COMPREHENSIVE STUDY REPORT ON THE

DECOMMISSIONING AND RECLAMATION OF THE

BREWERY CREEK MINE

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Government of Yukon

Executive Summary

<u>The Project:</u>

The Brewery Creek Project ('the project') is a cyanide heap leach gold mine located 57 km due east of, or approximately 77 road km from Dawson City, Yukon. The site is within the traditional territory and upstream of extensive settlement lands owned by the Tr'ondek Hwech'in First Nation.

The Brewery Creek development was originally subject to environmental assessment pursuant to the *Environmental Assessment and Review Process Guidelines Order* (EARPGO) and water licencing pursuant to the *Yukon Waters Act* in 1995. Subsequent amendments to the original licence were further subject to environmental assessment pursuant to the *Canadian Environmental Assessment Act* (CEAA). Active mining and placement of ore on the heap took place between 1996 and 2000, while active leaching continued until late 2001.

A condition of the water licence that regulated the Brewery Creek Mine was a requirement to submit a decommissioning and reclamation plan. Viceroy submitted their decommissioning and reclamation plan in September 2001, triggering a Comprehensive Study pursuant to the CEAA.

<u>The Environmental Assessment:</u>

This environmental assessment was triggered because the decommissioning of a physical work is defined as a project pursuant to CEAA. Furthermore, the daily mining tonnage rate at the Brewery Creek Mine exceeded the threshold as established in the Comprehensive Study List Regulations pursuant to CEAA, thereby triggering a Comprehensive Study level of environmental assessment. The Department of Indian Affairs and Northern Development (DIAND) was identified as a Responsible Authority (RA) pursuant to CEAA and initiated the Comprehensive Study in September of 2001.

Effective on 01 April 2003, the control and administration of the Yukon's land and water resources devolved to the Government of Yukon. Mirror legislation replaced the federal statutes that governed environmental assessment, water and land resource management in the Yukon; as a result, this Comprehensive Study was transferred to the administration of the Yukon Government and was subsequently completed pursuant to the *(Yukon) Environmental Assessment Act* (EAA), the mirror legislation that replaced CEAA.

Viceroy's decommissioning and reclamation plan outlines procedures to detoxify the heap, reclaim pits and waste rock dumps, and decommission access corridors. Contingencies are provided for backup water treatment should proposed primary detoxification methods fail to meet decommissioning objectives.

Viceroy has proposed an in-situ biological detoxification of the heap. A combination of sugars, fats and alcohol would be added to the heap as a means of destroying cyanide and precipitating elemental metals into an immobile form. Contingencies included an effluent treatment and land application system for residual heap effluent run-off, the construction of a biological treatment cell. Once detoxified, the heap would be re-seeded.

Mined areas and waste rock dumps would be re-contoured and re-seeded. As haul roads and trails were no longer required, they would be reclaimed. The 'Blue' waste rock storage area was identified as having the potential for acid rock drainage. Viceroy provided information on the geochemical characteristics at the site and included a plan to cap and seed the area, yet the RA expressed concern on Viceroy's methodology for characterizing the site.

Several concerns were raised by reviewers which included the requirement for clarification on the biological heap treatment attenuation mechanisms, further information on the heap cover proposal, further explanation on the contingencies and when each would be employed, geotechnical stability concerns including a clarification on the geochemical stability of the Blue zone and other details. Viceroy responded with an addendum to their original plan in February of 2002. This addendum addressed the identified concerns but some issues remained outstanding.

In May of 2002, DIAND, the Tr'on dek Hwech'in First Nation and Viceroy representatives met to discuss outstanding issues related to this Comprehensive Study. Outstanding technical issues were discussed in detail. Viceroy agreed to submit a revision to their plan incorporating the technical information that DIAND required to successfully complete the environmental assessment. Viceroy submitted their final addendum in December of 2002. Viceroy further submitted a document to DIAND outlining a proposed site specific selenium discharge criteria in February of 2003. All technical reports submitted in support of this Comprehensive Study were available to interested members of the Regional Environmental Review Committee (RERC) for review and comment.

This Comprehensive Study Report was completed by the Environmental Assessment Unit of the Executive Council Office of the Government of Yukon. All technical comments received during the course of this assessment were considered in the development of this report. Listed on the Public Registry for this project is a detailed issues tracking document that summarizes technical comments received and how they were ultimately addressed.

The primary concern raised during the technical review of the DRP was the potential for movement of contaminants in water and the potential resulting adverse effects on receptor organisms, including humans. Numerous mitigation measures have been specified concerning the implementation of the decommissioning plan and contingencies, with the intention of protecting identified values within the area and downstream. A follow-up program is mandatory for Comprehensive Studies and is detailed in s.10 of this Comprehensive Study. The purpose of the follow-up program is to verify the accuracy of the assumptions made during this

Comprehensive Study and to assess the effectiveness of mitigation measures. As well, contingencies or adaptive management programs must be in place to ensure that decommissioning objectives can be met if the primary decommissioning proposal fails. Measurable criteria to assess decommissioning success and long term physical and geochemical stability must be developed and incorporated into Viceroy's regulatory authorizations.

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1. Introduction

The purpose of this Comprehensive Study Report (CSR) is to summarize the results of an environmental assessment that was conducted on the Brewery Creek Decommissioning and Reclamation Project. The assessment was conducted pursuant to section 17 of the *(Yukon) Environmental Assessment Act* (EAA[1]), and it includes a consideration of the factors set out in subsection 12(1) of the EAA.

The format of this Comprehensive Study is based on guidance provided in the Canadian Environmental Assessment Agency's Guide to the Preparation of a Comprehensive Study for Proponents and Responsible Authorities (CEAA Agency, 1997).

1.1 Project Overview

1.1.1 Background

The Brewery Creek Mine is located 57 km due east of, or approximately 77 road km from Dawson City, Yukon. The project site is accessed by travelling 40 km east of Dawson City on the Klondike Highway, 6 km north on the Dempster Highway, 21 km east on the Klondike Ditch Road and 10 km north on the Viceroy Minerals Corporation (Viceroy) road. Figure 1 provides an overview of the overall location of the project area.

The site is within the traditional territory of the Tr'ondek Hwech'in First Nation. Considerable land claim settlement lands are within the immediate project location and downstream. The project location area is of importance to the Tr'on dek Hwech'in people for numerous traditional and current pursuits.

The Brewery Creek Project is situated approximately six km. from the Klondike River. The adjacent water bodies in the project area are Lee, Laura and Golden Creeks, all tributaries of the Klondike River. Other streams in the project area include Pacific Creek (tributary of Lee Creek), Carolyn Creek (tributary of Laura Creek) and Lucky Creek (tributary of Golden Creek). Refer to Figure 2 for an overview of the mine and its component locations.

The heap leach pad and processing infrastructure are located in the Carolyn Creek drainage. The Pacific, Blue, Canadian and Fosters ore zones are within the Laura Creek drainage. The Moosehead zone straddles the divide between the Laura and Pacific watersheds and the Kokanee zone lies between the Laura and Lucky drainages. The Golden and Lucky zones are in the Lucky Creek drainage.

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[1] Appendix 1: Acronyms and abbreviations, contains a listing of all acronyms used in this report, as well as what the acronym stands for.

The Brewery Creek mine employed a cyanide heap leach, adsorption/desorption recovery (ADR) process to recover gold from non-crushed, run-of-mine ore. The deposit comprised a series of shallow, largely oxidized gold deposits along a seven km. corridor. Mining operations at Brewery Creek commenced in November 1995 and mining has taken place in the Fosters, Blue, Canadian, Pacific, Kokanee, Moosehead, Golden and Lucky deposits. Additional exploration targets and gold values have been identified but Viceroy has not considered the development of these deposits to be economically viable at this time.

Open pit mining was carried out each year from 1996 to 2000 on a seasonal basis, with 1.4 to 2.6 million tonnes of ore placed on the leach pad from early April through early November. Mining has been discontinued and Viceroy has not loaded any further ore on the leach pad beyond the 9,458,197 tonnes that was in place at the end of 2000.

The majority of waste rock generated during mining activities was backfilled into mined-out open pits. Additional "external" waste dumps were created in other areas. Areas affected by mining and waste dumps have been the target of progressive reclamation activities including regrading, slope stabilization and revegetation.

1.1.2 Current Project

The project subject to this CSR consists of the physical works and undertakings required to decommission and reclaim the mine site; this includes: roads, infrastructure, pits, waste rock dumps, heap leach infrastructure including water storage and treatment systems when they are no longer required for decommissioning purposes.

1.2 Purpose of the Project

The purpose of the project is to successfully decommission and reclaim the Brewery Creek gold mine.

1.3 Need for the Project

A condition of the original environmental assessment and Water Licence QZ96-007 required the submission of a decommissioning plan, and that the plan would be implemented once active leaching of gold from the heap had ceased.

1.4 Timing Considerations

It is in the best interest of the Yukon that the Brewery Creek Mine be decommissioned with as little delay as possible once active mining and leaching has ceased.

1.5 Regulatory, Policy and Planning Context

1.5.1 Environmental Assessment and Regulatory History

On June 9, 1995, the Department of Indian Affairs and Northern Development (DIAND) issued a screening and decision report pursuant to the *Environmental Assessment and Review Process Guidelines Order* (EARPGO). The decision report recommended that the initial proposal for the Brewery Creek Mine met the requirements of EARPGO and that pursuant to Section 12(c) the proposal could proceed to the regulatory process with the commitments and mitigation measures recommended in the Initial Environmental Evaluation (IEE), the IEE addendums and the decision report. The assessment considered all project aspects but identified the need for further assessment of future solution management plans, water treatment proposals and decommissioning plans. The Yukon Territory Water Board subsequently issued Water Licence QZ94-003 in August, 1995.

On May 26, 1997, DIAND issued a CEAA screening report that evaluated the effects of modifications and additions to the water supply at the Brewery Creek Mine. DIAND concluded that the modifications and additions were not likely to cause significant adverse environmental effects. Water Licence QZ96-007 was subsequently issued and remains in effect.

Other CEAA screenings conducted for this project are:

- On February 25, 1999 DIAND issued a CEAA screening report that evaluated the effects of delaying submission of the Detailed Decommissioning and Abandonment Plan. DIAND concluded that the delay was not likely to cause significant adverse environmental effects.
- On May 11, 1999, DIAND issued a CEAA screening report that evaluated the effects of modifying the heap leach pad liner design by replacing the upper silt liner with a geosynthetic clay liner. DIAND concluded that the modification was not likely to cause significant adverse environmental effects.
- On August 23, 1999, DIAND issued a CEAA screening report that evaluated the effects of reducing the ore cushion thickness from 1000 mm to 500 mm, and relaxing the ore cushion gradation standards. DIAND concluded that the modification of the ore cushion layer was not likely to cause significant adverse environmental effects.
- On August 10, 2001, DIAND issued a CEAA screening report that evaluated the effects of the Water Treatment Proposal, including the effects associated with the release of treated process solutions to a land application area. DIAND concluded that the Water Treatment Proposal was not likely to cause significant adverse environmental effects with mitigation and a limitation on the overall quantity of discharge.

- On March 31, 2003, DIAND issued a screening report that evaluated the effects of Viceroy's "Revised Updated Solution Management Plan, December 2000" whereby Viceroy proposed replacing passive solution storage capacity with contingency pumping systems. DIAND concluded that the original EARPGO requirement for full passive solution storage capacity was still relevant and that this proposal was not acceptable; a CEAA 20(1)b determination was issued.

Changes to the *Yukon Quartz Mining Act* and regulations that took effect on June 16, 1999 required that all quartz mines in the Yukon be licenced. Viceroy applied for a Quartz Mine Production Licence on February 22, 1999. DIAND determined that the initial EARPGO screening adequately scoped quartz mine activities with the exception of cumulative effects. Viceroy submitted a Cumulative Effects Assessment of the Brewery Creek area in April 1999 (see s. 8.3.1 of this CSR for information on cumulative effects). DIAND accepted it and Yukon Quartz Mining Licence A99-001 was subsequently issued to Viceroy.

1.5.2 Current Environmental Assessment Process

This CSR was triggered by Viceroy's submission to the Water Board of a Decommissioning and Reclamation Plan (DRP) for the Brewery Creek Mine in September of 2001. Water Licence QZ96-007 specified the requirement to submit this plan. The Water Licence will require an amendment to incorporate decommissioning standards and criteria for the determination of long term site stability.

Section 16 of the *Comprehensive Study List Regulations* pursuant to CEAA specifies the requirement for an RA to undertake a CSR for " The proposed construction, **decommissioning** or abandonment of (subsection (c)) a gold mine, other than a placer mine, with an ore production capacity of 600t/d or more". DIAND confirmed the CSR requirement with the Vancouver office of the CEAA agency.

DIAND confirmed its involvement in the CSR as a Responsible Authority (RA) pursuant to CEAA. On 28 September 2001, DIAND undertook an exercise to identify other potential RAs and expert Federal Authorities (FAs), as required by the *Regulations Respecting the Coordination by Federal Authorities of Environmental Assessment Procedures and Requirements* pursuant to CEAA. The departments of Fisheries and Oceans Canada, Natural Resources Canada, Environment Canada, Health Canada and Parks Canada were sent a letter requesting them to identify their involvement in this project; a deadline of 19 October 2001 was offered for response. Natural Resources Canada and Fisheries and Oceans Canada (Habitat and Navigable Waters sections) identified themselves as expert FAs who could offer specialized advice into this environmental assessment. No other departments identified themselves as RAs.

Subsections 24(1) and 74(3) of CEAA define the circumstances under which an RA is able to use the information in previously conducted CEAA or EARPGO assessments in the preparation of a CSR. The RA has reviewed and considered all relevant information contained in previous screening reports carried out on the Brewery Creek Mine to date, in the preparation of this CSR.

On 01 April 2003, the resources and responsibilities of the Northern Affairs Program (NAP) of DIAND were transferred from Canada to the Government of Yukon under the Yukon Northern Affairs Program Devolution Transfer Agreement(2001). As a component of the transfer of responsibilities, the (Yukon) *Environmental Assessment Act* (EAA) was passed as legislation that mirrors the CEAA. Subsequently, all environmental assessments of NAP related projects conducted by DIAND in the Yukon pursuant to CEAA not completed by 01 April 2003 will be completed by the Government of Yukon pursuant to EAA. This CSR was completed by the Environmental Assessment Unit of the Government of Yukon's Executive Council Office.

2. History of Mine Development

2.1 Overview of Site Development

Leaching of gold from the ore took place on the leach pad, by application and recovery of cyanide solution. The leach pad at Brewery Creek was constructed and operated as a permanent pad, on which the stacked ore was being leached and will be detoxified and left in place. Although originally designed and planned as a 460,000 m^2 pad, the pad has reached its ultimate size of 311,000 m^2 of which 158,000 m^2 was constructed in 1996, 60,000 m^2 constructed in 1997, 11,000 m^2 constructed in 1998, and 82,000 m^2 constructed in 1999.

The leach pad is a lined containment area. The liner system includes a combination of synthetic (PVC plastic) liners and low permeability soil liners. The system provides primary and secondary solution containment and detection/collection of solution leaking through the primary liner. The liner system is described in detail in the design documentation approved as part of water licence applications QZ94-003 (the original application for the Brewery Creek project) and QZ98-038. Through application QZ98-038, Viceroy sought and received authorization to modify the liner design, replacing the upper 300 mm compacted soil layer with a 7 mm geo-synthetic clay liner. The liner system requirements were further revised in accordance with water licence application QZ99-041 through which Viceroy received authorization to decrease the ore cushion thickness from 1000 mm to 500 mm. Only the construction completed in 1999 utilized the revised liner design.

Circulation of process solution (leaching of the heap) began in October 1996. The ADR plant commenced gold processing operations in November 1996. Leaching and gold recovery was carried out on a continuous, year-round basis. A network of pipes on the primary liner collected solution percolating through the stacked ore. This solution flowed by gravity to the ADR plant where precious metals were recovered using carbon adsorption, pressure stripping, electro winning and smelting. The solution was then re-circulated to the pad in a continuous circuit, with additional cyanide being added as necessary.

Until September 1998, leaching and recovery took place through a single circuit. At that time, Viceroy added an additional recovery circuit to the ADR plant and began operation of a secondary leach stage. Under this revised process, Viceroy applied barren solution to older areas of the pad, and recovered gold through the smaller, new recovery circuit. The same solution, after the addition of cyanide, was then circulated to the newer areas of the pad, followed by gold recovery through the larger, original recovery circuit.

