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A Review of Several Yukon Revegetation Projects and Techniques

By

EDI Environmental Dynamics Inc.

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A REVIEW OF SEVERAL YUKON REVEGETATION PROJECTS AND TECHNIQUES

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1 INTRODUCTION

Revegetation projects in Yukon typically involve reclamation and erosion control of disturbed areas from mining and road construction related activities. The general purpose of the revegetation is to restore or stabilize these disturbed areas. However, because of Yukon's harsh climate, lack of precipitation, and higher latitude, the success rate of various revegetation efforts is variable.

Revegetation techniques used with success in more southern locations are not guaranteed to work here and little is available in terms of comparative evaluations of their use in Yukon. This report provides a summary and an evaluation of various revegetation and erosion control projects completed mostly in the past 15 years. It describes their successes and failures in an attempt to provide a guide for future restoration work and to help improve success (Section 3).

Section 4 of the report provides an overall review summary to capture the essence of the various techniques.

We end the report with a short list of recommendations for future work in Section 5 and acknowledgements in Section 6. Summaries of monitoring information from each site reviewed are presented in Appendix A.

2 METHODS

Over the years, numerous revegetation projects have been completed in Yukon. Many involved typical techniques such as seeding with a variety of grass species. However, in the past 15 years, a larger diversity of techniques has emerged with methods like live staking and transplanting.

Due to the potentially large scope of this report, we had to limit the number of projects we could review. We therefore reviewed information on more recent projects (mostly in the past 15 years) and we focused on 24 that used a variety of revegetation techniques and were somewhat smaller in size[1] (Table 1). We grouped the techniques into five categories and discuss each in the following sections o[1]f this report. The five categories include:

- Soil salvage
- Seeding with native or agronomic species
- Transplants
- Root cuttings
- Stem cuttings.

[1] Large sacle reclamation evaluation such as has been conducted at Brewery Creek was beyond the scope of this project.

To update some of the monitoring data, EDI visited ten revegetated sites where information was unavailable or out of date. These site visits took place between June 6th and October 2nd, 2008 (Table 2). We visited an additional three sites with ongoing monitoring programs (Table 3).

Table 1. Summary of reviewed restoration projects.

Restoration Technique	Site Type	Site Name	Group Completing Revegetation Works	Location	Date of Works
Soil salvage /Seeding	Mining	Breakaway	Expatriate Resources Ltd.	15 Km NE of Ross River	1996
Soil salvage /Seeding	Mining	Division Coal	Cash Resources Inc.	22 Km W of Braeburn	1994
Soil salvage /Seeding	Mining	Dublin Gulch	New Millenium Mining Inc.	50 Km N of Mayo	1996 & 1997
Seeding/ Bioengineering	Mining	Clinton Creek	Arctic Alpine Reclamation Group	100 Km NW of Dawson	2004 & 2005
Seeding/ Bioengineering	Mining	Faro Mine	Laberge Environmental Services	15 Km N of Faro	2003 & 2004
Seeding/ Bioengineering	Mining	Faro Mine	Environmental Dynamics Inc.	15 Km N of Faro	2007
Seeding	Mining	Red Ridge	INAC Mineral Resource Directorate	65 Km SE of Whitehorse	1995
Seeding	Mining	Nucleus	INAC Mineral Resource Directorate	90 Km NE of Carmacks	1995
Seeding	Mining	Hawk	INAC Mineral Resource Directorate	25 Km SW of Dawson	1995
Seeding	Mining	Jason Knoll	Aberford Resources	220 Km east of Ross River	1981
Seeding	Riparian	Fisheries Compensation Channel	City of Whitehorse	Island upstream of Riverdale Bridge	1998
Seeding	Highway	Robert Service Way	City of Whitehorse	Whitehorse	1998
Seeding/ Bioengineering	Mining	Sa Dena Hess	Access Mining Consultants	45 Km N of Watson Lake	2001, 2003 & 2005
Seeding/ Bioengineering	Mining	Mt. Nansen	Arctic Alpine Reclamation Group	70 Km SW of Carmacks	2006
Transplant and root cuttings/ Bioengineering	Mining	Brewery Creek	Laberge Environmental Services	55 Km E of Dawson	2000
Bioengineering	Riparian	Croucher Creek	City of Whitehorse	Long Lake Road Near City of Whitehorse's Sewer Lagoons	1998
Bioengineering	Riparian	Porter Creek	Y2C2	Within City of Whitehorse; Alaska Highway in Rabbit's Foot Canyon	2002
Bioengineering/	Riparian	Range Road	EDI Environmental	City of Whitehorse	2006

Restoration Technique	Site Type	Site Name	Group Completing Revegetation Works	Location	Date of Works
Seeding		Dump	Dynamics Inc.		
Bioengineering/ Seeding	Riparian	Mayo River Side Channel	EDI Environmental Dynamics Inc.	1.5 Km upstream of the mouth of Mayo River	2004
Bioengineering	Riparian	Germaine Creek	Polster Environmental Services Ltd. and M. Miles and Associates Ltd	40 Km E of Dawson	2004
Bioengineering	Mining	Gold Run Creek	Laberge Environmental Services	52 Km SE of Dawson	2005
Bioengineering	Riparian	Noname Creek	Laberge Environmental Services	90 Km W of Dawson	2001
Bioengineering/ Seeding/ Transplants and root cuttings	Riparian	Mendenhall River	EDI Environmental Dynamics Inc.	Km 1557 of Alaska Highway	2002
Bioengineering/ Seeding/ Transplants and root cuttings	Riparian	Beaver Creek	EDI Environmental Dynamics Inc.	Upstream of Beaver Creek Bridge, KM 1921	2003

Table 2. Listing of follow-up monitoring of projects by EDI in 2008.

Site Name	Date of Monitoring
Division Coal	August 6, 2008
Red Ridge	September 5, 2008
Nucleus	August 5, 2008
Hawk	July 21, 2008
Robert Service Way	July 14, 2008
Mt. Nansen	October 2, 2008
Porter Creek	July 14, 2008
Germaine Creek	June 6, 2008
Gold Run Creek	July 22, 2008
Noname Creek	August 5, 2008

Table 3. Listing of projects with ongoing monitoring.

Site Name	Date of Monitoring
Faro Mine	September 19, 2008
Range Road	June 13, 2008
Mayo River Side Channel	August 19, 2008

3 REVIEW OF PROJECTS

We reviewed and summarized the revegetation progress of 24 reclaimed sites. The full reviews for all of the sites are included in Appendix A. The sections below describe the five revegetation technique categories with highlights of the project summaries, and an overall evaluation.

Although not always stated directly in the reviewed reports, we assumed the general purpose of the revegetation effort is to stabilize or restore disturbed ground, involving short- or long-term erosion, or ecological restoration:

- Short- term erosion control consists of limiting the occurrence of immediate erosion (i.e. the mobilization of fine sediments) usually by establishing some type of immediate ground cover by means of vegetation or engineering (i.e. matting) cover. Long- term erosion control typically involves the establishment of deeper-rooted species or cover to stabilize the site and prevent erosion in the long term.
- Ecological restoration involves the re-establishment of vegetation with native species to a state resembling (or the same as) prior to the ground disturbance. Typically, this process takes many years to accomplish and involves succession of different vegetation stages – from initial ground cover, to colonization by local plants, and development of the site similar to the surrounding area (whatever successional state this might be in).

The success of the different techniques or each individual project was evaluated using these definitions.

3.1 SOIL SALVAGE

Soil salvage involves stripping the topsoil or top organic layer from the land surface, which is re-spread over the site after completion of the soil disturbance activities. This method relies on the presence of a native seed bank in the surface material to provide seed material. Seeds in the soil typically emerge shortly after the material has been re-spread. In our review, we found that in many cases additional grass seeding included in this treatment as well.

3.1.1 PROJECTS

All soil salvage treatments we reviewed showed positive results. Salvaged soil (replaced in conjunction with additional grass seeding) in trenches at the Breakaway, Dublin Gulch, and the Division Coal sites all showed good evidence of growth within 1 to 2 years after application (Copland et al. 1998). EDI's site visit in 2008 at Dublin Gulch and Division Coal confirmed that the reclaimed trenches had revegetated with native forbs, spruce and a variety of shrubs. The Division Coal exploration property showed advanced succession (from the early 1990's) because the trenches were nearly indistinguishable compared to adjacent undisturbed areas.

Breakaway was the only site without addition grass seeding. However, since monitoring was only completed in the year following soil replacement works it is unclear how revegetation progressed at this site over time.

3.1.2 EVALUATION

Based on the success of establishing native vegetation, soil at the three reviewed projects must have contained a seed bank. None of the projects had serious short or long-term erosion control problems because the sites were on level ground, but soil salvage applications were an effective way to establish ground cover quickly.

The key to making this technique work is planning to salvage any stripped material prior to site disturbance. In cases where erosion is a concern (i.e. steep slopes or stream banks), replacement of salvaged material done in conjunction with other treatments, like seeding grass or installing erosion control blankets, helps establish a ground cover even quicker.

3.2 SEEDING WITH NATIVE OR AGRONOMIC SPECIES

3.2.1 GRASS

Seeding with grasses is the most common revegetation technique used in Yukon, including in the majority of the projects we reviewed (Table 1).

Although slightly outdated, the Guidelines for Reclamation / Revegetation in the Yukon (Yukon Government 1993) still provide the main listings with recommended species mixes used in the reclamation industry. The agronomic mixes typically include a legume (alfalfa or Alsike clover) in addition to a variety of grasses. Due to the lack of availability, native mixes often miss the traditionally recommended legume component of the mix.

Projects that describe seeding both native and agronomic species included Mougeot Geoanalysis and S.P. Withers Consulting Services, 2000; Schonewille, B. and Tobler, P., 2008; and Laberge Environmental Services, 2007b. All noted success in the revegetation effort.

The intent of grass seeding is generally to provide an initial ground cover. Intended or not, over time native plants typically colonize the seeded areas, which leads to a more permanent vegetation cover. Our review showed that this technique effectively helped to reduce or eliminate erosion at many of the sites. However, some studies noted concerns regarding successional progress related to dense establishment of grass cover. Heavy grass seeding (75 kg/ha) at the Hawk exploration property (seeded in 1995) resulted in high densities of grass that impeded establishment of other native species (Mougeot Geoanalysis 1999 and S.P. Withers Consulting Services 2000). These effects were still noticeable in 2008, 13 years after seeding, when EDI visited the site. Mougeot Geoanalysis and S.P. Withers Consulting Services (2000) made similar observations of the Nucleus exploration property four years after seeding. EDI's follow-up monitoring in 2008 (13 years after seeding) showed that aggressive grass growth has given way to colonization by alders at all plots. However, the control plot that was not seeded showed a denser coverage and taller alder growth.

3.2.2 OTHER SPECIES

We found only a limited number of projects that involved direct seeding with non-grass species. As mentioned in the previous section, typical agronomic seed mixes include a legume species. Successful legume reclamation species in Yukon include alfalfa (*Medicago* sp.) and Alsike clover (*Trifolium hybridum*) (Yukon Government 1993).

Native legumes, black spruce, alder, a several other native herbaceous plants have been tried with variable success. At the Brewery Creek Mine, black spruce seeds *(Picea mariana)* were planted at two mine pit sites and on a leach pad in the fall of 2001 (Laberge Environmental Services 2007c). The seeds germinated on both sites the following year. In 2006 there were only a few black spruce plants remaining at one site (Laberge Environmental Services 2007c). At the Sa Dena Hes mine showy locoweed *(Oxytropis splendens)* and bear root *(Hedysarum alpinum)* were seeded in 2001; alfalfa *(Medicago sativa)* in 2003; and yellow locoweed *(Oxytropis campestris*) and arctic lupine (*Lupinus arcticus)* were seeded in 2005 (Access Mining Consultants 2008). Monitoring in 2007 showed that only alfalfa had notable coverage on test plots (Access Mining Consultants 2008).

At the Faro mine site, locally collected alder seed *(Alnus incana)* was seeded in the fall of 2007. During monitoring in 2008, no alder seedlings were located (Tobler 2008).

In 1998 the City of Whitehorse hydroseeded areas of right-of-way and piles of excavated material stockpiled along the newly upgraded Robert Service Way (W. Tuck pers. comm.). They used two legume/wildflower mixes. The first mix, by weight, included 20% Jacob's ladder *(Polemonium pulcherriumumi)*, 40% Icelandic poppy (*Papaver nudicaule*) and 40%other wildflower species. The second mix, by weight, included 20% blue flax (*Linum perenne*) and 20% perennial lupine *(Lupinus perrinus)* and 60% other wildflower species (JMCD 1996). In 2008, monitoring showed that growth was poor on the dry and rocky soils of most of the site. Success appeared better on the stockpiled excavated material, with notable amounts of perennial lupine and Jacob's ladder.

3.2.3 EVALUATION

Grass seeding is very effective at addressing short-term erosion control issues on disturbed sites. However, at seeding rates over 30 kg/ha, colonization by native vegetation may be inhibited or reduced due to the heavy competition and sod formation from planted grasses.

In our review, we found that although the high or medium seeding rates may be slow down natural revegetation, native plants will colonize the site eventually. At the Jason Knoll site, grass seeding with an agronomic seed mix was completed in the early 1980's (Brown 1985). Monitoring in 1999 showed that native species had re-grown on disturbed sites and only a small amount of the seeded red fescue remained (Mougeot Geoanalysis and S.P. Withers Consulting Services 2000).

If erosion control is the main objective, or if the goal is to keep other vegetation out intentionally (such as along highway corridors), seeding at high rates (50 kg/ha) is recommended.

Seeding of non-grass species may be an option for revegetation. In Yukon, relatively few treatments have involved the seeding of non-grass species and these have been mostly experimental in nature. The availability of large amounts of seed may be one of the limiting factors. Given the limited data on the effectiveness of the treatments, prescriptions should be designed carefully.

3.3 TRANSPLANTS

Transplanting involves removing entire plants from a donor site and relocating them. Species planted this way include willow, birch, various berry bushes, and other shrubs.

3.3.1 PROJECTS

At Brewery Creek, eight species were transplanted to areas of reclaimed waste rock storage and a leach pad (Laberge Environmental Services 2007c). These species included Alaska birch (*Betula neoalaskana)*, prickly rose *(Rosa acicularis)*, black spruce, Beauverd's spirea *(Spirea beauverdiana)*, black currant *(Ribes nigrum)*, raspberry *(Rubus idaeus)*, trembling aspen *(Populus tremuloides)* and dwarf birch *(Betula nana*; Laberge Environmental Services 2007c). Overall, the most successful transplants were black spruce and Alaska birch (Laberge Environmental Services 2007c), but also Beauverd's spirea, trembling aspen and prickly rose showed good survival.

At the Beaver Creek Bridge, large soil wads from a nearby area were planted within the voids of riprap in the spring of 2005. The wads contained willow, aspen, and other local vegetation. Observations in 2007 indicated new growth of willow, aspen, and grasses in the wads (P. Tobler pers. comm.). At another restoration project, along a disturbed section of the Mendenhall River, most of the large clumps of willow *(Salix sp.)* transplanted in 2003 were still alive in 2008.

3.3.2 EVALUATION

The use of transplants as a reclamation technique is limited, probably because of the large amount of work involved. Smaller shrubs like willow or roses are more suitable for transplanting than (larger) trees. Transplants are often successful if as much of the main root mass is kept intact.

3.4 ROOT CUTTINGS

Another way of propagating some trees and shrubs is by means of root cuttings. Roots (2 cm diameter or thicker) cut in smaller section are planted directly into the soil. In particular, severed root masses of aspen can reproduce by suckering if replanted (Perala 1978).

3.4.1 PROJECTS

Trembling aspen root cuttings were collected from donor sites at the Brewery Creek Mine and planted in a test plot on the leach pad in the fall of 2000 (Laberge Environmental Services 2007c). In 2006, approximately half the aspen root cuttings were growing well, to a maximum height of 2.5 m (Laberge Environmental Services 2007c). Han Construction Ltd and Arctic Alpine Reclamation Group (2005) also planted root cuttings (mostly *Salix sp.*) at the former Clinton Creek mine site; however, specific information on species or long-term monitoring information on success was unavailable.

3.4.2 EVALUATION

The projects involving root cuttings that we reviewed were pilot scale projects, but appear to be successful at Brewery Creek (Laberge Environmental Services 2007c).

Additional research and experimental trials may be needed to assess the full potential of root cuttings in Yukon.

3.5 STEM CUTTINGS

Propagation with stem cuttings involves cutting dormant tree and shrub stems and planting them directly in the ground. Any buds and previous year's growth are removed and the stakes are soaked in water for several days before planting, in order to promote root formation. When successful, new stems form on the above-ground portion of the stake. Besides directly planting in the ground, stem cuttings have several different applications in bioengineering.

Bioengineering is the use of living plant materials to perform some engineering function like re-enforcing a steep slope or stream bank. There are many specific techniques, each designed with a function to address a specific engineering issue.

3.5.1 LIVE STAKES

Live staking is one of the most basic forms of bioengineering. In this technique, cuttings are inserted into the ground vertically (Photo 1). In our review, we found numerous projects that used this method, most with varying levels of success. One of the most successful projects was the live staking conducted along the banks of Porter Creek in Rabbits Foot Canyon, Whitehorse during the summer of 2002. Recent monitoring showed that native vegetation has re-colonized the majority of the site. The vegetation on the stakes was on average 1.5 m high. Soils were made of fines and the site was quite moist. These soil conditions were favourable for live willow cuttings and likely contributed to the success of the treatment at this location.

At the Faro Mine site, stem cuttings planted around Rose Creek and tributary riparian zones (in 2003 and 2004) had high survival rates (Laberge Environmental Services 2007b).

However, growth of stakes was much poorer at most reviewed sites. Examples include Mendenhall River, Croucher Creek near Whitehorse, and Noname Creek near Carmacks. In general, the lack of success appears to be related to site conditions and/or methods used. At Mendenhall frozen ground limited planting depth and dry soil conditions likely limited success (P. Tobler pers. comm.). At Croucher Creek, live cuttings were small (<2 cm) and planting depths were shallow (<75% of the total stake length; A. von Finster Pers. Comm.). Observations during the summer of 2008 suggest that this situation was similar at some areas of Noname Creek.

Photo 1: Close-up view of a willow live stake planted at the Faro Mine in 2007. Photo taken in fall of 2008.

3.5.2 WATTLE FENCES

Wattle fences are a method of using live cuttings to construct retaining walls. The fence holds back the soil and forms a narrow terrace on a slope or bank (Photo 2). The stakes in the fence end up forming a "live fence" when they start to sprout. Wattle fences were constructed at the former Range Road Dumpsite and at Goldrun Creek. The wattle fence was installed in 2005 at Goldrun Creek to stop erosion in a gully (Laberge Environmental Services 2006). During inspection in 2008, we observed the majority of these structures undercut due to erosion, which caused them to collapse. The remnants of one section of the fence were still intact and showed good growth. We found similar conditions and results on an eroding bank on McIntyre Creek at the former Range Road Dumpsite. Wattle fences installed in the fall of 2005 collapsed over the course of the next couple of years. The topography now reflects a rough slope, rather than a stepped slope. Few of the cuttings showed live growth in 2008.

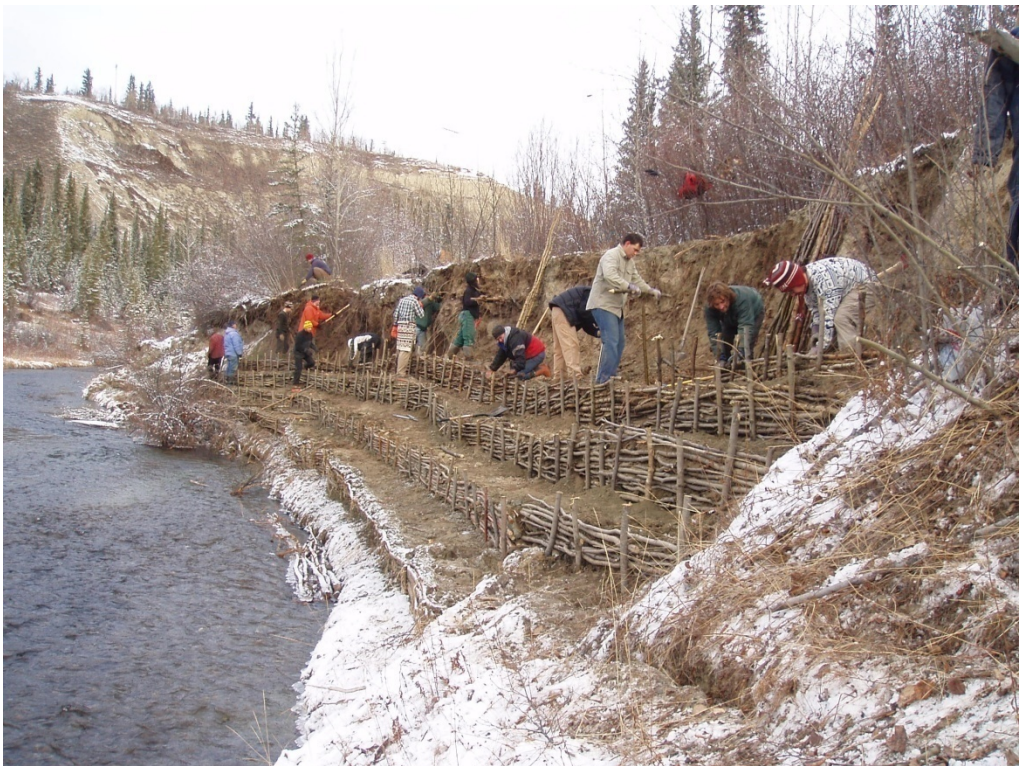

Photo 2: Wattle fences installation along McIntyre Creek, Whitehorse, fall 2005.

3.5.3 BRUSH LAYERS

Brush layers are horizontal rows of live cuttings buried in cut slopes or backfilled material (Photo 3). Typically, brush layers are applied to steeper slopes, where the cuttings help bind and retain the fill material. Brush layers installed along the Mendenhall River, a side channel of the Mayo River, and at the former Range Road Dump sites showed moderate to good success. Although survival rates of cuttings were as low as 28% (Range Road) when the site was visited in 2008, growth on the ones alive was good. The heavy stocking rate of this technique may have compensated for stem mortality. In all cases, it appears that enough growth has established to help stabilize the sites. Of note, this technique was by far the most successful bioengineering technique at the Mendenhall site where EDI implemented several different bioengineering methods (including brush mattresses, live stakes, and live fascines; P. Tobler pers. comm.).

