CLINTON CREEK MINE WASTE ROCK DUMP

TRIAL REVEGETATION TECHNIQUES

SEPTEMBER 2008

FOR

Yukon

ASSESSMENT AND ABANDONED MINES

ENERGY MINES AND RESOURCES

BY

Laberge
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1.0 BACKGROUND

The former Clinton Creek Asbestos Mine is located approximately 100 km northwest of Dawson City, Yukon and nine km upstream of the confluence of Clinton Creek and the Forty Mile River. The mine operated from 1967 to 1978. The site encompasses three open pits (Porcupine, Snowshoe and Creek), two waste rock piles (Clinton Creek Dump and Porcupine Creek Dump), and a tailings pile.

In 1974, 60 million tonnes of the Clinton Creek waste rock pile slumped across the Clinton Creek valley creating the formation of Hudgeon Lake. During the 1980s various weirs were constructed to reinforce the Clinton Creek channel in attempts to stabilize and control the outflow from Hudgeon Lake, with limited success. The structures were washed out during a high flow event in 1997. The Federal Government (DIAND) assumed responsibility for the site in 1999; following Devolution in 2003, the Government of Yukon (YG) assumed responsibility for site management. In a series of stages from 2002 to 2004, gabion drop structures were constructed within the channel downstream of the Hudgeon Lake outlet. YG continues to monitor these structures and conducts repairs as necessary.

Equipment, buildings and physical hazards were removed between 1978 and 2006. No equipment or structures currently exist at the site with the exception of the old drill and shovel that remain as a static display of previously operated mining equipment, and the concrete foundations of the crusher, tram towers and mill site.

1.1 Previous Revegetation Attempts and Assessments

A large proportion of the waste rock disposal area has remained undisturbed for approximately thirty years. The rate of natural revegetation can be observed by the success of primarily balsam poplar (*Populus balsamifera*) and willow (*Salix spp.*) as well as shrubs such as wild rose (*Rosa acicularis*). Based on this observation it can be assumed that natural revegetation on this site will be an extremely lengthy process by anthropogenic standards.

According to previous records, a number of prior revegetation test / demonstration plots had been established in various areas of the mine site (Han Construction 2005). These included riparian zone rehabilitation work in conjunction with channel stabilization along Clinton Creek in 2004. The Clinton Creek riparian reclamation work consisted of planting bundles of stem cuttings and live stakes in eight areas associated with the channel stabilization project. There were no specific co-ordinates supplied in the report from which to easily determine test plot locations. Success rates of the previous work were not readily evident. If the entire areas between gabions were planted on both sides of the creek as the report site map indicated, then cursory overall impressions were that revegetation success was relatively minimal.

The report also states that in 2004 and 2005, the entire disturbed area of the former mill site was seeded. In 2005, approximately 5% of the total tailings pile area was seeded. Seeding was also undertaken along the former mill site access road to the top tailings pile; as well as along the waste rock dump site access road to the former crusher site. Approximately 20% of the total area of the waste rock dump site was seeded in 2005 (Han Construction, 2005). Again, specific co-ordinates on the Clinton Creek Waste Rock Dump were not given, preventing any monitoring on the success of these attempts during the 2008 assessment and revegetation programs.

In addition to the previous revegetation work, recontouring of the former crusher site was undertaken between August and September 2006 as reported in the *Clinton Creek Mine Site Commercial Dump Permit #81-004 Post Construction Report*. According to this report, a dump site was constructed adjacent to the present shovel/drill site where scrap steel and other mine debris was buried and covered by a minimum of one meter of waste rock. This area was devoid of any vegetation at the time of the 2008 revegetation program.

As Phase I of the current study, a reconnaissance survey of the waste rock dump was conducted on July 16th, 2008 (Laberge Environmental Services, 2008). The survey included an inventory of naturally occurring revegetation and the collection of soil samples from several sites of the waste rock dump. Of the shrub species colonizing the waste rock dumps, balsam poplar (*Populus balsamifera*) was by far the most prevalent.