Recovery of gold by heap leaching relies on continued circulation of cyanide solution to the heap. Fresh ore also placed on the pad consumed water (i.e. process solutions or precipitation) for initial wetting and the total quantity of solution in circulation increased directly in proportion to the quantity of ore under leach at any time. In addition, the large lined area collected all precipitation that falls within the area. This additional water from precipitation eventually mixed with the process solutions and reported to the ADR plant.

Once under active leaching however, the ore reached a steady-state where the flow of solution onto the heap was essentially equal to the flow returning from the heap. In this steady-state condition, significant solution volumes were stored as transition moisture within the ore. The continued storage of solution in this transitional sink relied on continued operation of the circulating system. If the circulating system failed, the heap would have drained down through the solution collection system and accumulate in ponds (as long as there was sufficient pond capacity).

The Brewery Creek Mine facility includes two process ponds: the pregnant pond and the barren pond, with capacities of 27,300 m^3 and 27,200 m^3 respectively. Viceroy routinely stored process solutions in these ponds, which have double synthetic (HDPE plastic) liners with a leak detection and recovery system between the liners.

To retain sufficient storage capacity in ponds, the excess water must be either dissipated through evaporation, or treated and released. In their March 2001 Brewery Creek Mine Effluent Treatment and Land Application Water Licence Submission Proposal, Viceroy had requested authorization for treating of process solutions with subsequent discharge by application to land. This proposal has received a positive CEAA determination (August 10, 2001) and was subsequently licenced in July 2002.

An intensive evaporation program has been used at the site to deal with process solution volumes. In 2000, two evaporative units were installed at the site. These units consisted of spray nozzles that atomize the solution and promote high evaporation rates. The two units were installed within the barren pond in 2000 and on top of the heap in 2001.

In recognition of the potential for catastrophic drain down events and severe climatic conditions, the Brewery Creek Mine facility includes a third lined solution containment pond, the overflow pond. The overflow pond has a single synthetic (HDPE plastic) liner and a capacity of 95,500 m^3. The overflow pond has never been used for storage of process solutions and design documentation referenced in the water licence restricts its use to short-term periods following extreme events. In order to ensure short-term storage, any process solutions stored in the pond were to be utilized as process make-up water, or dissipated through evaporation or treat-and-release.

2.2 Effluent Treatment and Release Background

The original mine proposal contained limited information in relation to water treatment systems and design. The initial 1995 EARPGO screening and decision report recommended the establishment of a requirement for submission, review and approval of detailed water treatment system design specifications prior to construction of a water treatment system. The water licence established a requirement for submission but did not specify the need for review and approval. Loki Gold later agreed to the requirements of the screening and decision reports through a series of letters to DIAND. This included an agreement to complete a final design for the water treatment system before the end of the third year of operations.

In an intervention on water licence amendment application QZ96-007, DIAND recommended that the Water Board address the outstanding water treatment related commitments through an amendment to the licence. The Board convened a hearing on 10 September 1997 to consider this and other amendments requested by DIAND; to date, the Board has not completed deliberations on these amendment requests.

Water Licence QZ96-007 specified effluent release to Laura Creek in accordance to quality standards for numerous parameters. An investigation of conventional water treatment technologies by the proponent determined that they were relatively ineffective for the removal of some solution contaminants, namely selenium and ammonia. Viceroy requested (March 2001 document) less stringent effluent quality standards for discharge of effluent to a land area. Viceroy evaluated the environmental effects of the water treatment and effluent discharge proposal on the basis of modelling which incorporates a consideration of contaminant attenuation in soil.

The proposal consisted of four stages:

1. Stage one consisted of a cyanide oxidation step using hydrogen peroxide. The hydrogen peroxide was to be added via a rapid mix tank after which the solution would enter a series of three reaction ponds with a total retention time of approximately six hours at the design flow rate. Viceroy anticipated that the majority of the cyanide destruction would take place at this stage, including the formation of precipitates.

2. Following the three reaction ponds, the solution was to decant to one of two second stage settling ponds for precipitation of metal hydroxides. Approximately 24 hours of retention time was planned during stage two at designed flow rates.

3. Solution would be pumped to the vertical carbon adsorption columns in use for gold recovery in the ADR plant. Viceroy anticipated that the carbon polishing would result in additional removal of metal contaminants.

4. The final stage of this process relied on soil attenuation in undisturbed forest land to further reduce contaminant loads, particularly ammonia and selenium. Suction lysimeters were to be installed in the application area; discharge activities would

be revised based on pore water quality analysis from the lysimeters installed within the discharge area.

Viceroy identified an initial land application area of 55,000m^2 that they anticipated would be sufficient to attenuate approximately 175,000m^3 of effluent. The area identified is on a southwest facing slope located to the immediate south of the pond/ADR plant site. Hydrogeological evaluations completed during initial project permitting indicates that the groundwater table is 40 to 90 metres below surface with a gradient towards Laura Creek. Measured horizontal conductivity in the subsurface bedrock ranges from 1.2×10^{-5} m/s to 2.0×10^{-6} m/s. Viceroy's modelling has assumed that the vertical conductivity is 6.0×10^{-7} m/s. Soil samples have identified a profile that includes a surface layer of organic material, approximately 0.75 m of mixed silt and clay and then approximately 2.0 m of mixed sands and gravels. The site currently supports a mixed black spruce boreal forest.

Viceroy proposed to undertake the following mitigation measures in their proposal:

- Relocate solution distribution lines to an alternative location within the application area;
- alter the solution application rate to reduce infiltration of effluent into the land application soils;
- conduct additional monitoring (pore water) to assess soil attenuation capacities;
- cease solution application within the land application area; and/or
- establish a new land application area (or areas) for solution distribution on the property should attenuation capacity in the primary area be exceeded.

On August 10, 2001 DIAND completed a detailed CEAA screening of this application. The resulting report and mitigation is further discussed in s. 8 Predicted Environmental Effects of the Project. A signed water licence for land application was issued in July, 2002. The volume of effluent discharge to the land application area can not exceed 200,000 m^3 per year and a total of 400,000 m^3.

Viceroy's licence amendment established two effluent quality standards: Criteria 1, which would apply to the effluent discharged to the land application area, and criteria 2 (Table 2.1) which would apply a series of suction lysimeters located at a depth of 5 m. The licence further required that Criteria 2 would be used as a response criteria for managing land application activities, based upon the results of monitoring of suction lysimeters located at a depth of 2 m.

The licence required Viceroy to install suction lysimeters within the land application area. They are used to withdraw pore water from within the soil profile so that water quality can be evaluated. In the event that pore water from a depth of less than 5 m exceeded Criteria 2 thresholds, Viceroy is required to prepare and submit to the Board an action plan that addresses the problem. In a addition, two groundwater monitoring stations were installed to monitor the groundwater flow from the land application area.

Soil quality parameter concentrations are also required to be measured to determine if they are in accordance with the allowable soil quality criteria for Residential/Parkland used established by the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CCME, 1999), unless the proponent has submitted to the Board a site specific Ecological Risk Assessment. Should the soil concentration exceed the required criteria, Viceroy must submit to the Board an action plan to address the problem.

Table 2.1: Effluent Quality Standards - Criteria 1 and Criteria 2

Parameter	Proposed Criteria 1 (mg/l) Discharge from Stage 3	Proposed Criteria 2 (mg/l) Groundwater Quality
Selenium	0.750	0.300
Ammonia as N	15.000	15.000
Aluminums	1.000	3.000
Iron	1.000	5.000
Manganese	2.000	6.000
WAD Cyanide	0.250	0.125
Total Cyanide	2.000	1.000
Mercury	0.005	0.003
Molybdenum	0.500	0.250
Antimony	1.000	0.500
Arsenic	0.500	0.250
Bismuth	0.500	0.250
Cadmium	0.100	0.050
Chromium	0.500	0.250
Copper	0.500	0.100
Lead	0.200	0.100
Nickel	0.800	0.250
Silver	0.100	0.050
Zinc	0.500	0.250

Treatment and land application was conducted during the summer of 2002.

3. Project Description

3.1 Definition of the Project, Activities and Schedule

3.1.1 Decommissioning, Reclamation and Abandonment – General

The DRP identifies the methods and practices that the proponent believes will successfully decommission the site to a stage where it can be abandoned.

Viceroy's stated objectives with the current DRP include:

- Incorporation of comments received from regulatory agencies and stakeholders concerning the draft decommissioning plan into the final plan;
- update the plan with the most recent operational conditions and the status of the Brewery Creek Mine;
- Incorporate the results of an extensive testing program designed to support the closure basis used in the plan;
- provide a detailed environmental assessment of the impacts of implementing this plan;
- provide a complete and comprehensive report on the estimated decommissioning and reclamation costs of the Brewery Creek Mine;
- address the adequacy of the security component of the Water Licence; and
- provide a release mechanism for the current reclamation bond.

Viceroy completed their DRP on the assumption that mining has been completed. In the event of a resumption of mining pad loading or leaching activities, the DRP would be revised to incorporate new areas of disturbance and additional tonnes of ore on the leach pad.

The DRP describes the decommissioning, reclamation and specific environmental protection objectives of the various components of the mine which include:

- Open pits and waste rock storage areas;
- roads;
- heap detoxification and long term treatment;
- buildings and infrastructure;
- site specific selenium criteria; and
- site monitoring.

Details of each of the specific project activities are described in the following sections.

3.1.2 Pits and Waste Rock Storage Area's (WRSA's)

As of December 2002, the North and South Golden Pits, Kokanee Pit, and Lucky Pit have been re-contoured and re-seeded. The Canadian, Lower Fosters and Moosehead mine areas will be reclaimed and re-seeded during the summer of 2003. Chemical stability of wall rocks and contained backfill has been assessed. All pits and both WRSA foundations (Blue and Canadian) were assessed for geochemical stability and assessed by a geotechnical engineer prior to reclamation.

3.1.3 Blue Waste Rock Storage Area

The Blue Waste Rock Storage Area (WRSA) contains lithologies that in the opinion of the RA, are potentially acid generating.

Viceroy's modelling to arrive at their WRSA cover proposal is briefly described below.

Water quality data, where possible, was taken from lysimeters at the Upper Fosters, West Canadian and Canadian Pit waste dumps, and measured seep data from the Blue Waste dump have been used in place of projections of contaminant release rates calculated from humidity cell test data. Where such data was unavailable, projections of contaminant release rates were taken from humidity cell testing. Viceroy noted that predicted contaminant release rates that were calculated from humidity cell test data are significantly higher than measured values from lysimeters or seepages. (Viceroy, 2001).

A mass-loading model was used to calculate the change in water chemistry. This modelling method does not consider any chemical attenuation that may occur and is therefore somewhat conservative, according to Viceroy. There are two components to the mass-loading model: water balance, on which flows are based and the concentrations and/or loads on which the chemical loading is calculated. Viceroy's modelling generally assumed that decommissioning and reclamation activities as described in the DRP were implemented and performed as expected. Also specified were some assumptions on drainages reporting to various catchments within the project site. (Viceroy, 2001).

Viceroy's DRP Vol. IV contained the results of additional fieldwork on the Blue WRSA. In-situ soluble metal concentrations were calculated and compared to the 2000 humidity cell data. A 'modified' version of the BC Ministry of Energy and Mines shake flask procedure was performed; see s.8.1.1.7 of this CSR for further discussion on the acid generating potential of the Blue WRSA.

Based on Viceroy's modelling work and their analysis of the available ARD information the company has proposed a 0.5 m storage and release cover for the Blue WRSA. They estimate that this growth media storage and release cover will result in an average annual infiltration of 19 %.

Viceroy further proposes to construct a monitoring mechanism for determining ongoing water quality trends in the Blue WRSA as well as soil cover infiltration performance. The monitoring device will consist of a 10m x 10m excavated trench in a representative section of the Blue WRSA. Trench logs completed during the August 2002 field program will be used to determine the location of the monitoring station. The bottom of the trench will be lined with a synthetic liner and a perforated collection pipe installed along with appropriate rock around the drainage pipe. A manual weather station will be installed adjacent to the monitoring station to obtain precipitation, evaporation and temperature data. The monitoring pipe will be located approximately 3 m below the surface of the WRSA. The storage and release cover will then be constructed over the surface of the monitoring station. The water quality data collected from the monitoring pipe will be used to determine any adverse changes in water quality data within the WRSA. The objective of locating the monitoring station appropriately is to ensure that early action triggers can be established for unexpected water quality changes prior to the onset of ARD and metals release to groundwater.

3.1.4 Roads

Viceroy has committed to managing post closure access in consultation with the community of Dawson City, the Tr'on dek Hwech'in First Nation, stakeholders and government regulators. Once it has been decided that access and haul roads are no longer required for decommissioning activities and access, stream crossings will be removed, excavations contoured and the surfaces scarified prior to seeding.

3.1.5 Buildings and Infrastructure

Mine infrastructure including buildings, will be removed from site as they are no longer required; foundations will be covered and growth media spread where required prior to seeding. Viceroy has committed to maintaining electrical power generating capability for as long as required due to its importance in the effluent treatment and land application process.

3.1.6 Revegetation

Viceroy has been conducting revegetation programs at the Brewery Creek site for several years and have developed a successful regeneration program utilizing native seed mixtures. Viceroy has committed to seeding and fertilizing areas that have been disturbed by mining activity as they are no longer required for decommissioning purposes.

3.1.7 Heap

The detoxification and reclamation of the heap leach pad as proposed in the DRP includes three steps: heap draindown, treatment and release, heap detoxification, heap cover and revegetation. Secondary treatment processes and long term heap effluent treatment were proposed as contingencies in the event that heap effluent did not reach and maintain licenced water discharge standards; these steps are summarized below.

Heap Detoxification

Viceroy has proposed to detoxify the heap leach pad through an in-situ bacteria treatment process. Column tests undertaken by Viceroy indicated that the in-situ biological treatment process using an engineered source and supply of nutrients offered the most effective approach for the detoxification and closure of the heap. This process involves the application of a supply of nutrients consisting of sugars, alcohols, fats and proteins to the heap. These nutrients are continually supplied to the recirculating heap solution until a pre-determined amount of nutrient addition has been satisfied. The existing bacteria already present in the process solution and spent ore utilize the nutrients supplied to promote the reduction of cyanide and metal cyanide compounds through bacteria reduction processes.

Viceroy has decided to implement the Green World Science (GWS) process. This process involves the in situ creation of hydride hydrogen on a NAD+ carrier (NADH) and its release into a subsurface environment to transform species using reduction reactions. The NADH is formed by carbon-source oxidation. The carbon source is typically a sugar or sugar/alcohol mixture. In this case, molasses concentrate-based sugar syrup is proposed. The typical process of removal is as follows:

- Oxygen reduction to water;
- reductive attach on metal cyanide precipitates closely coupled to the reduction of nitrogen species;
- reduction of metals to elemental states and (usually); and
- sulphate reduction and dissolution of the elemental metals into a sulphide or sulphur phase.

Viceroy provided the results of column tests to demonstrate the effectiveness of this proposed technology. Details of these column tests are provided in Section 4 of this CSR, Alternative Means. Further test results were forwarded to DIAND on 14 February 2002 as a response document to concerns raised during the RERC review of the DRP.

During the RERC technical review of the DRP, some concern regarding the effectiveness of the proposed in-situ detoxification of the heap was raised and conveyed to Viceroy; these included concerns regarding the use of this technology in a northern environment and a lack of clarity on the actual attenuation mechanisms. On 14 February 2002, Viceroy provided clarification on their understanding of the attenuation mechanisms that would detoxify the heap. The addition of cyanide for gold recovery ceased in early December, 2001. By January 2002, the level of cyanide in the Brewery Creek system was approximately 4-ppm as opposed to the 30-ppm that the column tests were based on.

Viceroy is proposing a heap detoxification standard and sampling protocol for the demonstration of successful detoxification and long term chemical stability. This program consists of a solids sampling program consisting of a pattern of holds drilled across the leach pad, within 5 meters of the liner. Viceroy proposes that this sampling program will demonstrate that the driving force for metals release and remobilization is no longer available through the analysis of reactive free cyanide. As well, to demonstrate the long term stability of metals within the heap, a SWEP test (Solid Waste Extraction Procedure) will be conducted on composite samples from each hole.

Viceroy eventually plans to cut a notch through the heap containment dike near the location of the overflow pipes in the southwest corner of the heap. The notch will be 1-2 m wide at the base of the cut, extending down through the liner system to provide gravity drainage from the heap. An analysis of the stability of the breach was provided in the DRP Vol. IV.

