore, illustrates several reclamation methods currently being used on exploration sites in Yukon. The earliest exploration activities at the site did not require reclamation until the TLUR came into effect in 1977. This gives us the opportunity to compare land disturbances from these two eras of exploration activity and document the benefits of reclamation.

Ongoing exploration activities on the property have predominantly included diamond drilling, excavator trenching, and the construction of access roads to drill pad and trench sites. The 1970's trenches were not reclaimed and very little natural revegetation has taken place over the 25 years since their excavation (Figure 34). Trenches excavated in the 1990's have been reclaimed and show minimal evidence of disturbance. These trenches have been infilled with the original overburden, the vegetative mat material has been restored to the surface layer, and buried trenches are seeded with a northern mix designed specifically for the region. Figure 35 shows a 1994 trench which was reclaimed in this manner, and brush was then dragged over it to make it look more natural.

Diamond drilling on the property has been ongoing since 1993. Construction for all drill sites includes clearing of a pad large enough for the drill, and the excavation of a sump pond used to contain drill fluids. The use of sump ponds results in a minimal area of land disturbance and suspended particles in the drill fluids can settle out before water re-enters the ground water system. Once drilling is completed, the sump ponds are refilled and the site is recontoured and seeded. Where practical, brush and trees which were cut down in order to clear the drill site are spread over the reclaimed area . Figure 36 shows a reclaimed 1994 drill pad on which poplars quickly re-established themselves because careful clearing at the onset disturbed minimal surface area. Spruce tree seedlings obtained from the immediate area have been transplanted successfully onto several drill pad sites.

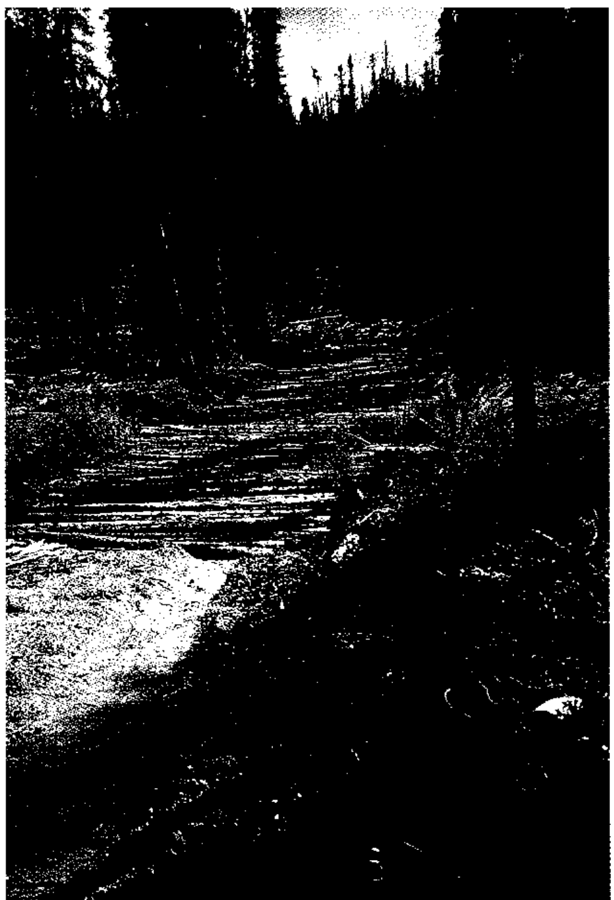
Roads have been constructed on the property for the transport of excavation and drill equipment since the early 1970's. Most of these roads have not yet been reclaimed since exploration of the property is ongoing. Some side roads to drill sites or trenches which likely won't be used again have been "put to bed" as shown in Figure 37. The road in this example was scarified using a backhoe and then seeded. Where erosion and damage of a currently used road has become a problem to the preservation of the underlying permafrost, the company has lined it with logs in order to insulate the subsurface and prevent further melting of the permafrost layer (Figure 38).

Howard's Pass

Howard's Pass is a zinc-lead deposit located in the southeastern Yukon along the Northwest Territories border, and is currently owned by joint venture partners Placer Dome

