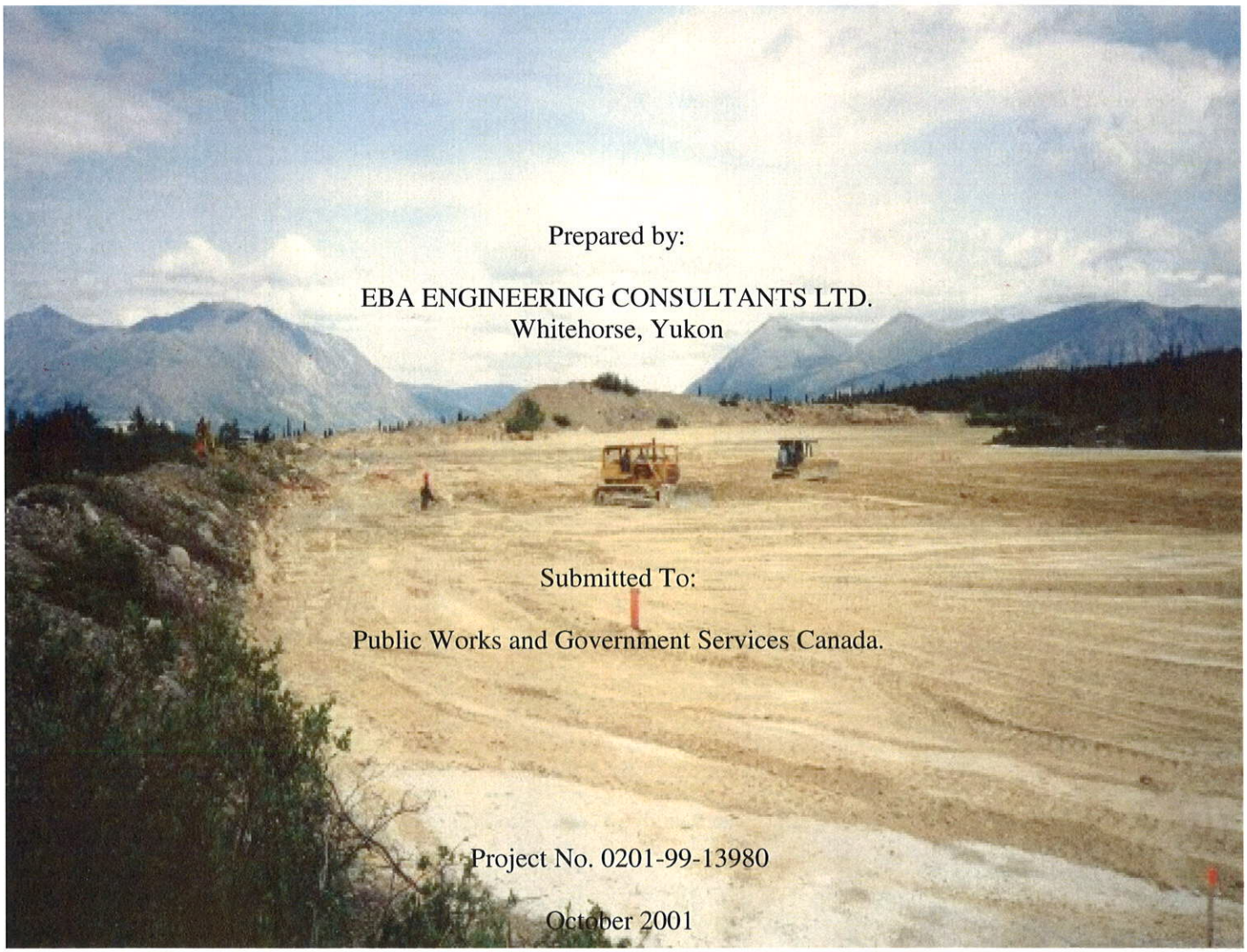
MN002

EBA Engineering Consultants Ltd.

Summary Report
Arctic Gold & Silver Tailings Site Remediation
Near Carcross, Yukon



Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
Whitehorse, Yukon

Submitted To:

Public Works and Government Services Canada.

Project No. 0201-99-13980

October 2001

Calcite Business Centre, Unit 6, 151 Industrial Road, Whitehorse, Yukon Y1A 2V3
Tel: (867) 668-3068 - Fax: (867) 668-4349 Internet: whitehorse@eba.ca - Web Site: http//www.eba.ca

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 PROJECT DESCRIPTION 3

2.1 SITE DESCRIPTION 3
2.2 REMEDIATION PLAN & DESIGN 4
2.3 CONSTRUCTION MANAGEMENT SERVICES 6
2.4 CONTRACTOR 6
2.5 SURVEYING 6

3.0 PHASE I SITE WORKS 6

3.1 WORK SUMMARY 6
3.1.1 Inert Waste Clean Up 7
3.1.2 Tailings Grading 7
3.1.3 Tailings And Ore Consolidation 9
3.1.4 Demolition of the Mill Loading Ramp 10
3.1.5 Supply and Placement of Silt Cap 11
3.1.6 Construction of the Drainage Channel 12
3.2 QUALITY ASSURANCE TESTING 12
3.3 SURVEYING 13
3.4 COST SUMMARY 13
3.4.1 Contractor's Costs 13
3.4.2 Contract Administration Costs 17

4.0 PHASE II SITEWORKS - UNNAMED LAKE DRAWDOWN 17

4.1 WORK SUMMARY 17
4.2 COST SUMMARY 18

5.0 PHASE III UNNAMED LAKE TAILINGS RECOVERY 18

5.1 WORK SUMMARY 18
5.2 COST SUMMARY 20

6.0 PHASE IV OUTLET STRUCTURE AND RESEEDING 20

6.1 WORK SUMMARY 20
6.2 COST SUMMARY 21

TABLE OF CONTENTS

7.0 PHASE V SUB-AQUEOUS TAILINGS IMPOUNDMENT COVER 22

7.1 WORK SUMMARY 22

7.2 COST SUMMARY 23

8.0 REPORT CLOSURE 24

Appendix A: Photographs

Appendix B: Specifications & Work Scope Letters

Appendix C: Daily Inspection Reports, Work Summaries, & Site Visit Reports

Appendix D: Site Meeting Minutes

Appendix E: Quality Assurance Test Results

Appendix F: Quantity Survey Reports

EXECUTIVE SUMMARY

In May 1999 the Environmental Services Directorate of Public Works and Government Services Canada (PWGSC) issued plans, specifications, and tender documents for the Remediation of the Tailings Site at the abandoned Arctic Gold and Silver tailings site near Carcross, Yukon.