Other shrub species included willows (*Salix alaxensis, S. arbusculoides, S.bebbiana) and S. myrtilifolia*), white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), soapberry (*Shepherdia canadensis*) and prickly rose (*Rosa acicularis*). Several species of forbs and grasses were also documented. The soil samples collected were alkaline (pH 7.8 to 8.4); were deficient in the macronutrients nitrogen, phosphorus and potassium and were generally low in organic matter.

1.2 Scope of Work for September 2008

Site reclamation by assisted revegetation is intended to expedite the return of the Clinton Creek mine site to a biodiverse ecosystem, projected in time, to emulate the surrounding undisturbed area. Soil stabilization and reduced potential for wind and water related soil erosion would also be achieved as vegetation becomes established.

A revegetation test plot program was implemented on the Clinton Creek Waste Rock Dump from September 8th to 13th, 2008. The intent was to use various revegetation methods, local vegetative species and growing conditions to determine what would increase the revegetation success and potentially augment the natural succession presently taking place on the waste rock disposal area.

The 2008 program consisted of harvesting local dormant vegetation and transplanting to chosen sites within the Clinton Creek waste rock area. Vegetation islands (mats of vegetation); willow (*Salix spp.*) crowns (also known as root wads); balsam poplar (*Populus balsamifera*) root cuttings; and willow and poplar live stakes were used. Balsam poplar and upland willow species were chosen as tree species as these are the primary species naturally re-establishing on the waste rock disposal site.

Three individual locations were chosen as planting sites. The sites were mapped and their locations recorded using a handheld GPS (Figure 1). Individual plots were physically demarcated with painted rebar stakes and flagging within each location.

The initial site was located at the highest elevation of the three sites (at approximately 420 m asl) near the Porcupine Pit Lake (Figure 2).

The second site was situated near the abandoned drill/shovel (Figure 3). This area had previously been contoured in the fall of 2006 following mine debris burial. The history of this site was unknown to the revegetation team prior to choosing this location for revegetation plots. The associated buried debris proved to be a challenge when excavating plots and had to be avoided at times when individual plots were located.

The third site was located approximately 200 meters upslope and east of Hudgeon Lake adjacent to the terrace edge above the main mine access road (Figure 4).

Due to the lack of recent air photos of the area, the aforementioned figures have been plotted on an air photo taken in 1999. This was prior to the installation of the gabion baskets in Clinton Creek at the outlet of Hudgeon Lake, but other than that, there has been little change regarding the physical appearance of the waste rock dump.

2.0 METHODS

A Caterpillar 320 tracked excavator equipped with a finishing bucket was used to remove vegetation islands and provide appropriate excavations for transplanting. All vegetation used on these plots was dormant when planted in September 2008. The vegetation islands and root stock were transported from the donor sites to the planting locations using both a pickup truck and small trailer. Live stakes were hand cut and trimmed to appropriate lengths (one to two metres) depending on whether the staking was installed vertically or in trenches. Following transplanting, each plot was watered with approximately 200 litres of lake water using an ATV transported water tank and transfer pump. Watering appeared to provide adequate soil to root/stem contact following soil placement.

2.1 Donor areas

Donor areas were chosen based on vegetation availability, quality, species mix, soil substrate and proximity to the transplanting sites. Vegetation islands were primarily obtained from the northwest side of Clinton Creek along the upslope side of the road shoulders leading to the tailings area. The upslope road shoulder was chosen as opposed to the down slope roadside to minimize future potential road bed/shoulder runoff erosion. Live staking material was selected, hand cut and collected along the mine access road.

2.2 Vegetation Islands

Vegetation island dimensions were approximately 1.5 meters square by 0.5 meters thick depending on substrate material cohesiveness and the success of removal and placement with the bucket. Vegetation islands were transplanted into individual plots (Photo #1) as well as grouped together to form communities of four to five islands (Photo #2). Vegetation island communities were created with the intent of determining whether these communities may have a synergistic effect on the ability to survive and propagate.