36. Reclaimed 1994 drill pad at the Division Coal property (August, 1997)

37. Reclaimed 1994 drill road at the Division Coal property (August, 1997)



38. Corduroy style road construction at Division Coal property

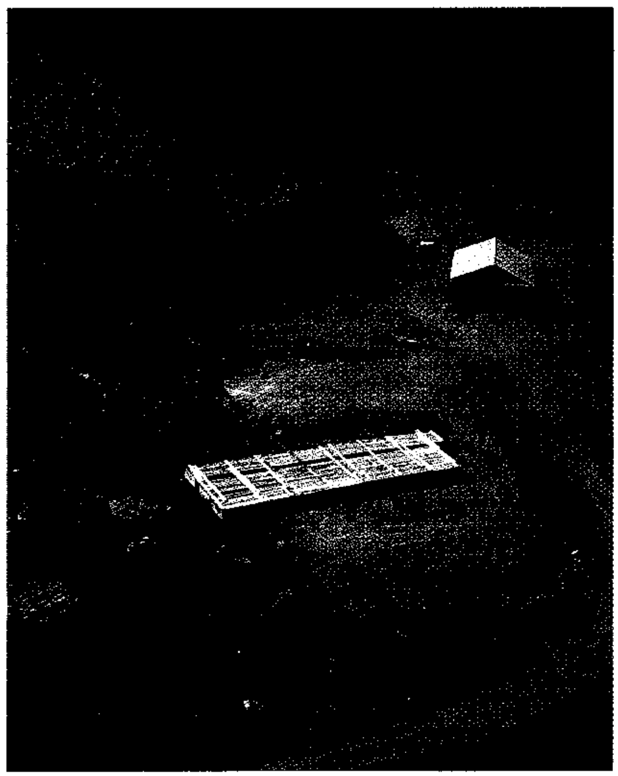
Canada and US Steel Corporation. The majority of advanced exploration occurred between 1972 and 1982. An access road from the Cantung road was built to the property in 1977, and underground exploration continued from 1980 to 1982. No exploration activity has occurred on the property since then.

Placer Dome Canada performed some clean up work at the site in 1986, including removal of the exploration trailer camp via the access road, and then the removal of the bridge at Lydia Creek to prevent further access to the site. Figures 39 and 40 compare the camp site between 1986 and 1997, showing that no trace of the camp site exists. The final cleanup of the property occurred in the summer of 1997, leaving the exploration property in a near immaculate condition. A local contractor (Connelly Enterprises, Atlin, B.C.) performed this work with a crew of three people over approximately 4 weeks. The total budget for the 1997 cleanup was $290,000.

Any remaining buildings were burned, or dismantled and removed, with the exception of one structure which was retained to house salvageable timber. This remains at the site as well a drill core which was re-stacked in a secure manner (Figure 41). Garbage, including metal, wood, equipment, trash, etc., was either burned, buried or removed from the site via air transport. All fuel stored at the site (since at least 1981) was burned and drums were removed by aircraft. The underground adit was sealed using a 22 cm thick cement and rebar barrier, and a metal pipe drains water from the adit into the surrounding creek. The pipe is sealed with a sturdy metal grate so that small animals cannot enter. Debris and sheds from the adit and vicinity were cleaned up and removed.

39. Howard's Pass camp in 1986 before the removal of trailers

40. Location of the previous camp at Howard's Pass was in the centre of the photograph



41. The shed and core still remaining at the Howard's Pass property (August, 1997)

Killer Gold

The Killer Gold Property is located approximately 45 km northwest of Haines Junction, and is accessible only by air. It was discovered in 1986. The claims were optioned by Cash Resources Ltd. in 1994 who conducted exploration on the property in 1995. This exploration program occurred amidst protest from local conservation groups because the claims are located within a sheep habitat area and also lie within the migratory route of woodland caribou. The claims were also situated immediately adjacent to a hunting outfitters cabin, creating an additional land use conflict. Conservationists felt that the planned exploration activities should not be allowed to proceed and appealed to the federal government to refuse issuance of the land use permit required to mobilize a backhoe across crown land to access the claims.

Taking into account the concerns raised by the various interest groups, Cash Resources went to a great deal of effort and expense to minimize any environmental impacts of the exploration program. Three people from the Champagne-Aishihik Band were hired to participate in the project, including an elder to help route the off-road trail required to mobilize the backhoe, and two people to co-ordinate and participate in reclamation work at all stages of the program. The elder had previously operated a horse tour company in this area for many years and was accordingly familiar with the region.

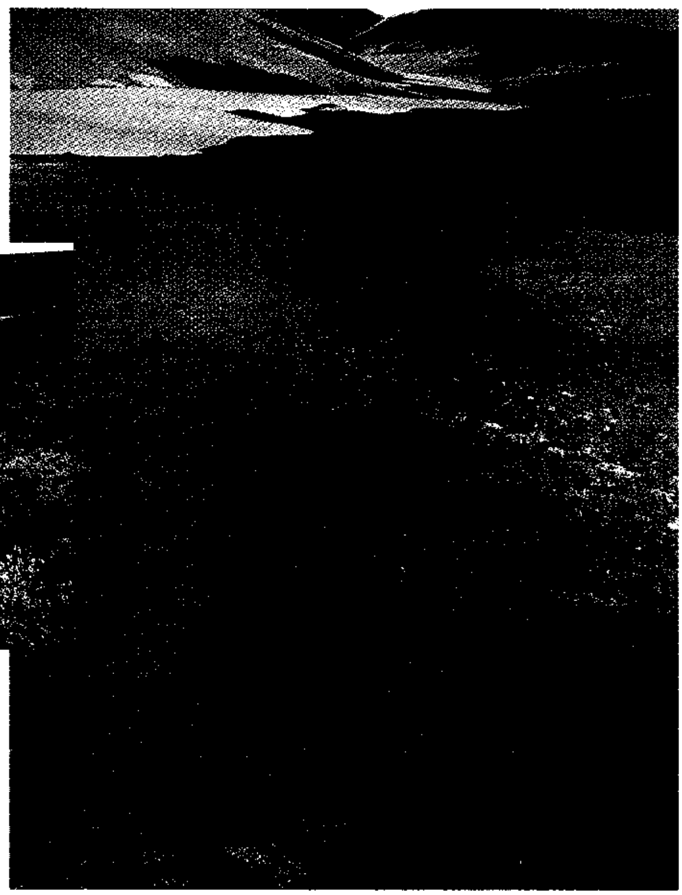
One of the major public concerns about the project was that the off-road trail required to walk the backhoe onto the property would increase access into the area. Hence the route was carefully reconnoitered on foot along it's entire 26 km length by the first nation elder hired for the job, and once selected it was well flagged. A portion of the trail deliberately traversed a significant stretch of rock talus, to ensure it was not reusable by others. This tactic necessitated flying in timber with a helicopter which was used for the backhoe to walk over the talus, and then removing the timber at the cessation of the trail use.