The remediation plan consisted of a "consolidate and cover" option consisting of gathering all tailings and remaining ore exterior to the tailings impoundment (including subaqueous tailings) and consolidating them within the impoundment. Inert debris and waste exterior to the impoundment would be consolidated into a new landfill and/or disposed of offsite.

Tailings and ore consolidated into the tailings impoundment would be covered using locally available granular soils and imported fine grained soils. Existing decant piping from the impoundment would be sealed and surface drainage would be established. Finally, the site would be revegetated to control erosion from the site.

EBA Engineering Consultants Ltd. (EBA) was contracted by PWGSC to provide construction administration and resident engineering services during the execution of the site work that was undertaken in five phases between July 1999 and September 2001.

The first phase included: consolidation of the land deposited tailings and ore located outside of the impoundment; collection and disposal of inert site wastes; removal and reuse of the former mill loading ramp soils; and covering of the tailings impoundment with soils from the ramp structure and with fine grained soils imported to the site.

The second phase was conducted in the fall of 1999 and consisted of lowering the water level within the unnamed lake so that sub-aqueous tailings could be accessed. The third phase of site work consisted of the February 2000 collection of recoverable sub-aqueous tailings within the adjacent unnamed lake and placement of these tailings in a subsidiary impoundment constructed adjoining the main tailings impoundment.

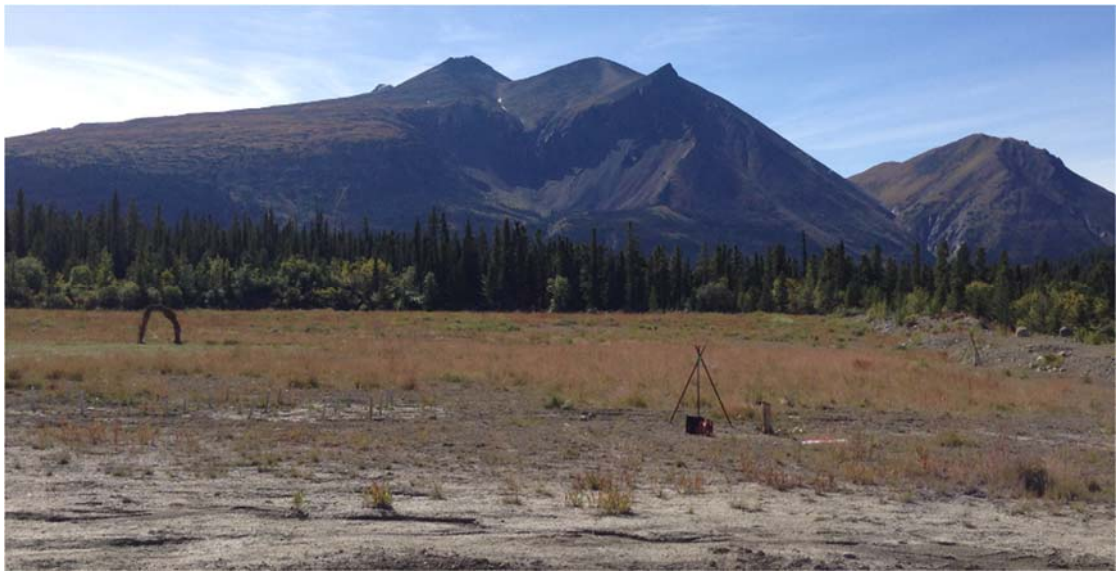
The fourth completed phase of the site work consisted of re-seeding of the effected site area and removal of existing culvert structures from the unnamed lake in August and September of 2000. The fifth and final phase of the site work consisted of consolidating and covering the sub-aqueous tailings impoundment. This was completed by September 2001.

The final costs, inclusive of GST, to complete the site remediation by the Contractor and by EBA were in the order of $ 479 800 and $ 109 000, respectively.

Site Characterization and Risk Assessment in Support of Remedial Planning for the Arctic Gold & Silver Tailings Site, Yukon – Final Report

Prepared for

Indigenous and Northern Affairs Canada



Prepared by

SRK Consulting (Canada) Inc.
1CA030.013
January 2017

Site Characterization and Risk Assessment in Support of Remedial Planning for the Arctic Gold & Silver Tailings Site, Yukon – Final Report

January 2017

Prepared for

Indigenous and Northern Affairs Canada
415C - 300 Main Street
Whitehorse, Yukon Y1A 2B5
Canada

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Project No: 1CA030.013

File Name: AGS_SiteCharacterization_Report_1CA030-013_kss_njh_mdr_20170124_FNL

srk consulting

Executive Summary

SRK Consulting (Canada) Inc., in cooperation with Azimuth Consulting Group Partnership, were contracted by Indigenous and Northern Affairs Canada (INAC) to evaluate the causes and potential risks associated with recent changes observed in water quality at the Arctic Gold and Silver tailings site, near Carcross, Yukon.

The first phase of the work included a detailed review of available information, a site reconnaissance, and an initial workshop to identify critical information gaps. Based on the findings of these activities, a more detailed work plan was developed. The second phase of work included targeted field investigations to address critical information gaps and a qualitative human health and ecological risk assessment. The overall objective of this work was to determine what level of remedial action may be required to address known and potential risks at the site. A conceptual site model was also prepared to help inform the risk assessment and remedial planning.

Field Investigation. The field program included groundwater investigations, and sampling and analysis of surface and groundwater quality, soil, lake sediments, aquatic invertebrates, and berries.

Groundwater flow. Groundwater flow is generally from east to west towards the Unnamed Lake, and travels in a uniform flow path, through moderate to low hydraulic conductivity soils. Monitoring data indicate that groundwater interaction with tailings is mainly due to infiltration through the cover leading to localised mounding. This vertical flow is likely mobilizing contaminants from the oxidized tailings and picked up by underlying lateral groundwater flow system. The interaction and subsequent flushing of the constituents from the tailings by the groundwater does not appear to be significant, but requires further definition.

Surface and groundwater quality. The majority of historical sampling locations have relatively few changes in water quality, with few signs of increasing concentrations over time. The only significant changes over time are increasing trends in concentrations of arsenic and cadmium in MW-2 and MW-4 in recent years, and a slight increase in copper concentrations in AGS-2 starting in 2010. These are attributed to breakthrough of the attenuation capacity for these metals in the soils below the tailings.