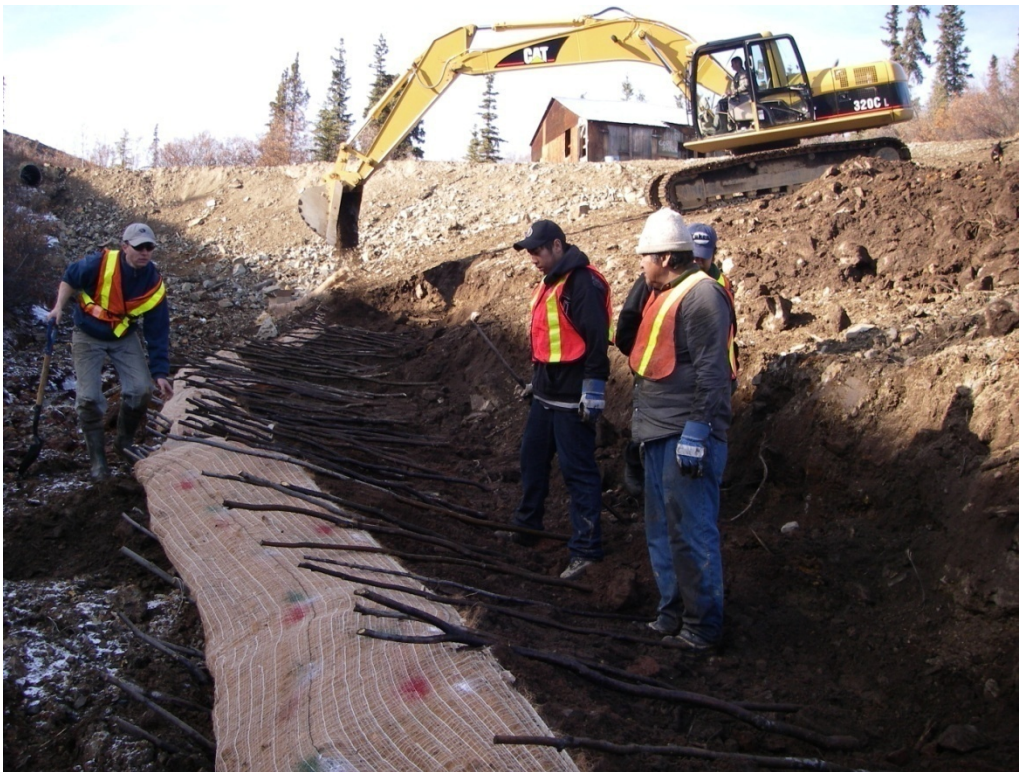

Photo 3: Brush layer installation at the Mt. Nansen mine site, near Carmacks. Rows of live cuttings are laid down into the slope, wrapped in bio-degradable erosion control matting, and buried (September of 2008).

3.5.4 GRAVEL BAR STAKES

Gravel bar or river bank staking is a variation of the live staking method used specifically for river or stream bars. Stakes are inserted diagonally into the substrate with the top facing the stream flow. An excavator is often used for the installation (Photo 4). The stakes slow the water flow when the river bar or bank floods. This results in deposition of fine sediments and debris, which in turn provides suitable substrate for native plant establishment.

Gravel bar staking was completed on a side channel of the Klondike River at Germaine Creek (M. Miles and Associates Ltd. and Polster Environmental Services Ltd. 2007) and near the Beaver Creek Bridge (P. Tobler. pers. comm.). Both projects show successful growth of the stakes. The Germaine Creek site showed 110 cm long willow plants (on average) on the left bank gravel bar four years after reclamation.

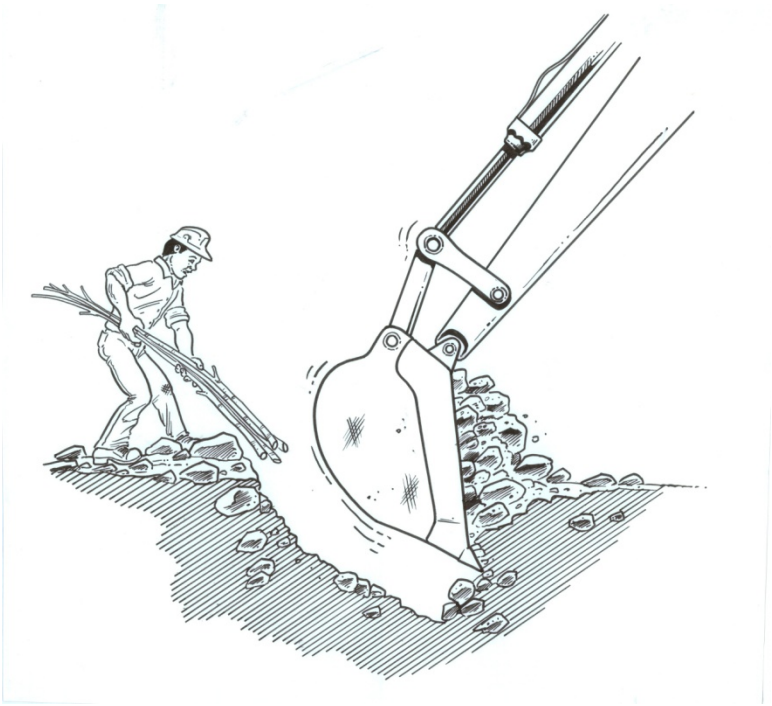

Photo 4: Diagram of live gravel bar staking. Live cuttings are inserted diagonally into gravel bars (Diagram courtesy Poster Environmental Services, 2009).

3.5.5 LIVE PALISADES

Live palisade installation involves large diameter (>5 cm) cuttings that are planted vertically, much like vertical stakes. The palisade can be as big as a tree trunk and requires the use of an excavator to plant. This technique is applied mostly along eroding stream banks and helps to create a root network that will stabilize the bank (Polster 2001; Photo 5). Live palisades planted along a side channel of the Klondike River at Germaine Creek (M. Miles and Associates Ltd. and Polster Environmental Services Ltd. 2007) and Beaver Creek (P. Tobler pers. comm.). The live palisades at Germaine Creek showed low survival rates (estimated at 17 % in 2008); at Beaver Creek, initial observations show a high survival rate and good growth of live palisades.

Photo 5: Row of live palisades along Beaver Creek near KM 1921 of the Alaska Highway, upstream of the Bridge (planted in fall of 2004, photo July 2005)

3.5.6 LIVE POLE DRAINS / FLUMES

Live pole drains or flumes are constructed from bundles of live cuttings and are used to safely collect and funnel water down moist slopes, without causing excess erosion (Photo 6). These structures are partially buried in the ground and can be effective treatments on slopes were excess moisture is a concern (Polster 2001). In Yukon, there are at least two sites where live pole drains/flumes have been installed. Two live pole drains made from willow at Noname Creek were installed at the top of a steep, erosion prone slope in the fall of 2001 (Laberge Environmental Services 2002). Although a forest fire burned the area in the summer of 2004, monitoring in 2008 showed good growth along the length of both pole drains and no erosion concerns.

In the fall of 2005, a live willow flume was installed at the top of an eroding gully at Goldrun Creek (Laberge Environmental Services 2006) in order to collect run-off water and spread the flow across the bottom of the gully. In 2008, a visit to this site showed that the gully had expanded and the majority of the live willow flume was buried under slumped-over material.

Photo 6: Live pole drain being installed at the Mt. Nansen Mine near Carmacks in September 2008 near. Trenches containing bundles of live cuttings were backfilled to complete the installation.

3.5.7 OTHER BIOENGINEERING METHODS

We reviewed several other bioengineering treatments including live brush mattresses, live fascines and live gully breaks.

Brush mattresses are layers of interlaced live cuttings installed on gentle slopes or nearly level areas to reduce erosion (Photo 7). Live fascines are bundles of live cuttings buried in excavated trenches, perpendicular to a slope (Photo 8). Both of these structures were tried at the Mendenhall River crossing. Limited or no success was documented for these methods at this site.

Live gully breaks are wattle fences constructed in gullies; they are supported by vertical stakes and built perpendicular to the slope (Photo 9). These structures help to prevent torrents from developing in the gullies. Live gullies breaks, made in 2001 from willow cuttings at Noname Creek showed good growth when we visited the site in 2008, and we noted no substantial erosion concerns.

Photo 7: A live brush mattress installation at the Mendenhall River crossing, near KM 1557 of the Alaska Highway in the summer of 2003. The brush mattress was buried by an excavator after taking this photo.

Photo 8: Live fascines assembled and ready for burial in trenches at the Mendenhall River crossing (summer 2003).

Photo 9. Live gully breaks installed at Noname Creek west of Carmacks in the fall of 2001. Photo courtesy Laberge Environmental Services 2008.

3.5.8 EVALUATION

Most of the bioengineering projects that use stem cuttings showed mixed success. To improve this success, information on site-specific conditions such as soil chemistry, moisture, and slope needs to be incorporated into the design and choice of bioengineering treatment. Also important to consider is that the success of direct planting with cuttings is likely not a hundred percent and any design needs to account for this, for instance by over-planting.

On drier sites, such as slopes, results indicate that bioengineering methods have to be carefully selected to ensure moisture concerns are considered. Our observations in 2008 suggest that the high density of stems and high proportion of individual stems that are buried by the brush layering technique appears to help the overall success of this method compared to other bioengineering methods. Staking depth and stem diameter also appear to play an important role in the success of live staking treatments on drier sites. In general, we found that shallow planted (where more than 25% of the total cutting length is above ground) and small diameter (< 2cm) stakes were more prone to drying-out.

Riparian sites are better suited to stem cuttings treatments because of favourable soil conditions (moist, organic rich soils) and the ease of burying stakes deep into the ground. Examples of this that we reviewed include live staking at Porter Creek and the Faro Freshwater Reservoir and the live pole drain and live gully breaks at Noname Creek.

So far, the species most suitable for using stem cuttings are willow (*Salix spp.*) and balsam poplar (*Populus balsamifera*). While there is limited systematic evaluation information on species success, there are some signs that balsam poplar may be more suited to drier sites. Survival rates and growth of balsam poplar at the Faro upland site and at Range Road Dump were higher than the survival rates of willow species (Laberge Environmental Service 2007b; Marjanovic 2008). The only monitoring data from wetter sites where two species were used (Germaine Creek palisades) indicated better success of willow. At this point, it is best to use a variety of species when possible in order to ensure some success.

The success of bioengineering treatments on erosion-prone sites in Yukon has been poor to date. Specifically, the use of wattle fences and live flumes to address serious active eroding sites has not been successful (former Range Road Dump and Goldrun Creek). Bank or slope instability due to permafrost and frost heaving may be some of the reasons for lack of success. The bioengineering structures may also not be able to stabilize the site quickly enough to address the erosion issue and deal with underlying issues. It is important to consider that the treatment of some challenging sites may be outside the realm of bioengineering and may require different engineering solutions.

4 REVIEW SUMMARY

The projects reviewed in this study provide useful insight in the success of various revegetation methods and their application in Yukon. There were limitations in some of our evaluations due to a lack of reporting information, but we feel we were able to make some valuable conclusions, summarized in Table 4 below.

Table 4. A summary of revegetation treatments used in Yukon and reviewed in this report.

Method	Comments
Soil Salvage	• An effective treatment to quickly revegetate an area, due to the presence of a natural seed bank in the soil. • Needs to be well planned so top organic layer material is saved and stockpiled as part of site development. • Can be supplemented by adding grass seed to accelerate revegetation.
Seeding	• Seeding with a variety of grasses is the most effective method to establish rapid ground cover. • Slower growing native non-grasses could be included, but will not be useful for short-term erosion control. • Heavy seeding with grasses (50 kg/ha or more) could result in reduced colonization rate by native plants. • Consider inter-planting with other species (by means of live staking, transplanting, etc.) if ecological restoration is the end goal.
Transplants	• Limited data exists for this treatment in Yukon. • Transplants with good root masses are more likely to survive in drier conditions.
Root Cuttings	• Limited data exists for this treatment in Yukon. • Trembling aspen is the only known reclamation species successfully grown from root cuttings.
Stem Cuttings	• Works best for riparian restoration where soil moisture level is high. • In dry conditions, soil must have good moisture holding properties. • Cuttings should be at least 50 cm long. • Plant vertical stakes, brush layers, gravel bar stakes, palisades with at least 75% of the stake length in the ground. Diameter of the wood should be >2 cm. • Because survival rate could be low, increase the stocking rate and plant more than one species.

5 RECOMMENDATIONS

Based on our findings, we think there is a need to improve the available revegetation tools and suggest the following studies:

- Additional monitoring and research of seeding with non-grass species, transplanting, and root cutting techniques is needed to determine the effectiveness as reclamation techniques.
- Direct planting success rate of locally collected plant material (cuttings, transplants, stakes) is unreliable, but there are alternatives available from the nursery and forestry industry. For instance, growing rooted stock in a nursery from locally collected seed or cuttings is possibly a viable and cost effective method for reclamation projects. More options need to be explored, with research and experimental trials to provide necessary insight into their usefulness for Yukon conditions.

6 ACKNOWLEDGEMENTS

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A. von Finster 2008. Senior Resource Restoration Biologist, Department of Fisheries and Oceans Canada, Habitat and Enhancement Branch. Via email, August 1st, 2008.

P. Tobler. **2008.** EDI Environmental Dynamics Inc., Senior Biologist. Meeting with Ben Snow, March 1st, 2009.

W. Tuck. 2008. Manager, Engineering and Environmental Service, City of Whitehorse. In person, July 18th, 2008.

Appendix A. Summary Monitoring Information

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Beaver Creek Bridge Bioengineering	**General Location:**	Km 1921 of the Alaska Highway
Date of Monitoring by this Project:	Not monitored		
Date of Re-vegetation:	Fall of 2004 and June 2005		
Re-vegetation Company or Group:	EDI and White River First Nation		

Monitoring Overview

Monitoring dates: Informal monitoring between 2005 and 2008.

Monitoring Company or Group: EDI

Full Reference:

P. Tobler. Personal Communication. EDI Environmental Dynamics Inc., Senior Biologist. Meeting with Ben Snow, March 1st, 2009.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Establish riparian vegetation along the banks of Beaver Creek upstream of the bridge. An extensive guide bank made of riprap was required upstream of the bridge to keep river in stream channel. Concerns over riparian vegetation loss were mitigated by these re-vegetation works.

Treatments:

In fall of 2004, gravel bar staking (with willow) was completed within the floodplain of Beaver Creek (three locations). Live palisades (willow and balsam poplar) were installed in two locations (total of 55).

In spring of 2005, soil was placed in the voids of riprap and pocket planting was completed in these soils. Planting methods included live staking (willow, balsam poplar) and transplanting (with trembling aspen, white spruce, willow, balsam poplar among others). These areas were also grass seeded with an agronomic seed mix and covered with straw.

Existing Monitoring Information (yes/no):

No formal monitoring has been completed; however, several casual visits by EDI staff to the site have provided an indication of success.

Gravel bar staking: Notable growth has been documented at this site (Photo 1). In most locations the structures have trapped debris and fine sediments. Average growth height was estimated to be over a meter in 2007.

Live Palisades: Notable growth has been observed (often in excess of 2 m) on the majority of cuttings (Photo 2). Few mortalities were noted.

Live Staking in Soil in Void of Riprap (Pocket Planting; including grass seeding): In the first growing season, extensive grass growth was observed (Photo 3); however, this grass cover appeared to die out in subsequent seasons. Many live stakes were showed growth, during all site visits (Photo 4). Many of the stakes were > 1 m high in 2007. No evaluation on the success rate was completed.

Monitored by this Project in 2008 (yes/no):

No.

Objectives Met as Stated?: Although a formal assessment has not been completed, it appears that the works have resulted in notable riparian establishment in the area. Longer term success will be important to monitor.

Additional Comments

This site was well suited to re-vegetation and many areas were planted within the floodplain (i.e. moisture levels were high).

Photo Documentation

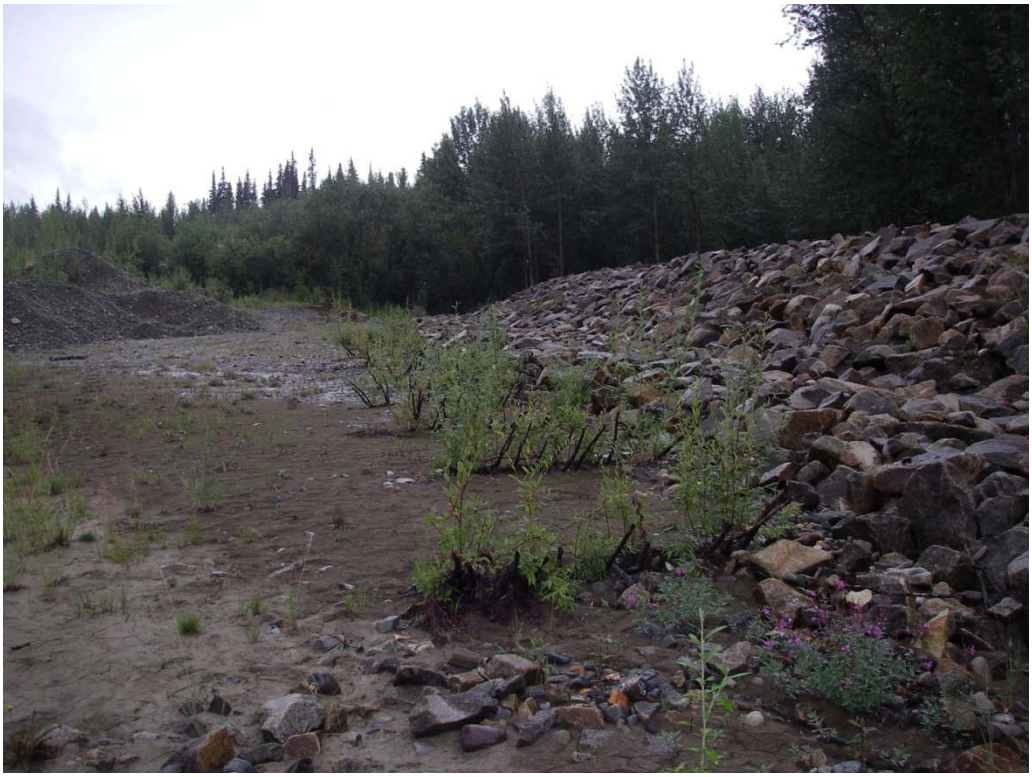

Photo 1. View of gravel bar staking upstream of Beaver Creek bridge. Photo taken in July 2007.

Photo 2. Photo of growth on live palisades, upstream of the Beaver Creek bridge. Photo taken in July 2007.

Photo 3. Photo of pocket planting on riprap, upstream of the Beaver Creek bridge. Photo taken in August 2005.

Photo 4. Photo of live stake (left) and transplant (right) on soil placed in voids of riprap, upstream of the Beaver Creek bridge. Photo taken in July 2007.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Breakaway

General Location: 15 km north east of Ross River, accessed by the North Canol Road

Date of Monitoring by this Project: No monitoring

Date of Re-vegetation: 1996

Re-vegetation Company or Group Expatriate Resources Ltd.

Monitoring Overview

Monitoring dates: 1997

Monitoring Company or Group:

Monitored by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Full Reference:

Craig, D.B., J. E. Craig, K. Pelletier, D. Emond and H. Copeland. 1998. Reclamation practices and research on mineral exploration properties in the Yukon Territory. Prepared by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

None stated, perceived objective would include accelerating the natural re-vegetation of lead-zinc exploration trenches and excavator trails through soil salvage and re-covering with vegetation which was initially cleared from the site.

Treatments:

Material excavated from the trenches was separated into two piles, one containing overburden and the other containing the vegetative soil layer. The excavator used to dig the exploration trenches was lighter than other similar models and was chosen because it would cause less damage and compaction of the soils. After exploration work was completed, this material was restored to its original position and the refilled trench was covered with the vegetation cut during the initial clearing of the trench. Mosses were also salvaged and restored on the backfilled trenches after the completion of exploration work.

Existing Monitoring Information (yes/no):

Yes. Monitoring in 1997 showed that mosses had begun to re-establish and new vegetative growth was visible on the trenches.

Monitored by this Project (yes/no):

No.

Objectives Met as Stated?:

It is difficult to determine the success of this re-vegetation effort without additional monitoring. However, monitoring showed evidence of re-growth after the first year. In 1997, observations of the re-vegetation of roads constructed in 1981 (on the same site) showed that they are nearly fully overgrown with natural vegetation. Since these older roads were not seeded or reclaimed in any way, it is likely that the works carried out in 1996 have had equal or greater success.

Additional Comments

Photo Documentation

Photo 1. View of an excavated trench at the Breakaway property near Ross River in 1995. Photo courtesy of the Yukon Geological Survey.

Photo 2. View of an re-filled trench at the Breakaway property near Ross River in 1997, note vegetation growing in the foreground. Photo courtesy of the Yukon Geological Survey.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Brewery Creek Experimental Shrub Treatments

General Location: 55 km East of Dawson City, accessed by the Dempster Highway

Date of Monitoring by this Project: July 22, 2008

Date of Re-vegetation: September 2000

Re-Vegetation Company or Group: Laberge Environmental Services Ltd.

Monitoring Overview

Monitoring dates: Monitored in 2001, 2002 and 2006.

Monitoring Company or Group: Laberge Environmental Services Ltd.

Full Reference:

Laberge Environmental Services Ltd. 2007. Shrub Trial Plots – Brewery Creek Mine 2006 Follow-up Monitoring Report. Prepared for the Mining and Petroleum Environment Research Group (MPERG) and Alexco Resources Corporation.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Eleven species of shrubs were planted using various methods in experimental plots in order to determine which locally-occurring shrub species and methods would be useful for re-vegetating large open disturbed areas on Yukon mine sites.

Treatments:

Six 2 m x 3 m plots were laid out at 3 sites. These included 2 sites in the Canadian pit (C-1 and C-2) as well as another site below the leach pad (LP-1). These sites had differing slopes, elevation and aspect. Plots were placed adjacent to one another, without any spaces in between and perpendicular to the slope. Prior to planting (as part of a different project), all sites had been seeded with legumes and grasses. Half of each plot was cleared of vegetation and in the other half the existing vegetation was left undisturbed. Shrub and tree material was collected from the area around the mine site. Planting methods included transplanting, stem cuttings and root cuttings. One species was planted in each plot.

Eight species were transplanted, including Alaska birch, prickly rose, black spruce, Beauverd's spirea, black currant, raspberry, trembling aspen and dwarf birch. Stem cuttings were harvested from Bebb's willow, little tree/blue-green willow and blue-green willow plants. In addition, root cuttings were harvested from trembling aspen plants 4 grams of seeds from black spruce cones was planted at each site.

Existing Monitoring Information (yes/no):

Yes. The most recent monitoring data from 2006 showed that many of the transplanted species are growing well. Black spruce (105%) Alaska birch (93%), Beauverd's spirea (88%), trembling aspen (85%) and prickly rose (76%) and showed good overall survival, across all plots. However, black currant (0%), raspberry (49%), dwarf birch (46%) showed poor overall survival. The stem cuttings did very poorly, overall. Only little tree/blue-green willow cuttings were surviving (5% overall) when monitoring was conducted in 2006. The monitoring of the root cuttings in 2006, showed that survival was lower (41%) overall but appeared to be increasing, likely from reproduction due to suckering. Seeded black spruce had germinated in 2 out of 3 sites, but by 2006 only a few seedling were growing in at a single site. Success of this treatment was poor overall.

Monitored by this Project (yes/no):

Yes. A site visit was conducted; however, none of the sample plots could be located. The general area of the three sites appeared to have good natural growth of aspen and birch trees.

Objectives Met as Stated?:

Results show black spruce (105% survival) and Alaska birch (93% survival) transplants are the most successful treatment/species combinations at this mine site. The removal of vegetation did not appear to have a large impact on the survival of planted species.

In order to more fully determine which of the test species are the most useful in re-vegetating Yukon mine sites, several more trials should be carried out with larger plot sizes and in different areas.

Additional Comments

The methods do not describe the diameter, preparation or planting depth of willow stem and aspen root cuttings It is not possible to tell whether cuttings were soaked, the size used or how deep they were planted. Also, very few cuttings were planted. For example, approximately 20 willow cuttings were planted and monitored in each of the three trial sites, resulting in a few square metres in area. The coordinates of the test plots were not given nor were the plots perimeters marked with permanent, easily visible materials.

Photo Documentation

Photo 1. View of the plots at the Brewery Creek C-1 site during construction in September 2000 (looking west). The Alaska birch plot is in the foreground. Photo courtesy of Laberge Environmental Services Ltd.

Photo 2. View of the plots at the Brewery Creek C-1 site during the latest monitoring event in 2006 (looking west). The Alaska birch plot is in the foreground. Photo courtesy of Laberge Environmental Services Ltd.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Clinton Creek – Channel Stabilization

General Location: 100 km north west of Dawson City, accessed by the Top of the World Highway.

Date of Monitoring by this Project: Unsuccessful due to road washout on July 21, 2008

Date of Re-vegetation: 2004 and 2005

Re-Vegetation Company or Group: Han Construction Ltd. and Arctic Alpine Reclamation Group.