Heap Cover and Revegetation

The purpose of a heap cover is twofold: To reduce the infiltration rate of meteoric water passing through the spent ore thereby minimizing the requirement for secondary passive treatment; and to restore the natural capacity for revegetation.

Regrading of the heap began in 1999 as an ongoing process to maximize gold recovery; the majority of the heap has been resloped and recontoured to date. Flat surfaces will be slightly graded to shed water, hollows filled in, edges resloped and a diversion ditch constructed around the outside edge of the heap to capture and redirect surface water drainage.

Viceroy proposes to revegetate the heap using the current LAQM material plus the addition of growth media to ensure successful revegetation. The proposal is to avoid the placement of a compacted layer on the heap and instead selectively distribute stockpiled growth media to the heap and seed the existing heap thereby producing a store and release cover. The results of field and test work completed by BGC Engineering were provided for the proposed store and release cover. Viceroy estimates that the proposed LAQM material on the heap along with a revegetated surface will achieve a 24% infiltration rate. For revegetation, Viceroy is proposing a modified seed mixture for the heap cover, utilizing plant species that maximize water uptake through evapotranspiration. The proposed seed mixture is: 50% Violet Wheatgrass; 20% Kentucky Bluegrass; 20% Red Fescue; and 10% Alfalfa.

Status of Heap Effluent to date

During the summer of 2002, Viceroy implemented the biological treatment of the heap. Approximately 86,000 kg of molasses concentrate-based sugar syrup was added over a period of 5 weeks, along with 31,000 kg of phosphoric acid. Both reagents were added to the barren and intermediate pump intakes and evenly distributed over the leach pad. Viceroy's DRP Vol. IV document elaborated on progress made on heap detoxification to late 2002. By July 2003, the heap effluent had improved considerably, with the exception of selenium.

Secondary Effluent Treatment Processes

Viceroy has proposed the construction of a biological treatment cell (BTC) as a means of treating heap effluent should it not meet surface discharge criteria in the long term. A BTC is an anaerobic cell constructed within a lined facility and promotes reduction of cyanide and metal cyanide compounds through a sulphide reducing environment. A nutrient solution is added to the heap effluent solution prior to entering the BTC. Viceroy conducted a BTC test program on site and determined that this method would be effective; results are provided in appendix B of the DRP.

In the 14 February 2002 response document, The exact purpose of the BTC was clarified in that it is intended to be a short term contingency while heap effluent improves, it is not intended to be a long term passive water treatment system. Viceroy offered to alter their original planned location for the BTC in response to RERC concerns.

Due to issues raised by some technical reviewers during the RERC review of the DRP, Viceroy amended their proposed BTC location. They now plan to locate it up gradient of the existing process ponds so that the treated effluent could be captured and analysed prior to final release. This builds an additional level of contingency into the BTC system because the process facility has the capability of evaporating 100% of the expected annual heap drainage volume of 25,000m^3 after the installation of the heap cover. Viceroy committed to maintaining the 3 process ponds and the evaporative unit in place until the heap effluent reaches discharge quality standards for a sufficient period of time to demonstrate that the heap has been fully detoxified.

In the event that BTC output does not meet water quality criteria for discharge, Viceroy proposed the following contingencies in their 14 February 2002 response document:

1. Treatment and land application;
2. capture of BTC effluent and re-treatment through BTC;

3. pump-back to process ponds;
4. pump-back to heap; and
5. intensive evaporation.

Viceroy identified the specific proposed location of the BTC as being placed within one of the effluent treatment land application metals precipitation ponds.

The BTC facility would be engineered to operate between April 15 and Nov. 01, designed to accommodate average precipitation conditions and a 100 year snowpack melt.

3.1.8 Selenium

In February 2003, Viceroy submitted a site-specific selenium report to the RA, proposing the development of a surface release criteria based on site specific receiving water quality criterion.

This report proposed lowering the discharge for selenium from the current 0.05 mg/l to 0.25 mg/l as the end of pipe standard. The report offered technical justification for the proposed criteria based on previously accepted models and approaches. Viceroy proposed a one-time discharge of 100,000 m^3 of stored process solution and an ongoing annual discharge of 25,000 m^3 into Laura Creek based on the proposed new site specific selenium criteria.

The previous water licence limited the selenium concentration to 0.05 mg/l and a minimum dilution factor of 1:1 in Laura Creek for a maximum volume of 200,000 m^3/year; this maximum translates into 10kg of selenium discharge per year into receiving surface waters. The one time proposed release of 100,000 m^3 of stored 0.25 mg/l selenium process solution would represent a release of 25 kg of selenium into Laura Creek and an ongoing release of 25,000 m^3 annually would result in a release of 6.25 kg/year of selenium.

Viceroy's site specific proposal employed a 'Canton and vanDerveer ' selenium regression equation as was accepted for the Kudz Ze Kayah project. This modelling incorporated selenium and total organic carbon (TOC) values from Laura Creek and the South Klondike River. The overall TOC used in the determination was 1.5%. A site specific in-stream selenium criterion of 3.8 ug/l was developed for the South Klondike River based on this methodology. (Viceroy, 2003).

This proposal and an evaluation of its environmental effects are discussed in detail in s.8.1.1.4 of this CSR.

4. Project Alternatives

4.1 Alternative Means of Carrying out the Project

"Alternative means" of carrying out the project are methods, activities, facilities, practices, designs, etc. of a similar technical character or are functionally the same. Alternative means also includes alternative methods for construction, operation and mitigation. Alternative means that are economically and technically feasible must be considered in a comprehensive study.

For the purpose of evaluating the environmental effects of the DPR, nine separate activities associated with this project have been identified:

1. Heap detoxification;
2. Draindown, treatment and discharge;
3. Long term treatment and discharge;
4. Heap cover;
5. ARD management;
6. Waste rock storage areas;
7. Pit reclamation;
8. Roads; and
9. Monitoring and mitigation.

Alternative means have been considered, focussing on the heap detoxification. Alternative means of decommissioning the mine, plant and infrastructure were not examined in detail. The RA considers these components of the project, such as road reclamation and pit erosion control, as standard land use practices.

The proponent evaluated and rated the following seven (7) different methodologies for heap detoxification processes based on eleven separate technology features:

1. No heap treatment;
2. Fresh water rinse;
3. Natural degradation
4. Chemical treatment using hydrogen peroxide;
5. Chemical treatment using alkaline chlorination;
6. Biological treatment using continuous bio-reactors (RBC); and,
7. Biological treatment using Green World Science nutrient technology.

Each technology feature was rated on a scale of 0 to 10 based on its application at Brewery Creek. A score of 0 was highly negative and a score of 10 was highly favourable. The ranking system also incorporated the site specific conditions of Brewery

Creek. When there was no information available for a particular technology or parameter, no score was given. The total score for each technology did not include categories for which no score was given. The technology features evaluated were:

- Demonstrated technology within the industry;
- successfully demonstrated with actual BCM solution/spent ore;
- deleterious by-products;
- demonstrated at cold weather sites;
- effectiveness on selenium reduction;
- effectiveness on ammonia reduction;
- site-specific Brewery Creek concerns;
- time required to implement;
- Cost effectiveness;
- technical and operating expertise to implement; and
- employee safety concerns

The following provides a summary of the seven methodologies evaluated by Viceroy. Additional background information has been added where applicable. As well, where applicable, results of bench scale test and column tests are included.

No Heap Treatment

Not treating the heap at all is a technology that has been demonstrated at one known large-scale heap in the industry. Although no chemical, biological or active means of treating and reducing the cyanide and metal compounds in the heap is employed, a storage and release soil cover system is constructed over the heap to essentially eliminate any precipitation and meteoric water from infiltrating through the heap. This technology is a very site-specific application and approach. In addition, it requires that an existing mining and processing operation continues at the site and any residual solution that infiltrates through the storage and release cover can be directed into the existing process stream. Low precipitation, high evaporation rates and significant depth to groundwater are all contributing factors to successfully applying this technology. Due to these reasons, Viceroy did not pursue this option during the closure plan preparation.

Fresh Water Rinse

One of the traditional approaches to heap closure is the rinsing of heaps with several pore volumes of fresh or treated water. The rinse water is often treated and recirculated until the appropriate water quality criteria are met. The use of this method of heap detoxification at various sites indicates that while cyanide and pH standards can be met, those for metals and other compounds such as ammonia cannot be achieved.

Rinsing cyanide and metal compounds from the spent ore through continuous addition of fresh water has been applied at heap leach operations, primarily located in higher evaporation and drier climates. The approach is to flush all contaminants from the heap until established effluent discharge standards are met. This technology, although seemingly simplistic and attractive, has a number of significant obstacles that make it impractical at Brewery Creek. Rinsing of the spent heap with fresh water until compliance standards are met can take several years. Large quantities of water would be generated that would require additional treatment and/or land application to meet desired criteria. The primary concern at Brewery Creek is the fact that the effluent solution during the rinsing phase would not meet discharge standards and would require further treatment and land application. At a solution application ratio of 1.25 tonnes of solution to 1 tonne of spent ore, approximately 11,800,000 m^3 of fresh water would be required to rinse the heap. The effluent from the heap resulting from fresh water rinsing would not meet discharge standards, particularly for selenium.

Natural Degradation

Natural degradation is a term for all of the processes that may reduce the levels of cyanide in solution or a heap without any human intervention. These processes include:

- Microbial degradation;
- volatilization;
- hydrolysis;
- anaerobic biodegradation; and
- complexation.

For the purpose of heap detoxification, natural degradation relies on continued recirculation of process solution throughout the heap and then natural destruction of cyanide through processes such as microbial degradation, volatilization and photodegradation. The efficiency of cyanide degradation can tend to be lower in the interior of the heap. Given the reliance of this method of detoxification on natural processes, the time frame required for detoxification is variable. It is highly dependent on the site specific environmental conditions such as temperature and UV exposure. Cold weather can impact natural treatment methods, with reduced rates of degradation in the winter months. The process is essentially similar to chemical treatment using hydrogen peroxide with the exception that the cyanide destruction is through natural degradation rather than active chemical processes. While this process may prove effective on the reduction of cyanide levels in the heap, it is not as effective on the removal of other parameters such as metals and ammonia.

This process was tested at the Brewery Creek operation as one of the large-scale column sets. Testing of this process also provided the baseline performance upon which other technologies such as hydrogen peroxide and in-situ treatment are compared. The process required longer recirculation times than peroxide to achieve the same baseline effluent cyanide levels. In addition, the target of 0.25 ppm WAD cyanide was difficult to achieve and natural degradation does not destruct stronger cyanide bonds such as iron and cobalt. In addition, there is no reduction of metals such as selenium or arsenic. The time to achieve the WAD CN target for natural degradation was longer than peroxide and there were no apparent advantages of natural degradation over hydrogen peroxide. No further consideration has been given to natural degradation as a detoxification technology.

Chemical Treatment (Hydrogen Peroxide)

This method of cyanide destruction is the most common and well understood technology used in the mining industry. The cyanide in solution is oxidized using hydrogen peroxide (H_2O_2). The cyanate ion formed then hydrolyses to form ammonia and carbonate. Copper ions can be used as a catalyst for this process. This treatment method is used for cyanide destruction, and does not deal effectively with metals, although there may be some metals removal through hydroxide precipitation when the pH is controlled through the addition of lime. As well, with ammonia being a by-product of these reactions, ammonia removal is generally minimal.

The hydrogen peroxide process is effective for the oxidation of free and WAD cyanides, and iron cyanides are removed through precipitation of insoluble copper-iron-cyanide complexes. The reaction is typically carried out at pH of 9.0 to 9.5 for optimal removal of cyanide and metals such as copper, nickel and zinc. Metals previously complexed with cyanide (copper, nickel and zinc) precipitate as metal hydroxide compounds.

A number of heaps in the industry have been detoxified through chemical means such as cyanide destruction using hydrogen peroxide. Hydrogen peroxide was one of the treatment technologies that Viceroy considered and tested in its large-scale program in 2001. As part of this technology category, other similar chemical treatments such as the Inco/SO_2 cyanide destruction process and Caro's acid (H_2SO_5) can be included in this general chemical treatment category. The Inco/SO_2 technology has been successfully used in the industry for cyanide destruction, primarily in CIP/CIL slurries, Merrill-Crowe bleed streams and tailings pond water. Caro's acid has also been used for cyanide destruction but again is primarily used for cyanide destruction of pulp slurries in a milling flowsheet. The same technical issues that are raised with hydrogen peroxide are generally included with these other chemical treatment technologies.

Hydrogen peroxide offers the advantage of immediate cyanide destruction of the heap effluent solution prior to recirculation back to the heap. Cyanide is continually flushed from the spent ore and then chemical destruction of cyanide occurs in one of the process ponds. In the case of peroxide, approximately 1.1 tonne of solution per tonne of ore was required to flush the cyanide in the column effluent and achieve the target of 0.25 ppm WAD CN. However for the case of hydrogen peroxide, cyanide destruction is not the major obstacle to overcome. Hydrogen peroxide is not a viable treatment technology for selenium and ammonia.

As part of their Effluent Treatment and Land Application project, Viceroy had International Metallurgical and Environmental Inc. complete an evaluation of the effectiveness of hydrogen peroxide on cyanide detoxification. The effectiveness of this treatment method on reducing other contaminants such as metals was given a cursory review. They evaluated this technology both with and without the use of a copper catalyst. The conclusions of this evaluation were:

- Hydrogen peroxide was successful in significantly reducing concentrations of total and WAD cyanide;
- the addition of copper as a catalyst did not effectively improve the effectiveness of this treatment; and
- increases in concentrations of ammonia, nitrate and nitrite.

Test work carried out by Process Research Associates (PRA) confirmed these findings for hydrogen peroxide treatment. Although, an effective treatment for the reduction of cyanide, ammonia levels in the treated effluent significantly exceed discharge criteria. PRA evaluated three methods for reducing ammonia levels: activated carbon, zeolite and air stripping. None of which were effective at reducing ammonia to discharge levels. The treated effluent was also found to contain concentrations of cyanate, thiocyanate, nitrate and nitrite at concentrations that PRA felt were sufficient to result in a toxic effluent on the basis of a LC50 test. Hydrogen peroxide treatment was also investigated by Viceroy in their large scale column tests. Although effective at reducing cyanide, high levels of ammonia remained in the heap effluent after treatment.

Viceroy also tested a number of chemical post-treatment processes for meeting discharge standards for selenium and ammonia. Detailed results of these testing programs were included in the Effluent Treatment and Land Application Permit. These technologies included hydrogen peroxide, alkaline chlorination, ferric sulfate, ferric chloride, barium sulfate, barium chloride, sodium sulfide and zeolite. None of these known technologies proved to be effective in reducing selenium and ammonia to discharge standards.

The proposal to use hydrogen peroxide as the detoxification technology would have posed the same obstacles in that selenium and ammonia standards could not have been achieved. Therefore, additional freshwater rinsing would have been required to supplement the chemical process and the same concerns over excessively high volumes of solution requiring land application would have resulted. Short of significant volumes of solution being land applied, the direct surface water standards for selenium and ammonia would have to be changed to accommodate the values achieved in the chemical process.

Due to these obstacles, Viceroy decided that hydrogen peroxide was not the most viable approach for heap detoxification since it had been demonstrated that selenium and ammonia standards could not be achieved with this technology and significant land application volumes would be required in order to approach acceptable heap effluent standards.

Chemical Treatment (Alkaline Chlorination)

Alkaline chlorination is one of the oldest cyanide destruction methods. The cyanide in solution is oxidized to cyanate using chlorine or hypochlorite. Draindown is reacted with chlorine or hypochlorite and the pH is maintained in the alkaline range through the addition of lime. Metals removal is achieved through precipitation. Ammonia can also be removed through the use of breakthrough chlorination. In this case, excess chlorine is available and ammonia in solution is fully oxidized to nitrogen gas. Limitations of this process are that it is not effective in the removal of iron cyanide complexes and chloramines and free chlorine remain in solution, both of which are toxic to fish.

This process can be expensive to operate due to high reagent use. The process is effective for the removal of free and WAD cyanide but to a lesser extent iron cyanides. Upon completion of the cyanide oxidation reaction, metals are precipitated as metal-hydroxide compounds.

Alkaline chlorination is essentially the same treatment technology as hydrogen peroxide. Chemical means are used to destruct cyanide prior to recirculation back to the heap for continued flushing. The only difference is the use of chlorine to destruct cyanide rather than hydrogen peroxide. Alkaline chlorination does provide the ability to reduce ammonia through breakthrough conditions. Essentially, excessive chlorine is added and ammonia is reduced. Significant concerns arise with the use of breakthrough chlorination due to residual chlorine being a byproduct of the reaction. Residual chlorine is toxic to aquatic life and would become a concern in direct surface water discharge. In addition, the same issues arise with the inability to treat for selenium.