Soil. Soil in the areas surrounding the tailings impoundment, primarily the historical spill locations and the animal burrow areas on the tailings cover, has arsenic concentrations that exceeds the Canadian Council of Ministers of the Environment (CCME) soil quality guidelines for the protection of environmental and human health by factors by more than 100-fold. Exceedances of applicable guidelines also exist to a lesser degree for other metals, including antimony, cadmium, iron, lead, silver, and zinc.

Lake sediment. Sediment in the Unnamed Lake contains concentrations of arsenic and cadmium in excess of the CCME sediment quality guidelines for the protection of aquatic life (probable effect level) by up to a factor of 10. Copper and zinc also exceed their respective sediment quality guidelines, to a lesser degree.

Aquatic invertebrates. Some, but not all, aquatic invertebrates in the Unnamed Lake have higher concentrations of arsenic, cadmium, lead and zinc in comparison to upstream reference samples.

Berries. Lowbush cranberry tissue samples collected from the shoreline of Unnamed Lake downgradient of the tailings impoundment contained elevated concentrations of arsenic relative to samples collected from reference locations.

Preliminary Risk Assessment. A preliminary qualitative human health and ecological risk assessment was undertaken to systematically evaluate and characterize the potential human health and ecological risks associated with environmental contamination at the site. The level of detail of the preliminary risk assessment would not satisfy all of the requirements for risk assessments submitted for review under federal or territorial contaminated sites regulatory frameworks, but are sufficiently rigorous to identify relative priorities in the context of remedial planning and site management decisions. Risks were characterized as the likelihood, based on available data and best professional judgement, that the findings of a detailed quantitative risk assessment would trigger the need for risk management.

- Risks that were categorized as likely to require management action were (1) risks to human health from direct contact with contaminated soils at locations of historical tailings spills or where burrowing ground squirrels have brought tailings material to the surface of the tailings cover and (2) risks to frogs, or other small animals, from direct contact with puddles of acidic, tailings-impacted water on the shore of Unnamed Lake.
- There is some potential for risks to human health from the consumption of plants or small animals as food or other traditional uses and risks to wildlife species that frequent the site and eat insects or burrow into tailings. However, there is currently not enough information exists to determine, with sufficient certainty, if management actions are required to address these issues.
- Risks that were characterized as unlikely to require management action include risks to humans from consumption of drinking water or large animals and risks to fish, terrestrial plant and invertebrate communities, and large or herbivorous animals.

Indigenous and
Northern Affairs Canada

Affaires autochtones
et du Nord Canada

Operation, Maintenance and Surveillance Manual for the Tailings Impoundment Area at Arctic Gold and Silver Tailings Site - Revision 2017-01

Prepared for

Indigenous and Northern Affairs Canada

Prepared by

srk consulting

SRK Consulting (Canada) Inc.
1CI001.034
December 2017

Operation, Maintenance and Surveillance Manual for the Tailings Impoundment Area at Arctic Gold and Silver Tailings Site - Revision 2017-01

December 2017

Prepared for

Indigenous and Northern Affairs Canada
415C – 300 Main Street
Whitehorse, Yukon Y1A 2B5
Canada

Tel: +1 867 667 3888
Web: www.aadnc-aandc.gc.ca/

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Tel: +1 604 681 4196
Web: www.srk.com

Project No: 1CI001.034

File Name: AGS_OMS_1CI001 034_rev01_phm_sdm.docx

Key Contacts

Project Administration: Indigenous and Northern Affairs Canada (INAC)		
General Number	Whitehorse Office	1-867-667-3888
Site Manager	Jason Berkers	1-867-667-3161 Office 1-867-334-1703 Mobile
Environmental Coordinator	Clayton Dyck	1-867-667-3862 Office
Engineer of Record: Indigenous and Northern Affairs		
Geotechnical Engineer	Chris Dixon	1-867-667-3888 Office 1-867-667-3268 Direct
Regulatory Agencies		
Environment Canada	General Enquires	1-800-668-6767
	Reporting an Environmental Emergency	1-800-668-6767
Fisheries and Oceans Canada		1-867-393-6722
Yukon Water Board		1-867-456-3980
Natural Resources Canada		1-867-667-3957
Transport Canada (Prairie and Northern Region)		1-888-463-0521
Yukon Environmental and Socio Economic Assessment Board		1-867-668-6420
Environment Yukon		1-867-667-5652
Yukon Government - Energy, Mines and Resources		1-867-667-3130
Yukon Water Resources Branch		1-867-667-3171
Local Authorities: Town of Carcross		
Carcross	Carcross Fire Department	1-867-821-2222
	Carcross Ambulance	1-867-821-4444
	Carcross RCMP	1-867-536-5555
	Yukon Spill Line	1-867-667-7244
	YTG Report a Fire Line	1-888-798-3473
Yukon Emergency Measures Office		1-867-667-5220
Director – Yukon OH&S		1-867-667-5450

Table of Contents

1 Introduction 1
1.1 Purpose of OMS Manual 1
1.2 OMS Manual Updates 1
1.3 Related Documents 2
2 Role and Responsibilities 3
2.1 Organization Chart 3
2.2 Individual Responsibilities 3
2.3 Competency and Training 4
2.4 Managing Changes 4
2.5 Document Control 5
3 Facility Description 6
3.1 Physical Location 6
3.2 Site Conditions 6
3.2.1 Site Reference Data 6
3.2.2 Climate 6
3.2.3 Hydrology 7
3.2.4 Vegetation 7
3.2.5 Fish and Wildlife Resources 7
3.2.6 Tailings Properties 8
3.2.7 Surrounding Soils and Borrow Materials 9
3.2.8 Hydrogeology 10
3.3 Site History 10
3.4 Facility Components 13
3.5 Regulatory Requirements 14
3.6 Dam Hazard Classification 14
3.7 Basis of Design and Design Criteria 14
4 Operations 16
5 Maintenance 17
5.1 Objective 17
5.2 Inventory of Components Requiring Maintenance 17
5.3 Maintenance Schedule and Triggers 17
5.4 Event Driven Maintenance 19
5.4.1 Surficial Cracks and Erosion Gullies in Tailings Impoundment Berm and Cover 19
5.4.2 Drainage Structures 19
5.4.3 Monitoring Equipment 19