Monitoring Overview

Monitoring dates: 2004 and 2005.

Monitoring Company or Group: Han Construction Ltd. and Arctic Alpine Reclamation Group.

Full Reference:

Han Construction Ltd. 2005. Clinton Creek Mine Site Reclamation Report 2005. Prepared with the assistance of the Arctic Alpine Reclamation Group

Monitoring Specifics

Objectives (if none stated, perceived objectives):

The objective of this project was to minimize erosion and assist in the stabilization of riparian areas of Clinton Creek.

Treatments:

Shrub staking, using primarily willow species, was carried out over approximately 3 hectares the riparian area along Clinton Creek. Two weirs were constructed prior to shrub staking. Donor plant material (with dormant buds) was collected onsite and assembled into bundles, which contained several different shrub species. These were planted horizontally across the channel banks at 8 different sites within the area. Five different methods were used between the 8 sites. The methods were as follows:

- Method 1: Bundles (3 to 4 stems) of locally harvested plant material approximately 50 cm in length were bundled together and planted horizontally in trenches to a depth of 15 to 30 cm, depending on the soil.
- Method 2: Cuttings (stakes) of locally harvested plant material approximately 50 cm to 1.5 meters in length were planted vertically to a depth of 50 cm to 1 meter with a tree planting spade.
- Method 3: Cuttings (stakes) of locally harvested plant material approximately 50 cm to 1.5 meters in length were planted vertically to a depth of 50 cm to 1 meter with a weighted metal probe depending on soil structure and porosity.
- Method 4: Below ground plant biomass (roots) were harvested and planted to a depth of 15 to 50 cm.

- Method 5 (Mechanical horizontal trench, developed onsite): A loader with a tooth bucket was used to create trenches 2 meters in length approximately 50 cm in depth. Approximately 9 trenches were created in this way .Cuttings (stakes) of locally harvested plant material approximately 50 cm to 1.5 meters in length were planted vertically in the trench to a depth of 30 cm, additional cuttings were placed horizontally in the trench to provide for more vegetative material to be placed on the site .

Existing Monitoring Information (yes/no):

Yes. Monitoring in October of 2005 showed that all of the areas staked in the riparian area of Clinton Creek in 2004 showed positive germination and establishment.

Monitored by this Project (yes/no):

No. An attempt was made to monitor re-vegetation treatments at the Clinton Creek mine site. However, a road washout prevented access to the treatment areas.

Objectives Met as Stated?:

Monitoring information suggests initial success of staking in riparian areas along Clinton Creek. However, additional monitoring would be required in order to determine whether the objectives were being met.

Additional Comments

It is difficult to gauge the success of the re-vegetation works without quantitative measurements of the success of the germination and establishment of the planted species.

Photo Documentation

Photo documentation unavailable.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Clinton Creek – Seeding

General Location: 100 km north west of Dawson City, accessed by the Top of the World Highway.

Date of Monitoring by this Project: Unsuccessful due to road washout on July 21, 2008

Date of Re-vegetation: 2004 and 2005

Re-vegetation Company or Group: Han Construction Ltd. and Arctic Alpine Reclamation Group

Monitoring Overview

Monitoring dates: 2004

Monitoring Company or Group: Han Construction Ltd. and Arctic Alpine Reclamation Group

Full Reference:

Han Construction Ltd. 2005. Clinton Creek Mine Site Reclamation Report 2005. Prepared with the assistance of the Arctic Alpine Reclamation Group.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

The objective of the project was to reclaim areas of the former mill site and waste rock area that were prepared by earlier cleanup projects. A second objective was to establish a series of test plots on the east side of Clinton Creek above the first weir.

Treatments:

Two areas of the Clinton Creek mine site were seeded in 2004. The former mill site access road to the top of the tailings pile was seeded along a 4 m wide area on either side of the road as well as another 4 m wide area along the top of the tailings pile. An additional 5 m x 5 m area on the slope adjacent to the access road was also seeded. The second seeded area, the waste rock dump site access road to the former crusher site, was also seeded along 4 m area on both sides of the road. Seeded areas were harrowed or raked to a depth of 15 to 30 cm to loosen up the soil prior to planting. In all plots, the seed mix contained violet wheatgrass, tickle grass, tufted hairgrass, Sheep Fescue, Northern Fescue, Alpine Bluegrass and Alkali Grass. This rate of seeding of this mix was approximately 25 kg/hectare.

A series of individual test plots were established at a different location, along the east side of Clinton Creek above the 1st weir. Each test plot was seeded with a single species. The seeded species included, yarrow, violet wheatgrass, sheep's fescue, *Mackenzii Hedysarum*, Arctic lupine, alpine bluegrass, glaucous bluegrass and alkali grass. Details on the site preparation at this location are unknown.

Existing Monitoring Information (yes/no):

Yes. Monitoring in October of 2005 showed that former mill site and waste rock area showed positive germination and establishment. Also, each species in the test plot had germinated and had established themselves to second leaf stage.

Monitored by this Project (yes/no):

No. An attempt was made to monitor re-vegetation treatments at the Clinton Creek mine site. However, a road washout prevented access to the treatment areas.

Objectives Met as Stated?:

Monitoring information suggests initial success; however, additional monitoring is required to determine whether objectives were met.

Additional Comments

It is difficult to gauge the success of the re-vegetation works without quantitative measurements of the success of the germination and establishment of the planted species.

Photo Documentation

Photo documentation unavailable.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Croucher Creek

General Location: Right of way for the Croucher Creek Bridge, Long Lake Road Approximately 5 km from downtown Whitehorse.

Date of Monitoring by this Project: No monitoring

Date of Re-vegetation: Summer 1996

Re-vegetation Company or Group: City of Whitehorse.

Monitoring Overview

Monitoring dates: No formal monitoring.

Monitoring Company or Group: None.

Full references:

W. Tuck 2008. Personal Communications, Manager, Engineering and Environmental Service, City of Whitehorse. Meeting with Ben Snow, July 18th, 2008.

McDiarmid, J. Sewerage Treatment and Disposal Facility [map]. 1:2000. [Whitehorse, Y.T.]: City of Whitehorse, 1996. Map prepared as a component of the 1996 Whitehorse sewage treatment and disposal facility upgrade project.

A. von Finster 2008. Personal Communications, Senior Resource Restoration Biologist, Department of Fisheries and Oceans Canada, Habitat and Enhancement Branch. Via email, August 1st, 2008.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Re-vegetate the riparian areas upstream and downstream of the Croucher Creek bridge for erosion control purposes. This work was completed in conjunction with upgrades to the Whitehorse sewage treatment and disposal facility.

Treatments:

An area of road right of way approximately 200 m north and 400 m south of the bridge was seeded with an agronomic seed mix. In sloped areas within this section, a mulch cover was applied so as to minimize erosion issues. Also, willow stakes approximately 60 cm long were planted in an irregular grid (spaced 15 cm apart) along the creek banks.

Existing Monitoring Information (yes/no):

No formal monitoring. A. von Finster of the Department of Fisheries and Oceans suggested that some willow stakes were planted too shallow (only 10 to 15 cm) and were of too small a diameter to function properly (Photo 2). A few of the willow stakes on the left bank of the stream upstream of the bridge were still present but exhibited poor growth. No dates were given for these observations.

Monitored by this Project (yes/no): No.

Objectives Met as Stated?:

The success of the grass seeding treatment is unknown, due to insufficient monitoring. Observations of the site suggest that survival of the willow stakes was poor. Natural vegetation eventually established in the area of the crossing site and addressed the erosion concerns.

Additional Comments

A. von Finster indicated that a small area approximately 1 m^2 to 2 m^2 was willow staked within the last 5 to 6 years as part of a separate re-vegetation treatment. It was reportedly conducted in a high traffic location and the stakes were trampled and killed.

Based on the photo documentation, it appears that the stakes were of too small a diameter to ensure treatment success.

Photo Documentation

Photo 1. View of the live staking carried out along Croucher Creek near downtown Whitehorse, upstream of the bridge. Photo taken on May 31st, 1996. (Photo courtesy of Department of Fisheries and Oceans).

Photo 2. Close up view of some of the live stakes planted along Croucher Creek, near downtown Whitehorse, upstream of the bridge. Note the small diameter of the stakes, which likely contributed to their poor survival Photo taken on May 31st, 1996. (Photo courtesy of Department of Fisheries and Oceans).

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Division Coal

General Location: 22 km west of Braeburn.

Date of Monitoring by this Project: Aug 6, 2008

Date of Re-vegetation: 1994

Re-vegetation Company or Group: Cash Resources Inc.

Monitoring Overview

Monitoring dates: Monitored in 1997 and 1999

Monitoring Company or Group:

Monitored by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1997 and Mougeot Geoanalysis and S.P. Withers Consulting Services in 1999.

Full References:

Craig, D.B., J. E. Craig, K. Pelletier, D. Emond and H. Copeland. 1998. Reclamation practices and research on mineral exploration properties in the Yukon Territory. Prepared by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Mougeot Geoanalysis and S.P. Withers Consulting Services. 2000. Assessment of Long-Term Vegetation and Site Conditions at Reclaimed Yukon Mineral Exploration Sites. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

None stated, perceived objectives would include accelerating the re-vegetation (through backfilling, re-contouring, seeding and recovering with woody debris) of drill pads, excavator trenches and access roads associated with diamond drilling in the early 1990s.

Treatments:

Trenches dug in the early 1990s were refilled with original overburden material. The vegetative mat material was restored to surface level and then seeded with a northern seed mix. On drill pad sites, the area was re-contoured and covered with large and small woody debris which had been cut down during the initial clearing of the site. Some drill pads were also planted with local spruce seedlings (Withers 2000). Unused roads were scarified with a backhoe and seeded. Roads where permafrost melting and associated erosion problems were likely to occur were covered with logs to provide insulation.

Existing Monitoring Information (yes/no):

Yes. In 1997, monitoring showed that reclamation of the backfilled trenched appeared successful -- minimal evidence of past disturbance was visible. A reclaimed drill pad was quickly re-colonized by poplars and another showed successful growth of locally transplanted spruce seedlings. The re-vegetation success of the access roads was not reported. Photo documentation showed a reclaimed road where grass and small shrubs have successfully re-colonized and lush growth was evident (Photo 1).

Monitoring in 1999 focused on 4 trenches and 1 drill pad. Results indicated that rough topography is aided in the re-vegetation of the trenches. The associated microsites seemed to help speed up the re-vegetation process by providing moisture and shade to shrub seedlings. This rough topography also helped control erosion. Steeper areas within the trenches were re-vegetating much more slowly and would not be fully re-vegetated for some time. Colonization by native species was observed within the trenches. The source was from either the surrounding area or the vegetation mat that had been replaced during initial reclamation. Shrub roots within this vegetation mat had regenerated after being placed on top of the backfilled trenches.

On the flatter drill pad sites, a thicker growth of agronomic species was observed. This likely impeded colonization by native plants as fewer native species were observed on the drill pad site compared to the trenches. These agronomics were; however, limited to the disturbed areas of the property and had not spread into the surrounding undisturbed areas.

In areas were permafrost had melted, both native and agronomic plant species had positive plant growth due to added soil moisture

Monitored by this Project (yes/no):

Yes. EDI monitored two trenches in the burned area of Division Mountain. The two sites observed in this area were difficult to distinguish from the surrounding undisturbed area. The species composition is very similar to the adjacent undisturbed areas. However, there was more abundant presence of grasses and slightly fewer spruce trees in the disturbed area. The trenches had shorter spruce trees and contained greater amounts of large woody debris (as compared to the adjacent undisturbed areas). There were few areas of bare soil, even on the shallow walls of the trenches.

Objectives Met as Stated?:

It was difficult to distinguish re-vegetated trenches from the surrounding undisturbed areas. This confirmed that the trenches were successfully re-vegetated. It was difficult to assess whether the soil salvage and replacement of large woody debris accelerated succession since there were no trenches that were left bare. However, photo documentation (include in the 1997 monitoring report) shows a trench dug in 1972 that appears to be more poorly re-vegetated than the more recently excavated trenches observed in 1997, 1999 and 2008 (this photo was unavailable at the time of writing of this report). This suggests that the restoration of vegetative material and large woody debris has in fact accelerated the re-vegetation process.

Additional Comments

In 1999, monitoring showed that the small and large woody debris re-placed on top of reclaimed sites was effective in impeding access to the site, even on foot.

Due to an equipment malfunction, photo-documentation from 2008 monitoring is not available.

In addition to trenches re-vegetated in the 1990s, EDI observed several newer trenches located on the Division Mountain property. These were located approximately 3 km northwest of the burned area site visited during the

monitoring conducted in 1999. It was suspected that no re-vegetation treatments were applied here and the sites were left to re-vegetate naturally.

Although the date of disturbance for these newer sites was not known, some qualitative observations on the natural re-vegetation of these sites were made. The first site was a flat bottomed, shallow trench measuring approximately 10 m wide by approximately 40 m long. In 2008, the ground at this site was being re-colonized by spruce seedling (on average 50 cm tall). There was also smaller amount of fireweed and rose. Grass was absent from the trench. The second trench site was located at a higher elevation and was a much deeper V shaped trench with a coal layer visible approximately 60 to 80 cm below the surface. The depth of this trench was estimated to be about 4 to 5 m. The trench was approximately 10 m x 50 m. Re-growth was most prominent in the bottom of the trench. Large aspens and some smaller willows were observed in the trench bottom while the steep sides of the trench were mostly bare, with the exception of a few small clumps of bunch grass.

Photo Documentation

Photo 1. View of a trench reclaimed in 1994 at the Division Mountain coal exploration property, west of Braeburn. Lush grass and shrub growth is evident. Photo taken in 1997, courtesy of the Yukon Geological Survey

Photo 2. View of a drill pad reclaimed in 1994 at the Division Mountain coal exploration property, west of Braeburn. Photo taken in 1997, note the large amount of shrub stage species that have colonized this site. Photo courtesy of the Yukon Geological Survey.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Dublin Gulch

General Location: 50 km north of Mayo

Date of Monitoring by this Project: No monitoring

Date of Re-vegetation: 1996 and 1997

Re-vegetation Company or Group: New Millennium Mining

Monitoring Overview

Monitoring dates: 1997

Monitoring Company or Group:

Monitored by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Full Reference:

Craig, D.B., J. E. Craig, K. Pelletier, D. Emond and H. Copeland. 1998. Reclamation practices and research on mineral exploration properties in the Yukon Territory. Prepared by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

None stated, perceived objective would include accelerating the natural re-vegetation of exploration trenches and pits through topsoil salvage and seeding of re-filled trenches.

Treatments:

Trenches and pits dug in 1996 and 1997 were backfilled and the salvaged topsoil was replaced. Seeding was reported; however, no information on the application rates, times and seeded species was given.

Existing Monitoring Information (yes/no):

Yes. Monitoring in 1997 showed notable re-growth on sites reclaimed in 1996.

Monitored by this Project (yes/no): No.

Objectives Met as Stated?:

It is not possible to determine the long term success of re-vegetation due to lack of long term monitoring data. However, there was evidence of re-growth after the first year of re-vegetation. This site is above the tree line in many

locations and natural re-vegetation is likely to proceed slowly. Therefore, it is possible that little re-growth has occurred since 1996.

Additional Comments

Photo Documentation

Photo documentation unavailable.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Faro Mine Site / Grass seeding and shrub staking of the dewatered reservoir area.	**General Location:**	Anvil Range Mine, 15 km north of Faro.
Date of Monitoring by this Project:	Not monitored		
Date of Re-vegetation:	June & September 2003, June, July, September and October 2004		
Re-Vegetation Company or Group:	Arctic Alpine Seeds Ltd and Laberge Environmental Services.		

Monitoring Overview

Monitoring dates:

Yearly from 2004 to 2007.

Monitoring Company or Group:

Seeding and staking by Arctic Alpine Seeds Ltd. Monitoring by Laberge Environmental Services.

Full Reference:

Arctic Alpine Seed Ltd. 2005. Anvil Range Mining Complex, Faro, Yukon. Former Fresh Water Supply Reservoir. Reservoir Site Revegetation and Rose Creek Riparian Zone Rehabilitation. Project Report 2003-2004. Prepared for Deloitte & Touche Inc., Toronto, ON.

Laberge Environmental Services. 2005. 2005 Revegetation Assessment – Dewatered Freshwater Reservoir – South Fork of Rose Creek, Yukon. Assessment Report Prepared for Deloitte & Touche Inc., Toronto, ON.

Laberge Environmental Services. 2006. 2006 Revegetation Assessment – Dewatered Freshwater Reservoir – South Fork of Rose Creek, Yukon. Assessment Report Prepared for Deloitte & Touche Inc., Toronto, ON.

Laberge Environmental Services. 2007. 2007 Re-vegetation Assessment Dewatered Freshwater Reservoir. South Fork of Rose Creek, Yukon. Assessment report prepared for Deloitte & Touche Inc., Toronto, ON.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

None stated, perceived were to prevent erosion of newly exposed areas of the now dewatered reservoir and prevent erosion of the Rose Creek riparian zone, associated tributaries below the dam and floodplains next to the breached dam.

Treatments:

The newly exposed areas of the now dewatered freshwater reservoir were seeded with a commercial grass mix containing 6 different grass species. By weight the seed mix contained sheep's fescue (38%), slender wheatgrass (38%), violet wheatgrass (20%), ticklegrass (2%), alpine bluegrass (1%) and tufted hairgrass (1%). The rate of seeding was 29.48 kg/ ha.

The seed mixture for the floodplains area was different and contained, by weight, sheep fescue (40%), violet wheatgrass (40%), ticklegrass (10%) and tufted hairgrass (10%). This mix was seeded at a rate of 10 kg/ha. Two different areas of the new exposed shoreline were seeded in June and September of 2003. The newly exposed bottom of the reservoir was seeded in June and July of 2004. The dam area, the disturbed area downstream of the dam, and the floodplains adjacent to the dam breach were seeded in September and October of 2004.

Riparian areas of Rose Creek and its tributaries below the breached dam as well as the floodplains next to the breached dam were staked with stem cuttings from 8 different species of shrubs. These species included diamond-leaf willow, felt-leaf willow, Scouler's willow, Barclay's willow, trembling aspen, balsam poplar, soapberry and white spruce. This was done in September of 2003 and then at two different sites in May and October of 2004.

Existing Monitoring Information (yes/no):

The most recent monitoring data was collected in 2007. For all grass seeded sites, percent cover over the entire area was estimated and a qualitative description of species diversity and relative abundance was given. Plant heights and rooted depths for the 6 seeded grass species were also measured and the averages across all three sites were reported. The newly exposed areas of shoreline that were grass seeded in June and September of 2003 measured 17.2 ha and 17.5 ha, respectively. Cover in this zone has grown up to nearly 100%, with the exception of the area immediately upstream of the dam where cover is only 30 to 40%. Most of the area is dominated by sheep's fescue, except for the far eastern portion where there is a more even distribution of species. The newly exposed reservoir bottom measured approximately 17 ha and was seeded in June and July of 2004. Vegetation cover in this zone has grown up to nearly 90% and is characterized by a more diverse group of grasses as well as large amount of non-seeded native plants. The fourth seeded area is made up of the dam area, the disturbed area downstream of the dam, and the floodplains adjacent to the dam breach. The size of this area was not reported. This area was the last to be seeded in September and October of 2004. In the floodplains adjacent to the dam, the vegetation has grown up to 20 to 40% cover with a few areas of up to 70%. In 2004 and 2005, the seeded areas of the floodplains were flooded and seed loss occurred.

On the dam wall itself there is little grass growth on the northwest side, 40 to 60% cover on the southeast side and 5 to 20% cover on the sides of the dam breach. The core of the dam breach is made of highly compacted clay and is nearly barren of vegetation. Areas downstream of the dam have a grass cover of approximately 80%. Plant height and rooting depths for the dominant grass species (sheep's fescue and tufted hairgrass) are 55 cm high and 95 mm deep and 90 cm high and 330 mm deep, respectively.

Monitoring of live staking treatments in 2007 shows that overall survival rates for all shrub species on the floodplains upstream and downstream of the dam breach varies between 50 and 90%. In the Rose Creek riparian zone and the lower reaches of the tributaries, overall survival is approximately 80%. Willows staked along the upper reaches of the tributaries and along the upper reaches of Rose Creek have a survival rate of only 5 to 30%. Among the species that were staked initially, Diamond-leaf willow and Felt-leaf willow are the most successful.

Monitored by this Project (yes/no):

No.

Objectives Met as Stated?:

Re-vegetation efforts have helped prevent erosion in most areas, thereby meeting stated objectives. However, re-vegetation of the compacted dam core is proceeding poorly, causing limited erosion. Grass seeded and shrub staked areas are growing well with the exception of the dam breach and the upper reaches of Rose Creek and the tributaries.

Additional Comments

In general, grass seeding prescriptions have addressed short-term erosion concerns such as aggressive grass growth in the old freshwater reservoir. There has been some concern that these methods may not be favorable to natural succession processes (Jacobsen et al. 2008; i.e. slowing establishment of native shrub species).

Photo Documentation

Photo 1. View of the south side of the breached dam at the Anvil Range mine site, near Faro, in the summer of 2006. Areas of the compacted core (visible in the background) still have limited vegetation cover. Photo courtesy of Laberge Environmental Services.

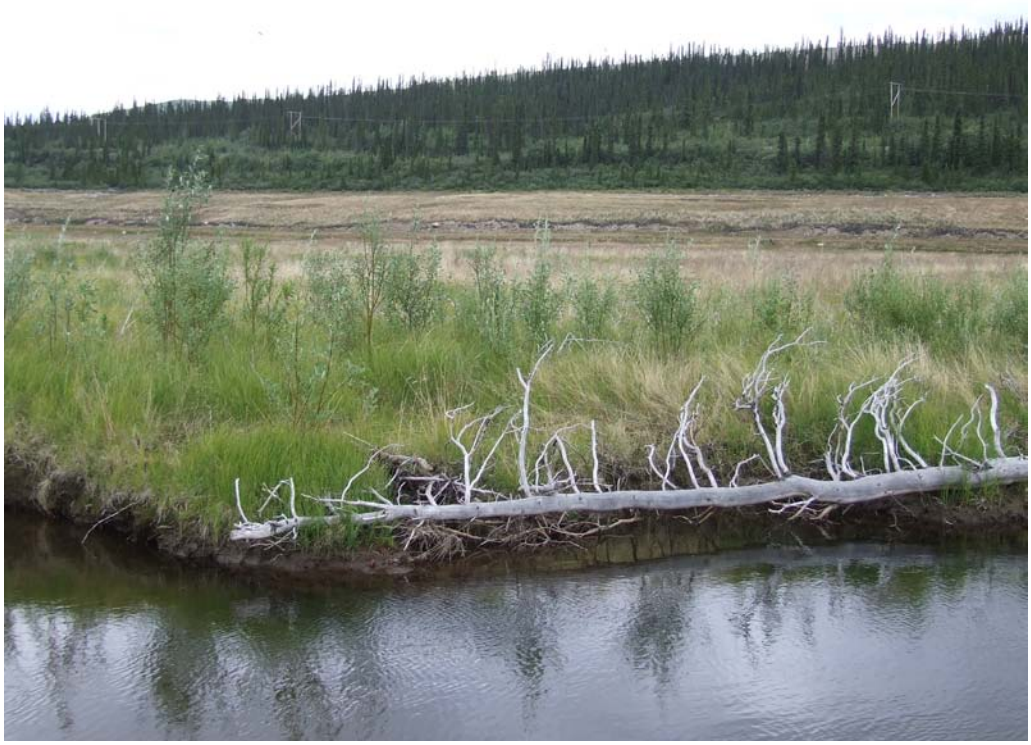

Photo 2. View of live staked willow on the south fork of Rose Creek at the Anvil Range mine site, near Faro, in the summer of 2006. Good growth is evident on several of the stakes. Photo courtesy of Laberge Environmental Services.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Faro Mine Site /Re-vegetation trail on Vangorda Waste Rock Dumps and Shrub staking test Plot on Grum slope.	**General Location:**	Anvil Range Mine, 15 km north of Faro.