Individual vegetation islands consisted of a variety of small trees, shrubs, forbs, grasses and moss. Shrub species included kinnikinnick (*Arctostaphylos uva-ursi*), soapberry (*Shepherdia canadensis*), wild rose (*Rosa acicularis*), and shrubby cinquefoil (*Potentilla fruticosa*). Forbs included fireweed (*Epilobium angustifolium*), dandelion (*Taraxacum officinale*) and various other native species. Willow (*Salix spp.*), spruce (*Picea spp.*), poplar (*Populus spp.*) and birch (*Betula papyrifera*) seedlings in varying species densities were the dominant tree species. Grasses and moss were also present in varying densities. Individual species densities were not tallied.

2.3 Root Propagule and Live Stake Test Plots

Five meter square test plots were demarcated, mechanically scarified and excavated for transplanting willow crowns and poplar bare root cuttings. Each five meter by five meter plot had either willow crowns (root wads) or bare balsam poplar root cuttings planted approximately 25-35 cm below surface (Photo # 3 and #5 respectively). Live stakes approximately one meter long were then hand planted using planting dibbles around the periphery of each plot and trimmed to approximately 15-20 cm above the surface (Photo #4 and #6). Heavy compaction and the presence of large subsurface rocks and other debris in areas outside the scarified areas made live staking difficult by hand or often impossible. Therefore live stakes were planted in the scarified soil. Willow plots received poplar live stakes and poplar plots received willow stakes. This planting method will simplify future determination of the particular planting method without confusing species and planting method.

2.4 Trench style live staking

Trench excavations approximately two to three meters long by 0.5 meter deep sloping to ground level were created to transplant two meter long willow and poplar stems (Photo #7 and #8 respectively). This method was implemented to determine the success of using a more mechanized transplanting procedure, thereby expediting the transplanting process. This is compared to individual hand live staking which is time consuming if instituted on a large scale and proved difficult due to physical limitations such as soil compaction and large rock fragments.

2.5 Live staking along Shoreline

A combination of willow and poplar live stakes was hand-planted near the base of the waste rock pile and lakeshore where an erosion gully had begun to form (Photo #9). Live stakes were approximately one meter long and inserted fairly easily into the fine sediments leaving 15 to 20 cm of each stake above ground level. This trial was initiated to determine the survivability of live stakes in a more moist soil condition. It is intended that the growth of these live stakes will provide added soil stability and reduce future erosion in this specific area.

3.0 DISCUSSION

3.1 Soil Conditions, July 2008

Laboratory analytical data based on soil samples collected during the reconnaissance survey of the waste rock disposal area July 2008, indicated that the samples collected were slightly alkaline (pH 7.8 to 8.4); were deficient in the macronutrients nitrogen, phosphorus and potassium; and were generally low in organic matter. Soil samples were analysed based on agricultural soil analysis criteria. Criteria based on agricultural requirements can indicate that higher nutrient requirements are needed based on nutrient requirements necessary to produce acceptable yields for agricultural purposes.

Agronomic nutrient requirements may vary substantially from those required for local, native, colonizing plant species to grow successfully. No definitive published nutrient requirements are known to exist for native vegetation. However, low concentrations of organic matter and subsequent low concentrations of nitrogen can be expected due to the complete lack of topsoil, since nitrogen reserves are stored in the form of organic matter. Electrical conductivity levels were high (considered toxic to vegetation) in two of the seven sites. These conditions could potentially contribute to impeded plant growth.

In-situ soil moisture analysis indicated that the percent moisture saturation ranged from 10% to 63% (Laberge 2008). The downloaded weather data from the Hobo weather station located on the Clinton Creek Waste Rock Dump, indicated a wetter than average July with a total of 119.8 mm of rainfall (Appendix A). Visual soil moisture was also relatively high during the September field work, with rainfall occurring frequently during the week. The soil moisture was adequate for transplanting, however each plot was still watered to ensure adequate soil to root contact. Eliminating large soil voids and air gaps between soil and root interfaces will maximize rooting potential and minimize overwinter desiccation.

The soil samples were also analyzed for metal content. This analysis was requested of the lab following the submission of the reconnaissance report. The data is summarized below in Table 1. The analytical data is in included in Appendix B.