5.5 Documentation 20
6 Surveillance 21
6.1 Objective 21
6.2 Responsibility 21
6.3 Surveillance Parameters and Observations 21
6.3.1 Water Quality Sampling and Testing 22
6.3.2 Event Driven Inspections 24
7 Reporting and Communications 25
7.1 Communication Procedures 25
7.2 Documentation 25
7.3 Operations, Maintenance, and Surveillance Reporting 25
8 Emergency Preparedness and Response Plans 26
8.1 General 26
8.1.1 Alert Level 26
8.1.2 Emergency Level 26
8.1.3 Failure Level 27
8.2 Failure Modes and Associated Incident Levels 27
8.2.1 Berm Overtopping 27
8.2.2 Berm Instability 28
8.2.3 Seismic Events 28
8.3 Emergency Response Plan 29
8.3.1 Site Access 29
8.3.2 Communication Systems & Procedures 29
8.3.3 Call-out procedure 29
8.3.4 Training, Testing, and Updating 30
8.3.5 Contingency Plans 30
8.3.6 Incident Investigation Procedure 30
8.4 Key Contacts 31
9 References 32

List of Figures

Figure 1: General Location

Figure 2: Organization Chart and Contact Information

List of Tables

Table 1: OMS Manual Revision Control 2

Table 2: List of Documents Related to the OMS Manual 2

Table 3: Personnel implementing the OMS manual 3

Table 4: Personnel Core Competency and Training 4

Table 5: Mean Monthly Climatic Parameters from Carcross Station (1984 to 2008) 7

Table 6: Site History of the AGS tailings site remediation. 10

Table 7: Description of Facility Components Illustrated Appendix A-2, Figure 2 13

Table 8: CDA Design Criteria 15

Table 9: Typical Routine Maintenance Items 18

Table 10: Typical Event Driven Maintenance Items 18

Table 11: Surveillance Parameters and Critical Observations 22

Table 12: Water Quality Monitoring Locations 23

Table 13: Regulatory monitoring parameters 23

Table 14: Berm Overtopping – Alert Incident Level Response 28

Table 15: Berm Instability – Incident Level Response 28

Table 16: Seismic Event – Incident Level Response 29

List of Appendices

Appendix A – Drawings

Appendix A1 - SRK (1999) - Final Report - Assessment of Remedial Measures for Arctic Gold & Silver Tailings Site

Figure 2.2 - Plan of Tailings Area
Figure 2.3 - Section A-A and B-B

Appendix A2 - EBA (2001) - Summary Report - Arctic Gold & Silver Tailings Site Remediation

Figure 1 - Pre-Remediation Site Plan
Figure 2 - As-Built Site Plan
Figure 3: Sub-Aqueous Tailings Impoundment

Appendix A3 - EBA (2011) - Assessment of Low Permeability Cover as Infiltration and Oxygen Barrier to Reduce Acid Generation in Mine Tailings at Arctic Gold and Silver Mine Site

Figure 11 - Tailings Thickness

Appendix A4 - SRK (2017) - Site Characterization and Risk Assessment in Support of Remedial Planning for the Arctic Gold & Silver Tailings Site

Figure 4 - Historical and New Groundwater Monitoring Locations
Figure 5 - Historical and New Surface Water Monitoring Locations

Appendix B – Monitoring Plan (INAC 2015)

Appendix C – Borehole and Instrumentation Logs (EBA 1998)

Appendix D – Site Inspection Forms

List of Abbreviations

AGS	Arctic Gold and Silver
AGSWG	The Arctic Gold & Silver Working Group
CCME	Canadian Council of Ministers of the Environment
CDA	Canadian Dam Association
CTDC	Carcross Tagish Development Corporation
DSR	Dam Safety Review
DTA	Devolution Transfer Agreement
EPRP	Emergency Preparedness and Response Plan
INAC	Indigenous and Northern Affairs Canada
IPRP	Independent Peer Review Panel
MW	Monitoring Well
OMS	Operations Maintenance and Surveillance
PWGSC	Public Works and Government Services Canada
YCSR	Yukon Contaminated Sites Regulations

1 Introduction

SRK Consulting (Canada) Inc. has been retained by Indigenous and Northern Affairs Canada (INAC) to prepare an Operations, Maintenance, and Surveillance (OMS) manual for the covered tailings impoundment located at the reclaimed Arctic Gold and Silver (AGS) tailings site in the Yukon, Canada (Figure 1). Reclamation of the site was completed in five phases between 1999 and 2001 by Tetra Tech Inc., formerly EBA Engineering Consultants Ltd. (EBA). Completed work was administered by the Environmental Services Directorate of Public Works and Government Services Canada (PWGSC). The AGS site has since been monitored by the Waste Management Program by INAC and its agents.

This manual is prepared in accordance with the guidelines provided by the Mining Association of Canada (MAC 2011) and the Canadian Dam Association (CDA) publication Dam Safety Guidelines (CDA 2013), and the technical bulletin (CDA 2014) prepared by the CDA Mining Dams Committee.

1.1 Purpose of OMS Manual

This OMS manual provides the framework for the monitoring and maintenance of the tailings impoundment and water management structures. This manual defines and describes the following:

- Roles and responsibilities of parties associated with the monitoring and maintenance of the site
- Procedures and processes for managing change
- Key components of the facility
- Procedures to monitor the performance of, and maintain the facility to ensure that it functions in accordance with its design, and meets regulatory obligations
- Procedures of the emergency and preparedness and response plan
- Requirements for analysis and documentation of the performance of the facility

1.2 OMS Manual Updates

This OMS manual is the property of INAC, which has sole authority on the distribution of this document. INAC, specifically the Site Manager, is responsible for revisions to the manual or to contract a third party to accomplish the revisions.

This OMS manual should be reviewed as part of the routine environmental monitoring and annual inspections. Furthermore, the OMS manual should be referenced if significant changes on site occur to assess the validity of the content under the prevailing conditions at the time of the review. Revisions to the manual should be undertaken within a reasonable time frame (e.g. six months) and re-issued.

As far as practical, revision to the OMS manual should be made in advance of major changes to the closure monitoring and maintenance plans or regulations. Should any changes to these plans

be required, the OMS manual will require an update. Table 1 summarizes the revision history of this document.