Date of Monitoring by this Project: n/a

Date of Re-vegetation: September 2007

Re-vegetation Company or Group: EDI Environmental Dynamics Inc. and Ross River Dena

Monitoring Overview

Monitoring dates: September 16, 2008

Monitoring Company or Group: EDI

Full Reference:

Jacobsen, C., M. Setterington, P. Tobler, D. Polster, J. Straker. 2008. *Faro Mine Site Revegetation Study: Waste Rock Dumps and Tailings.* Prepared by EDI Environmental Dynamics Inc., Polster Environmental Services Ltd. and C.E. Jones and Associates. Prepared for Deloitte & Touche Inc.

Tobler, P. 2008. Re: 2008 Faro Re-vegegation Works Summary. Letter Report to Douglas Sedgwick, Deloitte and Touche Inc.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Develop prescriptions for long term re-vegetation and reclamation of the mine site using locally available species . Initiate an operational trial to test site preparation and vegetation prescriptions for the Faro mine site area .

Treatments:

In 2007, a re-vegetation trial was conducted on a 25 m x 25 m lysimeter (a device used to measure plant evapotranspiration) plot on the Vangorda waste rock dumps. The site was mechanically tilled to create a rolling topography that provided suitable microsites for seed germination and growth. The plot was then seeded and staked with local native species that are pioneering species on disturbed sites. A non-compacted till layer 0.5-1.0 m was placed loosely over the trial plot. Alder seed was collected on site, and prepared by drying the alder cones indoors in paper bags until the cones released their seed, the bags were then shaken to help fully release the seed from the cones. Seed was separated from the cones and broadcast seeded by hand and with a rotary seeder. Fourteen grams of seed was applied. Willow and poplar cuttings were collected from the north east corner of the mine and were cut to approximately 1 m in length and at least 2 cm in diameter. Due to shallow cover depth, live stakes were planted to an average depth of 0.5 m, which was considerably less than optimal (1 m). Once planted, the stakes were trimmed to leave 0.15 to .2 m above the ground.

Existing Monitoring Information (yes/no):

Yes. EDI personnel reviewed the shrub staking and alder seeding treatments carried out on the Vangorda waste rock dumps. All stakes within the plot were counted and identified as either living (showing signs of sprouting and no signs of drying out), dead (showing no signs of sprouting and signs of trying out) or sprouted but appearing dead (showing signs of sprouting but also of drying out). This process was carried out separately for willow and balsam poplar stakes. Due to the timing of sampling, many of the cuttings had already lost their leaves and this made it difficult to determine whether some of the cuttings were actually dead or had simply shed their leaves.

Overall approximately 50% survival rate was found for live stakes. A total of 54 willow stakes were located; of these, 28% were classified as living, 22% were classified as dead and 50% were classified as sprouted but appearing dead. Forty-seven balsam poplar stakes were located; of these 74% were classifies as live, 15% as dead and 11% as sprouted but appearing dead. In general, balsam poplar cuttings grew better then willow cuttings and larger willows grew more successfully than smaller ones. No alder or alder seeds were observed during this monitoring event.

Monitored by this Project (yes/no):

No.

Objectives Met as Stated?:

Shrub staking with balsam poplar cuttings has been successful. However, shrub staking with willow cuttings was less successful. It is possible that the alder cones blew away during the winter or were swept during the previous year's flooding.

Since these treatments were applied as a trial, the objective of testing vegetation prescriptions has been achieved. Additional monitoring is planned and should be completed during the growing season.

Additional Comments

Due to shallow cover depth on the lysimeter plot, staking was limited to an average depth of 0.5 m. This shallow depth was not optimal for live staking.

In 2008, many of the cuttings had lost their leaves by the time of monitoring. This made is difficult to determine whether some of the cuttings were actually dead or had lost their leaves.

Photo Documentation

Photo 1. View of the lysimeter plot at the Anvil Range mine site, near Faro, in September 2007. These plots were constructed in August 2007 on the Vangorda waste rock dumps.

Photo 2. View of the lysimeter plot at the Anvil Range mine site, near Faro, in September of 2008. Note the emergent shoots on several of the stakes.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Germaine Creek Soil Bioengineering Demonstration Project	**General Location:**	40 km east of Dawson City, on a seasonally wetted side channel of the Klondike River.
Date of Monitoring by this Project:	June 6, 2008		
Date of Re-vegetation:	September 2004		
Re-vegetation Company or Group:	Polster Environmental Services Ltd. and M. Miles and Associates Ltd.		

Monitoring Overview

Monitoring dates:

Monitored in 2005 and 2006. No formal monitoring in 2007.

Monitoring Company or Group:

Polster Environmental Services Ltd. and M. Miles and Associates Ltd. in 2004 to 2006.

Full Reference:

M. Miles and Associates Ltd. and Polster Environmental Services Ltd. 2007. CRE-87-06 Klondike River at Germaine Creek Soil Bioengineering Demonstration Project Results of 2006 Monitoring. Prepared for the Yukon River Panel.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Gravel bar staking was completed with the goal of accelerating gravel bar re-vegetation and successional processes. Live palisades (a wall of stakes) were installed to protect an eroding section of channel bank. This project was intended to be a demonstration project for use of this technique in the region.

Treatments:

In 2004, 2 gravel bars were live staked in 3 distinct areas with willow and poplar. Gravel bar staking typically traps fine sediments on the gravel bars, raising elevation and providing good growth medium for other plants. A live palisade was also set up on the channel bank across from the gravel bars using 2 rows of live stakes.

Existing Monitoring Information (yes/no):

Yes. In 2005 and 2006, ten 0.01 hectare circular plots were used to sample the bioengineering treatments on the gravel bars. All stakes within the circular plot were counted and identified as either living or dead. Circular plots were not used to sample the palisade; instead stakes were counted and designated as dead or living. The rows of stakes were counted separately since the row closest to the river had suffered ice damage.

Monitoring in 2005 and 2006 showed that the survival rate of stakes in the gravel bar plots decreased from 73% to 69%. In 2006, the stakes in the area on the left bank had an average height of 77 cm while those in the area on the right bank had an average height of 48 cm.

The live palisade survival rate decreased from 50% in 2005 to 14% in 2006. In 2006, all the balsam poplar stakes in the palisade except for one had been killed by fungal infections. It was suspected that flooding for an extensive period of time caused these fungal infections. Willow stakes did not get affected by fungal infections; however, only 87 out of 546 willows were alive in 2006.

Monitored by this Project (yes/no):

Yes. In June of 2008, three 10 m x 7.5 m rectangular plot were laid out within the treated areas of the gravel bars (2 plots on the left bank and 1 on the right bank). All stakes were counted in each plot and identified as having no growth, old growth or new green growth. In addition, the heights of 10 willow and 10 poplar stakes within each plot were measured. The live palisade was sampled using 3 plots, measuring 10 m in length and of a width equal to that of the palisade.

In the gravel bar staking areas, the average stake height was 110 cm on the left bank and 50 cm on the right bank. The average measured height of balsam poplar (48 cm) and willow stakes (49.9 cm) were similar on the right bank areas. On the left bank areas, the average measured height of willow stakes (112.8 cm) was approximately 5 cm higher than the average heights of balsam poplar stakes (107.1cm). Approximately 49% of the counted stakes on the right bank area were living and approximately 36% of the counted stakes on the left bank areas were living. All areas of the staked gravel bars had trapped sediments. The left bank area had notable fine deposition which the right bank had limited amounts of fine sediments. Gravels had covered up most of the exposed cuttings in the right bank area resulting in a lower survival rate in this area. Some grasses and herbs have established in the left bank area

In 2008, the live palisade survival rate was estimated to be 17%. Since monitoring of the palisade was done using plots in 2008, the total number of live balsam poplar and willow stakes was not counted.

Objectives Met as Stated?:

Sediment buildup on the gravel bars was observed in 2006 and 2008 with grass and herb species starting to establish in these area. Palisade growth is poor and did not show signs of improving from 2006 to 2008.

Gravel bar staking appears to be accelerating gravel bar succession as designed. Growth of palisade remains poor; however, the area is not currently an erosion concern.

Additional Comments

Photo Documentation

Photo 1. View of gravel bar staking on the mid-channel island of Germaine Creek, a tributary of the Klondike River near Dawson. Photo taken in May of 2005, growth is visible of several stakes in the foreground. Photo courtesy of M. Miles and Associates Ltd. and Polster Environmental Services Ltd.

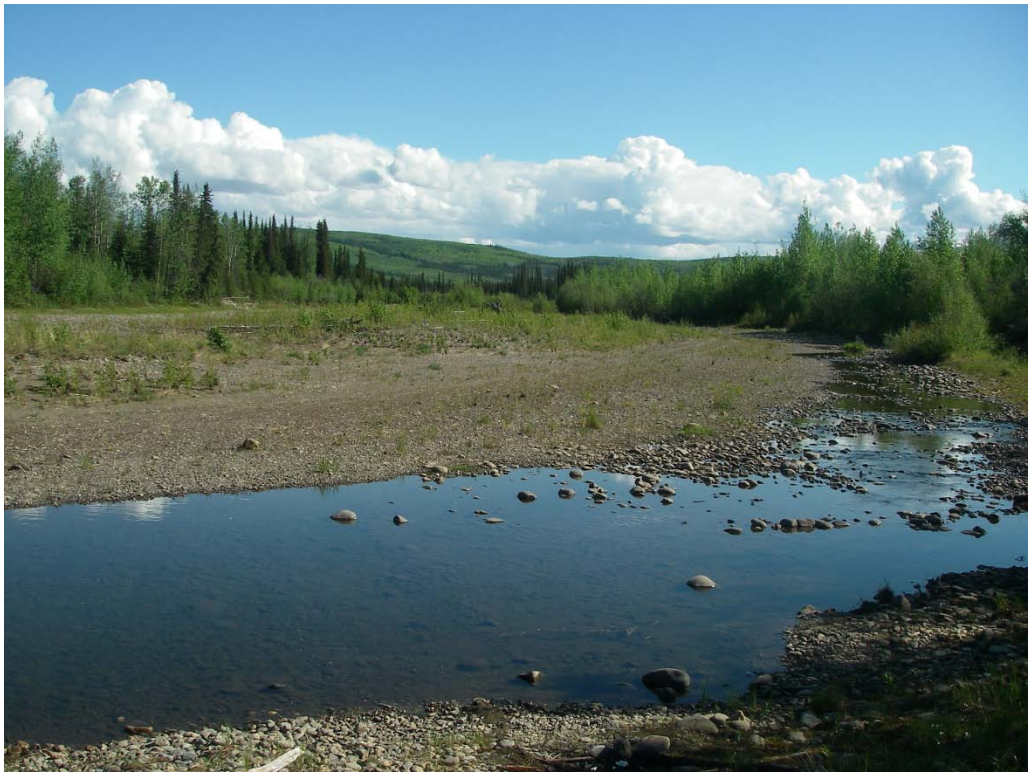

Photo 2. View of the gravel bar staking on the mid-channel island of Germaine Creek, a tributary of the Klondike River near Dawson. Photo taken during the most recent monitoring event, in July of 2008. Note the increased sedimentation on the right side of the island.

Photo 3. Gravel bar staking area with extensive growth of grass and herbs, on the mid-channel island of Germaine Creek, a tributary of the Klondike River near Dawson. Photo taken in 2008.

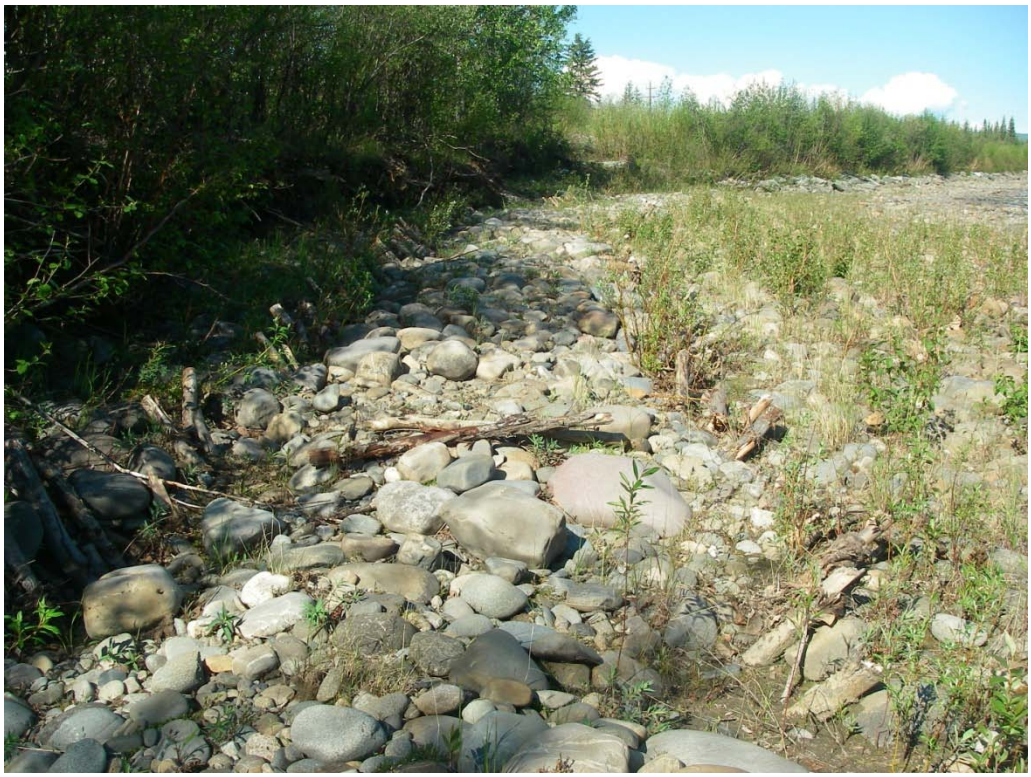

Photo 4. Photo of live palisade along the channel bank of Germaine Creek, a tributary of the Klondike River near Dawson. Photo taken in 2008.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Gold Run Creek

General Location: 52 km south east of Dawson City.

Date of Monitoring by this Project: July 22, 2008

Date of Re-vegetation: September 2005

Re-vegetation Company or Group: Constructed by Laberge Environmental Services Ltd.

Monitoring Overview

Monitoring dates: 2006.

Monitoring Company or Group:

Monitoring and by Laberge Environmental Services Ltd.

Full References:

Laberge Environmental Services. 2007. Gold Run Creek Erosion Control Project: 2006 Follow-up Monitoring. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Laberge Environmental Services. 2006. Pilot Scale Erosion Control Using Bioengineering Techniques at Gold Run Creek, 2005. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

The installed bioengineering structures will help halt slope failure and stabilize the disturbed section of overburden. A large erosion cut, approximately 300 m long and up to 50 m deep, has occurred on a stockpile of frozen overburden on the east bank of Gold Run Creek. The eroded area resulted from a slope failure in the 1980s. Melting permafrost led to further slumping and erosion.

Treatments:

In 2005, walls along the erosion cut were reconstructed until a gradient was produced that allows the construction of wattle fencing (a terrace like construction made of willow stakes and using larger spruce anchor poles). Structures included an earth retaining wall, a wattle fence placed at the eroding top of the retaining wall, and a flume constructed of live willow cuttings (harvested from the stockpiled overburden) to channel runoff and allow stakes to establish and grow. This flume was installed to allow the flow to diffuse across the bottom of the gully, thereby reducing erosion

damage. Live willow staking was also done upstream of the cut in the path of the flow in order to help decrease flow velocities through the gully.

Existing Monitoring Information (yes/no):

Yes. In 2006, the flume had failed to direct the flow over the retaining wall and upstream erosion of the gully increased. A water diversion pipe that had been setup in 2005 to divert the flow around the flume for the fall was no longer working by the spring of 2006. Since the 2005 installation of the bioengineering structures, upstream erosion had increased by approximately 5 meters, presumably due to increased flow from spring and summer melt water. However, at the time of the 2006 monitoring event, the estimated water flow was very low (10 to 20 ml/s). The earth retaining wall was intact and the willow support structure showed signs of growth. Live staking survival for the willows upstream of the bioengineering structures was good and signs of growth were visible. Some areas of the gully and walls continued to stabilize and exhibited good growth. However, the lower section area had eroded away below the southeast facing wall and caused it to destabilize.

Monitored by this Project (yes/no):

Yes. EDI found that the flume and nearly all of the wattle fencing had collapsed. The only intact section of the fencing was a small section approximately 5 m in length along the lower portion of the south east wall of the gulch. The fencing of the west wall was completely collapsed and was buried by slumping material. The intact fencing on the southeast wall was undercut by runoff to such an extent that the bottom of the fence was suspended 3 m above the bottom of the gulch. Good growth of new willow shoots was visible on the fence. The average shoot height was approximately 30 cm and the tallest shoots measured approximately 1 m. Willows staked within the flow were not found and had most likely been buried by slumped over bank material.

Fireweed and grass grew on slumped soil materials. EDI observed tufted hairgrass, tall blue bell, and narrow-leaved hawksweed growing in slumped material and within the wattle fence. Toppled willows sent up new shoots measuring less than 10 cm. This new growth suggests that the willows have toppled over within the last year and that slumping is ongoing. The gully continues to erode and is now approximately 15 m longer then when it was measured in July 2006.

Objectives Met as Stated?:

Although some parts of the gully have stabilized, overall gully erosion has continued and therefore the goals of halting slope failure and stabilizing the disturbed section of overburden have not been achieved.

Although the remaining bioengineering structures are showing healthy growth, are not functioning. If erosion continues at present rates, the gully will reach the edge of the mature forest above the gulch within 1 to 2 years.

Additional Comments

Toppled willows are sending up shoots from their prone position and this could aid in helping to stabilize the slope; however, it appears that slumping is occurring too rapidly for these willows to establish themselves before they are buried under new material. Unless the extensive melting of the underlying permafrost is slowed or halted, this situation will likely remain unchanged.

Photo Documentation

Photo 1. View of the completed live retaining walls (wattle fences) and live willow flume on the Gold Run Creek erosion cut, approximately 50 km south east of Dawson City. Photo taken on September 9th, 2005, courtesy of Laberge Environmental Services Ltd.

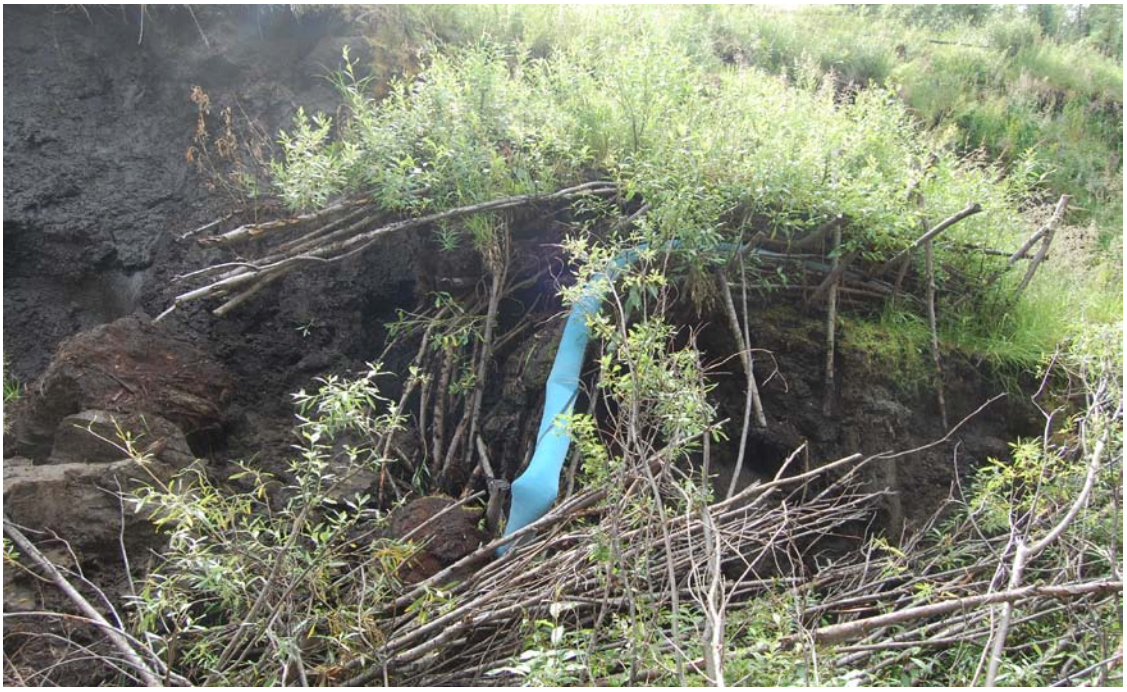

Photo 2. View of the collapsed live retaining walls (wattle fences) and undercut live willow flume on the Gold Run Creek erosion cut, approximately 50 km south east of Dawson City, in July, 2008. Note that the wattle fences have been undercut and have collapsed.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Hawk Trench

General Location: 25 km from Dawson City above a gulch on the Upper Reach of Eldorado Creek

Date of Monitoring by this Project: July 21, 2008

Date of Re-vegetation: 1995

Re-vegetation Company or Group: Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1995.

Monitoring Overview

Monitoring dates: 1996, 1997, 1999.

Monitoring Company or Group:

Monitored by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1996 and 1997 and Mougeot Geoanalysis and S.P. Withers Consulting Services in 1999.

Full References:

Craig, D.B., J. E. Craig, K. Pelletier, D. Emond and H. Copland. 1998. Reclamation practices and research on mineral exploration properties in the Yukon Territory. Prepared by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Mougeot Geoanalysis and S.P. Withers Consulting Services. 2000. Assessment of Long-Term Vegetation and Site Conditions at Reclaimed Yukon Mineral Exploration Sites. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Test re-vegetation procedures on a moist permafrost site. These plant species will provide a nurse crop, but will not impede encroachment of local native plant species.

Treatments:

Prior to seeding, the trench was backfilled until an angle of approximately 10 to 21 degrees was achieved (similar to the surrounding hillside). Five experimental plots, 5 m x 5 m, were setup on the backfilled trench. These plots were hand seeded with an agronomic seed mix. By weight, the seed mix contained alsike clover (15%), fowl bluegrass (5%), creeping red fescue (30%), meadow foxtail (10%), red top (5%), reed canary grass (10%), timothy (15%) and slender wheatgrass (10%). The rate of seeding was 75 kg/ha.

Fertilizer and inoculants were also added to some of the experimental plots. Fertilizer consisted of 1 kg of 34-0-0 (ammonium nitrate) fertilizer and 1.5kg of 8-24-24 (nitrogen-phosphorus-potassium) fertilizer, per plot. Inoculants consisted of nitrogen fixing bacteria, to help increase the speed of re-vegetation on nitrogen poor soil. These bacteria were a mix of lab cultured *Glomus intraradix* bacteria and bacteria collected from root nodules of Yukon alsike clover plants (a nitrogen fixing species). These cultures were mixed with water and a peat moss stabilizer in order to form a liquid slurry that was spread onto plot by hand watering. 4 liters of inoculants were used at each site.

Four different treatments were applied at the Hawk Trench site, these included:

- 1) fertilizer, seed, inoculants, no mulch
- 2) fertilizer, seed, inoculant, imported mulch blanket
- 3) fertilizer, seed, inoculants, topsoil (8 cm)
- 4) control, bulldozed and left bare
- 5) fertilizer, seed, no inoculants

Existing Monitoring Information (yes/no):

Yes. Monitoring in 1996 by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada showed that plot 2 (treated with imported mulch) and plot 3 (treated with topsoil) had much higher coverage and more growth than plots 1 and 5. The control plot had only 5 % cover and had been colonized by willow, rose, fireweed and raspberry. With the exception of plot 3, where strawberry blite, lamb's quarters and hawkweed were found, all treated plots showed exclusive growth of seeded species.