When the backhoe was walked in along the selected route by a First Nations operator, it was followed on foot by a group of people including the company's environmental personnel and project geologist, as well as a biologist from Renewable Resources,Yukon Government. Care was taken not to disturb the ground cover, and where the vegetative mat was displaced, it was immediately restored where possible (Figure 42). All flagging marking the route was removed at the conclusion of its use. The route followed by the backhoe in 1995 was retraced from the air by helicopter in July, 1997. The tracks made by the backhoe are only locally visible, and the route was difficult to find in most places (Figure 43).

The program was carefully timed to occur at post-lambing and pre-rutting season in consideration of the local sheep population, and to avoid the hunting season in consideration of the local outfitter. The company also jointly funded a study with Yukon Government, Fish and Wildlife Branch to document the impact of the 1995 exploration activities on the sheep (Frid, 1995). Preliminary observations made during the study resulted in changing helicopter flight paths to minimize the impact on the sheep during the exploration program. Timing of helicopter flights were also planned to minimize disturbance at times when the sheep were bedding.

The location of the camp was chosen so that the exploration sites could be reached by foot, therefore minimizing the disturbance on the sheep population residing in the vicinity. The drill was moved using a helicopter in order to minimize ground disturbance and the core was left on site, stacked in a stable manner. Once rock sampling and mapping were completed, the trenches were buried and the topsoil was replaced to the surface layer where some natural revegetation has already occurred (Figure 44). No clearing was necessary for any of the exploration activities, but because the area is an alpine setting, natural revegetation is likely to be slow. Nevertheless, eventually the disturbances will not be discernable because of the reclamation work done.

42. Mobilizing a backhoe onto the Killer Gold property in 1995



43. The backhoe trail to the Killer Gold property in 1997

44. Reclaimed trench at Killer Gold property (July, 1997)

Dublin Gulch

Dublin Gulch is located approximately 50 km north of Mayo and is currently owned by New Millennium Mining. Exploration on the property has been ongoing by various owners since its discovery in 1901. The bulk mineable gold deposit is currently undergoing the environmental assessment process in order to begin development and mining. Reclamation work at the property consists of the refilling of exploration trenches and pits dug in 1996 and 1997. Topsoil was retained and then restored to the surface layer. Figure 45 shows a reclaimed trench which was refilled and seeded in 1996, and photographed in the fall of 1997.

45. Reclaimed 1996 trench at Dublin Gulch property (September, 1997)

Hoole

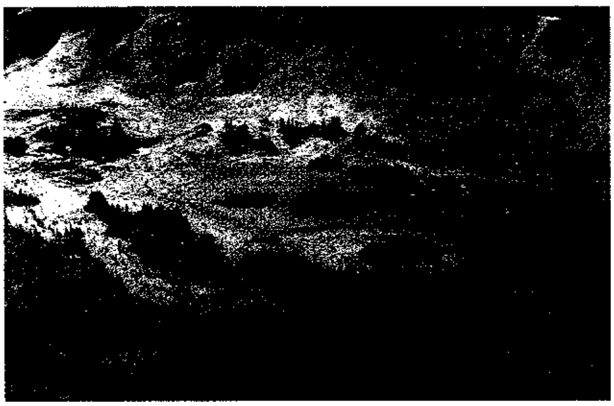
The Hoole property, located approximately 120 km east of Ross River, is owned by Cominco Ltd. who last did exploration work on the claims in 1992. Tent floors and garbage, spread over a wide area due to snow movement, were spotted by company employees while flying over the claims in 1997. Consequently, two employees spent 4 hours consolidating and burning the wood and waste materials, and all waste metal and fuel drums were removed from the site. The total cost of the cleanup was $3,372. Figure 46 shows the campsite immediately following the cleanup. Any sign of the disturbance will likely be obliterated after a winter season.