Table 1: OMS Manual Revision Control

Revision	Prepared By	Primary Author(s)	Changes
2017-1	SRK Consulting (Canada) Inc.	Stuart McPhee, EIT; Peter Mikes, PEng; Reviewed by Michael McIsaac	Initial version

The OMS manual is to be distributed as follows:

- One copy to the INAC Project Manager/Representative
- One copy to the Engineer of Record
- One copy to the Environmental Coordinator
- One copy to the Carcross Tagish First Nations
- One copy to the Yukon Emergency Measures Office

1.3 Related Documents

The following documents listed in Table 2 are expected to be referenced and utilized in conjunction with the OMS Manual.

Table 2: List of Documents Related to the OMS Manual

Document Title	Year	Relevance
Site Characterization and Risk Assessment in Support of Remedial Planning for the Arctic Gold and Silver Tailings Site	2017	Evaluates the causes and potential risks associated with recent changes observed in water quality.
Monitoring Plan for DTA – Contained Sites: Venus Mine Tailings and Arctic Gold and Silver Tailings	2015	Describes the monitoring plan for the site.
Summary Report Arctic Gold and Silver Tailings Site Remediation	2001	Provides the as-built details of the remediation measures implemented between 1999 and 2001
Assessment of Remedial Measures for Arctic Gold and Silver Tailings Site.	1999	Summarizes the investigations and remedial measures for the site.

Example Remediation Options, including Cost Estimates for the Arctic Gold & Silver Tailings Site, Yukon – Final Report

Prepared for

Indigenous and Northern Affairs Canada

Prepared by

SRK Consulting (Canada) Inc.
1CA030.013
January 2017

Example Remediation Options, including Cost Estimates for the Arctic Gold & Silver Tailings Site, Yukon – Final Report

January 2017

Prepared for

Indigenous and Northern Affairs Canada
415C - 300 Main Street
Whitehorse, Yukon Y1A 2B5
Canada

Prepared by

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2
Canada

Project No: 1CA030.013

File Name: AGS_ExampleOptions_Report_1CA030-013_KSS_EK_PMH_20170130_FNL

srk consulting

Executive Summary

INAC, in cooperation with the Carcross/Tagish First Nation (CTFN) contracted SRK Consulting (Canada) Inc. to identify and develop costs for a range of potential remedial actions that could be implemented to address potential human health or ecological risk identified for the Arctic Gold and Silver site near Carcross Yukon. The objective of defining example remediation options was to provide a basis for evaluating the cost-benefits of further investigation versus implementation of remediation measures. The example options were also intended to form a basis for gathering input from various stakeholders, including CTFN on potential remediation measures for this site.

Example options are described as follows:

- Example 1 addresses likely risks identified in the risk assessment, and includes removal and on-site consolidation of the contaminated soils on-site, and construction of a physical barrier to prevent exposure of terrestrial and aquatic wildlife to seepage water discharging along the shoreline.
- Example 2 addresses likely risks, as described above, as well as uncertain risks associated with contaminant loading to Unnamed Lake. Reductions to contaminant loading would be achieved through improvements to the existing cover system and improved drainage around the perimeter of the facility.
- Example 3 addresses the both likely and uncertain risks by relocating these materials to an off-site engineered containment facility. This alternative includes the costs of relocating the materials to a new facility and reclaiming the existing site.

Estimated costs for these options ranged from $2.2 million for Example 1 to $14.3 million for Example 3.

It is emphasized that further work to address some of the uncertainties identified in the risk assessment is required before final decisions regarding remedial actions can be made. Additionally, there are many other possible remediation measures that could be considered. However, the project is now at a stage where further input from other stakeholders, including clarity on future land use objectives is required to support further evaluation of options.

JACOBS®

Memorandum

202C Strickland Street, 2nd Floor
Whitehorse, Yukon Y1A 2J8
Canada
www.jacobs.com

Subject	**2018 Data Gap Analysis and Site Investigation Workplan for the Arctic Gold and Silver Mine**
Attention	Carcross Tagish Management Corporation (CTMC)
From	Jacobs Engineering Group Inc. (Jacobs)
Date	August 2018
Project No.	707123
Revision No.	1
Reviewed by	Liz van Warmerdam/Jacobs

1. Introduction

The Carcross/Tagish Management Corporation (CTMC) retained CH2M HILL Canada Limited (CH2M), now Jacobs Engineering Group Inc. (Jacobs), as the lead consultant to complete a series of pre-determined tasks in anticipation of future remediation activities, with the end goal of site closure at the Arctic Gold and Silver Mine Site (AGS or the Site). It is Jacobs' understanding that the Carcross Tagish First Nation (CTFN) community wants the Site to be closed such that it can be used by community members. Their goal is to have the Site meet residential land use standards, such that the Site and surrounding area are safe to be used in a variety of ways, ranging from harvesting the local flora and fauna to being able to develop some areas for potential commercial purposes.

In the June 8, 2018 Revised Work Proposal, we outlined six tasks to be completed by the Jacobs team, which included a gap analysis and Site investigation work plan; the subject of this Technical Memorandum (TM). This TM identifies and briefly discusses the data gaps identified and outlines the Site investigation workplan proposed to address the data gaps in order to provide the CTMC with a better understanding of the Site conditions, and the risks associated with the current state of the former Site, with the intent of achieving Site closure as soon as possible. The findings of the Site investigation will then be communicated to the CTMC with an updated Site Characterization and Risk Evaluation Report, which is the sixth and final task outlined in the Revised Work Proposal (Jacobs, 2018).

2. Background

The Site is located 4 kilometres (km) south of Carcross, on Montana Mountain, at an elevation of 1,025 metres above sea level (masl) (SRK, 2017). Montana Mountain holds great cultural significance for the CTFN and has traditionally been used as a camp for hunting moose, trapping ground squirrels, and collecting plant-based traditional foods and medicines (Patrick James, pers. comm.). Mining on Montana Mountain spanned the entirety of the 1900s leaving behind a complicated legacy that is a critical part of CTFN's history (Mann, 1998).