In 1999, Mougeot Geoanalysis and S.P. Withers Consulting Services found that slender wheatgrass had come to cover 40% of each of the treated plots. Other grass species included timothy, red fescue, and reed canary grass. There was no apparent benefit from the addition of imported mulch and topsoil. However, inoculant treatments aided the growth of red fescue. Inoculant treated plots also supported a few alsike clover plants. The control plot showed significant growth of native species, with a dominant willow cover of 15%. Overall, all treated plots had dense mats of dead grass that slowed new growth and succession by other species.

Monitored by this Project (yes/no):

EDI found that after 9 years, treated plots remained much the same as they had been in 1999. Treated plots had a similar composition of grass species. However, a denser mat of dead grass was observed in all treated plots then when the plots were monitored in 1999. The amount of mat coverage varied from 20% in plot 3 (topsoil treatment) to 65% in plot 2 (mulch treatment). The topsoil treatment showed the most lush grass growth with the smallest dead vegetation mat. Treatments of inoculant and inoculant with imported straw mulch both led to an increase in dead vegetation mats in excess of 50%. In all treated plots, live grass growth dominated the uphill side of the plots while the dead vegetation mats were more prominent on the downhill side of the plots. Plots 5, 3 and 2 had been colonized to varying degrees by small amount of fireweed and poplars, the fireweed was on average 30 cm high and the poplars were on average 60 cm high. Plot 3 also had a few Jacob's ladder and raspberry plants. In plot 1, soapberry and alder have colonized a small area on the downhill edge of the plot; other plant species include milk vetch and yarrow. Alsike clover was not found on any part of the reclaimed trench.

In the control plot, there is not extensive shrub coverage, similar to the adjacent forested areas. now nearly indistinguishable from the surrounding undisturbed areas. A few grass plants are visible in this plot but they do not appear to have impeded succession. The plot is dominated by poplar, willow and some aspen. The tallest of these trees was estimated to be about 4 m tall. A single lodge pole pine has grown in this plot.

Objectives Met as Stated?:

Reclamation techniques had successfully established rapid grass cover on the experimental sites. However, the establishment of native species has been impeded by the large amount of dead vegetation mats in the plots where grass seeded established. No significant colonization has occurred within any of the treated plots. The control plot has not impeded the establishment of native species, likely because it lacked a nurse crop.

It appears that in moist permafrost zones such as this, aggressive grass seeding and fertilizing impedes succession over the long term.

Additional Comments

EDI and Mougeot Geoanalysis and S.P. Withers Consulting Services found that minimal erosion has occurred at this site. This suggests that the restoration of the slope profile may was sufficient to of halt any potential short term erosion. Personal communications with local placer miners indicated that disturbed sites in this area are nearly undistinguishable from surrounding forest if left to re-vegetate naturally for approximately 5 years.

Photo Documentation

Photo 1. View of the Hawk Trench test plots, near Eldorado Creek, in 1995.The control plot is in the foreground and topsoil plot is in the background. Photo courtesy of the Yukon Geological Survey.

Photo 2. View of the Hawk Trench test plots, near Eldorado Creek, in July 2008. The control plot is in the background and the topsoil plot is in the foreground. Note the large mats of dead grasses which have impeded succession.

Photo 3: View of the control plot at the Hawk Trench site, near Eldorado Creek in July 2008. Note the extensive growth of shrub species, similar to the nearby forest.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Jason Knoll

General Location: 220 km east of Ross River, accessed by the North Canol Road.

Date of Monitoring by this Project: No monitoring

Date of Re-vegetation: 1981

Re-vegetation Company or Group: Aberford Resources

Monitoring Overview

Monitoring dates: 1982 to 1985, and 1999.

Monitoring Company or Group: DIAND (1982 to 1985) and Mougeot Geoanalysis / S.P. Withers consulting Services (1999).

Full References:

Brown, G., 1985. Results of Revegetation Experiments 1981-85 Macmillan Pass, Yukon Territory. Prepared by the Department of Indian and Northern Affairs, Government of Canada.

Mougeot Geoanalysis and S.P. Withers Consulting Services. 2000. Assessment of Long-Term Vegetation and Site Conditions at Reclaimed Yukon Mineral Exploration Sites. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

The objective was to develop site-specific re-vegetation techniques in the eventuality that a mine would be developed in the Macmillan Pass area.

Treatments:

Three re-vegetation test sites were established in 1981. One plot was located in a trench above the tree line in the tundra while the other two plots were located in the boreal forest at lower elevations. At each of the three sites, 8 pairs of test plots were established; half the plots were fertilized and the other half not. At each plot, one plant species was tested. The seeded species were: engmo timothy, durar hard fescue, roreal red fescue, arctared red fescue, nugget Kentucky bluegrass, fortress red fescue, violet wheatgrass, fowl bluegrass, covar sheep's fescue, meadow foxtail, annual ryegrass, Russian wild ryegrass and sodar streambank wheatgrass. Native grass seeds were also collected (five species) or purchased and seeded in 1982. Those species are ticklegrass, red fescue, alpine bluegrass, wood rush, northern rough fescue, red top, alpine holy grass and tufted hairgrass.

Existing Monitoring Information (yes/no):

Yes. In 1985 Brown found that ticklegrass had colonized the majority of the higher and lower elevation sites. Other successful species included wood rush, alpine holy grass and northern red fescue. These species grew more slowly but survived well. Red fescue, alpine bluegrass and red top also showed good potential. Agronomic species that grew well included boreal red fescue, arctared red fescue, nugget Kentucky bluegrass, fortress red fescue, engmo timothy and annual ryegrass. The recommended and best performing species overall were ticklegrass and wood rush. Species richness was high in 1985, although abundance was quite low. The maximum cover in any one plot was approximately 20%.

In 1999 Mougeot Geoanalysis and S.P. Withers Consulting Services found little cover of the agronomic seeded grasses and greater dominance of native shrubs. Red fescue persisted as the only remaining agronomic species in 1999. Monitoring also showed that none of the agronomic species were present in the undisturbed area. Mougeot Geoanalysis and S.P. Withers Consulting Services suggested that the surrounding vegetation influenced shrub colonization by acting as a seed bank: those undisturbed areas along the trenches where shrubs were most abundant produced a similar abundance of shrub species within the adjacent trench. Rough and irregular microtopography aided re-vegetation by providing good moisture retention. Mougeot Geoanalysis and S.P. Withers Consulting Services noted that the replacement of overburden and organic material was beneficial to colonization, especially to the shrubs species.

Monitored by this Project (yes/no):

No.

Objectives Met as Stated?:

The objective of developing site specific re-vegetation techniques was achieved. Based on monitoring by Brown and Mougeot Geoanalysis and S.P. Withers Consulting Services, seeding with red fescue would provide a strong and lasting grass cover.

The long term re-vegetation of sites in the Jason Knoll area worked best when using local species. Since immediate erosion control is not a problem at this site, seeding with hardier native species is an effective prescription.

Additional Comments

It appears that natural succession is well underway at this site, the results of the 1999 monitoring event suggest that agronomic species may eventually disappear from this site

Photo Documentation

Photo documentation unavailable.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Mayo Side Channel Post-Construction Re-vegetation	**General Location:**	1.5 km upstream of the mouth of the Mayo River.

Date of Monitoring by this Project: August 19, 2008

Date of Re-vegetation: October 2004

Re-vegetation Company or Group: Na-Cho Nyak Dun and EDI Environmental Dynamics Inc.

Monitoring Overview

Monitoring dates: Yearly monitoring since construction in 2004.

Monitoring Company or Group: Na-Cho Nyak Dun and EDI Environmental Dynamics Inc.

Full References:

Schonewille, B. and Tobler, P. 2005. 2004 Lower Mayo River Chinook Habitat Restoration. CRE-19N-04. Prepared for Yukon River Panel.

Schonewille, B. and Tobler, P. 2006. Lower Mayo River Chinook Habitat Restoration – A Post Construction Assessment CRE-19-05. Prepared for Yukon River Panel.

Schonewille, B. and Tobler, P. 2007. Lower Mayo River Chinook Habitat Restoration - Assessment of Juvenile Habitat (Year 2) CRE-19-06. Prepared for Yukon River Panel.

Schonewille, B. and Tobler, P. 2008. Lower Mayo River Chinook Habitat Assessment of Juvenile Habitat (Year 3) CRE-19-07.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

The objective of this works was to stabilize a reconstructed stream bank on a side channel of the Mayo River. This was conducted following the construction and use of a temporary access road used by during channel restoration works. The grass seeding was designed to provide short-term erosion control and the brush layering was completed to stabilize the bank and accelerate growth of the riparian vegetation.

Treatments:

In October of 2004, a side channel of the Mayo River was lowered to recruit ground water and to provide juvenile salmonid rearing habitat. A temporary road leading to the channel was constructed to allow heavy equipment to access the side channel. Following the completion of channel, the stream bank area that was disturbed by the access road was reconstructed. The bank is situated above a deep pool and flow velocities at this location are quite low. The bank was constructed with logs (as a base) and grass seeded soil lifts wrapped in a bio-degradable erosion control matting (North American Green C125BN). Re-vegetation consisted of three brush layers. A total of 209 stakes were planted including willows and red osier dogwood. The remainder of the access road was re-contoured, covered with woody debris and grass seeded (unknown agronomic seed mix).

Existing Monitoring Information (yes/no):

Yes. In 2005, 203 of 209 stakes were located. Sixty percent of the willow stakes in the top row had new growth. Seventy-one percent of stakes in the middle row showed new growth and 30% of the stakes in the lowermost row had new growth. Grass had grown in the seeded areas of the access road and no signs of erosion were visible.

Monitoring in 2006 showed that 200 of the original 209 stakes were still present. In the top row, 49% of the willow stakes had new growth. In the middle row, 52% had live growth and in the lowermost row 30% had live growth. Grass seeded areas had established growth and no signs of erosion were visible.

In 2007, monitoring showed that, 45% of the original 209 stakes had live growth. The number of live stakes in each row was not noted. Grass seed was well established and natural recruitment of shrub species had started to take place.

Monitoring carried out by EDI in 2008 located 178 of the original 209 stakes. In 2008, 31% of the original total had live growth. During this monitoring event, live growth was also further divided between those stakes which had good growth (defined as greater then 50% green leaves) and poor growth (defined as less then 50% green leaves). Under this new monitoring scheme, the topmost row had the most live growth of all three row, with 39% of stakes showing live growth (19% good growth and 20% poor growth).

The grass seeded section of the access road showed lush grass growth. However, dense grass cover and a few mats of dead grass were beginning to form which may impede further colonization of native vegetation. As of 2008, native species such as alder, wild rose, strawberry, small bedstraw and bunchberry have re-colonized the re-contoured access.

Monitored by this Project (yes/no):

Yes.

Objectives Met as Stated?:

The objective of reducing the risk of short term erosion associated with the temporary access appears to have been met. The brush layers appear to have helped to stabilize the stream bank and provided some natural riparian vegetation. Although the number of live stakes has decreased, there was no significant erosion along the bank or the seeded area during the 2008 site visit. Also, the surviving stakes appear to have good enough growth to compensate (in terms of function) for those that have died out.

Additional Comments

Red osier dogwood stakes were not a successful species in this re-vegetation treatment. No live dogwood stakes were seen in 2008. Aggressive grass seeding may be slowing natural colonization of native shrub species.

Photo Documentation

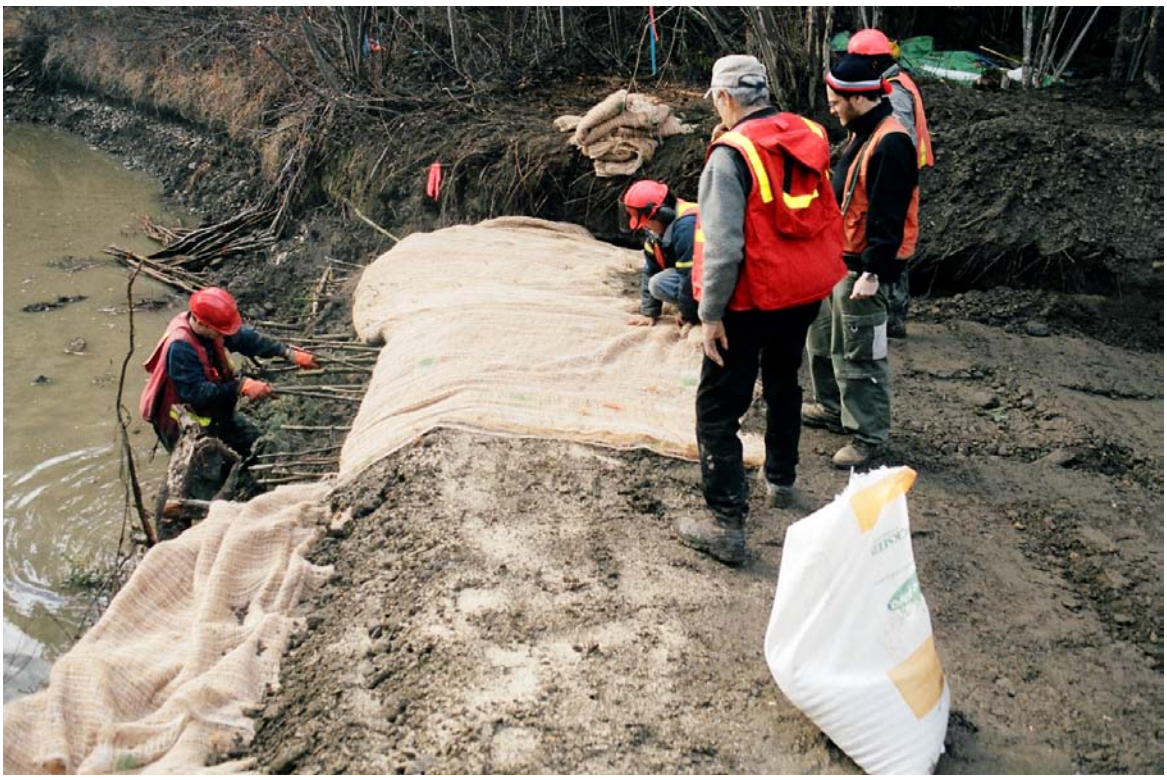

Photo 1. Restoration of the site access road on a restored side channel near the mouth of the Mayo River, in the summer of 2004. Willow stakes were planted in the bank, soil lifts were placed on top, grass seeded and wrapped with erosion control matting.

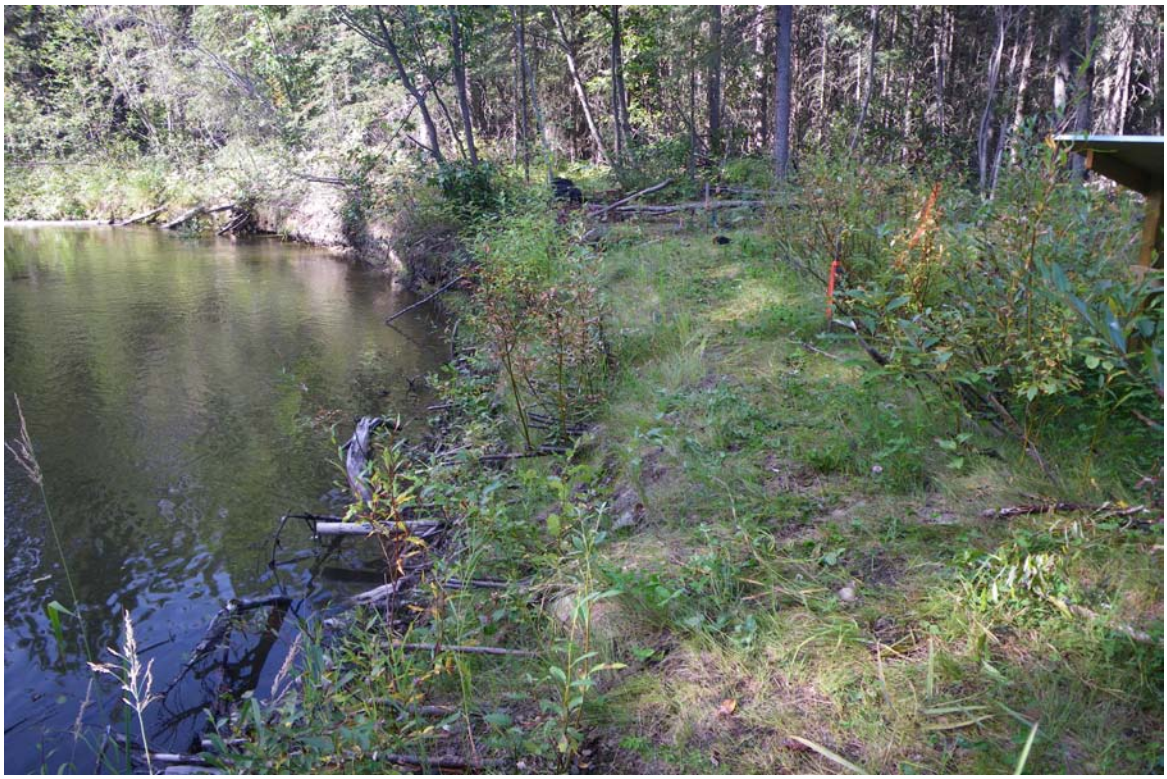

Photo 2. View of the restored access road, near the mouth of the Mayo River, during the most recent monitoring in August of 2008.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Mendenhall River Bioengineering	**General Location:**	Km 1557 of the Alaska Highway
Date of Monitoring by this Project:	No monitoring		
Date of Re-vegetation:	October 2003		
Re-vegetation Company or Group:	EDI Environmental Dynamics Inc.		

Monitoring Overview

Monitoring dates:

June, July and August 2003 by EDI, August 2007 by R & D Environmental Consulting Ltd.

Monitoring Company or Group:

EDI and R & D Environmental Consulting Ltd.

Full References:

Sharples, R. and Tobler, P. 2002. Mendenhall River, Alaska Highway KM 1557 – Vegetation Inventory. Prepared for Infrastructure – Transportation Branch, Government of Yukon, Whitehorse, Y.T.

R & D Environmental Consulting Ltd. 2007. Mendenhall River Alaska Highway Crossing KM 1557 Post Construction Monitoring and Fish Habitat Assessment, 2007. Prepared for the Transportation and Engineering Branch, Highways and Public Works Department, Government of Yukon.

Sharples, R. 2003. Re: Inspection of the Mendenhall Bioengineering Works on August 18, 2003. Letter to Jane Keopke, Environmental Co-ordinator, Transportation and Engineering Branch, Highways and Public Works, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Objectives would be to help stabilize, prevent erosion and establish riparian vegetation near the new culvert installed at the Mendenhall River crossing of the Alaska Highway.

Treatments:

In the spring of 2003, YTG Highways and Public works department constructed a new stream crossing over the Mendenhall River at the Alaska Highways. A culvert was installed at this new location and the river was diverted into a new stream channel. Rip-rap was installed at the culvert inlet and outlet in order to help prevent erosion of these areas. Several bioengineering treatments, using approximately several willow species and a small amount of balsam poplar, were employed in the inlet and outlet areas, as well as some other locations around the crossing site.

At the new inlet channel, a soil wrapped live brush layer consisting of willow stakes placed 3 cm apart was installed. This structure was placed immediately upslope of the riprap. Above the live brush layer, 3 rows of live fascines, consisting of bundles of approximately 20 cuttings were installed and were secured to the top of the channel backslope.

A similar treatment was used at the new outlet channel. Brush layers were installed (cuttings spaced 3 cm apart) above the riprap along both banks of the outlet channel. Above this, a brush mattress made up of overlapping cuttings was constructed.

Individual live stakes were planted throughout the site including along the toe of the infilled slope (upstream of the highway crossing) and within the riprap itself. Approximately 500 cuttings were installed in this manner.

Several large clumps of willows were transplanted by an excavator upslope from the bioengineering treatments. These were harvested from the adjacent right of way areas.

Finally, the area was seeded with a agronomic mixture of grass seed.

The majority of works were completed in May and June of 2003. Some additional live staking was completed in 2004.

Existing Monitoring Information (yes/no):

Yes. In June 2003, EDI setup several plots to conduct early monitoring of the success of the re-vegetation works. Four meter linear plots were setup on the east and west sides of the inlet channel. Also 2 m x 2 m plots were setup on the east and west sides of the both the inlet and outlet channel as well as along the toe of the infilled slope.

The 4 m linear plots were used to evaluate the success of the live fascines. This was done by counting the number of new shoots on these structures. The 2 m x 2 m plots were used to evaluate the brush layer, live stakes and brush mattress treatments. The brush layers and the live stakes were evaluated by counting the total number of stems present as well as the number of stems which had successful budding. The brush mattress was evaluated in the way as the live fascines: by counting the number of new shoots present.

Monitoring was carried out in June, July and August of 2003. In August of 2003, growth of the live fascines was quite patchy. Some sections had a large number of new shoots while other area had none. In the 4 m plot on the east side of inlet channel, 34 new shoots were found. On the east side of the inlet channel, no new shoots were found in the 4 m monitoring plot. However, the rows above the plot showed better growth (23 new shoots).

Growth in the brush layers across all four treated areas was about 50%. Successful growth within the plot areas was lower than this, but some nearby areas outside the test plots showed vigorous growth. The most successful of these was at the upper end of the west inlet channel where 80-90% of stems had successful budding. This may be correlated with high moisture levels in the soil in this area.

A single plot was used to evaluate success of the live stakes planted in the toe of the infill slope. Only 9% of the stakes that were checked had successful budding, all of these surviving stakes had large diameter stems. It was thought the frozen soil during the planting event in May contributed to the poor success of the live stakes.

The live brush mattress treatments on the east and west sides of the outlet channel had patchy growth, similar to the live fascines. The plot in the west side of the channel showed no new shoots; however, areas of good growth were visible near the plot. On the east side of the channel, 4 new shoots were found. More successful growth was also observed outside the plot area on this side of the channel as well. Overall, the live fascines and the brush mattress together with surrounding grass growth provided good growth at the time.

R & D Environmental Consulting Ltd. surveyed the bioengineering structures in August, 2007. They found that, of the stakes planted vertically along the banks, only approximately 5 % are still alive. The brush layers (incorrectly identified as live fascines in R&D report) on the upper sections of the rip-rap (both upstream and downstream of the culvert

were alive and showed good growth. Also, grasses were well established along much of the bank. R & D Environmental Consulting Ltd. found that the banks were stable and no significant erosion was evident. No mention of either the brush mattresses (Photo 2) or the actual live fascines was mentioned in the 2007 monitoring report; however, success appears to be minimal.

Monitored by this Project in 2008 (yes/no):

No.

Objectives Met as Stated?:

Remaining bioengineering and seeding treatments appear to provide enough growth to successfully prevent any significant erosion of the stream banks or upslope areas. The growth of shrubs has not been fast and associated values such as riparian shading have not yet been fully realized.

Additional Comments

This is a very dry site and treatments with shallow depths such as live fascines and brush mattresses were less successful than the brush layers, where installation with an excavator allowed for notable planting depths. The transplants were through to be successful given that there was already an extensive root base.