Viceroy investigated the effectiveness of alkaline chlorination for cyanide destruction and ammonia removal combined with metals removal using carbon polishing, ferric sulphate, ferric chloride, sodium sulphide, barium chloride and barium sulphate. Alkaline chlorination was found to be effective in reducing cyanide and ammonia, although the presence of residual chlorine may result in toxic effects. Most metals were reduced to acceptable levels using alkaline chlorination alone and the use of carbon polishing was relatively ineffective. None of the evaluated metals precipitation methods were successful in reducing selenium to target concentrations.

Overall, alkaline chlorination would again rely heavily on land application to meet heap effluent standards. Due to these reasons, alkaline chlorination was not further pursued.

Biological treatment using continuous bio-reactors (RBC)

A variety of biological treatment methods have been used for the treatment of mine wastes. One example is the very successful “Homestake” process in which an aerobic attached growth biological treatment system is used to remove cyanide, thiocyanate, cyanate, ammonia and metals for solution (US EPA, 1994). Other systems utilize a suspended sludge system with both aerobic and anaerobic treatment to remove cyanide, ammonia, nitrate and metals. The applicability of these systems is primarily in situations where there are continuous solution flows with temperatures above about 10ºC.

Microbial action can convert cyanide to ammonia. Metals in solution are absorbed by the biomass and thiocyanates are converted to sulfate. Furthermore, under aerobic conditions, bacteria will convert ammonia to nitrate. This nitrate can be further converted to nitrogen gas under anaerobic conditions. Treatment using continuous biological treatment (i.e. "Homestake" process) was considered as both a treatment process for solution release as well as a detoxification technology. This technology relies on continuous growth and propagation of bacteria which are added to the process stream for cyanide and metals destruction. A laboratory test program was conducted by Microbial Technologies as part of the Yukon Mining Environment Research Group (MERG) program.

Continuous biological-reactor processes such as the one proposed by Microbial Technologies (and other companies in the industry) are substantially different than the technology patented by Green World Science discussed below. Rotating biological contactors (RBCs) are used to treat the water which has had nutrients added. When the disks in the RBC are rotated out of the tank, the biological growth attached to the media is exposed to air. The biomass consumes nutrients in solution and converts cyanide to ammonia. Continuous biological-reactor systems require significant growth of new bacteria and constant addition of bacteria to achieve reductions for cyanide and other parameters. In some instances, biological reactors have been used to treat water being recirculated through heaps as part of the detoxification process.

As part of the Effluent Treatment and Land Application project, Process Research Associates (PRA) evaluated the use of biological detoxification for the treatment of Brewery Creek heap effluent. Nitrification under aerobic conditions could reduce cyanide and ammonia level to below discharge criteria. Coupled with this reduction, was an increase in nitrite and nitrate concentrations sufficient to fail an LC50. Anaerobic denitrification was effective in reducing nitrite and nitrate concentrations. As well, after denitrification, metal concentrations in the final effluent met discharge criteria with the exception of selenium.

The company is not aware of any large-scale application where this technology has been applied in similar site specific conditions as Brewery Creek. It was Viceroy's decision that there were not sufficient large-scale examples of this technology to warrant its consideration at Brewery Creek. Concerns over temperature and application in the north are much more warranted with this type of biological technology. Although the company obviously has considerable faith in biological processes, the use of technologies such as proposed by Microbial Technologies would require significantly more time in terms of research and development before it could become a viable detoxification process for Brewery Creek.

Biological Treatment using Green World Science Nutrient Technology

The technology patented by Green World Science uses existing strains and population of bacteria already present in the solution and spent ore and provides nutrients in the form of alcohols, sugars, fatty acids and proteins to immobilize cyanide and metals in the spent ore from further transport and release from meteoric water. This process is not a degradation process but utilizes the ADTP cycle, an internal cellular metabolic process. This process was tested as one of the large-scale column programs, along with natural degradation and hydrogen peroxide. By analyzing the pore water that is flushed after treatment, the testwork demonstrated that the effluent from the treated spent ore was of significantly better water quality than the other processes investigated. In addition, no deleterious by-products are produced. Most significantly, in-situ nutrient treatment offered the best selenium reduction of any of the processes investigated and requires the least amount of solution to be land applied.

Technology Rating and Alternative Selection

Table 4.1 summarizes the technology rating system used by Viceroy. A brief note on the primary reason for each category score is given. Viceroy then used the total percentage calculated for each technology is used as the basis for selecting the detoxification technology.

Of the processes evaluated by Viceroy, those based on biological processes were generally found to be the most effective at removing the majority of the contaminants of concern: specifically cyanide, ammonia and metals. As well, these biologically based technologies offered the best selenium reduction.

Viceroy’s selection of the preferred alternative of in-situ treatment was based primarily on the result from comparative column tests in which a moderately better effluent quality was attained through in-situ treatment.

The RA conducted this environmental assessment based on Viceroy’s choice of the Green World Science technology for heap detoxification.

4.2 Alternatives to the Project

"Alternatives to" the project are functionally different ways of achieving the same end. Consideration of alternatives to the project is discretionary on the part of the RA in the preparation of a CSR; it is the RA's discretion not to consider alternatives to this project.

Brewery Creek Mine
Heap Detoxification Technology Comparison
Table 4.1

	Heap Detoxification Technology													
Process Consideration	**No Heap Treatment**	**Score**	**Fresh Water Rinse**	**Score**	**Natural Degradation**	**Score**	**Peroxide**	**Score**	**Alkaline Chlorination**	**Score**	**Continous Bio-reactors**	**Score**	**GWS Nutrient Technology**	**Score**
Demonstrated technology within the industry	Only 1 large scale site currently known	3	Yes, primarily in desert sites with high evaporation rates	4	Yes, primarily in warm, low precip conditions and operations	5	Yes, primary heap detoxification technology used	9	Yes, but mainly for water treatment and less for heap detoxification	5	Yes, but mainly for long-term water treatment and not heap detoxification	5	Approximatley 100,000,000 tonnes treated in industry	7
Successfully demonstrated with actual BCM solution/spent ore	Not tested	NA	Not tested	NA	Demonstrated in large-scale column tests at BCM	6	Demonstrated in large-scale column tests at BCM	7	Conducted bench scale tests at independent lab. Specific to water treatment, not detox	5	Conducted bench scale tests at independent lab. Specific to water treatment, not detox	4	Demonstrated in large-scale column tests at BCM	8
Deleterious by-products	No effect on cyanide metals	2	No	7	Yes, no effect on metals	3	Increased nitrate leads to increased ammonia	5	Residual chlorine, chloramines Very toxic to aquatic life	3	Increase in nitrate due to nitrification of cyanide, thio	5	No deleterious by-products from known sites	8
Demonstrated at cold weather sites	No	0	No	3	No	3	Yes: South Dakota Northern Nevada	8	Not aware of any sites, however not sufficient information to determine	NA	South Dakota, however is not a heap leach site, continuous warm water treatment, indoors	5	Yes: Northern Idaho Nevada	8
Effectiveness on Selenium reduction	Not effective	2	Ultimately reduce Se through flushing/dilution	7	Not effective on Se reduction	3	Not effective on Se reduction	5	Not effective on Se reduction	5	Not enough information to verify	NA	Effective on Se reduction by over 70%	8
Effectiveness on Cyanide reduction	Not effective	2	Ultimately reduce CN through flushing/dilution	7	CN reduction requires long-term solution recirculation	5	Effective on CN destruction	8	Effective on CN destruction	8	Effective on CN destruction higher CN feed may be detrimental	6	Effective on CN destruction	8
Effectiveness on Ammonia reduction	Not effective	2	Ultimately reduce NH3 through flushing/dilution	7	Not effective on NH3 reduction	5	Not effective on NH3 reduction	5	Can be effective on NH3 reduction by breakthrough chlorination, risk to high Cl	6	Can generate NH3 depending on specific aerobic/anerobic conditions	6	Reduces NH3 from long-term release	7
Site specific Brewery Creek concerns	Precipitation too high, no active processing facilities	2	Excessive amount of solution to land apply, significant water management/availability concerns	2	Higher effluent levels to treat, more risk for treatment failure	4	Does not treat for selenium or ammonia	6	Does not treat for selenium	6	Concerns over application in northern conditions, no known cold weather sites	4	Concerns over application in northern conditions	7
Time required to implement (months)	No treatment period	NA	24-36 months to implement 6-8 months for final results	6	24-30 months to implement 6-8 months for final results	5	18-24 months to implement 6-8 months for final results	6	18-24 months to implement 6-8 months for final results	6	18-24 months to implement 6-8 months for final results	6	4 months to implement 6-8 months for final results	7
Cost Effectiveness ($/tonne)	Cost related to construction of soil cover system to eliminate infiltration	5	Additional manpower and electrical power costs due to time of recirculation	7	Additional manpower and electrical power costs due to time of recirculation	6	Additional costs of H2O2, equipment and manpower, power	6	Costs of chlorine prohibitive especially if operated at breakthrough conditions	5	Excessive high costs for engineering, construction operation of RBC.	4	Additional costs related to nutrients	8
Technical and operating expertise to implement	Additional soil cover modeling to construct no infiltration cover	8	No additional expertise or technical assistance required	8	No additional expertise or technical assistance required	7	No additional expertise required technical assistance required for chemistry oversight	7	Close process monitoring required, more prone to upset conditions	5	Most technically challenging No Viceroy personnel with experience	4	Simple technology to apply. No additional process requirements	7
Employee safety concerns	No	8	No	8	No	8	Increased hazard to employees	6	Increased hazard to employees	6	No identified additional hazards	8	No additional hazards	8
Total Score Total Possible Score Percent Overall Ranking		34 110 30.9% 7		66 120 55.0% 3		60 130 46.2% 6		78 130 60.0% 2		60 120 50.0% 4		57 120 47.5% 5		91 130 70.0% 1

Possible Score of 0-10 for each process category
Score of 0 is highly negative to BCM and 10 is highly favorable to BCM
NA is category is not applicable to the technology, does not effect overall rating percentage

5. Scope of the Assessment

5.1 Scope of the Project

The scope of the decommissioning, reclamation and abandonment of the Brewery Creek Mine and associated infrastructure for the purposes of this CSR includes the physical works and undertakings in relation to the project as outlined in the September 2001 DRP, addendums and subsequent correspondence between the proponent and the RA. The physical works and undertakings required to successfully decommission and reclaim the mine are in relation to the following components:

- Heap leach pad and associated facilities;
- ADR plant and associated facilities;
- proposed heap detoxification and reclamation;
- proposed water treatment and disposal facilities (excluding the proposed infiltration gallery);
- solution storage ponds;
- remaining infrastructure including buildings, fuel storage areas and maintenance facilities;
- water supply facilities;
- mine pits (Pacific, Blue, Moosehead, Canadian, Lower Fosters, Upper Fosters, Kokanee, Golden and Lucky deposits);
- waste rock disposal areas; and
- the access road from the Klondike Ditch Road to the mine site and haul roads to mining areas.

The infiltration gallery as proposed by the proponent in their DRP and subsequent addendums has been excluded from the scope of the project for the purposes of this assessment. The RA requested additional information in order to assess the hydrogeological feasibility of this proposal, ground sratigraphy, infiltration rates and storativity; this information was not provided. The RA was unable to assess the feasibility of, and the environmental effects of the infiltration gallery based on the information provided and have therefore excluded it from the scope of the project for the purposes of this CSR.

The scope of this project includes routine maintenance and minor modifications to the proposed project in accordance with regulatory requirements in effect at the time. Minor modifications cannot increase the temporal or geographic scope of the project or effects, as defined in this CSR.

5.2 Factors to be Considered

Section 12(1) of the EAA requires that the assessment consider the following factors:

1. Environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects.
2. The significance of the effects.
3. Public comments.
4. Mitigation measures.
5. Purpose of the project.
6. Alternative means of carrying out the project.
7. The requirements of a follow-up program.
8. Sustainability of renewable resources.
9. Any matter the Minister or Responsible Authority may require to be considered, including need for and alternatives to the project, that the responsible authority may require to be considered.

With respect to item 9, there were no other matters that the RA required to be considered as part of this assessment.

5.3 Scope of the Assessment

The Brewery Creek Mine has been constructed and operated; the decommissioning and reclamation phase of the mine life is underway.

Previous screenings, Viceroy's DRP and subsequent addendums provided the basis of information by which this CSR was conducted. By evaluating previous screenings, the RA was able to compile a list of Valued Ecosystem and Cultural Components (VECCs) in order to accurately focus the evaluation of environmental effects on tangible values in the project area.

The VECCs identified are:

- Water quality and aquatic habitat;
- soils and terrestrial biota;
- traditional/heritage resources; and
- recreation

Furthermore, consideration was also given to the following other factors:

- Effects of environmental changes on human health;
- effects of environmental changes on socio-economic conditions;
- effects of environmental changes on physical and cultural heritage;
- effects of environmental changes on current and future use of lands and resources for traditional purposes by aboriginal persons;

- cumulative environmental effects;
- effects of possible malfunctions or accidents;
- effects on sustainable use of renewable resources;
- effects of the environment on the project;
- mitigation measures;
- the significance of the effects; and
- the requirements of a follow-up program.

5.3.1 Temporal Scope of Assessment

It is unknown exactly how much time will elapse after the implementation of the decommissioning and reclamation activities subject to this CSR to the point that they reach the criteria that will be established in regulatory authorizations relating to discharge standards and determination of long term physical and chemical stability. In recognition of this uncertainty, the temporal scope of this CSR is not based on a definitive period of time but on the time that it takes for the decommissioning and reclamation objectives to achieve the standards that will be specified in the Water Licence and possibly the Quartz Mine Production Licence.

Regulatory bodies may require that some mine components be monitored for an extended period of time, possibly beyond the timeframes that Viceroy has outlined in their DRP; this possibility is within the scope of this CSR.

5.3.2 Spatial Scope of Assessment

For the purposes of evaluating the effects on water and aquatic ecosystems as a result of this project, the RA adopted a spatial scope that encompasses the surface and groundwaters of Lee Creek, Golden Creek and Laura Creek watersheds to the confluence of the South Klondike River including the drainage between these streams along the South Klondike River and the surface water within the Klondike River downstream of the mine. The RA further includes the area along the Ditch Road and mine access road from the Dempster Highway. This spatial area is a logical choice as it includes all the watersheds and access corridors that may be affected by this project.

For the purposes of this CSR, the effects on land and terrestrial ecosystems arising from this project were considered to encompass the Lee Creek, Golden Creek and Laura Creek watershed areas; this spatial area is extended to include receptor organisms interacting with the project activities (ie: ‘home range’ for terrestrial wildlife species).

5.3.3 Scope of Cumulative Effects Assessment

The cumulative effects assessment considers the effects of this project in combination with the effects of past, existing and proposed projects and activities; these may include, but are not limited to mining, exploration, forestry, transportation, wildlife harvest and recreational activities.

For the purposes of the Cumulative Effects Assessment for this project, the RA included the full North and South Klondike River watersheds to their confluence to encompass any upstream environmental effects that may contribute to cumulative effects when combined with the Brewery Creek decommissioning project. This spatial area is extended to include receptor organisms interacting with the project activities (ie: 'home range' for terrestrial wildlife species).

5.3.4 Factors Not Within the Scope of this Assessment

The scope of this project and assessment is limited to the physical works and activities required to decommission, reclaim and abandon the Brewery Creek Mine. This does not include physical works and undertakings required to accommodate future mine or exploration developments in the Brewery Creek area should gold prices improve and Viceroy or another proponent wish to resume mining and processing within the Brewery Creek area.

6. Public Consultation Program

The draft Comprehensive Study Report document was broadly distributed to government and non-government agencies for comment. (See Appendix 2 for Brewery Creek distribution list).

The Environmental Assessment Unit broadly distributes a Quarterly Public Bulletin which contains summaries of environmental assessments and provides contact information if anyone has any questions. The environmental assessment of the Brewery Creek Project was included in previous bulletins, however there were no public inquiries regarding the project or the assessment.

The Environment Directorate maintains a Public Registry of the relevant documents for major environmental assessments including the Brewery Creek Project. The public can review the documents on file during regular business hours. No comments from the public were submitted in regards to documents on the Public Registry.

Interested members of RERC reviewed and commented on the initial draft report. The EAA Branch then offered the draft CSR to the public for review with a 30 day period in which to comment, between 21 June and 22 July 2003. No comments were received during this public review. The draft CSR was then referred back to the RA by the EAA Branch. A finalized version of this CSR will be forwarded to the Minister (or designate) of the Executive Council Office for authorization.