Mining activities at AGS occurred over a 4-year period from 1965 to 1969. The mine workings consisted of two horizontal shafts driven near, and eventually connected to, the previous mine workings of the Big Thing and Peerless mines. Gold and silver was recovered from the quartz veins of the Montana Pluton

Human Health and Ecological Risk Assessment for the Arctic Gold and Silver Tailings Site – 2018 Update

Prepared for:

CARCROSS TAGISH
MANAGEMENT CORPORATION

Carcross Tagish Management Corporation
Suite #15 – 1114 Front Street
Whitehorse, YT, Y1A 1A3

FINAL

May 2019

AZIMUTH

Azimuth Consulting Group Partnership

218-2902 West Broadway
Vancouver, B.C. V6K 2G8

Project No. CT-18-01/AGS ERA

Report Distribution

Version	Dates	Distribution
Draft for client review	Report issued: March 1, 2019	CTMC: K. Gardner, R. Lewis, N. Lepine
Final	Report issued: June 3, 2019	CTMC: K. Gardner, R. Lewis, N. Lepine

EXECUTIVE SUMMARY

Azimuth Consulting Group Partnership (Azimuth) has been working on behalf of the Carcross Tagish Management Corporation (CTMC) to determine if environmental contamination associated with the former Arctic Gold and Silver (AGS) mill and tailings storage facility (the Site) pose risks to human health or the environment. The studies and information summarized in this report will help guide decisions on how best to manage the Site to ensure people and the environment are protected from the potential harmful effects of the contamination. This report presents our current understanding of the potential risks associated with current conditions at the Site, but we caution that investigations are ongoing and the extent of contamination is not yet clearly defined and that Site conditions may change in the future. This Executive Summary should be read in conjunction with the remainder of the report and is subject to the same limitations as described therein.

Tsélgi shaa – AGS is located on a sub-alpine plateau on the shoulder of Tsélgi shaa (Montana Mountain) in the traditional territory of the Carcross / Tagish First Nation (C/TFN). Montana Mountain and the surrounding region is a culturally important area for the C/TFN and was used traditionally for hunting wildlife and birds and harvesting plants for food and traditional medicines. In recent years, the C/TFN have developed a world-class network of recreational mountain biking and hiking trails. AGS is located on Category A Settlement Land, meaning the C/TFN owns and governs the land (surface and subsurface rights) and has the final authority and decision body regarding how the land is reclaimed and used.

Mining – In addition to its cultural significance, Tsélgi shaa is also a highly mineralized area, and several mining claims were established on the mountain during the Windy Arm gold rush at the end of the 19th century. Big Thing Mine, along with Venus on Tagish Lake, were the two most developed and heavily worked claims in the region. During the early mining phase (1905 to 1917), ore from Big Thing Mine was transported to Carcross and shipped by rail to Skagway on the White Pass Rail Line for milling in Washington State. It wasn't until the mid-1960's that the mill was constructed at AGS. This phase of operations was brief, and by 1970 the mill at AGS had ceased operating.

1999-2000 Rehabilitation – ore from the Big Thing Mine was milled for gold and silver, but was also naturally elevated in other metals such as arsenic, cadmium, lead, and zinc. Processing, handling, and stockpiling of ore, dispersion of tailings by wind, and leaching of metals from tailings resulted in elevated metals in concentrations of metals in soils and groundwater near the Site and in sediments in the Mine-Made Lake. Some Site rehabilitation work was undertaken in 1999 and 2000. Tailings, some contaminated soils, and a limited amount of sediment from Mine-Made Lake were consolidated and covered to form a tailings storage facility with the goal of containing the contamination and preventing metals from leaching into groundwater and migrating to Mine-Made Lake. The soils around the Site were, not remediated. Tailings-contaminated sediments in Mine-Made Lake were also left largely un-

remediated. These areas were the focus of environmental investigations in 2015 and 2018 to identify if humans and wildlife using the Site are at risk from exposure to contaminants.

Human Health

Metals Contamination in Soils – A soil-sampling program was completed in 2016 and 2017 to determine how far metals contamination extends and the concentrations of various metals in the soil. Several metals, most notably arsenic, exceeded concentrations associated with risks to human health. Importantly, soils in the area are naturally high in metals, which is often the case in mine settings. In the case of arsenic, the natural level exceeded the human health guideline. A site-specific human health guideline was calculated based on quantitative human health risk assessment methods and taking into consideration different health endpoints, different routes of exposure and differences between adults and toddlers. The lowest Site-specific soil criterion for protecting human health was 300-mg/kg arsenic in soil (Azimuth, 2017). This guideline will help identify areas of the Site that require active remediation or other types of management to protect human health. By remediating/reclaiming the soils, health risks to people using the Site for traditional purposes, such as collecting berries or traditional medicines, will also be reduced.

Human Health Risks

Processing ore at the AGS resulted in high concentrations of arsenic and other metals in the soil. Measured concentrations of arsenic exceed concentrations that are safe for people using the Site.

Ecological Health

Terrestrial Environment – Contaminated soil in the areas surrounding the former mill site and tailings area require remediation to protect human health. If these soils are cleaned up and the tailings cover is restored to its original design, the plants growing on Site and the resident Arctic ground squirrel colony and other animals that periodically use the land will also be protected.

Aquatic Environment – Mine-Made Lake is the closest aquatic habitat to the Site and is home to several aquatic birds during the open water season. Water levels (and flow) fluctuate seasonally and overall the lake does not support a fish population. Water flows from the outlet of Mine-Made Lake through a culvert into Tank Creek.

The metals entering the Mine-Made Lake will be reduced or eliminated when the contaminated soil and tailings storage facility are remediated. What was unclear is whether current concentrations of metals in the Mine-Made Lake pose risks to wildlife that live in or use the lake. The goal of the ecological risk assessment is to determine if the risks are high enough to require remediation of the Mine-Made Lake in addition to tailings storage facility and contaminated soil.

2015 Investigation

Background – A reconnaissance-level sampling program was completed in 2015 to better understand risks to birds and wildlife that use the Site. One of the main objectives of the 2015 investigation was to determine if metals are accumulating in the freshwater food web compared to the lake upstream that is not affected by the AGS. Aquatic plants and invertebrate communities in the Mine-Made Lake form the base of the aquatic food web, providing food for a variety of bird species. Most metals in aquatic environments are taken up (accumulated) by invertebrates to higher concentrations than aquatic plants, meaning species that feed primarily on aquatic invertebrates from the Mine-Made Lake are likely more exposed to metals than aquatic birds that feed mainly on plants.