TABLE 1

METALS (mg/kg) IN SOIL SAMPLES (N=7) FROM CLINTON CREEK WASTE DUMP, JULY 16, 2008

Parameter	CCME Guideline for Parkland	Mean	Standard Deviation	Range
Aluminum		9163	5829	3610 to 18000
Antimony	20	2.8	1.5	0.6 to 5.12
Arsenic	12	12.4	5.8	3.7 to 22.7
Barium	500	133	169	53.2 to 513
Beryllium	4	0.5	0.1	0.3 to 0.737
Bismuth		<0.5	0	<0.5 <0.5
Cadmium	10	1.5	0.9	0.3 to 3.3
Calcium		17786	7193	4100 to 24900
Chromium	64	94.4	109.8	11.4 to 290
Cobalt	50	23.2	6.8	14.6 to 35.8
Copper	63	48.9	10.5	39.1 to 67
Iron		47486	3215	43200 to 51700
Lead	140	18.6	4.3	14.0 to 26.7
Lithium		21.3	12.9	7.0 to 35.8
Magnesium		20671	14677	8220 to 45100
Manganese		491	66	421 to 568
Molybdenum	10	9.2	5.9	1.9 to 18.5
Nickel	50	227	231	42 to 644
Phosphorus		637	142	399 to 802
Potassium		568	66	480 to 692
Selenium	1	3.8	1.3	1.9 to 5.53
Silver	20	0.5	0.2	0.3 to 0.92
Sodium		55.5	12.4	46.0 to 82
Strontium		88.6	28.0	28.9 to 112
Sulfur		5486	3764	812 to 11600
Thallium	1	0.5	0.1	0.3 to 0.61
Tin	50	0.5	0.0	0.5 to 0.64
Titanium		38.7	14.2	26.2 to 62.7
Vanadium	130	23.4	4.8	19.0 to 33.3
Zinc	200	128	57	64 to 236
Zirconium		5.8	1.8	4.6 to 9.84

The CCME guidelines for Parklands and Recreation have been included to put the data into context as the Clinton Creek and Forty Mile River region is a recreational area and tourists visit the site during summer months. Individual and/or mean metal concentrations present in the soil sediments met the applicable guidelines for most metals. The guideline concentrations for chromium, nickel and selenium were exceeded in several samples. In this instance, it is apparent that the lack of nutrients and organic matter is a more limiting factor for plant growth than are sediment metal concentrations.

3.2 Revegetation Techniques, September 2008

Vegetation island removal along the road shoulder donor areas and subsequent transplanting proved to be challenging due to the soil substrate's coarse fragment content and very friable soil consistency. This soil combination resulted in many vegetation islands losing cohesion and in some cases, reducing the size of the vegetation islands and resulting in some root damage. Using a tipping trailer, different backhoe buckets and other refinements would help to make sure the transplants don't fall apart during installation. Vegetation islands that were removed from undisturbed forest areas maintained cohesion much better and resulted in intact vegetation islands being transplanted. Availability of vegetation on formerly undisturbed soil within close proximity to the transplant sites is limited.

Harvesting appropriate live stakes within close proximity to the transplant sites also became limited. Acquiring additional staking material would likely require gathering from a greater distance in future. Mechanized, trench style live stake installation appeared to be the favoured installation method for time efficient staking due to the coarse, compacted soil consistency which limited individual hand staking in non scarified soil.

Lakeshore live staking was relatively easy due to the soil moisture and consistency. Depending on the survivability rate of live stakes this may be a location to focus on for future transplanting. As well as providing shoreline stabilization in the disturbed area, a successful transplanting program will provide a denser tree cover and ultimately a seed source for continued natural revegetation. However, local beaver activity may be problematic in maintaining future tree establishment. This potential issue could be overcome by low cost fencing options.

It is believed that a combination of factors including: an overall lack of seed/propagule source; low soil nutrient level, lack of topsoil/organic matter and associated beneficial soil micro-organisms; as well as substantial soil compaction have hindered more vigorous natural revegetation.

3.3 Plot Descriptions

3.3.1 Plot #1, Near Porcupine Pit Lake

Figure 2 displays the layout of the various treatments at Plot #1, and the table below summarizes each treatment, the specific location of each and the prominent species within each island.