7. Description of the Exiting Environment

7.1 General Regional Environmental Context

The project lies within the Mackenzie Mountains ecoregion, but many of the effects may occur in the Yukon Plateau North ecoregion. General descriptions of both ecoregions are provided below.

Mackenzie Mountains

This extremely rugged, heterogeneous mountainous ecoregion spans the Yukon–Northwest Territories border from Alaska to the Mackenzie Valley. It includes the Ogilvie and Wernecke mountains in its westernmost section, the Backbone Ranges in its interior, and the Canyon Ranges to the east. The eastern ranges of the Mackenzie Mountains that lie in the rain shadow of the higher Selwyn Mountains to the west are also included. The ecoregion shows evidence of localized alpine and valley glaciation.

The mean annual temperature for the area is approximately –5°C with a summer mean of 9°C and a winter mean of –19.5°C. Mean annual precipitation is highly variable with the highest amounts, greater than 600 mm, occurring in the southwest portion of the ecoregion. Moving west towards Alaska and the southern Ogilvies, precipitation drops to approximately 400 mm. Higher precipitation occurs at higher elevations.

The region is characterized by alpine tundra at upper elevations and subalpine open woodland vegetation at lower elevations. Alpine vegetation consists of lichens, mountain avens, intermediate to dwarf ericaceous shrubs, sedge, and cottongrass in wetter sites. Barren talus slopes are common. Subalpine vegetation consists of discontinuous open stands of stunted white spruce and occasional alpine fir in a matrix of willow, dwarf birch, and Labrador tea.

The Ogilvie Mountains, composed of Palaeozoic and Proterozoic sedimentary strata intruded by granitic stocks, reach 2134 m asl in elevation. The Wernecke Mountains are formed of phyllite and nearly horizontal carbonate rocks carved by glaciation. They are divided into several ranges by broad northwesterly-trending valleys.

Permafrost is continuous and of low ice content in most of the Yukon portion of the ecoregion. Permafrost is extensive but discontinuous with variable ice content in the Northwest Territories portion of the ecoregion. Alluvium, fluvioglacial deposits, and morainal veneers and blankets are dominant in the region. Rock outcrops are common at higher elevation. Turbic Cryosols with some Dystric Brunisols and Regosols occur on steeply sloping colluvium.

Characteristic wildlife includes caribou, grizzly and black bear, Dall's sheep, moose, beaver, fox, wolf, hare, raven, rock and willow ptarmigan, golden eagle, gyrfalcon, and waterfowl. These ranges support various forms of hunting and trapping, and contain considerable mineral potential, but for the most part the ecoregion is an isolated wilderness with little permanent human occupation. (Ecological Stratification Working Group, 1995).

Yukon Plateau–north

This ecoregion lies within the Stewart, Macmillan, and Pelly plateaus and the southern foothills of the Selwyn Mountains. The terrain includes rolling uplands, small mountain groups, and nearly level tablelands dissected by deeply cut, generally broad, U-shaped valleys. The Tintina Trench, a straight, steep-sided valley 5–22 km wide, traverses the ecoregion from southeast to northwest.

The mean annual temperature for the area is approximately –4°C with a summer mean of 10.5°C and a winter mean of –20°C. Mean annual precipitation ranges from 300 mm in the major valleys up to 600 mm in the mountains to the northeast.

Northern boreal forests exist at elevations up to 1500 m. White spruce in a matrix of dwarf willow, birch, ericaceous shrubs, and, occasionally, lodgepole pine forms extensive open forests, particularly in the northwestern portion of the ecoregion. Black spruce, scrub willow, birch, and mosses are found on poorly drained sites. Alpine fir and lodgepole pine occur in higher subalpine sections, whereas alpine vegetation consists of mountain avens, dwarf willow, birch, ericaceous shrubs, graminoid species, and mosses.

Extensive discontinuous permafrost with a medium ice content is widespread decreasing to sporadic discontinuous permafrost along the southwestern edge of the region. Turbic Cryosolic and Eutric Brunisolic soils predominate, and occasional pockets of Dystric Brunisols occur on coarse-textured morainal and fluvioglacial materials.

Characteristic wildlife includes caribou, grizzly and black bear, Dall's sheep, moose, beaver, fox, wolf, hare, raven, rock and willow ptarmigan, and golden eagle. Land uses reflect mining, recreation, hunting, and trapping values. (Ecological Stratification Working Group, 1995).

7.2 Description of Site Specific Environment

The Brewery Creek mine is located within the foothills of the Ogilvie Mountains along the northeastern boundary of the Tintina Trench. The elevation is about 700 m, with the lowest and highest elevations approximately 600 and 1,300 m respectively. These rolling hills have moderately incised drainages.

Mean daily temperatures at the mine site, based upon adjustment of long-term records from Dawson, range from -23.2°C in January to 16.4°C in July. On an annual basis, the mean temperature is estimated at -3.1°C.

Mean annual total precipitation at the site is estimated in the Updated Solution Management Plan (Viceroy, 2000) as 328.8 mm, with the highest mean precipitation in July (47.2 mm) and the lowest mean precipitation in April (8.2 mm). Annual runoff is approximately 214 mm.

Six vegetative community types are distinguished at the Brewery Creek site: riparian, black spruce, buck brush/ willow, mixed, aspen and sub-alpine. Permafrost is generally present in poorly drained areas hosting black spruce forests and moss ground cover, and occasionally in moderately drained areas with black spruce forests and mixed moss and lichen cover.

Han and Northern Tutchone people traditionally used the project area. The Han occupied the village of Nu-kla-ko near the mouth of the Klondike River. Specifically, Tr'on dek Hwech'in First Nation members routinely use the project area for hunting, trapping, fishing and other traditional and recreational pursuits. They are currently developing a retreat site on R-22A, accessed by the Klondike Ditch Road.

The Klondike River has been directly impacted by placer mining since 1896. In addition, the North Fork power plant was constructed on the Klondike River approximately 42 km from Dawson to provide power to placer operations. Facilities - including roads and diversion ditches - associated with the North Fork power plant are still part of the project area environment.

Heritage sites in the project area include the south fork diversion complex, the Lee Creek dam camp at the junction of Lee Creek and the diversion canal, and an unidentified cabin on Lee Creek.

Details about the environment at the Brewery Creek mine site are provided in the Brewery Creek Initial Environmental Evaluation (IEE) (SRK, 1994) submitted to the RERC by Loki Gold Corporation in August 1994.

7.3 Valued Ecosystem and Cultural Components in the Study Area

7.3.1 Water Resources and Aquatic Habitat

As noted in s.2.1 of this CSR, there are three stream systems within the Brewery Creek Mine area: Lee Creek, Laura Creek and Golden Creek. Mining activity was concentrated mainly in the Laura and Golden Creek catchments.

Viceroy's Environmental Assessment contained in Vol. I of the DRP described the local creeks and tributaries in relation to the location of mine facilities infrastructure.

Lee Creek is the most westerly and largest of the three creeks, contributing approximately nine times as much flow to the South Klondike River as Laura Creek and approximately three time that of Golden Creek. The Pacific Creek catchment drains to Lee Creek and receives some runoff from the northeast corner of the Moosehead Pit and waste rock dump, and from a portion of the site housing the camp, office, warehouse and equipment maintenance shop.

Laura Creek is the smallest of the three principal tributaries and flows via both subsurface and surface connections to the South Klondike River. The Blue, Pacific, Canadian and Foster pits and waste rock dumps are located within the Laura Creek catchment. The Moosehead Pit straddles the divide between the Pacific and Laura Creek catchments. Phases one to four of the Kokanee pits straddle the divide between the Laura and Golden Creek catchments. The Moosehead and Kokanee waste rock dumps are mainly within the Laura Creek catchment. The heap leach pad and associated infrastructure are located within the Carolyn Creek catchment which drains into Laura Creek.

Golden Creek and its tributary, Lucky Creek is the most easterly of the three main catchments. The Lucky and Golden pits and associated waste rock dumps are located entirely within the Lucky Creek catchment.

Fish species present in the Klondike River include chinook salmon, chum salmon, arctic grayling, round whitefish, burbot, inconnu, longnose sucker and slimy sculpin. During baseline studies, fish were found in Lee, Pacific and Golden Creeks. A Department of Fisheries and Oceans and Yukon Government study was carried out in 1994 and identified the presence of juvenile chinook salmon in Lee Creek upstream of the confluence of Pacific Creek.

7.3.2 Terrestrial Biota

Wildlife species identified or expected in the area include: moose, caribou, grizzly and black bear, beaver, lynx, marten, fox, mink, wolverine, wolf, squirrel, coyote, muskrat and otter. Identified or expected bird species include: spruce grouse, blue grouse, ruffed grouse, ptarmigan, sharptail grouse, waterfowl and raptors.

The Brewery Creek Mine is located on an active trapline (registered concession# 23). Lynx and marten are the primary species that are trapped on this line. Subsistence and recreational hunting and fishing are also prevalent in the project area.

Issues of aesthetics are within the category of terrestrial biota as this largely depends on the success of regeneration of vegetation.

7.3.3 Traditional/Heritage Resources

An historic resource assessment was completed as part of the initial mine development studies (Greer, 1994). A number of historic resources in the Brewery Creek area were identified; these included the Klondike South Fork Intake, North Fork Ditch, a camp on Lee Creek and a pre-contact site in the southeast corner of the Brewery Creek property.

The 1995 EARPGO screening recommended that known sites be avoided by mine developments, that the YTG Heritage Branch be notified if new sites are discovered and that a site impact assessment be conducted on the site in the southeast corner of the property prior to any development occurring nearby. This assessment took place and the archaeological site salvaged.

7.3.4 Recreation

The Klondike Ditch road corridor is frequently used for recreational activities. Cyclists, hikers off road vehicle users, berry pickers and recreational hunters and fishers frequent the area.

7.4 Relationships Between Environmental Components

There is a relationship between water quality and the health of aquatic ecosystems. Monitoring programs are in place that are intended to detect ecosystem level changes. Benthic monitoring for example, allows early detection of water quality changes because a change in species distribution or population density is an environmental indicator of changes in the water quality.

It is widely believed by the technical experts that assisted in this review that water is the most likely pathway via which contaminants of concern could spread to receptor organisms, including humans.

7.5 Sensitivity to Disturbance

There is some sensitivity to disturbance due to the project being located in the north. This is due to a slower growth and regeneration rate of vegetation. This in turn can extend the duration of the effects to wildlife that depend on the vegetation. However, the remoteness of the area and the lack of other disturbances to the vegetation once the project is reclaimed and abandoned provides for increased recovery potential.

There are no identified unique or rare natural features in this area (i.e. unique habitat, rare species, scarcity of a particular resource, etc.) requiring special consideration.

7.6 Potential Environmental Hazards

The Brewery Creek Mine facilities that may be affected by environmental hazards include the pits, leach pad (including cover), pond storage capacity and BTC.

Slumps, landslides, solifluction, avalanches and seismic event risks to the mine were evaluated in the IEE (SRK, 1994). At that time, it was concluded that the risks of slumps and landslides was minimal, but that some small scale slumping resulted from stream erosion; none of this was seen as affecting the mine project. It was further concluded that the risk of solifluction affecting the proposed development was determined to be minimal.

Energy Mines and Resources Canada, Geological Resources of Canada prepared a seismic risk calculation. Site acceleration and ground velocity for a 475 year return period earthquake were predicted. Historic records of earthquakes were searched to find the largest recorded earthquake in the study area. A 475 return period was utilized as the design event in the mine development.

It is the RAs position that these issues do not need to be revisited for the purposes of this project.

Extreme precipitation and snowpack events could detrimentally affect some components of this project. Excessive precipitation could erode the heap cover. Water balance issues were assessed during the initial EARPGO and subsequent CEAA screenings. Water balance was the focus of the CEAA screening for the Updated Solution Management Plan. The EARPGO and initial licence required that the facility be designed with sufficient storage capacity for the combined inputs from a 1:100 year snowmelt event and a full system drain down.

Wildfires are common in the mixed black spruce forests of the central Yukon. If a wildfire were to occur in the Brewery Creek vicinity, it is not anticipated that it would affect the mine infrastructure due to the considerable clearings on the site.

The RA has considered the effects of climate change on this project; this is summarized in s.8.3.3 of this report, Effects of the Environment on the Project.

8. Predicted Environmental Effects of the Project and Mitigation

8.1 Project Effects on Environmental Components

8.1.1 Water Quality and Aquatic Habitat

A surface water quality monitoring program has been in effect at the Brewery Creek Mine since mining operations commenced in 1996 and results have been provided annually in the proponent's water licence reports. The Environmental Assessment that Viceroy undertook while preparing their DRP is presented in s.9 of vol. I of the DRP; it focuses on downstream effects of the project on surface water quality and aquatic habitat.

Viceroy concluded that the data generated by their surface water-monitoring program suggests that there has been little change in the receiving water chemistry over the monitoring period. Average conditions were calculated from the monitoring results database. Viceroy then factored these values in a model to reflect the current background water quality conditions for Lee, Laura and Golden Creeks. Viceroy then conducted water quality modelling based on these current conditions as a means of estimating the predicted effects on receiving waters resulting from decommissioning and reclamation activities.

The RA's analysis of the current water quality at the site reveals that the mine development and operation has had some effect on water chemistry when compared to pre-mining conditions (based on the 1994 IEE (SRK, 1994)). This period was chosen to represent pre-mining conditions more accurately than the period that Viceroy used in DRP Vol. IV, 1991 – 1996. The construction of the mine began in August 1995, and according to a Water Resources Official, that despite the mine owners efforts there were significant releases in suspended sediment during 1995 and 1996. This could account for some of the elevated concentrations of contaminants during this period.

Based on the current site conditions presented in s. 9 of vol. I of the DRP, elevated concentrations of contaminants have been found in the receiving environment downstream of the mine site facilities. The Laura Creek valley, located downstream of the majority of the mining and processing facilities has been the most effected by the Brewery Creek Mine. Refer to Figure 3 for locations of key water quality monitoring stations. A comparison of pre-mining conditions and average conditions in Laura Creek during mine life (1996 – 2000) is presented in Table 8.1 and 8.2. From this it is evident that during the mine operation, various contaminants were elevated above pre-mine conditions, including aluminium, arsenic, copper, iron, mercury, manganese, and zinc. This data also indicates that there has been a noticeable improvement of water quality since the cessation of mining at the site.

Table 8.1

BC-32 Below Blue Pit Water Quality (mg/l)			
	Pre-Mine[1]	Mine Life[2]	Actual Post Mine[3]
Aluminum	0.027	3.61	1.23
Arsenic	0.0025	0.009	0.006
Copper	nd	0.003	0.002
Iron	0.33	0.8	0.42
mercury	0.0001	0.00008	0.00006
Manganese	0.006	0.06	0.07
Selenium	n/a	0.002	0.0022
Zinc	0.005	0.019	0.009
Sulphate	61	84.8	76.5
Ammonia	n/a	0.01	0.003

Notes:

1. Pre-mine data from Assessment Section of DRP Vol. I (1990 - 1994)
2. Mine Life data from DRP Vol. IV (1996 – 2000)
3. Actual data from DRP Vol. IV (2001-2002)

Table 8.2

BC-1 Laura Creek Upstream of Ditch Road Water Quality (mg/l)			
	Pre-Mine[1]	Mine Life[2]	Actual Post Mine[3]
Aluminum	0.13	0.56	0.18
Arsenic	0.003	0.021	0.011
Copper	0.003	0.013	0.004
Iron	0.18	5.37	1.28
mercury	0.00006	0.00014	0.00004
Manganese	0.011	0.14	0.09
Selenium	nd	0.0017	0.0015
Zinc	0.005	0.021	0.014
Sulphate	77	80.1	75.3
Ammonia			0.098

Notes:
1. Pre-mine data from Assessment Section of DRP Vol. I (1990-1993)
2. Mine Life data from DRP Vol. IV (1996 – 2000)
3. Actual data from DRP Vol. IV (2001-2002)

The two other catchments in the mine area are the Golden Creek catchment and Lee Creek catchement. The Golden Creek catchment receives loadings from Lucky, South Golden and Kokanee pits and waste rock storage areas. Based on data from BC-31 (Table 8.3), Golden Creek above the Klondike River, the mine has had some, although minimal impact on water quality. The Lee Creek catchment receives drainage from the Moosehead pit and waste rock storage. Base on data from BC-34 (Table 8.4), Lee Creek at Ditch Road, the presence of the mine operation has had some impact on the water quality with slightly elevated levels of aluminium, iron, zinc and manganese above pre-mining conditions.