Photo Documentation

Photo 1. View of the brush layers being installed at the new Mendenhall River crossing near KM 1557 of the Alaska Highway, in May 2003. Downstream (of the crossing) view, facing downstream

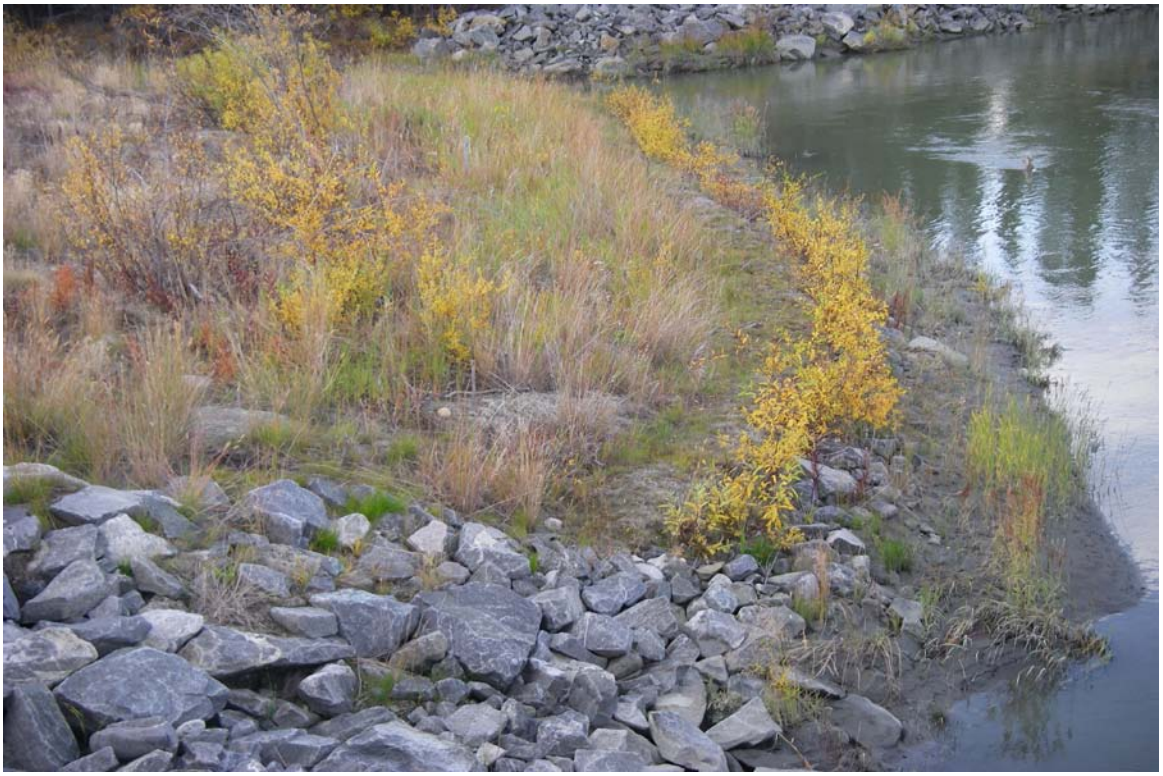

Photo 2. View of the brush layers (right), brush mattress (middle, little growth) and transplants (left) at the new Mendenhall River crossing near KM 1557 of the Alaska Highway during the latest monitoring event, conducted on September 17th, 2008.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Mt. Nansen

General Location: 70 km south west of Carmacks

Date of Monitoring by this Project: October 2, 2008

Date of Re-vegetation: Fall 2006

Re-vegetation Company or Group: Arctic Alpine Reclamation Group

Monitoring Overview

Monitoring dates: Not monitored

Monitoring Company or Group:

Monitoring by Arctic Alpine Reclamation Group and Environmental Dynamics in 2008.

Full Reference:

Arctic Alpine Reclamation Group. 2006. Mt. Nansen Mine Site Reclamation Report. Prepared for Assessment and Abandoned Mines Branch, Energy, Mines and Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

This was a pilot project. Perceived objectives included the seeding of the portal apron, waste rock and access trail of the Huestis adit (the entrance to underground mine areas) with an indigenous seed mix in order to reduce erosion and hasten the natural re-vegetation of the area. The second perceived objective would be to establish shrub species on site to accelerate succession processes.

Treatments:

Prior to seeding and planting, the Huestis portal was sealed with waste rock to prevent access but to allow water to continue to drain. Also the waste rock dump was contoured prior to seeding. Seed was distributed at a rate of approximately 25 kg/hectare. The indigenous seed mix contained, alkali grass, violet wheatgrass, tufted hairgrass, northern fescue and tickle grass. The seed mix was broadcast by hand and the soil surface was harrowed after seeding had taken place.

Shrub material was harvested locally from onsite donor material. Donor material was harvested with hand shears at a height of approximately 0.5 meters above the soil surface. This height was chosen since it is thought to be similar to the height range where the majority of herbivores graze the shrub. Harvesting was done after a major frost, in order to ensure that the plants had entered a stage of winter dormancy. Five different shrub species were harvested and planted to test their site specific suitability for re-vegetation. No fertilizer was used during seeding or shrub staking.

The 3 different methods of shrub staking were included:

- 1) Bundles (1 to 3 stems) of locally harvested plant material approximately 75 cm in length were planted horizontally in manually dug trenches to a depth of 15 cm.
- 2) Cuttings (stakes) of locally harvested plant material approximately 50 cm to 1.5 meters in length were planted vertically to a depth of 50 cm to 1 meter with a weighted metal probe due to the soil structure and porosity.
- 3) Bundles (3 to 4 stems) of locally harvested plant material approximately 50 cm in length were bundled together and planted horizontally in trenches to a depth of 15 to 30 cm. due to the soil structure and porosity.

Existing Monitoring Information (yes/no):

No.

Monitored by this Project (yes/no):

Yes. EDI personnel observed the general area of the Huestis portal area where grass seed and planting was conducted The site was very rocky and observations showed that the grass had a very sparse vegetation cover (a few individual plants of violet wheatgrass was observed). It was difficult to tell what was planted in terms of bundles or cuttings at this site; however, there were few signs of shrub growth at this location.

Objectives Met as Stated?:

It does not appear that the perceived objectives of reducing erosion via seeding and hasten the natural re-vegetation via planting have been achieved. Granted the site is quite rocky and thus appears resistant to erosion and difficult to re-vegetation.

Additional Comments

The names of the shrub species selected for staking were not given. It is possible that there were additional seeded grass species present on areas of the Huestis hillside that were not visited during the 2008 monitoring. However, the large area and low plant density suggest that even if this were the case success would be limited.

Photo Documentation

Photo 1. View of the Huestis hillside at the Mt. Nansen Mine site near Carmacks. Note minimal vegetation cover. Photo taken on October 2, 2008.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Noname Creek

General Location: 90 km west of Carmacks on an un-named tributary of Big Creek (locally called Noname Creek).

Date of Monitoring by this Project: Aug 5, 2008

Date of Re-vegetation: September 2001

Seeding Company or Group: Construction and upgrades by Laberge Environmental Services Ltd.

Monitoring Overview

Monitoring dates: Monitored in 2002. Upgrades installed in 2003 and 2004. Post-fire monitoring of the structures was carried out again in 2005.

Monitoring Company or Group:

Monitoring by S.P. Withers Environmental Consulting Services.

Full References:

Laberge Environmental Services. 2002. Experimental Trials for Restoring Disturbed Sites in Permafrost Areas Using Bioengineering Techniques. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Laberge Environmental Services. 2004. Follow-up Monitoring: Shrub Trial Plots at Brewery Creek Mine and Bioenginneering Trials at Noname Creek. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Laberge Environmental Services. 2005. Upgrades to the Bioengineering Installations at Noname Creek 2003/2004. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Withers, S.P. 2003. Follow-up Monitoring: Shrub Trial Plots at Brewery Creek Mine and Bioenginneering Trials at Noname Creek. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Withers, S.P. 2006. Bioengineering Trials at Noname Creek Post-Fire Evaluation. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Determine whether bio-engineering techniques can be used to stabilize permafrost rich slopes which have been disturbed by placer mining. These techniques include, live staking, live pole drains and gully breaks.

Treatments:

In September of 2001, an area of Noname Creek that had been subjected to intense gullying following improper road construction during placer mining activity in 1999 and 2000 was selected as a location for a re-vegetation using live gully breaks, live staking and live pole drains. All three bio-engineering works were created using willow cuttings collected from nearby tributaries. Twelve live gully breaks comprising lattice of 3-4 m long dormant willow cuttings were installed along approximately 100 m of the gully. These consisted of wattle fences constructed at 9 m intervals across the gully. Live willows were staked along the trench between the 1st and 6th gully breaks. These were 40 cm long, dormant willow stakes inserted approximately 30 cm into the ground, spaced 0.5 m apart. Two pole drains were installed in two locations: one upstream of the first gully break and a second between the 7th and 8th gully break. Pole drains were made from bundles of dormant willows, 3 to 5 m, placed in opposite directions and tied together with twine to create a bundle with a 0.2 to 0.3 m diameter. A shallow trench was dug and the bundles placed inside. The bundles in the upstream trench measured 25 m in length while those between gully breaks 7 and 8 measured 8 m in length.

In 2003 and 2004 Laberge Environmental Services Ltd. installed upgrades to the bio-engineering structures. In 2003, the length of the upstream pole drain was extended to 70 m. The top part of the drain was spread apart to attempt collect more seepage and part of the lower end of the drain was covered in biodegradable erosion control matting to attempt to prevent erosion alongside the drain. Additional live willow stakes were randomly planted along both sides of the drain and between the gully breaks. An attempt was made to rehabilitate the first gully break using biodegradable erosion control matting held in place with live stakes and backfilled. In 2004, most of the upgrades consisted of backfilling and compacting around the pole drains and placing biodegradable erosion control matting held in with live stakes (then backfilling) to stop the erosion cuts along the gully breaks. Some of the poles that supported the gully breaks were also replaced.

Existing Monitoring Information (yes/no):

Qualitative measurement of the structural stability of the bioengineering works as well as information on survival and new growth of the cuttings was collected by S.P. Withers Consulting Services in 2002. S.P. Withers Consulting Services determined survival was good and new growth had occurred on the gully breaks, pole drains, and live stakes (with the exception of a few stakes planted on the higher and drier side of the gully). There was some erosion underneath the gully breaks and along side the pole drains but there was evidence that the structures had also stopped some sediment from eroding. Some rodents had also browsed the new shoots on the live stakes and gully breaks. In 2005, a fire burned this area and S.P. Withers Consulting Services investigated the structures and upgrades following the fire. This qualitative inspection showed that the older structured installed in 2001 fared better then those installed in 2003 and 2004. Overall, there appeared to be new growth on all bio-engineering structures and they were all expected to survive and continue to function. Exceptions to this are a few gully breaks that were badly charred and that will need reconstruction in order to maintain their erosion control functions. During the post-fire assessment in 2006, S.P. Withers Consulting Services measured the depth to permafrost and the rate of flow of water seepage into the erosion gully from the surrounding burned over-ground.

Monitored by this Project (yes/no):

Yes. EDI personnel found that the majority of the bioengineering structures were intact and showed good plant growth in 2008. There was no visible flow at the time of sampling (early August) and seepage from the surrounding hillside into the gully was also absent. The only water observed was a small pool (10 to 15 cm across) below the most down slope gully break. The surrounding area showed early successional growth, dominated by large amounts of fireweed and bunch grass. Some small clumps of willows were also visible.

The live pole drain showed little evidence of burn marks and was intact along its entire length. Good growth was visible along the entire length. Willow shoots were slightly larger and more numerous at the top (up slope) end of the pole drain, measuring approximately 1.5 m. At the bottom end of the pole drain, shoots were fewer and measured an average of 75 cm. Much of the pole drain was buried beneath a shallow mat of grasses and mosses. A second live pole drain was constructed in 2003 between gully breaks 6 and 7. However, this structure appeared to have been more deeply buried and grown over with grasses and some fireweed. The pole drain showed little growth of willows.

Live gully breaks, numbered 1 to 11 (from the top to the bottom of the slope), were all located and structurally intact. Gully break 1 was the only one that appeared to be dead; it also had the most extensive burn marks. Breaks 2, 3, 6 and 10 showed varying amounts of fire damage but also showed signs of healthy growth. All remaining breaks exhibited good growth and no visible signs of fire damage. Shoot height across all the living gully breaks varied between 0.75 m to 2.5 m and was, on average, 1.5 m high. The number of shoots varied also, from 3 to several dozen, on average each break had approximately 6 or 7 shoots. Break 11 showed the best growth in term of both shoot height and number.

Willows stakes between the gully breaks did not appear to be growing, nor did they show much evidence of fire damage. A few of the dead stakes were pulled out; of those removed, only a quarter of the length of the stake was buried below ground (20 to 30 cm).

Objectives Met as Stated?:

Prior to the forest fire in 2005, it appeared that erosion damage had been mitigated and that the slope was being stabilized using the bio-engineering techniques. The forest fire damaged all the structures to varying degrees but the structures are functionally intact and show growth.

The lack of water flow at the time of sampling made it difficult to assess the intended function of the structures. Following the fire, there may have been some movement of material within the drainage bed. The general appearance of the drainage is of a small hills and hummocks covered with grasses and mosses. This possible alteration of the drainage appears to have eliminated the erosion problems that the bioengineering structures were originally intended to mitigate.

Additional Comments

In 2005, S.P. Withers Consulting Services anticipated that there would be an increase in the volume of flow over the next few summers due to the damaged insulating ground cover and the resulting permafrost melting. Based on 2008 observations, this does not appear to be the case, especially considering that the summer of 2008 has been wetter than average.

Photo Documentation

Photo 1. Upslope view of the live gully breaks on Noname Creek, 90KM west of Carmacks. Photo taken following construction, in September 2001. The most downslope gully break is visible in the foreground. Photo courtesy of Laberge Environmental Services.

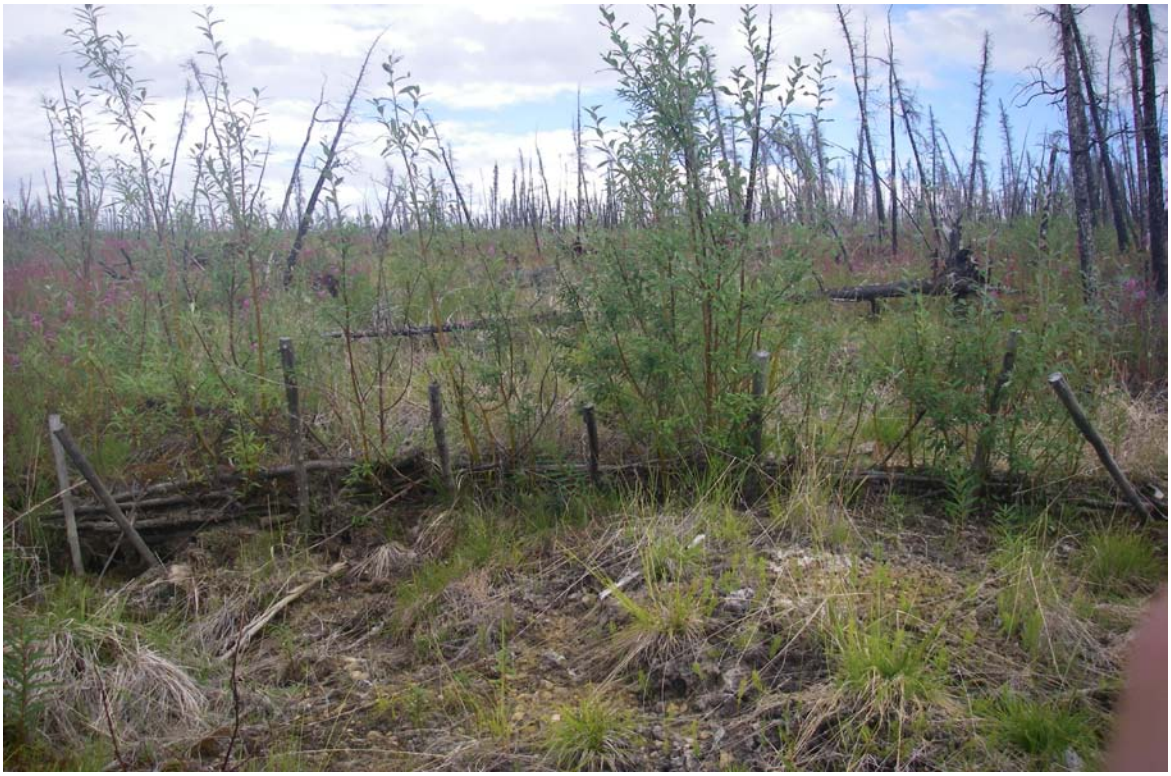

Photo 2. Upslope view of a live gully break on Noname Creek, 90KM west of Carmacks. Photo taken during the most recent monitoring, conducted in August 2008. Note that the visible growth has occurred since the forest fire of 2005 (no burn marks were visible).

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Nucleus

General Location: 90 km from Carmacks on the Mt. Freegold Road

Date of Monitoring by this Project: Aug 5, 2008

Date of Re-vegetation: 1995

Re-vegetation Company or Group: Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1995.

Monitoring Overview

Monitoring dates: Monitored in 1997 and 1999.

Monitoring Company or Group:

Monitored by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1997 and Mougeot Geoanalysis and S.P. Withers Consulting Services in 1999.

Full References:

Craig, D.B., J. E. Craig, K. Pelletier, D. Emond and H. Copeland. 1998. Reclamation practices and research on mineral exploration properties in the Yukon Territory. Prepared by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Mougeot Geoanalysis and S.P. Withers Consulting Services. 2000. Assessment of Long-Term Vegetation and Site Conditions at Reclaimed Yukon Mineral Exploration Sites. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Test re-vegetation procedures on an erosion prone down slope trench in a disturbed site in the boreal forest. These plant species will provide a nurse crop, but will not impede encroachment of local native plant species.

Treatments:

A section of trench was backfilled and an area of 20 m x 30 m was covered with material originally excavated from the trench. The original trench was 3.5 - 4 m wide. Seventy five percent of the soil here is made of fines and gravels less then 2.5 cm in diameter. Five experimental plots, 5 m x 5 m, were setup on the backfilled trench. These plots were hand seeded with an agronomic seed mix. By weight, the seed mix contained alsike clover (15%), fowl bluegrass (5%), creeping red fescue (30%), meadow foxtail (10%), red top (5%), reed canary grass (10%), timothy (15%) and slender wheatgrass (10%). The rate of seeding was 75 kg/ha.

Fertilizer and inoculants were also added to some of the experimental plots. Fertilizer consisted of 1 kg of 34-0-0 (ammonium nitrate) fertilizer and 1.5kg of 8-24-24 (nitrogen-phosphorus-potassium) fertilizer, per plot. Inoculants

consisted of nitrogen fixing bacteria, to help increase the speed of re-vegetation on nitrogen poor soil. These bacteria were a mix of lab cultured *Glomus intraradix* bacteria and bacteria collected from root nodules of Yukon alsike clover plants (a nitrogen fixing species). These cultures were mixed with water and a peat moss stabilizer in order to form a liquid slurry that was spread onto plot by hand watering. 4 liters of inoculants were used at each site.

Four different treatments were applied at the Nucleus site, these included:

- 1) fertilizer, seed, inoculants, no mulch
- 2) fertilizer, seed, inoculant, imported mulch blanket
- 3) fertilizer, seed, inoculants, topsoil (8 cm)
- 4) control, bulldozed and left bare
- 5) fertilizer, seed, no inoculants

Since this was an erosion prone site, the topsoil plot was laid out below the other plots, near the bottom of the slope. This was done to avoid having topsoil eroding down onto (and contaminating) the other test plots. Small logs were also placed at the bottom of the plot to attempt to minimize the loss of topsoil.

Existing Monitoring Information (yes/no):

Yes. Monitoring in 1997 showed that large amounts of growth had occurred after 2 years. Plots 1 and 5 had approximately 80% cover and very similar species composition, dominated by slender wheatgrass. Plot 1 showed small amounts of alsike clover and plot 5 had small amounts of fireweed. Plots 2 and 3 had approximately 90% cover. Plot 2 had large amounts of alsike clover and plot 3 showed large amounts of foxtail barley, which was not present in the seed mix or in the surrounding area. Small amounts of rose and mosses were also found in this plot. The log barrier below plot 3 had helped mitigate erosion problems. In the control plot, only 10 % cover of grasses was observed, and this was concentrated in small eroded gullies within the plot. Small amounts of fireweed and rose were also observed in the control plot. In the area below plot 3, small gullies up to 15 cm in depth had eroded the reclaimed trench area. Within the gullies, barley foxtail, wheatgrass and timothy were all growing. These grasses were likely growing up from seed transported down the slope from plot 3.

Monitoring in 1999 showed that red fescue was the most prominent of the seeded grass species within the test plots at the Nucleus (up to 85 % cover in some plots). Timothy, slender wheatgrass, reed canary grass and alsike clover also occurred in lesser amounts within the test plots. In the control plot, alsike clover was the most successful species. Fowl bluegrass, red top and reed meadow foxtail could not be found on any plots. The addition of inoculant did not have a large effect, and the topsoil treatment resulted in only slightly more growth of red fescue. Native vegetation was most abundant on the control plot; this was the only plot where black spruce, trembling aspen and willow had re-colonized. It is likely that the large mats of dead grasses had impeded colonization of the test plots by these species.

Monitored by this Project (yes/no):

Yes. EDI personnel found that the majority of the site has been aggressively re-colonized by alders and is now a nearly homogeneous stand. The surrounding undisturbed area is a mature, spruce dominated stand of trees. In 2008, there was active mining activity in the area and roadways and trenches were cleared on the south, east and west sides of the plots. The north side remained undisturbed. There was evidence of the forest fire which burned through the surrounding area in the summer of 2004; however, there was no indication that this fire had burned through any of the plots. Plot 3, the furthest downslope plot, was the only plot which was not dominated by a thick growth of alders. This

plot contained 2 alders approximately 2 m in height covering approximately 20% of the plot as well as a small amount of fireweed, rose and yarrow. Several small spruce trees approximately 20 cm tall had grown up along the northern edge of the plot. Grasses in Plot 3 were limited to timothy and reed canary grass but still covered approximately 50% of the plot area. Plot 4, the control plot, was the second most downslope plot and showed nearly 100% alder cover. The alders were approximately 4 to 5 m tall; beneath this canopy there were a few fireweed, some small rose plants and black spruce measuring 20 to 30 cm. There were small amounts of timothy in this plot. However the ground was covered in a layer of leaf litter rather then dead grass mats. The remaining experimental plots (2, 5 and 1) had between 70 - 80% coverage of 4 - 5 m tall alders. These three plots still show 20 - 30 % grass coverage with timothy and reed canary grass present. There was also fireweed, rose and a small spruce in the grassy areas. Due to shading effects, plots 1 and 5 showed minor amounts of grass growth beneath the alder covered portions of the plots. Plot 5 also contained a single trembling aspen, approximately 5 m in height.

Overall, there seems to have been a dramatic shift in the succession at the Nucleus site. The vegetative mats that were impeding colonization in 1999 have not impeded re-colonization by alder. Vegetative mats have disappeared in plots 4, 5 and 1. If current trends continue, alders will soon exclude the remaining grasses and shrubs from the re-vegetated trench.

Objectives Met as Stated?:

Since 1999, the majority of the trench has been colonized by alders. The control plot had notably higher (nearly 100%) amounts of alder coverage then the experimental plots (70-80%). This plot also had less growth of non-grass species.

By 1999, the control plot had also begun to re-vegetation naturally with willow, spruce and aspen. In 2008, alder had colonized most of the trench, regardless of what species were already present. This suggests that the nurse crop created by heavy grass seeding did not play a important role in the re-colonization of this site by native species.

Additional Comments

Although the factors allowing for the rapid growth of alders at this site are unclear, alder seedlings were observed in the unseeded area of the disturbed trench during the initial seeding in 1995. This is likely the source of the alders now visible in the seeded area.

Photo Documentation

Photo 1. View of the Nucleus test plots, approximately 90 km west of Carmacks. Photo taken in 1996, one year after seeding. Note the lush growth of plants grass species. Photo courtesy of Yukon Geological Survey.

Photo 2. View of the topsoil plot (plot 3), approximately 90 km west of Carmacks, in August 2008. This was the only plot that retained notable grass cover.