46. View of the Hoole property camp immediately following cleanup (September, 1997)

J.C

The J.C. property is located in the Rancheria area and is owned by Cominco Ltd. The last exploration work done on the claims was in 1982. The presence of considerable litter at the old camp site was brought to the attention of Cominco Ltd. by a local helicopter company and consequently a cleanup of the site was done in September, 1997. Four people, including the helicopter pilot, spent two days on the cleanup and 58 drums, 28 propane cylinders, diamond drill rods and 2 loads of trash were removed from the site. A total of $11,931. was spent on cleaning up the property. Figures 47 and 48 show the camp area before and after the clean up.

47. View of the J.C property prior to cleanup (September, 1997)



48. View of the J.C property immediately following cleanup (September, 1997)

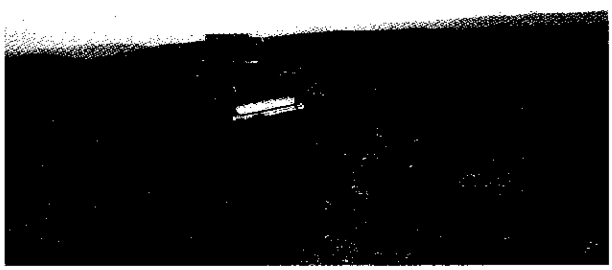
Rusty Springs

The Rusty Springs property is located approximately 270 km north of Dawson City, and is only accessible by air. It was first explored between 1976 and 1982 by previous owners, who accessed the property by winter road and a winter airstrip constructed in 1978. The property was restaked in 1992 and explored between 1994 to 1997 by the current owners Eagle Plains Resources Ltd. A new airstrip was constructed in 1994, and the company rebuilt and occupied the old campsite structures. They also consolidated empty fuel drums from early drill and trench sites and transported them to Dawson City on back hauls (Figure 49).

49. Fuel drums were collected at the Rusty Springs property in 1994 and flown out in back hauls

Scheelite Dome

Scheelite Dome is located approximately 25 km northeast of Mayo and is owned by Kennecott Canada. Exploration in the area has been ongoing since the early 1970's by several companies on various claim groups. The first known reclamation work occurred in the summer of 1996 when the company began burying trenches that could be used as access trails. In the summer of 1997, the company also began segregating material for the trenches and refilling them when the sampling and geological mapping were completed. Figure 50 shows a 1997 trench with overburden and topsoil segregated into two piles. This trench was later refilled with topsoil restored to the surface layer.



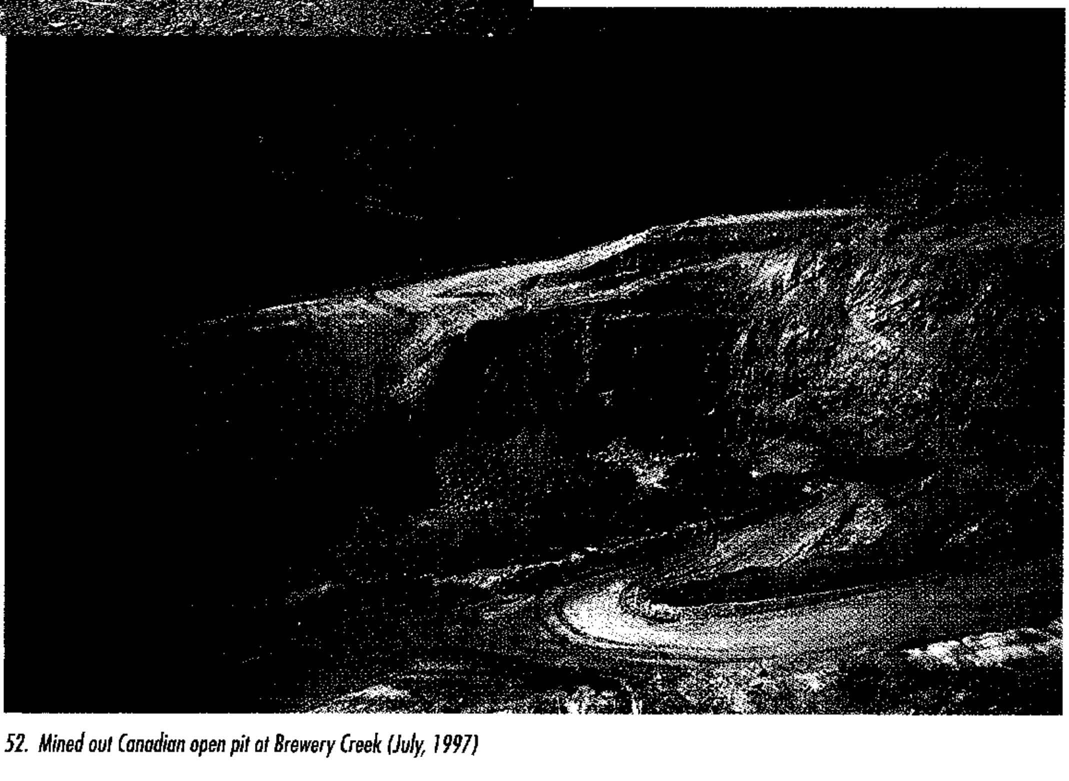
50. Trenching at the Scheelite Dome property (September, 1997)