Project components where runoff or discharge may contaminate ground or surface waters includes pits, waste rock dumps, roads (sedimentation), initial heap draindown and the heap leach pad and infrastructure. The following sub-sections discuss these potential sources in more detail.

Table 8.3

BC-31 Golden above Klondike Water Quality (mg/l)			
	Pre-Mine[1]	Mine Life[2]	Actual Post Mine[3]
Aluminum	0.2	0.17	0.31
Arsenic	0.0009	0.001	0.001
Copper	0.004	0.002	0.005
Iron	0.3	0.33	0.5
mercury	0.00003	0.00003	0.0001
Manganese	0.008	0.02	0.02
Selenium	n/a	0.002	0.0022
Zinc	0.007	0.008	0.012
Sulphate	85	98	110
Ammonia	n/a	0.004	0.066

Notes:

1. Pre-mine data from Assessment Section of DRP Vol. I (1990 – 1993)
2. Mine Life data from DRP Vol. IV (1996 – 2000)
3. Actual data from DRP Vol. IV (2000 – 2002)

Table 8.4

BC-34 Lee Creek at Ditch Road Water Quality (mg/l)		
	Pre-Mine[1]	Mine Life[2]
Aluminum	0.2	0.31
Arsenic	0.0002	0.0005
Copper	0.003	0.004
Iron	0.135	0.47
mercury	0.0004	0.000028
Manganese	0.007	0.019
Selenium	n/a	0.002
Zinc	0.0002	0.0005
Sulphate	86	65
Ammonia	n/a	0.003

Notes:

1. Pre-mine data from Assessment Section of DRP Vol. I (1990 – 1993)
2. Mine Life data from DRP Vol. I (1996 - 2000)

8.1.1.1 Initial Heap Draindown and Discharge

Viceroy's March 2001 effluent treatment and land application proposal considered 4 alternative means of heap draindown treatment: Oxidation using hydrogen peroxide, metals precipitation using hydrogen peroxide and bio-detoxification utilizing nitrification processes, alkaline chlorination and metals removal and soil attenuation (selected).

Concern has been raised that the treatment land effluent discharge option could lead to contamination of groundwater and eventually surface waters by contaminants that are not effectively removed from the effluent water by treatment or soil attenuation. The two main contaminants of concern are selenium and ammonia, with some concern regarding cyanate, thiocyanate, nitrate and nitrite.

DIAND completed a detailed screening of this proposal on 10 August 2001. Numerous mitigation and follow-up measures were included in the water licence; these included:

- Limit on volume of discharge;
- operational controls including a monitoring and response plan;
- discontinuance of discharge under conditions of precipitation;
- fish tissue monitoring program;
- monitoring of aquatic ecosystem components if significant groundwater contamination is identified through other monitoring programs;
- soil quality monitoring, combined with an action plan whereby discharge conditions would be modified if CCME criteria are exceeded;
- monitoring of vegetation and contamination before, during and after land application;
- establishment of a criteria for contaminants of concern; and
- installation of monitoring wells and suction lysimeters adjacent to the land application areas.

Viceroy's DRP and subsequent addendums describe the heap effluent treatment land discharge program as being a contingency measure should some parameters of concern exceed surface discharge criteria to be specified in the Water Licence. As per s. 20 of EAA, it is the RA's position that there have been no changes to the initial heap effluent disposal plan that was subject to the screening dated 10 August 2001; the RA still supports the CEAA s.20(1)a determination provided that mitigation and follow-up is implemented.

8.1.1.2 Heap Leach Pad Detoxification and Long Term Heap Chemical Stability

Viceroy has proposed to detoxify the heap leach pad using in-situ biological treatment. An RERC review of the DRP identified concerns with this proposed technology, particularly with regards to potential ground and surface water risks; these included:

- Lack of detail on mechanism for contaminant immobilization;
- long term stability of metals remaining in the heap;
- concern was raised by some reviewers that biological treatment methods were unproven in Canada's north;
- a means of determining heap detoxification success using core sample analysis rather than effluent analysis; and
- concerns regarding elevated levels of selenium and nitrogen in heap effluent after detoxification.

Since the biological detoxification program's implementation during the summer of 2002, it has proven to be effective in improving water quality, with the exception of selenium. The RA's research on heap detoxification indicates that heap chemistry can change over time. Viceroy has proposed contingencies should further heap effluent treatment be necessary; these were detailed in their original DRP and in DRP Vol. IV.

Throughout the course of this assessment, some reviewers have expressed concern that the technology that was employed in 2002 to detoxify the heap was not proven in the long term. The claim that the bio-treatment precipitated metals as sulphides in an anoxic environment has raised concern that the oxygen deprived environment and biological activity will not continue and could eventually result in the oxidation of metal sulphides. Viceroy's position is that a release of metals from sulphides through oxidation is not possible due to a NP:AP ratio of 8:1. The RA does not dispute the fact that the there is a high alkalinity within the heap, due mainly to long term leaching and the addition of lime (pre-production NP:AP ratio was 4.2:1). However, concern remains due to the fact that the technology applied to detoxify the heap is not proven in the long term. Concerns relate to the possibility that metals could be released in the future should biological processes wane or reducing conditions are not maintained.

The RA is of the position that contingencies for heap effluent treatment are necessary to ensure that a metals release does not occur in the future.

8.1.1.3 Heap Effluent Treatment Contingencies

A principal contingency for heap effluent treatment proposed by Viceroy was the BTC. The RERC review of the DRP revealed several concerns with the BTC in regards to uncertainties as proposed in the DRP in relation to potential effects on ground and surface waters; these included:

- Concern that the BTC would not be effective in a northern climate;
- lack of detail on BTC design in DRP;
- lack of clarity as to when the heap effluent will be directed into the passive BTC; and,
- question as to contingency measures should BTC output not be equivalent to Criteria I concentrations. (i.e. means of re-routing BTC output for alternative treatment).

In order to address concerns that the BTC output does not meet water quality criteria for discharge, the intention is to locate the BTC up-gradient from the process ponds so that out-flow can be analyzed prior to release and treated or re-directed as necessary. It was explained that the BTC was a non-passive system. Viceroy proposed the following contingencies in their 14 February 2002 response document to address concerns related to the BTC:

i. Treatment and land application;
ii. capture BTC effluent and re-treatment through BTC;
iii. pump back to process ponds;
iv. pump back to heap; and
v. intensive evaporation.

Metals release from heap effluent has been the main concern related to heap stability during the course of this CSR. Only the BTC and options i and ii above are capable of attenuating metals releases in effluent; pumping back to process ponds or heap are storage contingencies and evaporation concentrates metals. Options iii, iv and v are not capable of metals attenuation yet may be effective with ammonia. The pumpback to heap option will not be viable once the heap cover has been placed unless effluent can be distributed onto the heap bypassing the cover.

Test results provided in the DRP addendum IV submission (December, 2002) indicated that a BTC is capable of attenuating arsenic, mercury and ammonia. Test results for selenium were not conclusive due to analytical laboratory inconsistencies. Based on these and previous BTC test results provided to the RA during this review, it is the RA's position that the BTC remains a viable contingency for heap effluent treatment with the exception of selenium attenuation.

Mitigation:

Concerns arising from metals release in heap effluent and subsequent effects on water quality have been expressed by many of the reviewers inputting into this CSR. The means of mitigating elevated metals levels in heap effluent is therefore the focus of the required mitigation. Of the contingencies that were provided by Viceroy in their DRP, only treatment and land application and the BTC can attenuate metals; pump-back options are for storage purposes only and intensive evaporation concentrates metals. Therefore, the BTC and treatment and land application options are the only proposed contingencies considered acceptable to the RA for metals attenuation.

The objectives of heap effluent detoxification are the protection of water resources and aquatic habitat in the receiving environment. For certainty, criteria for determining heap detoxification and long term geochemical stability must be established. Such criteria must be consistent with the objectives of meeting CCME criteria in receiving waters for the protection of aquatic life and the LC50 toxicity test as these were the benchmarks under which the RA determined that there would be no likely significant adverse environmental effects of this project on VECCs.

Strategies for heap and effluent detoxification include adaptive management programs utilizing conventional treatment and land application as well as the BTC as necessary. A heap effluent quality monitoring and adaptive management plan must consider the following:

- Monitoring of heap effluent for contaminants of concern;
- sampling of representative heap materials for contaminants of concern, including cyanide species and metals; and
- triggers for implementing contingency effluent treatment activities.

Should it be necessary to construct the BTC as a heap effluent contingency, the following must be provided:

- Provide detailed engineered designs and QA/QC plans of the proposed BTC design to the Yukon Water Board;
- provide the Yukon Water Board with operating, monitoring and maintenance plans of the BTC; and
- provide the Yukon Water Board with details on BTC contents.

As-built specifications of the BTC must also be submitted to the Yukon Water Board.

The infrastructure for the treatment and land application system must remain in place as must the capability for batch metals precipitation, until long term site geo-chemical objectives are attained.

8.1.1.4 Selenium

Selenium is considered to pose a risk to the health of aquatic ecosystems when concentrated and in a bio-available form.

Selenate and selenite are the forms of selenium generally associated with aquatic systems. Selenate is considered to be less toxic than selinite. Reduced forms of selenium such as organoselenides are more toxic and bio-available than elemental selenium. Stored process waters at Brewery Creek consist of 80% selenate. Natural average concentrations of selenium in Laura Creek range from <1.0 ug/l to 2.34 ug/l. The current concentration of selenium in the heap effluent (Viceroy, 2003) is approximately 170 ug/l.

The CEAA screening conducted by DIAND in August of 2001 for the discharge of effluent to land considered the issue of selenium in detail. Alternatives to the proposal were considered and it was concluded that selenium is extremely difficult to remove from solution. The RA is not aware of new or alternate technologies that would prompt a reconsideration of this conclusion.

Research conducted on selenium uptake in aquatic environments has revealed that waterborne selenium is a poor indicator of chronic effects, especially in cold environments; rather, the mode for selenium uptake appears to be mainly through food sources. Viceroy has acknowledged that the wetland at the confluence of Laura Creek and the South Klondike River could serve as a means of increasing the selenium bio-uptake through the transformation of elemental selenium into organoselinides and by removing selenium through volatilization. Viceroy concluded that potential releases of organoselenides from the Laura Creek wetland would be mitigated by the oxidizing conditions in the South Klondike River. (Viceroy, 2003).

Viceroy's proposal would exceed CCME criteria for the protection of aquatic life in Laura Creek. CCME guidelines, however, do endorse the concept of site specific criteria for parameters where it can be demonstrated that the relationship between the variable fraction and their toxicity is firmly established and analytical techniques have been developed that unequivocally identify the toxic fraction of a variable in a consistent manner through a routine field verified measurement. (CCME, 1991).

The RA does not dispute the evaluation of selenium toxicity or the mechanisms by which selenium behaves according to Viceroy's site specific report. Viceroy's proposal has provided modeling to support the position that selenium values in the South Klondike River will remain below CCME drinking water criterion of 0.010 mg/l. The conclusion that modelling of elemental selenium biotransformation into organo-selenium that was undertaken in warmer environments, and does not necessary apply in colder environments, is scientifically defensible. Furthermore, the concentration of selenium in heap effluent will likely diminish over time as the concentrated process waters are flushed from the system.

This having been stated, Viceroy's proposal for a site specific selenium discharge criteria can only take place with a concurrent follow-up monitoring program to ensure that selenium concentration in the Laura Creek confluence wetland and South Klondike River remain consistent with the assumptions as described in the site specific report. Further baseline data on the Laura Creek wetland will be required prior to any surface discharge.

The RA accepts Viceroy's site specific selenium criteria as presented in their February 2003 document. Deviations from this proposal will be subject to further environmental assessment and relicencing.

Mitigation:

The objectives of a site specific selenium criteria are to ensure that water resource and aquatic values remain protected in receiving waters. The RA has concluded that based on the premise that drinking water and fishery values in the South Klondike River remain protected, there are not likely to be significant adverse environmental effects associated with Viceroy's site specific proposal.

Strategies for ensuring water and aquatic resource value protection include the following:

- The in-stream selenium criteria of 3.8 ug/l for the South Klondike River should be met within close proximity to the Laura Creek wetland, which is expected to act as a mixing zone; the site specific criteria of 3.8 ug/l cannot be exceeded in the South Klondike River.

- The timing of the release of stored effluent as described in Viceroy's February 2003 site specific criteria proposal must be adhered to and specified as a regulatory condition.

- Prior to any release of effluent subject to a site specific selenium criteria, baseline samples must be collected from the Laura Creek wetland, including: sediment samples, vegetation samples, nutrient levels, phytoplankton, algae, zooplankton, benthic invertebrate samples and a representative sample of fish tissue. These samples must be analyzed for selenium and other critical parameters with results forwarded to the Yukon Water Board. Furthermore, a one-time seasonal analysis of fish habitat utilization of the Laura Creek wetland must be undertaken with results forwarded to the Yukon Water Board.

- A comprehensive monitoring and follow-up program must be in place to ensure that the conclusions arising from Viceroy's February 2003 site specific selenium report prove accurate; monitoring in receiving waters must be comprehensive and consider nutrients, phytoplankton, algae, zooplankton, benthic invertebrates and fish. A program and triggers for action must be developed for adapting the site specific selenium criteria should the selected criteria be observed to contribute to unforeseen selenium levels in indicator species within the Laura Creek wetland and/or the South Klondike River.

8.1.1.5 Nitrates

Nitrates are not specifically regulated under the current Brewery Creek Mine Water Use Licence. Since Viceroy's bio-treatment of the heap during the summer of 2002, nitrate levels within the heap effluent have been elevated. This is a result of ammonia degradation. Some technical reviewers are concerned that the surface release of effluent with high nitrate levels could result in the eutrophication of receiving waters. Nitrates released to groundwater may also migrate to surface waters.

Nitrate levels in heap effluent are expected to diminish in a relatively short period of time.

Mitigation

Nitrate trends in heap effluent must continue to be monitored and reported on in groundwater in the land application area and surface waters during conditions of surface discharge; this is addressed in s.10.1, follow-up program.

8.1.1.6 Heap Cover

There are different rationales for the purpose of a heap cover. Firstly, it is to minimize the infiltration of precipitation through the heap. Secondly, it is a component of reclamation whereby the heap is revegetated to restore the productive capacity of the area. Both are of particular significance to the Tr'on dek Hwech'in First Nation. The issue of minimizing the infiltration of precipitation is of particular importance as long as the long term geochemical stability of the heap is uncertain.

The cover itself is not anticipated to contribute to adverse effects on VECCs as long as it remains physically stable.

Mitigation:

The objectives of a heap cover are to minimize infiltration through the heap and to restore the natural productive capacity of the heap. Criteria for determining revegetation success must be established (see s.8.1.2 of this report for a full discussion on issues pertaining to revegetation).

Strategies for ensuring proper heap cover placement include ensuring that stored growth material is used in the heap cover, to ensure that reseeding efforts will be successful; the original purpose of growth media storage was so that it could be used for reclamation purposes. This is in keeping with the goal of restoring the natural productive capacity of the heap; the proponent committed to this during the outset of the mine development project in the 1990's.

A monitoring program with adaptive management must be in place for the heap cover, and address the following:

- Monitoring of cover performance for infiltration and physical condition;
- monitoring of vegetation growth;
- criteria for determining the adequacy of revegetation; and
- triggers for implementing contingency activities.

8.1.1.7 Pits and Waste Rock Dumps

During the RERC review of the DRP, several technical reviewers raised concern with some of Viceroy's methodology and assumptions in relation to their water modelling, particularly in relation to geochemical issues surrounding the Blue Pit and WRSA.

In the opinion of the RA, there is a risk that ARD may develop in the Blue pit and WRSA.

Details on Viceroy's water modelling is found in s.9.2 of Vol. I of the DRP and in Vol. IV.

DIAND Water Resources raised a concern regarding the fact that the humidity cell data presented in Appendix D of the DRP was not converted into mass scaled release rates and therefore not used to predict impacts. Furthermore, they expressed concern that the proposed 0.5 m cover of silty soil and rock for the Blue waste rock dump may not be effective in controlling metal leaching in the long term. Viceroy's 14 February 2002 response document attempted to address these concerns.