Photo 3: View of the control plot, approximately 90 km west of Carmacks, in August 2008. Note the large amount of alders that now cover almost the entire plot area.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Porter Creek

General Location: On the right bank of Porter Creek, downstream of the Whitehorse dump road.

Date of Monitoring by this Project: July 14, 2008

Date of Re-vegetation: July 2002

Re-vegetation Company or Group: Planted by Y2C2

Monitoring Overview

Monitoring dates:

Monitored in 2003

Monitoring Company or Group:

Monitoring and construction by Y2C2, Department of Environment, Government of Yukon

Full Reference:

Whittle, M. 2003. Porter Creek Monitoring Program 2003. Prepared by Y2C2, Department of Environment, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Use live willow cuttings to stabilize an area of Porter Creek that was disturbed by heavy equipment used to remove a beaver dam. Several treatments of different sized stakes and a growth hormone called STIM-ROOT (used to stimulate rapid rooting of cuttings) were tried.

Treatments:

In 2002, Y2C2 crew members planted 148 live willow stakes in a 25 m long plot along the right bank of Porter Creek. Stakes were planted in rows perpendicular to the creek banks, spaced at 1.5 m intervals along the length of the plot. Approximately 125 of these stakes had stem diameters smaller then 1 cm and were classified as small. The remaining 23 stakes had diameters in excess of 1 cm and were classified as large. The 4 different treatments included small and large stakes planted with and without the addition of STIM-ROOT. Only one treatment was carried out within each row.

Existing Monitoring Information (yes/no):

Yes. Y2C2 found that 101 of the 125 small stakes had died by 2003. In rows where the spacing between stakes was less than 30 cm, all stakes died. The use of the STIM-ROOT hormone did not increase the growth of stakes.

Monitored by this Project (yes/no):

Yes. EDI personnel could not count the stakes because it was difficult to see which stems were planted versus natural. A few dead stems were found; these were typically small (<1 cm) in diameter and not planted very deep. Many planted rows throughout the site were noticeable, throughout the site suggesting some success of all methods. Three or four rows of the larger diameter willow stakes were found and showed the most growth. The average height of these larger diameter stakes was approximately 1.5 m with the largest measuring approximately 2.5 m. In addition, there appeared to be a large amount of natural recruitment of willows (of smaller sizes then the staked individuals) between the staked rows. Other plant species included horsetails, sedges, arctic aster, norweigan syncofoil and tall bluebell. Willow now accounts for 50% of the cover in this area, with the remainder of the plot being covered with horsetails (35%), sedges (10%) and a mix of flower species (5%). Soils are moist fines, composed of organic rich soils.

Objectives Met as Stated?:

Re-vegetation successfully stabilized the disturbed stream bank area. As of July 2008, vegetation cover is nearly 100%. A large portion of this is composed of naturally recolonized species. It appears that the staking has advanced the succession at this site -- the observed heights of naturally re-colonizing willows were no more than half the size of the planted willows.

Overall this site show good results for live staking in riparian areas with moist, fine soils.

Additional Comments

Moist, fine soils at the site provide an excellent growth medium for establishing planted willow cuttings due to increase water content in the soils, which promotes willow growth.

Photo Documentation

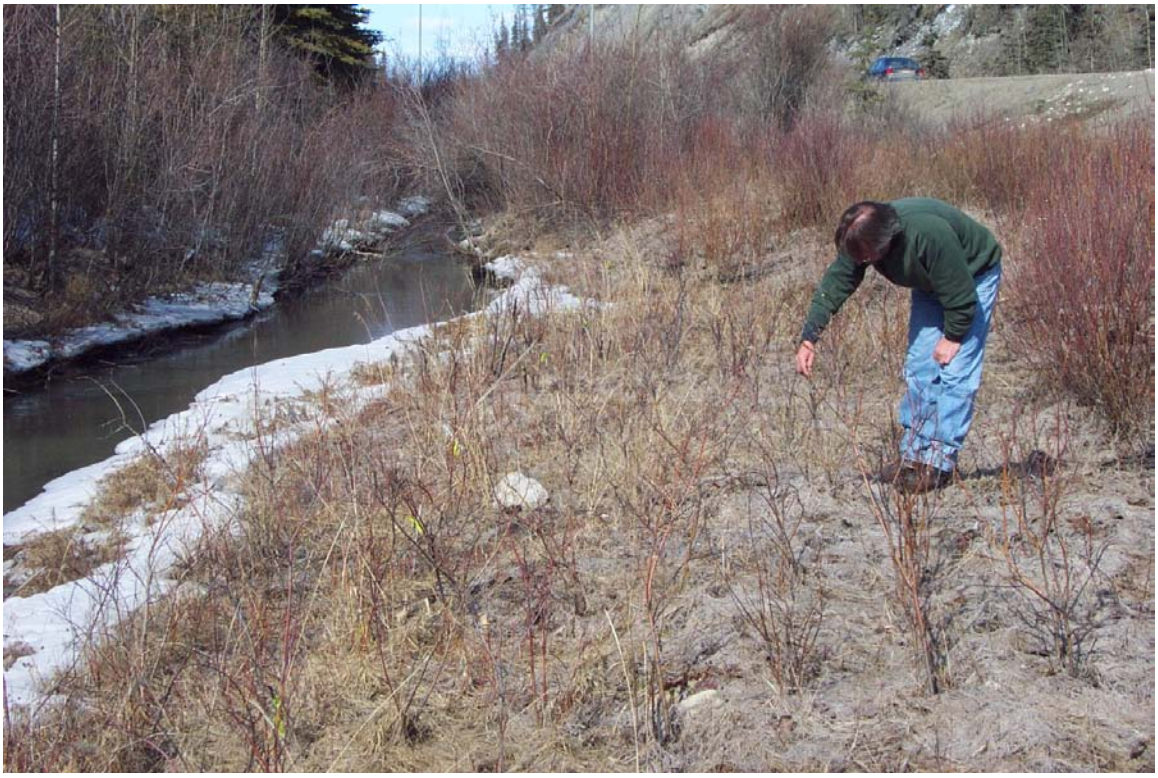

Photo 1. Downstream view of the live staking works along the right bank of Porter Creek, near Whitehorse. Photo taken in April 2004, two years after stakes were planted. Photo courtesy of Department of Fisheries and Oceans.

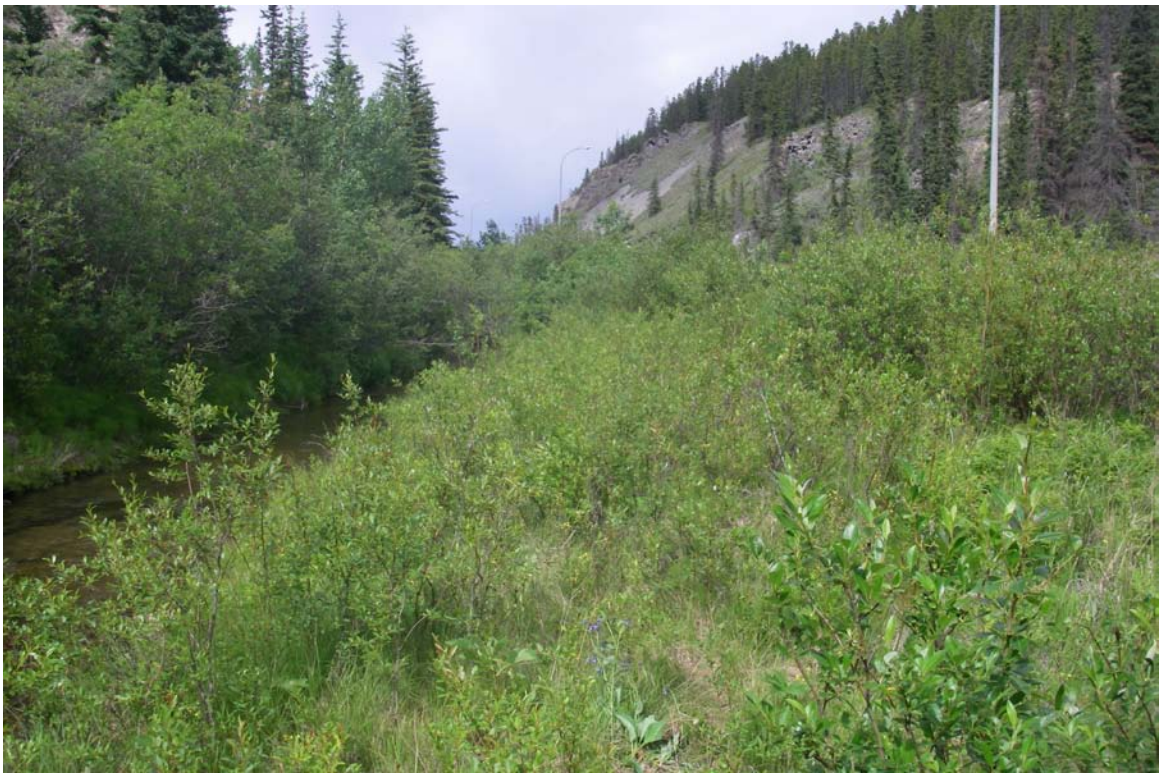

Photo 2. Downstream view of the live staking works along the right bank of Porter Creek, near Whitehorse during the most recent monitoring in July of 2008. Note that willows have begun to re-colonize the areas between the rows of live stakes.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Range Road Dumpsite Bioengineering	**General Location:**	Range Road Dumpsite, lower reach of McIntyre creek, Whitehorse

Date of Monitoring by this Project: n/a

Date of Re-vegetation: 2005 and 2006

Re-vegetation Company or Group: EDI Environmental Dynamics Inc. and Ta'an Kwäch'än Council. (the wattle fences were part of a bioengineering course and as such many individuals helped with this project)

Monitoring Overview

Monitoring dates:

Monitored in 2007 and 2008

Monitoring Company or Group:

Environmental Dynamics Inc. and Ta'an Kwäch'än Council stewards.

Full Reference:

Tobler, P. 2006. Range Road Dump Stabilization Project CRE-53-06. Prepared for Ta'an Kwäch'än Council and Yukon River Panel.

Marjanovic, M. 2008. McIntyre Creek Ta'an Kwach'an Council Community Stewardship 2008. Prepared for the Ta'an Kwach'an Council and the Yukon River Panel. Prepared by EDI Environmental Dynamics Inc.

Monitoring Specifics

Treatments:
Two bioengineering treatments were completed at this site. In the fall of 2005 a wattle fence was constructed on an eroding bank of McIntyre Creek. In August of 2006, brush layering was completed on a newly constructed berm designed to prevent McIntyre Creek from eroding into the toe of dump.

Both sites were seeded in with a native species mix in 2006 and again in 2007 after the first seed did not take.

Objectives (if none stated, perceived objectives):

The objectives of the wattle fence were 1) prevent erosion by changing the topography of the channel bank and 2) establish vegetation on an eroding bank. The project was treated a test of this method and used as a field site in a bioengineering course put on by Dave Polster in the fall of 2005.

The objective of the brush layer was to stabilize a newly constructed berm using willow and balsam poplar stakes. The ultimate objective is to prevent McIntyre Creek from moving into the toe of the old Range Road dumpsite and releasing contaminants into the Yukon River (Tobler 2006). Re-vegetation prescriptions were designed to stabilize the berm.

Existing Monitoring Information (yes/no):

Yes. The success of the brush layers and the height of the new berm has been monitored on a yearly basis by a Ta'an Kwäch'än Council Stewardship crew assisted by EDI Environmental Dynamics Inc. Every third stake was evaluated as either dead (brown leaves, dried out and brittle), intermediate (brown leaves with healthy green stems) or living (green leafy material with healthy green stems). Grass growth was quantified using a percent cover estimate.

In 2007, the height of the new berm was 0.6 meters above the old berm. Stake survival was 43% on the south west side and 50.6% on the north east side of the berm. Grass cover was not quantified; however, observations showed that grass sprouted on the lower half of the berm but not on the upper half.

In 2008, the height of the new berm was 0.58 meters above the old berm. Approximately 23.3% of the stakes on the southwest side and 32.9% of the stakes on the northeast side of the berm were living. Overall, approximately 28.1% of stakes were living. Grass cover was estimated at 75 - 80% of the berm area (Photo 3).

Observations of the wattle fences have been made throughout the past 3 years. The fences collapsed within the first couple years after construction. Few cuttings were observed to growing in 2008; however, substantial grass cover was noted as well as the establishment of some native species (Photo 5).

Monitored by this Project (yes/no):

No

Objectives Met as Stated?:

Brush Layers: Although stake survival has decreased, it appears that the remaining stakes are growing well (Photo 2). The creek has not breached the old berm but long term monitoring is required to ensure that the new berm prevents McIntyre Creek from entering the dumpsite.

Wattle Fences: The success of the wattle fences is poor; however, the establishment of some vegetation on the slope may help stabilize the site in the long term. Additional monitoring is required.

Additional Comments

There has been some speculation (EDI and Dave Polster) that the slope treated by wattle fencing has been affected by freeze-thaw activity.

Qualitative observations of live stakes growing in the berm suggest that the balsam poplar stakes have better growth the willow stakes.

Photo Documentation

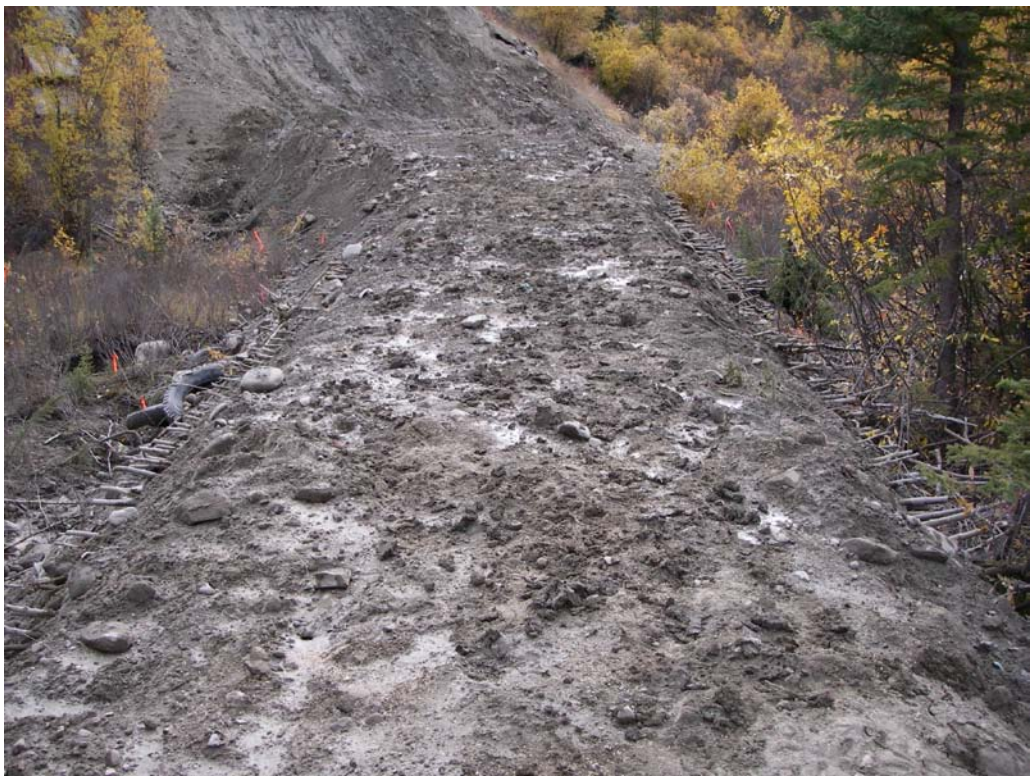

Photo 1. View of the completed berm, near the bank of McIntyre Creek, in Whitehorse. Photo taken in the summer of 2006, following construction and initial watering.

Photo 2. View of the re-vegetated berm, near the bank of McIntyre Creek, in Whitehorse during June of 2008.

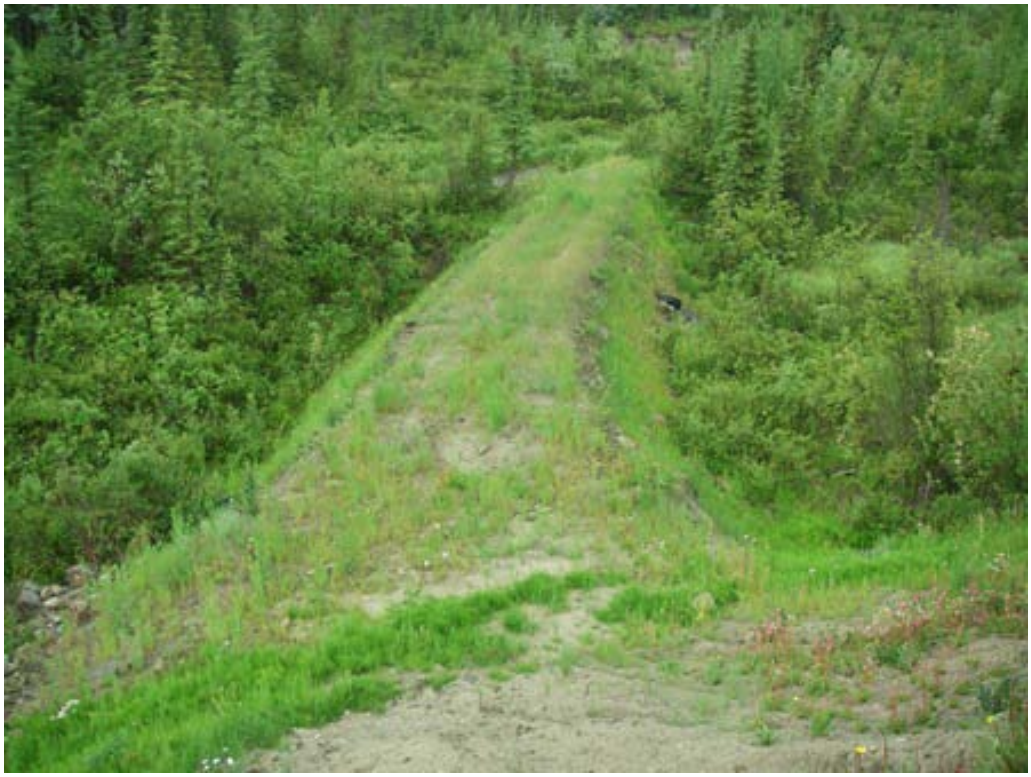

Photo 3. View of entire berm near the bank of McIntyre Creek, in Whitehorse taken in July of 2008. Note extensive grass growth since June.

Photo 5. Completed wattle fences along the bank of McIntyre Creek, in Whitehorse in Oct 2005.

Photo 5. View of wattle fences near the bank of McIntyre Creek, in Whitehorse. Photo taken in July of 2008.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Red Ridge

General Location: 65km from Whitehorse by road via the Annie Lake Road and a mining road to the property.

Date of Monitoring by this Project: September 5, 2008

Date of Re-vegetation: 1995

Re-vegetation Company or Group: Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1995.

Monitoring Overview

Monitoring dates:

Monitored in 1996, 1997 and 1999.

Monitoring Company or Group:

Monitored by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada in 1996 and 1997 and Mougeot Geoanalysis and S.P. Withers Consulting Services in 1999.

Full References:

Craig, D.B., J. E. Craig, K. Pelletier, D. Emond and H. Copeland. 1998. Reclamation practices and research on mineral exploration properties in the Yukon Territory. Prepared by the Mineral Resources Directorate, Indian and Northern Affairs Department, Government of Canada.

Mougeot Geoanalysis and S.P. Withers Consulting Services. 2000. Assessment of Long-Term Vegetation and Site Conditions at Reclaimed Yukon Mineral Exploration Sites. Submitted to the Mining Environment Research Group, Department of Energy, Mines & Resources, Government of Yukon, Whitehorse, Y.T.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Test re-vegetation techniques and procedures on disturbed sites above the timberline. These plant species function as nurse crop (a plant species that facilitates the recolonization of the site by later successional species), but will not impede encroachment of local native plant species.

Treatments:

Prior to planting, the trench was backfilled with material originally excavated from the trench. This refilled trench comprised an area 50m along the trench and 15m across. Five experimental plots, 5m x 5m, were setup on the backfilled trench. These plots were hand seeded with an agronomic seed mix. By weight, this mix contained alsike

clover (15%), alpine bluegrass (15%), creeping red fescue (30%), sheep's fescue (10%), meadow foxtail (15%) and timothy (15%). The rate of seeding was 75 kg/ha.

Fertilizer and inoculants were also added to some of the experimental plots. Fertilizer consisted of 1 kg of 34-0-0 (ammonium nitrate) fertilizer and 1.5 kg of 8-24-24 (nitrogen-phosphorus-potassium) fertilizer, per plot. Inoculants consisted of nitrogen fixing bacteria, to help increase the speed of re-vegetation on nitrogen poor soil. These bacteria were a mix of lab cultured *Glomus intraradix* bacteria and bacteria collected from root nodules of Yukon alsike clover plants (a nitrogen fixing species). These cultures were mixed with water and a peat moss stabilizer in order to form a liquid slurry that was spread onto plot by hand watering. 4 liters of inoculants were used at each site.

Four different treatments were applied at the Red Ridge site, these included:

- 1) fertilizer, seed, inoculants, no mulch
- 2) fertilizer, seed, inoculant, imported mulch blanket
- 3) fertilizer, seed, inoculants, topsoil (8 cm)
- 4) control, bulldozed and left bare
- 5) fertilizer, seed, no inoculants

Existing Monitoring Information (yes/no):

Yes. Monitoring in 1996 and 1997 showed that the topsoil plot had slightly greater growth then the plot treated with imported mulch. Plots 1 and 5 (plots with and without inoculants, respectively), showed moderately less growth than the topsoil and mulched plots. In plots 1 and 5, growth was concentrated in the micro-sites created by the grouser bars on the bulldozer track. Growth was negligible in the control plot, only a few bluegrass plants were present in 1997; probably accidentally seeded from adjacent plots. Native vegetation nearby the site consisted of patchy growth of goldenrod, saxifrage, willow, fescue and bluegrass.

Monitoring in 1999 showed that alpine bluegrass (15% cover in plots 3 and 5, 25% cover in plot 2) and sheep's fescue (30% cover in plot 2, 25% cover in plot 5) were the most successful of the seeded grass species at the Red Ridge site. Red fescue and meadow foxtail also occurred, but in lesser amounts. Timothy and alsike clover could not be found on any plots. The combination of the mulch treatment and fertilizer and seed treatment showed the highest overall cover (including grasses and native species). The dominant species in this plot were sheep's fescues and alpine bluegrass. The addition of topsoil did not appear to increase growth rates; however, several introduced species present in the topsoil germinated in that plot. Colonization by native species is occurring slowly. Cover is the control plot was very sparse, when monitored in 1999. There was little growth of native species in this plot, and alpine bluegrass and sheep's fescue had cover of only 2% each. Clumps of native vegetation have also colonized disturbed but unseeded areas of the trench.

Monitored by this Project (yes/no):

Yes. At some point between monitoring in 1999 and monitoring by EDI in 2008, a trench had been excavated in the middle of plots 4, 2 and 1. The excavated material had been stockpiled along the edges of the trenches. The width of the excavated and stockpiled material was greater then 5 m and so covered the entire areas of plots 4, 2 and 1. Markers for plot 5 could not be located, and it was therefore not possible to monitor the growth within this plot.

The topsoil added to plot 3 was still present and vegetative cover was approximately 25 %. This consisted of approximately equal parts bluegrass and fescue. The general area of plot 5 was covered by bare rock and very sparse

plant cover. The species composition appeared to be similar to that described in 1997, with the notable addition of fireweed and a single subalpine fir.

Objectives Met as Stated?:

A nurse crop was not established on plots 3 and 5. It is possible that a nurse crop had been established in plots 4, 2, and 1 prior to trenching, but observations of the surrounding area suggest a very sparse native vegetation cover area in the area, therefore it is unlikely that a nurse crop was present. Observations of plots 3 and 5 showed that little growth had occurred and it is likely that this was the case in the other plots as well.