Preliminary Results– Sediment collected from the Mine-Made Lake have high concentrations of metals, and metals concentrations in aquatic invertebrates from the Mine-Made Lake were higher than the Upstream Reference area. Several aquatic bird species at the Mine-Made Lake feed on invertebrates, but the rusty blackbird, was the only aquatic bird species observed on Site that has special conservation status in the Yukon Territory. Furthermore, rusty blackbirds have a relatively small home range and feed primarily on aquatic invertebrates, meaning they are likely more exposed to metals than semi-aquatic bird species or species that feed on plants. Based on the measured concentrations of metals in sediment and invertebrate prey items, and the listed status of the rusty blackbird, preliminary risk conclusions in the 2015 report were *likely, but uncertain* for listed aquatic bird species at AGS. Risks to listed amphibians, if they occur on Site, were also considered *likely, but uncertain*. Risks to common aquatic bird species and other receptors were *unlikely, but uncertain*.

Aquatic ERA Strategy

The investigation of potential risks to listed aquatic bird species and the Columbia spotted frog were identified as high priority data gaps in the 2015 ERA. ***The focus of the 2018 HHERA Update was further refined to focus on the rusty blackbird****. (i.e., Columbia spotted frog and horned grebe are unlikely to occur at AGS based on results of the 2018 investigations)*

2018 Investigation

Follow-up work was recommended to inform risk management decisions (i.e., remediate or not) with an emphasis on high priority receptors with *likely, but uncertain* risk ratings in the 2015 investigation. The 2018 investigations involved the following tasks:

- Collecting sediment and aquatic invertebrate (aquatic and emergent life stages) samples from Mine-Made Lake and off-Site reference areas to determine which metals are accumulating in the food web at the Mine-Made Lake. These data were used as inputs in a simulated food chain model to estimate the dose of metals for adult and juvenile rusty blackbirds. The estimated dose was compared against toxicity data reported in the scientific literature to determine whether current conditions have the potential to cause adverse effects to survival and reproduction.

- Bird and wildlife surveys with an emphasis on 1) determining if the horned grebe (a listed aquatic bird species) uses Mine-Made Lake, and 2) recording information on the reproductive success and foraging behaviour of the rusty blackbird.
- Determining the presence or absence of Columbia spotted frog (a listed species) using physical searches of the area and environmental DNA analysis.
- Supplemental sediment investigations were also conducted to better understand how metals accumulate and partition in the Mine-Made Lake and the spatial extent of metals concentrations downstream of AGS in Bennett Lake.

Food chain model (effects to rusty blackbirds) – The food chain model takes into consideration the concentration of metals from three sources: diet (aquatic invertebrates), incidental sediment ingestion, and water. Of the metals that occur on Site, only arsenic was predicted to cause adverse effects to survival and reproduction under current conditions. Incidental sediment ingested during feeding contributed over 90% of the arsenic dose to the adult and juvenile birds in the food chain model. Juvenile rusty blackbirds were more sensitive to effects on survival compared to the adults. The combined dose of arsenic in the simulated food chain model was estimated to cause 100% mortality to juvenile rusty blackbirds.

Rusty blackbird field observations –biologists visited the Site five times in July and August; key findings were:

- The horned grebe, a listed species with the potential to occur on Site, was not observed in 2018. Horned grebes are piscivorous and are unlikely to use the Site because the Mine-Made Lake is not fish bearing.
- Rusty blackbirds were recorded at the Mine-Made Lake and the Upstream Reference Area during multiple site visits in 2018. It's unclear from the survey if the adult rusty blackbird has a preference for one lake more than the other. What is certain is that they feed along the shoreline of both lakes and forage for organic debris (e.g., sticks and reeds) to build and maintain their nest. The nest was not observed directly, but its location in a patch of short scrubby spruce located in the wetland complex to the south and west of the Mine-Made Lake was inferred from flight behaviour.

- Two rusty blackbird chicks successfully fledged and left the nest. During one field visit, the biologists observed chicks being fed by the adults along the shoreline of the Mine-Made Lake.

Risk conclusion for the rusty blackbirds – The field observations from 2018 provide direct evidence that the rusty blackbirds are reproducing and rearing chicks that are surviving to fledge. The sensitivity of the field observations to determine if the local population is adversely affected by metals in Mine-Made Lake is low. More data is needed to understand if the successful fledging of two chicks is within the normal range for rusty blackbirds in the region.

Based on results of the food chain model, current concentrations of arsenic in sediment and invertebrate prey pose a significant risk to juvenile rusty blackbird survival. There is high uncertainty associated with the food chain model results based on conservatism and uncertainties in the model, namely: 1) the bioavailability of arsenic in sediment is assumed at 100%, 2) sediment arsenic concentrations are from samples collected away from the shoreline where the birds were observed foraging, and 3) the relative time spent foraging at Mine-Made Lake vs. Off-Site reference areas are not fully understood.

Taking into consideration all the available evidence collected in 2018, risks to the rusty blackbirds on Site were *high, with high uncertainty*. The apparent discordance between field observations (chicks survived to fledge) and food chain model results (100% mortality for juvenile birds) highlights the need for additional monitoring to assess the health of the rusty blackbirds.

Amphibians –Columbia spotted frog was not observed during physical searches of Mine-Made Lake or in analysis of water samples for eDNA. Wood frogs were observed at the Upstream Reference Area but not at Mine-Made Lake in 2018. Because the wood frog is common and abundant, potential risks to this species are *unlikely, but uncertain*. The conclusion is uncertain because it is not known whether the C/TFN consider potential impacts to a small number of common frogs acceptable or not.

Risk to other aquatic receptors – aquatic plants and invertebrates and common wildlife species were considered low priority for further risk assessment based on *unlikely, but uncertain* risk conclusions in the 2015 ERA. The risk conclusion for aquatic plants and invertebrates is uncertain because it is not known whether the C/TFN consider potential impacts to aquatic invertebrates and plants in a portion of the Mine-Made Lake acceptable or not. The risk conclusions for common wildlife species are uncertain because the rusty blackbird is the sentinel receptor for the wildlife risk assessment and, as discussed above, the risk conclusions for the rusty blackbird remain uncertain. If future risk assessment determines that risks to the rusty blackbird are acceptable, risks to other wildlife species would also likely be acceptable.

Results – Sediment investigations

Sediment investigations in Mine-Made Lake helped provided additional insight regarding metal concentrations in Mine-Made Lake and the potential for off-Site migration and accumulation of metals to Bennett Lake. Key findings from the 2018 investigation include:

- Evidence of tailings were measured at depth (20-25 cm) in an area of Mine-Made Lake that was not remediated in 2000. Tailings were not evident in the core collected from within the area that was remediated.
- Sedimentation rates for Mine-Made Lake were calculated to help inform rates of recovery in the lake. Arsenic and lead concentrations were highest in the sediment core horizons between 4 and 13 cm. Loading of arsenic and lead relative to the natural rate of sedimentation appears stable or decreasing. Cadmium, copper, iron, and zinc concentrations are highest in the surficial sediment layer in cores from the remediated and un-remediated areas. These results suggest ongoing source loading is occurring.
- Arsenic, cadmium and zinc were elevated above the sediment quality guidelines at the outlet of Tank Creek into Bennett Lake. It's unclear if the concentrations are representative of background or indicative of off-Site migration of metals. Relative to Mine-Made Lake, concentrations are low.