Viceroy's position is that humidity cell data to predict metal release rates does not accurately portray what is really taking place at the site. Initially, mass release rates were calculated to predict the rates of metal contaminants from the Blue Pit and WRSA. The use of this approach in the predictive water quality model resulted in projected contaminant concentrations in Laura Creek downstream of the Blue dump that were many orders of magnitude higher than concentrations currently measured at these locations. Viceroy's opinion was that this scenario was not representative of actual current conditions. Another possibility is that contaminants from the Blue zone have not reached Laura Creek to date because of lengthy travel times and potential attenuation in underlying materials.

A further concern related to the modelling for pits and dumps aside from the Blue area was raised regarding Viceroy's corrections applied to humidity cell test data used in the water quality model for temperature and for the difference in grain size between the test cell and the actual waste material. The correction resulted in a decrease of the magnitude of the discharge contamination used in the model of approximately 25 times less than the measured humidity cell data. If this theory does not match actual field conditions, a significant change in water quality of the actual discharge is a possibility. Viceroy responded to these concerns in their 14 February 2002 response document. The proponent's position is that the modelling predictions made using the humidity cell data are believed to overestimate actual outcomes, yet they do acknowledge that ongoing monitoring and preventative measures be implemented to ensure that Laura Creek is not detrimentally effected.

Viceroy's DRP Vol. IV detailed the results of the 2002 field season work undertaken to assess the geochemical properties of the Blue WRSA. Three groundwater monitoring wells were installed, one upslope of the dump, one through the surface of the dump and another immediately down slope of the toe of the dump; as of July 2003, monitoring revealed that ARD related metals releases were not apparent in these wells. The results of further acid base accounting and shake flask tests were provided based on 62 samples, to quantify the balance between acid generating and acid neutralization potential, and to facilitate the measurement of the concentration of soluble metals within the Blue WRSA. The analysis indicates that the samples have an average NPR of 2.9. However, if the seven most acid consuming samples are removed from the list, the NPR of the remaining 89% of the samples is 0.83 (Brodie Consulting, 2003). This suggests a strong possibility of acid generation potential in the Blue WRSA. The RA and Environment Canada are not satisfied that the acid base accounting and shake flask tests accurately describe the site conditions; humidity cell sampling would have provided more assurance of acid generating potential according to these reviewers. There is a concern that ARD issues could potentially manifest themselves in the receiving environment in the future.

During the course of this assessment, technical reviewers have requested additional humidity cell data from the Blue WRSA; to date this has not been provided. The RA is of the opinion that the proponent has not demonstrated that the site is geochemically stable.

Viceroy's proposal to place large scale lysimeters to monitor dump conditions and cover performance is an acceptable approach as long as adaptive management mechanisms are in place to respond to deficiencies in the proposed cover design and any ARD issues that may arise. The RA is of the opinion that an adaptive management approach to potential ARD issues is appropriate in the case of the Blue zone due to its relatively small size. Trench logs were kept during the 2002 field season (these have been provided to government); these logs will be used to determine the location of the lysimeter system based on areas of acid generating potential within the WRSA; Viceroy has committed to providing these logs to regulators prior to lysimeter system installation, as well as reaching agreement on the appropriate location of the system. It is of paramount importance that a monitoring and adaptive management approach be in place to adapt quickly to a situation of excessive infiltration prior to the onset of ARD. This is further discussed in mitigation below.

Environment Canada noted the issue of increased arsenic concentrations in Laura Creek from 1991 to present. Viceroy is of the opinion that these increases are due to the increase in arsenic bearing soils and not dissolved form. This particular reviewer considered the increase in metal concentrations to also be due to increased adsorption of arsenic into sediment. Viceroy's 14 February 2002 response document acknowledged that their modelling indicated that upper Laura Creek may see increased rates of arsenic in the post closure period but that the situation will improve in the post closure period as reclamation activities are implemented; arsenic follow-up monitoring is addressed in s.10.1 of this report.

The Tr'on dek Hwech'in First Nation raised a similar concern for mercury, regarding mercury concentration in Laura Creek and that there was virtually no discussion of this in the DRP. Viceroy acknowledged that mining activity may have impacted mercury levels in Laura Creek but that levels were still 1.5 times lower than CCME drinking water guidelines. Mercury follow-up monitoring is addressed in s.10.1 of this report.

A further concern with pits is the accumulation of sediment due to erosion of fine materials and the possibility that these fines could lead to the sedimentation of surface waters. Pit ponds collect surface runoff from disturbed areas at the Brewery Creek site for the purposes of settling sediment. Where possible, reclamation grading should be designed to direct surface flows from disturbed areas into the pit ponds. Pit ponds must be of adequate size to collect and settle runoff until reclamation efforts have proven stable over the long term.

Mitigation:

To date, the proponent has not demonstrated Blue Pit and WRSA geochemical stability to the RA's satisfaction. Based on the information provided during the course of this CSR, the RA believes that there is a risk of ARD at this site. As of July, 2003, Viceroy representatives had indicated that they had engaged the services of a geochemical consultant to characterize the stability of the Blue zone. The RA has consistently maintained the position that if the proponent is able to satisfactorily demonstrate that the Blue zone is geochemically stable (utilizing accepted testing methodology), or otherwise not exceed criteria that ensures no likely significant adverse environmental effects (see below), then not all mitigation strategies specified may be necessary.

The objectives of Blue Pit and WRSA mitigation are to ensure that the integrity of ground and surface waters is maintained by ensuring that ARD onset does not occur and/or migrate into the receiving environment. In order to achieve this, the proponent must take the adaptive management approach of either demonstrating that ARD will not occur, or that attenuating conditions exist, or actions will be taken to ensure that there will be no likely significant adverse environmental effects associated with ARD at the Blue zone. If the proponent is unable to demonstrate that ARD will not occur, the proponent must ensure that pits and WRSAs do not contribute to likely significant adverse environmental effects by confirming that CCME criteria for the protection of aquatic life will be achieved in receiving surface waters. It must be demonstrated that effects are compliant with the provisions of the Contaminated Site Regulation pursuant to the *Environment Act*. The point of compliance with criteria must be through a lysimeter system rather than groundwater due to the extreme depth of groundwater at the site.

Strategies to ensure that there will be no likely significant adverse environmental effects include:

Viceroy's proposal to install and monitor a large scale lysimeter in the Blue WRSA and to collect site weather data as a means of assessing ARD formation and the performance of the cover forms one component of the ARD evaluation. Other requirements consist of:

- An assessment of ARD potential must be carried out and made available to government;
- an adaptive management program must be in place to respond to ARD issues identified in the above mentioned geochemical assessment. This may include modelling to determine if any impacts occur based on the above mentioned criteria and/or other appropriate measures (ie. a cover that prevents ARD formation and migration) to mitigate against the impacts of ARD to ensure that criteria are met;
- Viceroy's commitment to reach agreement on lysimeter system location with water resource regulators must be carried out; and
- measurable criteria for a determination of long term geochemical and physical stability must be developed.

Pit pond size must be sufficient to collect surface runoff for sediment settling. Where possible, reclamation grading should be designed to direct surface flows from disturbed areas into the pit ponds.

8.1.1.8 Roads and Trails

Improperly reclaimed roads and trails could result in erosion and subsequent sedimentation of surface waterways. The RA considers the techniques for the mitigation of erosion on linear developments to be standard land use practice; this includes the removal of culverts and rock drains, stabilization of banks, installation of diversion berms on steep slopes, scarification of the surface and seeding.

The proponent committed to the decommissioning of access corridors when they were no longer required; the initial EARPGO screening was completed on that premise. Viceroy's approach to road reclamation is that the decision to reclaim the roads should be done with the involvement of the community, Tr'on dek Hwech'in First Nation and other stakeholders. The RA concurs with this approach due to uncertainty regarding the length of time the road will be necessary and whether or not the Brewery Creek Mine goes into production again at a later date. Road and trail decommissioning and reclamation must occur as soon as possible in situations where continued access would interfere with reclamation efforts or physical safety hazards are present. In any event, the decision to decommission roads and trails rests with mine and road regulators in the Yukon.

Mitigation:

The objectives of road reclamation are to ensure that the natural productive capacity of the area is restored and to ensure that reclamation measures taken will not be disturbed by continued site access. Strategies for ensuring proper road reclamation include the establishment of criteria for determining adequate reclamation.

It is accepted that access to the Brewery Creek mine will be required for a considerable period of time following the implementation of decommissioning and reclamation measures. Heavy equipment access to the site must be maintained until criteria to determine site stability has been met to the point that the main access road from the Klondike Ditch road and the various spur roads on site can be partially or fully decommissioned.

In the interests of safety and to allow for the successful regeneration of vegetation (see s.8.1.2 of this report) in the Brewery Creek area, public access to the site must continue to be restricted until the site has met the criteria for long term stability.

Haul Roads:

Haul roads must be reclaimed when mine regulators are satisfied that they are no longer required for reclamation purposes. Haul road water crossing specifications as described in Attachment 1 of Viceroy's DRP Vol. IV must be adhered to.

Main Access Road:

The decision to decommission the main access road from the Klondike Ditch Road must be made by road and mine regulators in the Yukon after a consideration of the interests of stakeholders in the Brewery Creek area including but not limited to: The Tr'on dek Hwech'in First Nation, the registered trapline concession holder and the Community of Dawson City; furthermore, the following must also be considered:

i. Public safety;
ii. the environmental effects of the roads and trails themselves as well as the environmental effects associated with continued access to the Brewery Creek site;
iii. the condition of culverts and rock drains; and
iv. the stability of the reclamation measures undertaken at the Brewery Creek site.

8.1.2 Terrestrial Biota

A project's negative effects on terrestrial biota may occur from:

- Loss of habitat from the construction of the project;
- habitat fragmentation or interference with wildlife migration routes;
- wildlife avoidance due to human activity;
- increased hunting pressure due to increased access;
- drinking water source contamination;
- wildlife death and injuries from collisions with mine vehicles; and
- spills of hazardous materials that poison terrestrial biota or destroy their habitat.

If properly implemented, the implementation of the DRP should improve the terrestrial biota habitat in the Brewery Creek area over current conditions.

Consultation with the trapline concession holder in November 2001 indicated that the Brewery Creek Mine has not noticeably affected the natural cycle of furbearing mammals in the vicinity of the site. He was of the opinion that the mine development may actually have improved habitat because surface disturbances have offered some habitat variety for wildlife compared to the relatively uniform black spruce forest in the surrounding area.

A reseeding program is intended to restore vegetation and forest succession is expected to eventually develop. Successful revegetation and eventual forest succession will create habitat for wildlife.

It is expected that the mitigation to prevent erosion, effects on water, re-seeding, spill contingencies (in water licence) and general site reclamation will be sufficient to mitigate the effects on terrestrial biota and restore aesthetic values as well.

Mitigation:

Terrestrial biota values are most effectively restored through an effective revegetation program. The objectives of the re-vegetation program are to prevent erosion, restore aesthetic values and restore the natural land productivity in the area. Revegetation programs at the Brewery Creek site must be self sustaining utilizing native seed mixes. Formal re-vegetation objectives based on the above must be established, as must criteria for measuring the long term success of revegetation efforts; it is recommended that such criteria be developed in consultation with the Tr'on dek Hwech'in First Nation.

8.1.3 Traditional/Heritage Values

The YG Heritage Branch was consulted during the RERC review of the DRP and was of the opinion that there were no heritage resource concerns with regards to the Brewery Creek DRP (Gotthardt, 2001). Heritage sites are known and will be avoided during decommissioning and reclamation activities. No new terrain is proposed for development as a result of this project.

Mitigation

The effects of this project on heritage resources are not likely to be significant with continuance of the mitigation currently in place.

8.1.4 Recreation

This project is intended to restore the Brewery Creek Mine area and if implemented as proposed with mitigation, will reduce the footprint currently in the area and enhance recreational opportunities.

8.2 Effects of Environmental Changes

8.2.1 On Human Health

Potential project effects that may impact human health are through the inhalation or ingestion of contaminants and consumption of country foods or water contaminated from project activities. A project's effect on the environment could affect the emotional and spiritual well-being of people.

To date there have been no identified changes in the environment identified to affect human health resulting from the Brewery Creek Mine. This may be due in part to the remoteness of the site and the limited human habitation in the area.

The Brewery Creek Mine has operated since its inception under a Water Licence that contains discharge standards to prevent the discharge of unacceptable quality water.

During the course of this environmental assessment the Tr'on dek Hwech'in First Nation raised concerns regarding mercury contamination in Laura Creek and the effects that this could have on fish rearing in the marsh area at the confluence of Laura Creek and the Klondike River. The levels of mercury in Laura Creek are currently below CCME water quality guidelines for human consumption. It is the RA's position that while present mercury levels are not known to be at a level that requires immediate mitigative action, the situation must continue to be monitored and mitigative measures employed should Water Licence discharge criteria not be met. A detailed water, fish and sediment monitoring and reporting program is required. This monitoring and reporting program must continue until site stability criteria is met; this is further discussed in section 10.1, follow-up Program. These measures also apply to other metals of concern, including arsenic.

This project is intended to reduce the environmental risks associated with the Brewery Creek Mine. If implemented as proposed, the project will reduce risks to human health as the leach pad is detoxified. The implementation of mitigation, ongoing monitoring of water and receptor organisms in combination with the follow-up program and adaptive management if necessary, will ensure that risks to human health are minimized.

Mitigation

The objectives of mitigating the effects of the project on human health is accomplished by ensuring that sedimentation control and adaptive management programs for heap detoxification and Blue zone are implemented; this will mitigate against metals releases and subsequent risk to human health. Parameters of concern including, but not limited to mercury, must continue to be monitored in water, fish and sediment.

8.2.2 On Socio-economic Conditions

It is not anticipated that the effects of the environmental changes of this project will have a detrimental effect on the socio-economic conditions of the Yukon. This project is intended to ultimately restore a disturbed area to as near to pre-development conditions as possible. Hunting, trapping and recreational opportunities will be improved over current conditions and can have a positive effect on the socio-economic conditions of the Dawson City area.

8.2.3 On Physical and Cultural Heritage

Heritage resources within the scoped area are documented and avoided. Please refer to s.8.1.3 of this report for information on physical and cultural heritage resources within the Brewery Creek area.

8.2.4 On Current Use of Lands and Resources for Traditional Purposes by Aboriginal Persons

The Brewery Creek Mine development has rendered a portion of land unsuitable for the pursuit of traditional purposes by aboriginal persons. The decommissioning and reclamation of the site is intended to restore the disturbed areas as much as feasible and successfully revegetate the site. This will thereby render the site more suitable for traditional pursuits such as hunting and gathering, over current conditions.

It is the RA's position that the nature of this project will enhance an already disturbed area and will benefit aboriginal persons who wish to use the area and its resources for traditional pursuits.

8.3 Effects in Relation to Other Factors

8.3.1 Cumulative Environmental Effects

A cumulative effects assessment (CEA) for the Brewery Creek Project entitled Brewery Creek Mine Cumulative Effects Assessment (Access Consulting Group, 1999) was completed in 1999. This was submitted to support Viceroy's application of a Quartz Mine Production Licence. The report concluded that no new projects were identified for the area but some existing projects may continue or be modified and that the potential for cumulative effects of the mine were moderate or insignificant on VECCs. DIAND accepted this report as an accurate evaluation of the cumulative environmental effects in the project area and subsequently issued Viceroy a Quartz Mine Production Licence.

The 1999 CEA identified a spatial scope to encompass the watersheds in the project area. Past, current and imminent projects within the study area were identified.

Past activities identified included a small scale forestry operation east of Lee Creek, the decommissioned Klondike Ditch hydro project, mineral claims, the ditch road upgrade and Lee Creek bridge replacement and several Land Use Permits granting access through the study area.

Current activities included the small scale forestry operation east of Lee Creek and access. The Tr'on dek Hwech'in First Nation hold considerable land claim settlement parcels in the area. Hunting, trapping and recreational activities are prevalent in the area.

A current review of the 1999 CEA was undertaken as part of this CSR. There are numerous mineral claims active throughout the study area. No new exploration or mine developments are currently being proposed. It can be reasonably anticipated that small scale forestry operations will continue in the study area. Logging operations adjacent to riparian areas can cause erosion and lead to sedimentation of water courses. Timber Resources on commissioner's lands in the Yukon are administered by Forest Resources branch of the Department of Energy, Mines and Resources, Government of Yukon. Timber permits issued in the Yukon contain conditions requiring setbacks on riparian areas, thereby mitigating this problem; furthermore, the forestry operation in question is of a small scale, clearcutting is not employed as a logging prescription thereby avoiding habitat fragmentation and disruption. It is not anticipated that the Klondike Ditch hydro project will be re-activated in the foreseeable future. No new roads or access corridors are being proposed in the study area.