TABLE 2 SUMMARY OF PLOT #1

Plot #	Treatment	Quantity of cuttings or roots	GPS Co-ordinates Datum NAD 27	Prominent Species
IC-1	Vegetation Community	4 islands arranged as a community	Lat.64˚ 26.891’ Long.140˚ 43.293’	
IC-1A	Island within community			Soapberry, spruce, moss, kinnikinnick
IC-1B	Island within community			Soapberry, kinnikinnick
IC-1C	Island within community			Spruce, shrubby cinquefoil, kinnikinnick, moss
IC-1D	Island within community			Spruce poplar, shrubby cinquefoil soapberry
I-1	Individual vegetation island	1	Lat.64˚ 26.903’ Long.140˚ 43.285’	
I-2	Individual vegetation island	1	Lat.64˚ 26.913’ Long.140˚ 43.327’	Spruce, kinnikinnick, willow, shrubby cinquefoil, grass,
WS-2	Willow trench staking	15	Lat.64˚ 26.939’ Long.140˚43.352’	
PS-2	Poplar trench staking	15	Lat. 64˚ 26. 930’ Long. 140˚ 43.350’	
WC-2	Willow crowns	9	Lat.64˚ 26.912’ Long.140˚ 43.338’	
PR-2	Poplar root cuttings	16	Lat. 64˚ 26.902’ Long. 140˚ 43.305’	
PR-2	Live willow stakes	25	Lat. 64˚ 26.930’ Long. 140˚ 43.350’	
WC-2	Live poplar stakes	25	Lat.64˚ 26.912’ Long.140˚ 43.338’	

3.3.2 Plot #2, Near the old Shovel and Drill

Figure 3 displays the layout of the various treatments at Plot #2, and the table below summarizes each treatment, the specific location of each and the prominent species within each island.

TABLE 3		SUMMARY OF PLOT #2		
Plot #	**Treatment**	**Quantity of cuttings or roots**	**GPS Co-ordinates Datum NAD 27**	**Prominent Species**
IC-2	Vegetative community	5 individual islands	Lat.64˚ 26.891' Long.140˚ 42.872'	
IC-2A	Island within community			Shrubby cinquefoil, poplar, spruce, grass
IC-2B	Island within community			Shrubby cinquefoil, willow
IC-2C	Island within community			Poplar, soapberry, moss, kinnikinnick, spruce, grass, yarrow, fireweed
IC-2D	Island within community			Kinnikinnick, grass, aspen
IC 2E	Island within community			Willow, soapberry, large spruce
I-3	Individual vegetation island	1	Lat.64˚ 26.891' Long.140˚ 42.771'	Willow, poplar, soapberry, kinnikinnick, spruce
I-4	Individual vegetation island	1	Lat.64˚ 26.893' Long.140˚ 42.765'	Spruce kinnikinnick, willow
I-5	Individual vegetation island	1	Lat.64˚ 26.856' Long.140˚ 42.779'	Soapberry, spruce, poplar
I-6	Individual vegetation island	1	Lat.64˚ 26.855' Long.140˚ 42.804'	Willow, grass, small spruce, trembling aspen, poplar,
I-7	Individual vegetation island	1	Lat.64˚ 26.844' Long.140˚ 42.796'	Soapberry grass, moss, willow
I-8	Individual vegetation island	1	Lat.64˚ 26.846' Long.140˚ 42.822'	Willow, lichen, moss, grass, fireweed, spruce
I-9	Individual vegetation island	1	Lat.64˚ 26.853' Long.140˚ 42.826'	Soapberry, willow, fireweed, grass, poplar, dandelion
WC-1	Willow crowns	6	Lat.64˚ 26.857' Long.140˚ 42.850'	

TABLE 3	**SUMMARY OF PLOT #2**			
Plot #	**Treatment**	**Quantity of cuttings or roots**	**GPS Co-ordinates Datum NAD 27**	**Prominent Species**
PR-1	Poplar root cuttings	14	Lat.64˚ 26.869' Long.140˚ 42.833'	
WC-1	Poplar live stakes	25	Lat.64˚ 26.857' Long.140˚ 42.850'	
PR-1	Willow live stakes	39	Lat.64˚ 26.869' Long.140˚ 42.833'	
PS-1	Poplar trench staking	15	Lat.64˚ 26.878' Long.140˚ 42.875'	
WS-1	Willow trench staking	15	Lat.64˚ 26.882' Long.140˚ 42.863'	

3.3.3 Plot #3, Near Hudgeon Lake

Figure 4 displays the layout of the various treatments at Plot #3, and the table below summarizes each treatment, the specific location of each and the prominent species within each island.