Encroachment of native species was not impeded. Native grass species observed in plots 3 and 5 included saxifrage, fireweed and a single fir.

Overall, plots on the Red Ridge site did not re-vegetate very successfully and this was likely the case prior to the destruction of the plot area by trenching.

Additional Comments

The majority of the topsoil was retained within the area of plot 3. The high elevation and topography suggest that the area experiences frequent high winds but this does not seem to have eroded the topsoil.

Large mats of dead grass that had impeded colonization in some parts of the Nucleus and Hawk sites are absent from this site.

Photo Documentation

Photo 1. View of the Red Ridge plots, approximately 65 km southwest of Whitehorse. Photo taken when test plots were established, in 1995. The topsoil plot is in the foreground. Photo courtesy of Yukon Geological Survey

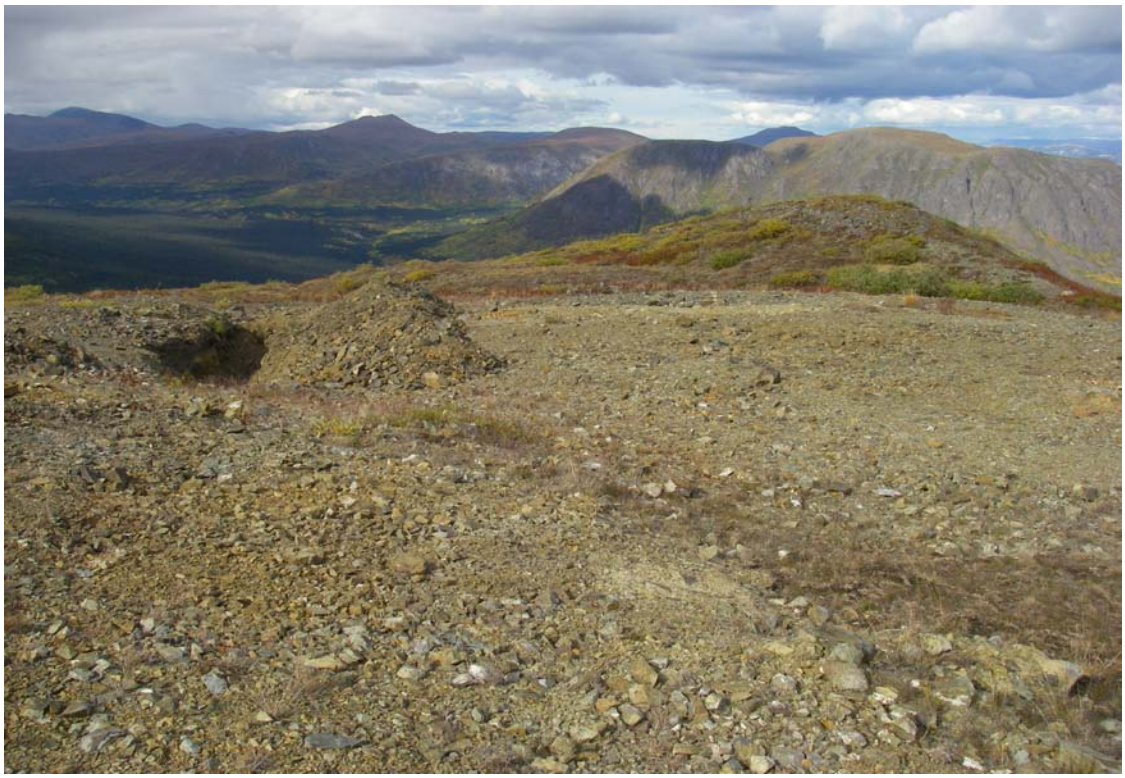

Photo 2. View of the Red Ridge test plots, approximately 65 km southwest of Whitehorse during the most recent monitoring in September 2008. The corner of the topsoil plot is visible in the bottom right corner of the photo. Note the large trench which has been cut across plots 4,2 and 1.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Robert Service Way – Compensation Channels

General Location: Approximately 1 km upstream of the Riverdale bridge in Whitehorse, on the Right bank of the Yukon River

Date of Monitoring by this Project: No monitoring

Date of Re-vegetation: Summer 1997

Re-vegetation Company or Group: City of Whitehorse.

Monitoring Overview

Monitoring dates: No formal monitoring

Monitoring Company or Group: None

Full Reference:

Tuck, W. 2008. Personal Communications. Manager, Engineering and Environmental Service, City of Whitehorse. In person, July 18th, 2008.

FVD (map author). Robert Service Way Reconstruction Fisheries Compensation Channel Features. [map] 1:2000. Sheets 43 and 44. [Whitehorse, Y.T.]: City of Whitehorse, 1997. Map prepared as a component of Robert Service Road upgrade project.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Perceived objectives would include the erosion control of a disturbed bank, island and floodplain area adjacent to the new Chinook salmon spawning compensation channel.

Treatments:

An area measuring approximately 10 - 20 m wide and approximately 180 m long, along the bank adjacent to the compensation channels was graded and hydroseeded with agronomic grass and wildflower mixes (unknown seed mix). The same treatment was applied to the mid channel island. This area measured approximately 10 - 20 m in width and approximately 80 m in length. An area approximately 60 m x 10 m on the upstream portion of the mid-channel island was not seeded.

Existing Monitoring Information (yes/no):

No formal monitoring. Communication with City of Whitehorse personnel indicates that the unseeded upstream areas of the mid channel island have since been colonized with willow and alder, and now appear similar to undisturbed areas along the adjacent river bank.

Informal visits by EDI staff over the past 8 years indicate that mid channel island has had notable grass cover. In recent years alder has established along the margins of the island as a result of natural colonization. Some willow has also been noticed higher up on the island. Other islands and banks of the Yukon River have extensive alder coverage at similar elevations to that found on this island currently.

Monitored by this Project (yes/no):

No.

Objectives Met as Stated?:

It appears the grass seed addressed short-term erosion concerns at this site. It did take some time for woody shrubs to establish at this site.

Additional Comments

Photo Documentation

Photo 1. View of the Robert Service Way fisheries compensation channels, in downtown Whitehorse during construction in 1997. Seeding treatment has been applied in the green area in the center of the photo. Photo courtesy of the City of Whitehorse.

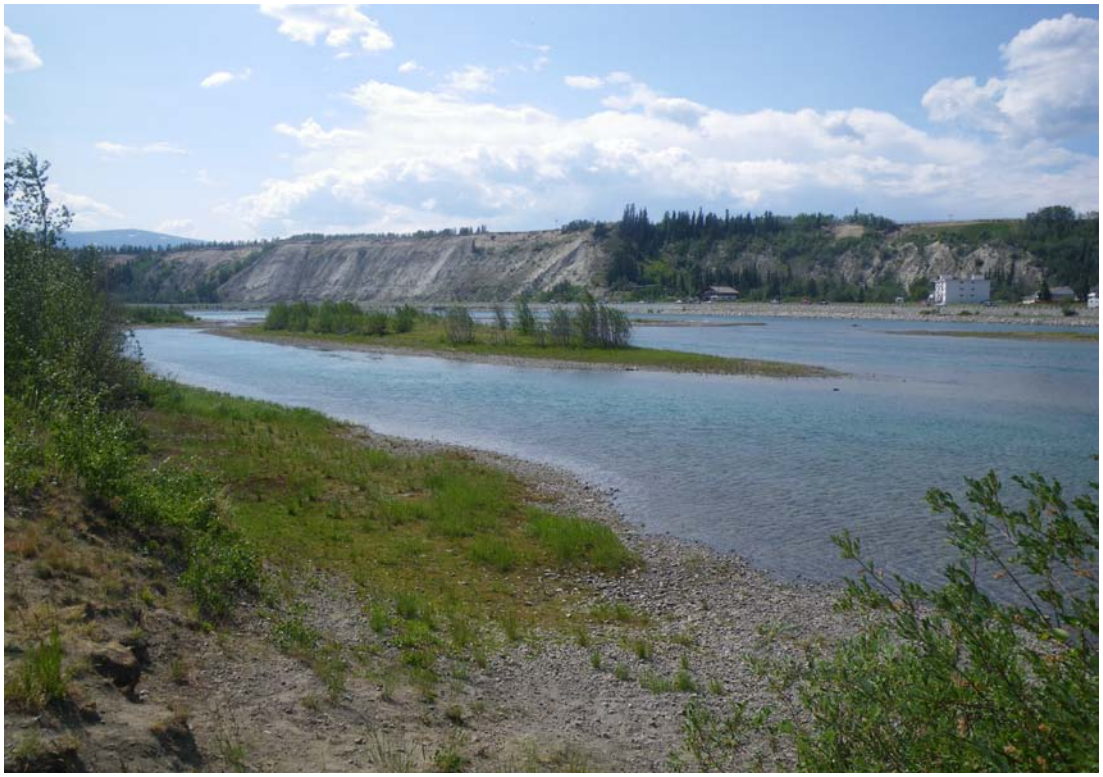

Photo 2. View of the Robert Service Way fisheries compensation channels, in downtown Whitehorse in July 2009. Note alder and willow which have established on the seeded area.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name:	Robert Service Way – Road Right of Way Re-vegetation project	**General Location:**	Robert Service Way, south access to the city of Whitehorse.

Date of Monitoring by this Project: July 14, 2008.

Date of Re-vegetation: Summer 1998

Re-vegetation Company or Group: City of Whitehorse.

Monitoring Overview

Monitoring dates: No prior monitoring.

Monitoring Company or Group: Monitored by Environmental Dynamics Inc. in 2008.

Full Reference:

Tuck, W. 2008. Manager, Engineering and Environmental Service, City of Whitehorse. In person, July 18th, 2008.

JMCD (map author). Robert Service Way 1997 Seeding Project. [map]. 1:2000. Sheets 1 to 4. [Whitehorse, Y.T.]: City of Whitehorse, 1998. Map prepared as a component of Robert Service Road upgrade project.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Perceived objectives include erosion control of disturbed sites around the highway ROW following construction of this access route. Secondary goals were likely related to improving the esthetics of the sites. The seeding of wild flowers was conducted on some of the less erosive sites. A natural escapement (clay cliff) was to be hydroseeded dependant on budget constraints, in order to prevent further erosion of the surface.

Treatments:

An area of highway median (10 m wide and 1 km long) was seeded with grass seed/legume mix. By weight this mix contained, *Hedysarum Mackenzii* (20%), bearded wheatgrass (40%) and violet wheatgrass (40%). Two additional median areas at the top of the hill (1350m x 1500m) were seeded with the same mix. Three areas at the base of the hill were treated with mulch and hydroseeded with a different agronomic grass seed mix. By weight this second mix contained violet wheatgrass (10%), bearded wheatgrass (10%), common red top (5%), common sheep's fescue (15%), boreal creeping red fescue (25%), Yukon wheat grass (10%), common Canada bluegrass (15%), northern fescue (5%) and common alsike clover (5%). Areas seeded with these mixes measured approximately 4900, 9100 and 9200m^2.

Nine areas of stockpiled excavated material were created from material removed during construction. These were shaped into small hills (150-500m^2). These hills were seeded with 2 different wildflower mixes. By weight the first mix contained, Jacob's ladder (20%), Icelandic poppy (40%) and other wild flower seeds (40%). The second mix contained, by weight, perennial lupine (20%), blue flax (20%) and other wildflower seed (60%). In addition, a shoulder area adjacent to the Miles Canyon turnoff was seeded with this wildflower mix.

Grass seeded was applied at rate of 25 kg/1000m^2. Wild flower areas were seeded at a rate of 15 kg/1000m^2, when grasses were not included in the mix. Common sheep's fescue was seeded at 4 kg/1000m^2.

Additionally, the entirety of the highway right of way along the newly built section of road was seeded with the same 9 species grass seed mix outlined above. This right of way is approximately 20 m wide on either side of the highway (with the exception of an area 150m x 120m along the north side of the hill. The length of this right of way is approximately 4 km.

Half of the provisional seeding of the escarpment slope was also carried out. Approximately 1.5 ha, was seeded with the same grass seed mix as the right of way.

Existing Monitoring Information (yes/no):

No.

Monitored by this Project in 2008 (yes/no):

Yes. Two areas that were seeded with wildflowers were visited in 2008, the shoulder area adjacent to the Miles Canyon turnoff and one excavated spoil pile adjacent to the Go-Kart tracks and railway.

Soils in the shoulder area were dry and rocky with few organics. No seeded species were found; however, there was notable ground cover of native (bunchgrasses, willow) and invasive species (sweet clover; Photo 1).

The seeding of the excavated material appears more successful; perennial lupine and Jacob's ladder were found there. However, many other species of grass and shrubs were found on the pile, likely from natural invasion. It was not clear what effect the wildflower seeding had on this area.

Hydroseeded and grass seeded areas were not formally monitored by this project in 2008. However casual observations of the sites indicate grass cover in most areas with the exception of the very steep escarpment area (clay cliffs; a portion of which was hydroseeded).

Objectives Met as Stated?:

All sites with the exception of the clay cliffs now have notable ground cover and as such likely have addressed erosion and esthetic concerns. Success of the wildflower seeding is not clear; however, the combination of seeding and invasion from other species has led to sufficient ground cover.

Additional Comments

Sites were not ideal for monitoring given, the high activity in this area.

Photo Documentation

Photo 1. View of Robert Service Way, near downtown Whitehorse during the most recent monitoring in July of 2008. Go-Kart course is in the background of the photo.

Re-vegetation Project Monitoring

Project Overview

Project/Site Name: Sa Dena Hes

General Location: 45 km north of Watson Lake.

Date of Monitoring by this Project: Not monitored by this project

Date of Re-vegetation: 2000, 2001, 2003 and 2005

Re-vegetation Company or Group: Access Mining Consultants

Monitoring Overview

Monitoring dates: Every year from 2001 to 2007.

Monitoring Company or Group: Access Mining Consultants

Full Reference:

Access Mining Consultants Ltd., 2000. Land Reclamation and Re-vegetation Plan Preliminary Test Program Summary Report. Prepared by Access Mining Consultants Ltd for Teck Cominco Ltd.

Access Mining Consultants Ltd., 2002. Sä Dena Hes Mine Land Reclamation and Re-vegetation Plan. Results Summary of Phase II Re-vegetation Test Program – 2001. Prepared by Access Consulting Group for Teck Cominco Ltd.

Access Mining Consultants Ltd., 2008. Sä Dena Hes Mine Land Reclamation and Re-vegetation Plan. Results Summary of Phase II Re-vegetation Test Program – 2007. Prepared by Access Consulting Group for Teck Cominco Ltd.

Monitoring Specifics

Objectives (if none stated, perceived objectives):

Five primary objectives have been established for the re-vegetation test programs at the Sa Dena Hes mine site. They are as follows:

- 1) determine seed mixtures that will provide short term soil stability while allowing the natural invasion of local plant species.
- 2) determine fertilizer applications optimal for sustaining the healthy growth of seeded species without inhibiting colonization by indigenous plant species.
- 3) investigate methods of encouraging natural plant succession on reclaimed surfaces.
- 4) determine the potential success rates of re-vegetation at test plots on different areas of the mine site, in particular the tailings management facility.

- 5) determine the metal uptake potential of vegetation at the mine site (seeded and naturally occurring species).

Treatments:

The freshwater pumphouse and its access road were seeded with a small amount of agronomic grass by mine owners in 1992. No report was written describing these works; however, Access Mining Consultants Ltd. (AMCL) personnel determined that 9 species, including both grasses and legumes were used. AMCL identified these species as smooth brome, orchard grass, wheatgrass, creeping red fescue, yellow alfalfa, purple alfalfa, timothy, Kentucky bluegrass and alsike clover. By 2000, these species colonized disturbed sections of the north tailings dam and the mill site.

In 1999 and 2000, AMCL carried out a full scale assessment of the feasibility of re-vegetating the area of the Sa Dena Hes mine site. AMCL made observations of the natural re-vegetation at the mine site. In addition, a soils analysis was carried out and the potential for using borrow materials (topsoil) from the mine site area was evaluated. Several recommendations for enhancing the success of future re-vegetation efforts were also made at this time. Recommendations included: re-contouring steep slopes, scarifying heavily compacted areas of the mine site, restoring the original vegetative mat and covering the site with trees and brush, limiting the planting of grasses and legumes to only the most erosion prone sites far from natural seed sources and avoiding the use of thick sod forming agronomic species that inhibit further succession.

In September 2000 two 2 m x 2 m test plots were created to test the potential for re-vegetating the site using willow stakes. Plots were located in two different borrow pits along the main access road. Two species of willows were tested and 20 cuttings of each species were staked in each of the plots. Prior to staking, lower leaves were removed and the cuttings were dipped in a solution of rooting hormone. Due to poor soil quality, success was expected to be poor. Fertilizer was not added to the plots.

In 2001, a second phase of the reclamation program was initiated. The objectives of this phase were to establish test plots at various mine site locations in order to determine the optimum applications of seed and fertilizer and to determine the metal uptake of the seeded plants. In 2001, 7 sites were selected and 4 plots were established on each site (24 plots total). Site 4 was seeded as part of the 2001 phase but was not reviewed in 2007. Within a site, the same group of species was seeded in all plots. Plots were 5 m x 5 m and were separated from adjacent plots by a 2 m buffer area. These sites included a site at KM 22 of the main access road (Site 1), a site on the Jewel Box Haul road (Site 2), a site in the Landfill (Site 3), a site on the Tailings Management Facility (TMF) with 200 mm of soil (Site 5A), a site on the TMF with 300 mm of soil (Site 5B) and a site on the TMF with 500 mm of rock and 300 mm of soil (Site 5C). Sites 1, 2 and 3 were scarified and re-contoured prior to seeding while plots on the TMF were capped with a soil layer (waste rock was also place on plot 5C). Violet wheatgrass, tufted hairgrass, ticklegrass, showy locoweed and bear root were seeded at all sites in 2001. Alpine Bluegrass was seeded at sites 2 and 3, glaucous bluegrass was seeded at sites 1, 5A, 5B and 5C. Sheep's fescue was seeded at sites 1, 2 and 3 and rocky mountain fescue was seeded at sites 5A, 5B and 5C. One plot was left bare as a control. Fertilizer mix of nitrogen, phosphorous, potassium (24% of each) was applied to each of the test plot (excluding the control plot). Seeding and fertilizing rates varied between sites and within sites, as follows:

- at sites 1 and 5C plot 1 was seeded at 24 kg/ha and fertilized at 120 kg/ha, plot 2 was seeded at 24 kg/ha and fertilized at 60kg/ha and plot 3 was seeded at 12 kg/ha and fertilized at 60 kg/ha.

- at sites 2 and 3 plot 1 was seeded at 26 kg/ha and fertilized at 120 kg/ha, plot 2 was seeded at 26 kg/ha and fertilized at 60 kg/ha and plot 3 was seeded at 13 kg/ha and fertilized at 60 kg/ha.

- at sites 5A and 5B plot 1 was seeded at 25 kg/ha and fertilized at 120 kg/ha, plot 2 was seeded at 25 kg/ha and fertilized at 60 kg/ha and plot 3 was seeded at 12 kg/ha and fertilized at 60 kg/ha.

In 2003, all plots were reseeded and re-fertilized. Violet wheatgrass, ticklegrass, alpine bluegrass and the legume alfalfa were seeded at all sites in 2003. Kentucky bluegrass and red fescue were seeded at site 5C. Tufted hairgrass, glaucous

bluegrass, sheep's fescue, rocky mountain fescue and the legumes showy locoweed and bear root were left out of the seed mix in 2003. Seed and fertilizer application rates differed in 2001. At all sites plot 1 was seeded at 25 kg/ha and fertilized at 120 kg/ha, plot 2 was seeded at 50 kg/ha and fertilized at 180 kg/ha, plot 3 was seeded at 75 kg/ha and fertilized at 240 kg/ha.

In 2005, sites 1, 2 and 3 were chosen for two additional test plots. One plot was seeded in the spring and the other in the fall, in an attempt to determine which time of year provided better growth rates. A similar seed mixture to the one used in 2001/2003 was used and Yellow Locoweed and Arctic Lupine were added to the mix.

In 2007, samples of balsam poplar were collected from areas around the TMF in order to determine their re-vegetation potential.

Existing Monitoring Information (yes/no):

Yes. In 2007, AMCL found that violet wheatgrass, which had been the most successful of all seeded species, had declined significantly in the 2001/2003 test plots. Tufted hairgrass is now the grass species with the most consistent coverage across all sites. Alpine bluegrass, violet wheatgrass and sheep's fescue are well distributed on a few sites. Alfalfa was the only legume to show good coverage, and this was limited to just a few sites. Rocky mountain fescue has a moderate distribution on a few sites. Ticklegrass, Kentucky bluegrass and the legumes showy locoweed and bear root showed poor growth. Glaucous Bluegrass was not seen on any of the sites.

Observations of the 2005 spring and fall seeding trial showed that the spring seeding has provided more coverage then fall seeding at site 1 and 2. The spring plot at the Main Access Road had 15% cover, compared to 5% in the fall plot. At the Jewel Box Haul Road site, the spring plot had 30% cover compared to 15% in the fall plot. The Landfill showed a higher coverage of the plants seeded in the fall (15%) compared to the spring (5%).In 2008, AMCL noted that it is still too early to determine which seeding time is optimum.

Monitoring of the 2 shrub plots established in 2000 shows that the plot at the borrow pit at KM 22 of the main access road has only 13 living willow stakes compared to the initial 40. The majority of the survivors did not appear healthy. The second shrub plot, at KM 16 borrow pit has 21 living willow stakes compared to initial 40. The living stakes at the second plot were much healthier and had large amounts of growth.

Monitored by this Project (yes/no):

No.

Objectives Met as Stated?:

1)The re-vegetation techniques have helped determined which seed mixtures would provide short term soil stability while allowing the natural invasion of local plant species. It appears that the mixture used during the 2001 and 2003 seeding has grown successfully across the mine site as a whole, although not all species are thriving equally in all areas. No erosion issues were reported and in the 2005 plots there were some observations of growth of native non-seeded plants.

1)Fertilizer applications rates that would be optimal for sustaining the healthy growth of seeded species without inhibiting colonization by indigenous plant species were partially determined. Different amounts of fertilizer were applied in 2001 and 2003; however, the seeded species also differed. This makes it difficult to isolate the effects of different seeding rates from the effects of different fertilizing rates. The amounts of fertilizer added to the test plots do not seem to have negative effects on the growth of seeded and non-seeded species. However, a broader range of fertilizer should be tested to determine the optimal fertilizer application rates at this site.

3)Re-vegetation methods have not fully explored different methods of encouraging natural plant succession on reclaimed surfaces. Although grass and legume seeding has been carried out, additional shrub staking and alder seeding would help determine which methods are most successful for encouraging natural succession.

4)Re-vegetation techniques have helped to determine the potential success rates of re-vegetation by using test plots on different areas of the mine site, in particular the tailings management facility. According to AMCL (2008), grass and legume seeding has been successful on all sites, including the tailings management facility. Areas of the tailings management facility where there was a 500 mm rock cover and 300 mm soil cover were re-vegetated most successfully, with all plots at this site showing between 90 and 100% cover. Other sites have also re-vegetated to varying degrees.

5)The metal uptake potential of vegetation was outside the scope of this project and was not reviewed.

Additional Comments

There are plans for an alder seeding program during the 2008 field season.

Photo Documentation

Photo 1. View of a plot on the TMF with rock and topsoil, at the Sa Dena Hes mine near Watson Lake. Photo taken during the 2001 seeding program. Photo courtesy of Access Mining Consultants Ltd.

Photo 2. View of the plot on the TMF at the Sa Dena Hes mine, near Watson Lake during the most recent monitoring conducted in 2007. Photo courtesy of Access Mining Consultants Ltd.