Brewery Creek

The Brewery Creek Mine is located approximately 30 km east of Dawson City and is road accessible off the Dempster Highway. The property was discovered in 1987 and was explored extensively between 1989 to 1995. Open pit mining began on the bulk mineable gold deposit in 1996 and this cyanide heap leaching operation is expected to continue for at least 10 years. Continued exploration on the property could, however, lead to an extended mine life. Mining is seasonal, with activity occurring mainly between May and November.

Mining had been ongoing for only one full season and was in the midst of its second season at the time it was toured in July of 1997. Consequently, reclamation work was in its early stages. Preliminary studies at the site include seed plots on waste dumps which were initiated in the fall of 1996. Various seed mixes obtained from a local supplier are being tested and have met with varied success as shown in Figure 51. Reclamation activity in 1997 also included the backfilling of open pits. Mining at the site is being done along a series of small, shallow open pits. The Canadian Pit, mined in 1996, was being backfilled with waste material from the Kokanee Pit where mining was taking place 1997 (Figure 52).

51. Test plot for seed varieties on a mine waste dump at Brewery Creek (July, 1997)



52. Mined out Canadian open pit at Brewery Creek (July, 1997)

Whitehorse Copper

Whitehorse Copper Mine is located within the city limits of Whitehorse, approximately 10 km southwest of the city centre. It is owned by Hudson Bay Mining and Smelting Company Limited, who mined the deposit between 1967 and 1982. Mining activity at the mine has resulted in a disturbed land area of approximately 320 hectares. This includes a tailings impoundment, as well as an area with active slope instability and subsidence at the Little Chief Pit and its associated underground workings (Brodie, 1995). Reclamation work at the mine has included reclamation of the tailings impoundment, waste dump and mill site area, some backfilling of the Little Chief Pit in areas of instability, sealing of shafts, and construction of berms across access roads to prevent access.

The reclamation work done on the tailings ponds between 1994 and 1997 is of particular interest for the purposes of this review (Figure 53). The work began with two separate initiatives in the first year, one by the company and the second by Dr. D.B. Craig sponsored by various sources (see Craig, 1995 and 1996). The project undertaken by the company included discing and seeding of a large part of the main tailings pond area, known as the Old Pond, which covers an area of approximately 55 hectares. Some legume growth was achieved in the first year, as shown in Figure 54, but was not maintained over time, as shown by the photograph taken in 1997 (Figure 53). The minimal and patchy growth on the pond reclamation site was probably due to the high alkalinity of the soil (D.Craig, personal communication).