TABLE 4	**SUMMARY OF PLOT #3**			
Plot #	**Treatment**	**Quantity of cuttings or roots**	**GPS Co-ordinates Datum NAD 27**	**Prominent Species**
IC-3	Vegetative community	4 islands arranged as a community	Lat.64˚ 27.094' Long.140˚ 43.664'	
IC-3A	Island within community			Spruce, kinnikinnick, soapberry, poplar, grass
IC-3B	Island within community			Spruce, soapberry, willow, moss, kinnikinnick
IC-3C	Island within community			Spruce, soapberry
IC-3D	Island within community			Spruce, cinqfoil, grass, moss, forbs, willow, aspen
IC-4	Vegetative community	5 islands arranged as a community	Lat.64˚27.091' Long.140˚43.701'	
IC-4A	Island within community			Spruce, willow kinnikinnick, moss,
IC-4B	Island within community			Willow, wild rose, grass, moss

TABLE 4	SUMMARY OF PLOT #3			
Plot #	**Treatment**	**Quantity of cuttings or roots**	**GPS Co-ordinates Datum NAD 27**	**Prominent Species**
IC-4C	Island within community			Grass, kinnikinnick, low bush cranberry, wild rose, poplar, birch
IC-4D	Island within community			Kinnikinnick, willow, grass, wild rose
WC-3	Willow crowns	6	Lat.64˚ 27.084' Long.140˚ 43.603'	
WC-4	Willow crowns	3	Lat.64˚ 27.076' Long.140˚ 43.619'	
PR-3	Poplar root cuttings	16	Lat.64˚ 27.80' Long.140˚ 43.585'	
WC-3	Poplar live stakes	25	Lat.64˚ 27.064' Long.140˚ 43.603'	
PR-3	Willow live stakes	25	Lat.64˚ 27.80' Long.140˚ 43.585'	
PS-3	Poplar trench staking	15	Lat.64˚ 27.037' Long.140˚ 43.624'	
WS-3	Willow trench staking	15	Lat.64˚ 27.089' Long.140˚ 43.631'	

3.3.4 Live Staking Along Shoreline

A combined total of 55 willow and poplar live stakes were hand-planted along the shoreline of Hudgeon Lake near the base of the Clinton Creek Waste Rock Dump at 64˚ 27.090' N and 140˚ 43.892' W.

Photos of the plots are included in Appendix C. Due to weather conditions (fog and rain) during the study period, the quality of many of the photos is compromised.

4.0 RECOMMENDATIONS

Implementing a long term, annual vegetation monitoring program would be beneficial in determining the success of the transplanting program. A minimum five year monitoring program would greatly add to the knowledge base of re-establishing vegetation on nutrient poor mine waste rock. It is recommended that annual monitoring commence in July 2009 to assess initial overwintering success. Long term monitoring will determine whether anthropogenic revegetation is beneficial and whether it can hasten revegetation when compared to the natural revegetation process in this particular setting. Also, by employing several different revegetation techniques, the success and potential future use of each method can be assessed over time.

Information gained from these trails will be beneficial and transferable to other waste rock revegetation challenges in the Yukon, such as the Faro Mine Complex. Although the metal composition of waste rock dumps may differ, the general waste rock physical characteristics and the lack of nutrients and initial organic cover are similar. The machine-assisted revegetation techniques used in this study are field ready and may be scaled up depending on the goals of the given revegetation program.

5.0 ACKNOWLEDGEMENTS

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APPENDIX A

CLINTON CREEK RAINFALL, MAY TO OCTOBER 2008

APPENDIX B

LABORATORY SOIL ANALYTICAL REPORT, JULY 16, 2008

APPENDIX C

PHOTOGRAPHS SEPTEMBER 2008