In short, there are limited activities in the project area and none in the opinion of the RA that are likely to cause cumulative environmental effects in combination with the Brewery Creek Mine decommissioning and reclamation project. This is due to the remoteness of the site and the lack of other industrial activity that is likely to interact with this project to detrimentally affect VECCs. Any cumulative effects that the Brewery Creek Mine may have contributed to will diminish as decommissioning and reclamation activities are implemented and take hold at the site. It is the RA's position that the cumulative effects of this project in combination with other past, present or imminent projects are not likely to be significant with the implementation of mitigation and follow-up.

8.3.2. Effects on Sustainable Use of Renewable Resources

If implemented as proposed, this project will have positive effects on the sustainable use of renewable resources in the Brewery Creek area as compared to current conditions. As reclamation is implemented and takes hold, human activity will diminish in the immediate project area thereby improving habitat for terrestrial wildlife. It is the RA's position that this project will eventually lead to the establishment of wildlife habitat and other renewable resources such as berries that can be harvested in a sustainable manner.

8.3.3. Effects of the Environment on the Project

An assessment of conventional environmental hazards on the Brewery Creek Mine project was conducted as part of the original IEE (SRK, 1994) and is described in s.7.5 of this report. Not evaluated at that time, however was an assessment of the effects of climate change on the mine development project.

As discussed in this report, it is the RA's opinion that there may be a potential for adverse environmental effects arising from this project should there be a failure of mine components and resulting contamination of ground and surface waters. The RA therefore concentrated on the effects that climate change has on precipitation events and subsequent surface water hydrology.

Environmental Assessment Unit staff contacted the Water Resources division of the Yukon Government's Department of Environment. A Water Resources' hydrologist had prepared a research paper entitled Impact of Recent Climate Variability on Peak Streamflow in Northwestern Canada With Implications for the Design of the Proposed Alaska Highway Gas Pipeline (Janowicz, 2001).

Mr. Janowicz's project analysed peak streamflow to assess the impact of climate change on design floods. The Yukon Territory was divided into four hydrologic zones: glacial (Coast Mountain), interior, northern and arctic; the Dawson City area / Brewery Creek mine is in a transition zone between the interior and northern hydrological zones. Streamflow in this region is characterized by a rapid increase in flow discharge in May due to snowmelt, rising to a peak in June. Summer rain events produce secondary peak events and occasionally the annual maximum. Minimum streamflow generally occurs during March, some small streams may experience zero winter flows. Ongoing meteorological records for the various zones were consolidated. Streamflow measurements were derived from DIAND's hydrometric station monitoring program. (Janowicz, 2001).

Findings demonstrate that Yukon temperature and precipitation trends have changed over the last several decades, yet the changes have not been consistent. Summer and winter temperatures have increased in most regions except the southern Yukon where no change was observed. Summer precipitation has increased in all regions while winter precipitation has decreased in all regions except in the southwest, where values increased. No change was observed in the westcentral region (Dawson area). The analyses of peak streamflow was undertaken to assess the impact of these changes on design floods. Annual peak streamflow has increased in southwestern Yukon, changed minimally in southeastern and interior Yukon and progressively decreased moving northward with the greatest departure from the mean in northern and arctic regions. (Janowicz, 2001).

In the Dawson City area, records indicate that over the last three decades, summer, winter and annual temperatures have increased. Summer and annual precipitation has increased while winter precipitation has remained constant. Ten year peak flows have decreased 6% and 1% respectively for the Klondike and North Klondike rivers based on 30 and 20 year records respectively (4% and 3% based on 20 year records for both). (Janowicz, 2001).

The findings of the above referenced research indicate that peak flows in the Brewery Creek area are decreasing in response to climate change but only slightly. For the purposes of evaluating the effects of climate change on the decommissioning and reclamation of the Brewery Creek mine, the RA is of the opinion that the observed trends do not indicate that additional contingency measures need to be developed to accommodate the effects of climate change on this project.

8.3.4. Effects of Possible Malfunctions or Accidents

The current water licence for this project requires that the licensee comply with a petroleum and chemical spill and emergency response plan that was submitted pursuant to the original licence and is required to be updated in annual reports to the Water Board. The current licence also requires that the proponent have all earth works structures at the mine inspected by a qualified professional engineer and a report be submitted to the Water Board as a component of the annual report.

Accidents and malfunctions can affect this project in that engineered structures could fail or proposed technologies do not achieve their projected goals. This could lead to a release of contaminated water onto the land, into groundwater or into surface waters.

Mitigation

A continuance of the conditions currently in place related to spills, inspections and reporting will mitigate the effects of accidents and malfunctions.

Refer to s.8.1.1.3 of this report for a discussion on contingencies should the heap detoxification methods employed malfunction or not perform as expected.

8.4 Financial Security

Financial security is a critical mitigation measure in ensuring that the Brewery Creek Mine is decommissioned and reclaimed without becoming a burden to taxpayers.

Under the current regulatory system, the Water Board sets financial security pursuant to the *Waters Act.* The Minister of Environment is responsible for the management of financial security pursuant to the *Waters Act*.

Mitigation

- Security held must reflect the cost of liability and certainty at the Brewery Creek Mine at any point in time, including but not limited to the environmental liabilities posed by the heap, pits, engineered structures and acid rock drainage potential;

In setting and managing security, the following should be considered:

- security should be adequate to allow government to carry out any necessary remedial work using third party contractors;
- long-term monitoring and maintenance costs should be included in the calculation of outstanding site liability;
- calculation of outstanding liability should include the costs associated with adaptive management contingency proposals as discussed in this CSR; and
- where there is a need for ongoing care and maintenance activities during planning for decommissioning and/or adaptive management actions, the costs of care and maintenance should be included in estimating outstanding liability.

9. Determination of Significance

The Environmental Assessment Unit has selected a qualitative approach to determine the overall significance of effects of the project on the selected VECC's. This approach takes into account five parameters in deciding whether the adverse effects are significant: duration (years), geographic extent (hectares for land and specified watercourse drainages for water), frequency, reversibility (%) and magnitude. For each of the parameters, descriptors were identified based upon a range of effect on the parameter (Table 9.1). The descriptors used were: very low, low, moderate, high and very high, and they were numerically ranked from 0 to 4 respectively for all but reversibility which was ranked in reverse order.

The first four parameters are relatively easy to quantify. Magnitude is a qualitative parameter which is more difficult to define. The magnitude of the adverse environmental effect refers to the degree of severity. Minor or inconsequential effects may not be significant, but effects that are major or catastrophic will be significant. The magnitude of the adverse environmental effect also depends on the nature of the receiving environment or VECC. The magnitude of the effect of the project may be significant if they occur in regions that are ecologically fragile and have little resilience to imposed stresses which could result in a significant change in the VECC's function or process.

The analysis of the significance of effects is based on residual effects after implementation of mitigative measures. Mitigation measures will in some cases result in a decrease in frequency duration, magnitude, geographic extent and reversibility. Refer to s.8 for details of the proposed mitigation.

The significance of the adverse environmental effects is determined based on an overall ranking descriptor. The overall ranking for each effect was obtained by summing the numerical ratings for each parameter for the project component under consideration. Environmental effects with an overall ranking of 11 or more out of 20 are significant.

The results of the Significance Evaluation are summarized in Table 9.2. The first column identifies the VECC. The second column identifies the project component where the effect might occur (heap detoxification, pits, WRSA, etc.). A point form summary of the consequence and effect is provided in the next column followed by a summary of the proposed mitigation. The next columns identify the numerical rankings for each of the five parameters used to determine significance of effects. Following this is the numerical and descriptive overall ranking for the effect. The last column identifies whether the overall rating is significant based upon the ranking exceeding 11.

Table 9.1

Level of Significance	Geographic Extent	Duration	Frequency	Reversibility	Magnitude
4	Yukon River drainage	Permanent	Continuous	Very low (1-40%)	Very Large *90% change in VECC function*.
3	Klondike River drainage	More than 10 years	Common *occurs on regular basis 50% or more of time or chronically over several years.*	Low (40-60%)	Large 50-90% *change in VECC function*.
2	Local: Laura, Lee, Golden Creeks	1 -10 years	Uncommon *occurs irregularly*.	Moderate (60-75%)	Medium 10-50% *change in VECC function.*
1	Spot effect	Less than 1 year	Rare *occurs less than 10% of the time.*	High (75-100%)	Minimal *less than 10% change in VECC function.*
0	None	None	None	None	None

The proponent provided additional information to address concerns with water quality issues. This additional information and the expert advice on this information enabled the RA to determine that the potential environmental effects to water quality are not likely to cause significant adverse environmental effects with mitigation, at the time of this assessment. However, the expert technical advisors have also raised some questions with the conclusions reached by the proponent. A follow-up program (s.10) has been established (mandatory for Comprehensive Studies) as a means of confirming that the assumptions made in this CSR are confirmed over the long term.

Table 9.2 Analysis of Significance of Environmental Effects

VECC	Development	Effect	Mitigation	Significance of Effects						Significant (Y/N)
				Duration	Geographic	Frequency	Magnitude	Reversibility	Overall Rating	
Surface Water Quality	HD	elevated levels metals	ensure meet criteria/implement adaptive management and follow-up	4	1	1	1	1	8	N
	HD	elevated levels nitrate	n/a	1	3	1	2	1	8	N
	HD	elevated levels selenium	site specific criteria	4	2	1	2	1	10	N
	WRSA	Metals	cover adequate to prevent ARD/prove ARD not at problem	4	1	2	1	2	10	N
	P	Metals	cover adequate to prevent ARD/prove ARD not at problem	4	1	2	1	2	10	N
	SD	elevated NO3	n/a	1	3	1	1	1	7	N
	SD	elevated selenium	site specific criteria	1	3	1	2	1	8	N
Groundwater Quality	WRSA	metals	cover adequate to prevent ARD/prove ARD not at problem	4	1	2	1	2	10	N
	P	metals	cover adequate to prevent ARD/prove ARD not at problem	4	1	2	1	2	10	N
Aquatic Habitat	HD	elevated levels metals	ensure meet criteria/implement adaptive management and follow-up	4	1	1	1	1	8	N
	HD	elevated levels nitrate	n/a	1	3	1	2	1	8	N
	HD	elevated levels selenium	site specific criteria	4	2	1	2	1	10	N
	SD	elevated NO3	n/a	1	3	1	1	1	7	N
	SD	elevated selenium	site specific criteria	1	3	1	2	1	8	N
	P	Metals	cover adequate to prevent ARD/prove ARD not at problem	4	1	2	1	2	10	N
	WRSA	Metals	cover adequate to prevent ARD/prove ARD not at problem	4	1	2	1	2	10	N
Terrestrial Biota	ALL	Disturbed areas	Reclamation/Revegetaion	2	2	1	1	1	7	N
Traditional/Heritage Resources	ALL	Disturbance of known heritage site	continuation of existing mitigation	4	1	1	1	1	8	N
Recreational Use	AR	Access to Klondike Ditch road	Ensure activities do not compromise access	4	2	1	1	0	8	N

HD= heap detoxification
P= Pits

ET=effluent treatment/land application
WRSA=waste rock storage areas
AR=access Roads
SD=one time direct discharge

10. Follow-up Program

Under the EAA, a follow-up program is mandatory for Comprehensive Studies. A follow-up program is intended to verify the accuracy of the environmental assessment, to monitor for unanticipated effects and to determine the effectiveness of any mitigation measures that have been implemented. Follow-up programs for this project can be tied to monitoring programs as established in s.8 of this report and can provide effective triggers for the implementation of adaptive management programs when established criteria are exceeded.

10.1 Water Monitoring – General

Surface water, groundwater, sediment, fish and benthic invertebrate must continue to be monitored and reported on a regular basis to the Yukon Territory Water Board. This monitoring program must include but not necessarily be limited to arsenic, mercury and selenium. This program must continue until licenced criteria for the determination of site geo-chemical stability have been met.

Rationale:

Viceroy's DRP and addendums contained data on current and predicted future water trends at the Brewery Creek Mine. It is necessary to ensure that the decommissioning and reclamation activities at the site achieve their intended objectives of ensuring the quality of surface and groundwaters that have been affected by the mine development.

10.2 Heap Geochemical Stability

A detailed geochemical monitoring and reporting plan must be developed to ensure that the heap remains stable over the long term. Metals of concern, nitrates and oxidation reduction potential must be monitored and reported on. In the event that the heap proves to be unstable over time, contingency measures must be implemented. This program must continue until licenced criteria for the determination of heap geochemical stability have been met.

Rationale:

Research on heaps indicates that heap chemistry can change over time. The technology employed to detoxify the Brewery Creek Mine heap is not proven in the long term or in a northern environment. Technical reviewers that contributed to this assessment are concerned that the anoxic conditions under which elemental metals were precipitated in the heap may not be permanent; a follow-up program is essential to ensure that the attenuating mechanisms are permanent.

10.3. Pits, Waste Rock Storage Areas, Heap Breach and Covers

10.3.1 Physical Stability

The proponent must conduct regular inspections and reporting on the covers that will be placed on the heap and Blue WRSA as well as the reclaimed pit closure components; the proponent must implement an adaptive management plan to mitigate the effects of excessive infiltration, erosion, gullying and frost cracking; an adaptive management plan involves but is not limited to the physical works required to re-cover and re-contour as necessary. The breach of the heap must also be subject to this inspection, reporting and adaptive management plan. The monitoring and adaptive management program must continue until licenced criteria for the determination of physical stability have been met.

10.3.2 Geochemical Stability

A follow-up monitoring program must be implemented for pits, waste rock dumps where Acid Rock Drainage (ARD) is a concern (notably the Blue pit and WRSA), as well as receiving waters, fish and sediments. Specifically, the cover and Blue WRSA materials must be monitored to ensure that the cover in question is effective and that no ARD metals migration is occurring. Monitoring of groundwater in vicinity of the Blue Pit and WRSA must continue but due to the depth of the water table in the area, cannot be regarded as definitive proof that no ARD migration is taking place.

This monitoring program must continue until licenced criteria for the determination of geochemical stability have been met.

Rationale: It can be reasonably expected that there will be a certain amount of settling after freeze thaw cycles or erosion damage on engineered covers and reclaimed pits during the post-decommissioning phase of these works.

ARD problems often do not manifest themselves in the receiving environment for a considerable period of time. An effective follow-up monitoring program is required to ensure that metals contamination is not occurring.

10.3.3 Revegetation Program

A revegetation monitoring and inspection program must be established. The progress of vegetation reestablishment must be reported annually. This must continue until licenced criteria for the determination of physical stability have been met.

Rationale: Revegetation programs must reach a self sustaining, free-to-grow stage.

11. Conclusions and Determination of the Responsible Authority

It is the determination of the Responsible Authority that taking into account the implementation of mitigation measures and follow-up, the project is not likely to cause significant adverse environmental effects.

Environmental Assessment Act determination:

33(1)(a)(i)
"where, taking into account the implementation of any mitigation measures that the responsible authority considers appropriate,
the project is not likely to cause significant adverse environmental effects"

Prepared By:

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August 14, 2003
Date

Authorization:

Michael McBride
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August 14, 2003
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Figure 1 Map of Mine Site Overview

Figure 2: Map of Specific Mine Components

Figure 3 Locations of Key Water Quality Monitoring Stations

APPENDIX 1: Acronyms and Abbreviations

ARD	Acid Rock Drainage
BTC	Biological Treatment Cell.
CEA	Cumulative Effects Assessment.
CEAA	The *Canadian Environmental Assessment Act*.
CCME	Canadian Council of Ministers of the Environment.
CSR	Comprehensive Study Report.
DIAND	The Department of Indian Affairs and Northern Development.
DRP	Decommissioning and Reclamation Plan.
EARPGO	The *Environmental Assessment Review Process Guidelines Order.*
ECO	Executive Council Office of the Yukon Government.
FA	Expert Federal Authority
IEE	Initial Environmental Evaluation.
LAQM	Limonitic Altered Quartz Menzonite.
RA	Responsible Authority pursuant to s.7 of the Yukon *Environmental Assessment Act.*
RBC	Rotating Biological Contactors
RERC	Regional Environmental Review Committee.
The project	The decommissioning, reclamation and abandonment of the Brewery Creek Mine.
VEC	Valued Ecosystem and Cultural Component.
WAD Cn	Weak Acid Dissociable Cyanide.

Water Board ('the Board'or YWB)	Yukon Water Board.
Water Licence	Water Use Licence as per the *Waters Act*.
EAA	The (Yukon) *Environmental Assessment Act.*

APPENDIX 2: Brewery Creek EA Consultation List

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