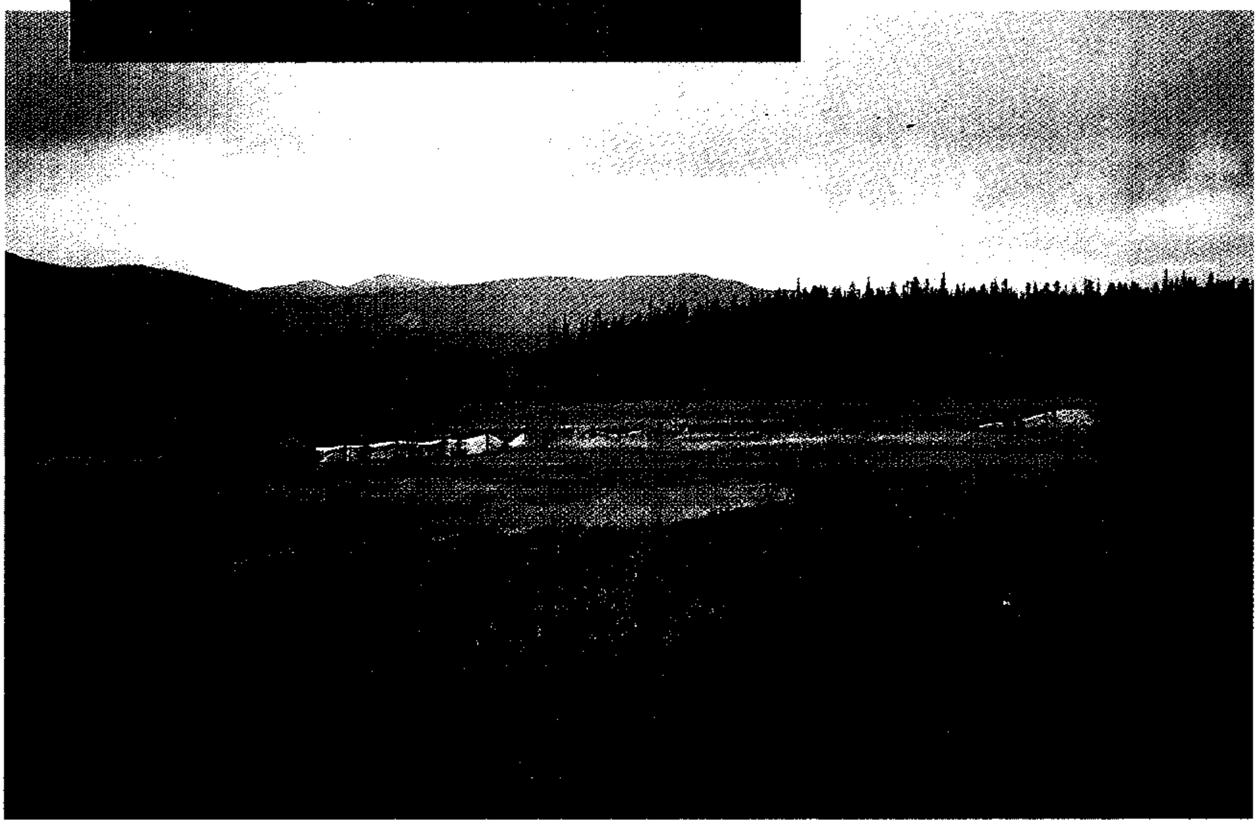
The study undertaken by D.B.Craig occurred over a three year period. During the first year, a 0.9 hectare area on the east side of the Old Pond was chosen as the study site specifically because it is subject to high wind erosion. It was isolated by a wind barrier fence, and trees were transplanted along its perimeter in order to eventually replace the fence as a windbreak. The area was then divided into plots, each of which were treated with varied applications of organic material (compost) and commercial fertilizer which were rototilled to a 15-20 centimetre depth. Finally, the plots were seeded with a recommended mix of grass seeds and in 1995, a sprinkler irrigation system was installed on the site. In 1996, growth characteristics were analysed for each of the five plots and were shown to be quite different (see Craig, 1994 and 1995). This project met with considerable success as shown in the photograph of the study area in 1997 (Figure 55).

53. View of reclaimed tailings pond at Whitehorse Copper in the fall of 1997

This project met with considerable success in that a portion of the mine tailings have been successfully revegetated (Figure 55). The study is site specific, but may be applicable to comparable skarn type deposits. Characteristics of the tailings are that there are no toxic chemicals present, the tailings are extremely alkaline with pH levels of > 9.0, and salinity readings are high enough to be toxic to plants. The following are some results from the study.

1. Preferential growth on test plots is clearly the result of differential amounts and quality of organic material applied to each test plot, with the plots receiving abundant, well composted material showing by far the most abundant growth. The control plot which was fertilized, seeded and rototilled resulted in zero growth.
2. The organic material (compost) has several essential functions in enhancing plant growth:
   (a) specific types of organic material (bark, shavings, sawdust and vegetable compost) are acidic upon decomposition and thus shifted the high alkaline tailings towards neutral;
   (b) the same materials also reduce salinity;
   (c) it improves the texture of the soil;
   (d) it helps the retention of moisture;
   (e) the compost provides plant nutrients, and is more susceptible to rapid leaching of nutrients than commercial inorganic fertilizer;
   (f) compost provides a habitat in which soil organisms can develop.

54. View of the reclaimed tailings pond at Whitehorse Copper. The Rotary Club test plot can be seen in the upper right hand side of the photo (September, 1994)



55. Rotary Club test plots with control plot in centre of photograph (September, 1997)

ACKNOWLEDGEMENTS

The writers acknowledge the support of other participants in this project. We would especially like to thank the mineral exploration companies that allowed us to use their properties for the reclamation tests: Archer, Cathro & Associates (1981) Ltd., and Arbor Resources Ltd. We would also like to commend those companies carrying out reclamation and in particular thank those that facilitated touring and examination their reclamation sites: G. Graham, Cominco Ltd.; H.R. Goddard, Placer Dome Canada; R. Carne, Cash Resources Ltd.; D. Eaton, Expatriate Resources Ltd.; R. Hulstein, Kennecott Canada Ltd; D. Lister, Viceroy Minerals Corporation; and R. Termuende, Eagle Plains Resources Ltd.

James Coyne and David Craig scouted out the Red Ridge and Nucleus properties, establishing access and estimates of the type and amount of work.

Daniel Coyne operated the bulldozer with considerable finesse, bringing the back filled trenches to a suitable profile and surface texture, making the plot work straight forward.

Mark Kean of Mikro-Tek Labs of Timmins, Ontario, provided mycorrhizal fungi and contributed much to the understanding of the problem and procedures of revegetating infertile environments. These exploration sites typically consist of broken rock, lacking organic material and any resemblance of topsoil.

Tony Hill, Yukon Agriculture was most kind and helpful in suggesting appropriate seed mixtures and fertilizers. Yukon Agriculture officers allowed use of the Department library and gave advice.

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APPENDIX A

Mycorrhizae in Trench Reclamation

Mark Kean, Mikro - Tek Labs

Background:

The Latin term mycorrhizia literally means "fungus roots" and defines the association between plant roots and specialized soil fungi. Under normal conditions, mycorrhizae live in most soils and on the roots of most terrestrial plants. Mycorrhizae act to extend a plant's root system through a network of hyphae, thereby increasing its capacity for nutrient and water absorption. Severe soil disturbance causes loss of organic matter, nutrients, soil aggregate structure and biodiversity, eliminating most mycorrhizae and severely curtailing the efficacy and diversity of any surviving. Loss of mycorrhizal fungi from functioning ecosystems substantially decreases primary plant productivity. In such cases, an appropriate mycorrhizal fungus strain can be reintroduced into the soil roots on host plants. Mycorrhizae have been shown to provide several beneficial effects on plant growth and survival including enhancement of the host plant's potential for mineral, water and nutrient uptake from the soil. They also improve soil structure and quality to enable the growth of diverse plant species and soil microbial communities. Because mycorrhizal fungi appear to have disproportionate influence on the survival and fitness of plants in new and restored habitats, it is believed that they are one of the cornerstone parameters to the re-establishment of a functioning plant ecosystem.

Alders, Shepherdia and Elaeagnus belong to the group of plants that are referred to as actinorhizal because they form a symbiotic nitrogen-fixing association with the actinorhizal bacteria, Frankia. This association makes atmospheric nitrogen available to the host plant as well as the adjacent plant community and is similar to the legume/rhizobium nitrogen-fixing systems that have been successfully used in grass-mix covers for mine waste and land reclamation projects worldwide. In addition, alders form a second symbiotic association in hosting ecto- and endo-mycorrhizal fungi, a group of highly specialized root inhibiting fungi. These combined features of plant/microbe interaction supply the plant with fixed nitrogen, phosphorus, water and other essential minerals, thus enabling the plant to grow in severe environments without large fertilizer amendments. The role of these pioneering actinorhizal plants in the natural reclamation process has long been recognized. Beyond increased capacity for water absorption and nitrogen-fixing, mycorrhizal and actinorhizal plants have also been proven to be more resistant to certain root diseases and other stressful conditions. The importance of a plant's increased capacity for stress resistance becomes greater as the harshness of soil conditions increases.

Inoculation procedure:

Since all three of the reclamation sites, Red Ridge, Nucleus and Hawk, were deemed to be deficient in organics and soil microbial populations, it was decided to attempt to enhance the soil's microbial condition in order to facilitate plant establishment and growth. To accomplish this a species of vesicular arbuscular (VA) mycorrhizae, Glomus intraradix, was chosen because of its wide geographic and species range. Four liters of Glomus were prepared by Mikro-Tek, in a peat moss solid state medium, and transported to the site.

Alsike Clover, a nitrogen-fixing legume species, was used in the seed mixtures for all three sites. Since a commercial source could not be located for its associated rhizobia, from this northern latitude, bacteria field collections were taken from local clover populations. The entailed collecting the roots along the Klondike Highway, between Whitehorse and Carmacks, and cutting the bacterial nocules from the root material. The rhizobia nodules were then crushed and mixed with the Glomus inoculum and water was added to form a slurry. The inoculum was hand watered into the soil of the appropriate plots.

Observations / Recommendation:

Sitka Alder (*Alnus viridis ssp. sinuata*) shrubs were observed doing very well on two of the three sites, Hawk and Nucleus. This natural establishment and rapid growth, compared to other conifers found on the sites, would indicate its suitability for use on such nutrient and organic poor sites. The rapid establishment of larger woody plants, in addition to a grass and legume cover, is an important consideration, especially when erosion control is of concern on the steeper terrains.

Containerized nitrogen-fixing alders, pre-inoculated with appropriate mycorrhizal fungi and bacterial microbes, would be a cost-effective method of establishing erosion control while concurrently improving soil fertility and conditions for other plants. Shepherdia and Elaeagnus, although not observed directly on these particular reclamation sites, are two other native nitrogen-fixing shrubs which could be utilized in the same way.

APPENDIX B

RED RIDGE FLORA

The Red Ridge site is above tree line.

Shrubs identified near the test plots are:

Arctic willow	*Salix arctica*
Snow willow	*Salix nivalis*
	Salix reticulata
Dwarf birch	*Betula occidentalis*
Shrubby cinquefoil	*Potentilla fruticosa*

Dwarf shrubs identified near plots:

Northern bearberry	*Arctostaphylis rubra*
Four angled mountaian heather	*Cassiope tetragona*
Lowbush cranberry	*Vaccinium vitus-idaea*
Bog blueberry	*Vaccinium uliginosum*
Mountain avens	*Dryas sp*

Forbs identified near plots are:

Fireweed	*Epilobium angustifolium*
Alpine fireweed	*Epilobium latifolia*
Tall Jacob's ladder	*Polemonium caerulium*
Bluebell	*Mertensia paniculata*
Mountain hairbell	*Campanula lasiocarpa*
Pussy toes	*Antennaria media*
Northern wormwood	*Artemisia borealis*
Lupin	*Lupinus alpina*
Arctic sandwort	*Arenaria arctica*
Antenna plant	*Androsace septentrionalis*
Black tipped groundsel	*Senecio lugens*
Large flowered flea-bane	*Erigeron grandiflorus*
Three toothed saxifrage	*Saxifraga tricuspidata*
Long stalked starwort	*Stellaria longipes*
Monkshood	*Aconitum delphinium*
Moss campion	*Silene acaulis*
Stonecrop	*Sedum lanceolatum*
Labrador lousewort	*Pedicularis labradorica*

Graminoids included are:

Purple reedgrass	*Calamagrostis purpurascens*
Alpine bluegrass	*Poa alpina*
Alpine sweetgrass	*Hierochloe alpina*
Altai fescue	*Festuca altaica*
Sedge	*Carex spp.*

Mosses are tiny and hard to identify. *Polytricum juniperinum*

Lichens found nearby:

Cetrerarias cucculata
Cladonia cornata
Thamnolia vernicularis
Rhizocarpon geographicum
Xanthoria elegans
Umbilicaria hyperborea

APPENDIX C

NUCLEUS PROPERTY FLORA

Vegetation on undisturbed area near trench were identified.

The canopy trees are:

Black spruce	*Picea mariana*
White spruce	*Picea glauca*
Aspen poplar	*Populus tremuloides*
Balsam poplar	*Populus balsamifera*
Paper birch	*Betula papyrifera*

Tall shrubs are:

Alder	*Alnus crispa*
Labrador tea	*Ledum groenlandicum*
Willow	*Salix sp*
Rose	*Rosa acicularis*

Low shrubs are:

Lowbush cranberry	*Vaccinium vitus-idaeus*
Bog blueberry	*Vaccinium uliginosum*
Mossberry	*Empetrum nigens*
Bastard toad flax	*Geocaulon lividum*

Forbs are:

Bluebell	*Mertensia paniculata*
Lomatius	*Lomatius*
Lupin	*Lupinus arcticus*
Black tipped groundsel	*Senecio lugens*
Fireweed	*Epilobium angustifolium*
Golden rod	*Solidago spathulata*
Polemonium	*Polemonium sp.*

Lichens are:

	Cladinia rangerfera
	Cladina mitis
	Cetreria cucculata
	Peltigera scabrosa
	Stereocaulon sp

Mosses are:

Feather mosses(should be present; ubiquitous to the area, CK)
Tomenthyptum nitens

Tiny pioneering mosses are hard to identify.

Graminoid are:

Bluejoint reedgrass	*Calamagrostis canadensis*

Regrowth in the trench floor had alder (10 -120 cm tall), some with catkins, spruce (5 - 12 cm tall), balsam poplar (10 -20 cm tall) and birch (2 - 12 cm tall). Individual plants of lupin, fireweed, golden rod and horsetail were present. Graminoids in small clumps were noted.

APPENDIX D

HAWK PROPERTY FLORA

The Hawk claims had grown up and revegetated with species from the undisturbed area.

The canopy trees are:

Paper birch	*Betula papyrifera*
White spruce	*Picea glauca*
Balsam poplar	*Populus balsamifera*

Shrubs are:

Willow	*Salix spp.*
Alder	*Alnus crispa*

Dwarf shrubs are:

Bunchberry	*Cornus canadensis*
Lowbush cranberry	*Vaccinium vitus-idaeas*
Blueberry	*Vaccinium uliginosum*
Raspberry	*Rubus idaea*
Soapberry	*Shepherdia canadensis*
Gooseberry	*Ribes lacustre*
Cinquefoil	*Potentilla fruticosa*
Highbush cranberry	*Viburnum edule*
Kinnikinik	*Arctostaphtlos uva-ursi*

Forbs present are:

Black tipped groundsel	*Senecio lugens*
Tall polemonium	*Polemonium caeruleum*
Fireweed	*Epilobium angustifolium*
Heart-leafed arnica	*Arnica cordifolia*
Tall larkspur	*Delphinium glaucum*
One sided wintergreen	*Pyrola secunda*
Pink pyrola	*Pyrola asarifolia*
Pink corydalis	*Corydalis sempervirens*
Lupin	*Lupinus alpina*
Pussy toes	*Antennaria racemosa*

Horsetail present are:

Dwarf scouring rush	*Equisetum scirpoides*
Horsetail	*Equisetum arvense*

Mosses and liverworts present are:

Juniper haircap moss	*Polytricum juniperinum*
Liverwort	*Pellia neesiana*

Graminoids present are:

Bluejoint reedgrass	*Calamagrostis canadensis*