Site Management Considerations

Azimuth understands that remedial activities will be implemented to eliminate human exposure to contaminated soil and that the tailings storage facility (TSF) will, if not be removed or replaced, will at least be restored to meet the original design objectives to limit the release of acidic, metals-rich leachate to Mine-Made Lake. Remediation of contaminated soils will also eliminate risks to land-based plants and animals and humans that might consume those plants or animals. Therefore, the primary purpose of the 2018 HHERA update was to help the C/TFN decide if any action, beyond monitoring, is required in the aquatic receiving environment in Mine-Made Lake.

Mine-Made Lake does not support a resident fish population. Therefore, contaminated water, sediment and biota in Mine-Made Lake can potentially present risks to humans and aquatic plants and invertebrates and aquatic wildlife.

Previous assessments concluded that risks to humans from drinking water from Mine-Made Lake, direct contact with contaminated sediment, or consuming plants or animals from Mine-Made Lake were unlikely, but uncertain. These risks only require limited additional assessment or monitoring to confirm that risks are acceptably low.

We recommend conducting additional sediment sampling and a quantitative HHRA to define the extent of sediment in the near-shore of Mine-Made Lake that may require risk management. Alternatively, it may be more cost effective to simply assume all the accessible sediments in Mine-Made Lake higher than water 1 m deep (at seasonal low water levels) require risk management.

To the extent that uncertainty about potential risks from consuming biota remains a community concern, we recommend completing a study of contaminant levels in the tissue of Arctic ground squirrel and aquatic plants and animals that are traditionally consumed by C/TFN Citizens.

The rusty blackbird was selected as the wildlife species likely to be the most sensitive to the potential adverse effects of contaminated water, sediment and biota in Mine-Made Lake. The 2018 HHERA Update concluded that potential risks to the rusty blackbird were high, but the conclusion also had high uncertainty because the results of the observational study, to some degree, contradicted the results from the predictive food chain model.

Given the high level of uncertainty associated with the conclusion about potential risks to rusty blackbirds, we do not recommend making a decision on the need to remediate Mine-Made Lake on the basis of the conclusion of the 2018 HHERA update. Rather, we recommend that consideration be given to the value of further risk assessment to refine the risk conclusion for rusty blackbirds. This would involve further observational studies on the reproductive success of rusty blackbirds. Depending on the level of confidence desired by C/TFN, several years of monitoring may be necessary to provide enough certainty about the potential risks to rusty blackbirds.

The potential costs and time-delays associated with further risk assessment must be weighed against the costs and potential environmental impacts of remediation. Unless a risk assessment clearly shows that environmental contamination exceeds acceptable levels of risk, the environmental and health benefits remediation of that contamination are uncertain. Without reasonably certain conclusions about the risks from leaving contamination in place, the possibility that remediation could cause more damage than good cannot be ruled out.

Arctic Gold and Silver Mine Remediation Project

Site Characterization and Conceptual Site Model Report

FINAL

April 2020

Carcross Tagish Energy Corporation

Arctic Gold and Silver Mine Remediation Project

Project No:	CE761100.A.CS.EV.7-1-1
Document Title:	Site Characterization and Conceptual Site Model Report
Document No.:	FES0124201507VBC
Revision:	FINAL
Date:	April 2020
Client Name:	Carcross Tagish Energy Corporation
Project Manager:	Charles Shewen, B.Sc., RP.Bio., PMP
Authors:	Alan Campbell, B.Eng., E.I.T. Andrew Canali, M.Sc. Charles Shewen, R.P.Bio., PMP Brian Schroth, P.G., C.Hg. Alex Biczok, B.ASc. Jeremy Piper, M.Sc. Peter Lawson, M.Sc. P.G., C.Hg. (E.) Liz van Warmerdam, M.Sc., P.Geo.

CH2M HILL Canada Limited, a wholly owned subsidiary of Jacobs

Nuvo Building – Suite 401C
309 Strickland
Whitehorse, YT Y1A 2J9
Canada
T +1.604.684.3282
F +1.604.684.3292
www.jacobs.com

Document History and Status

Revision	Date	Description	By	Review	Approved

Executive Summary

In 1998, the Government of Canada implemented a closure design for the Arctic Gold and Silver Site (the Site) to cap and isolate the tailings, with the design intent being to keep the tailings dry. In 2001, the Site was transferred to the Government of Yukon and subsequently to the Carcross/Tagish First Nation (C/TFN) through a Settlement Agreement as originally enacted via the Yukon Northern Affairs Program Devolution Transfer Agreement (DTA). The Site is located on Category A Settlement Land.

Acid-generating tailings are present at the Site. Some of the tailings are in contact with water, resulting in metal leaching from the tailings left on-site and the naturally occurring till materials. Historic mining process activities and the ore body type making up the tailings have resulted in exposure of shallow soils with elevated metals concentrations, groundwater with low pH, and elevated dissolved metals discharging to surface water, creating potential environmental and human health risks requiring remediation. Human health risks from contaminated soil require remediation (exceed risk-based standards). The extent and magnitude of potential ecological risks are still under investigation.

When the Site was transferred via the Devolution Transfer Process, it was considered ‘Contained’ where ‘Contained’ is defined as a site where an impact was remediated by containment only.

As part of the 2019 field program, the CH2M HILL Canada Limited, a wholly owned subsidiary of Jacobs (Jacobs) team installed drive points (DPs), drilled boreholes, and installed monitoring wells (MWs) at each drilled location. Some wells were nested (that is, two wells were drilled within close proximity to one another or a second well was added near an existing well). The intention of nesting the wells was to obtain groundwater and soil information from different vertical depths at the same location. Additionally, the team added two surface water gauge locations. Single-well hydraulic response testing was completed at all newly installed wells.

Regular monitoring and sampling of the existing sampling points was completed by others in 2019. These data were included in the Jacobs database and data up to and including January 2020 were included in interpretations completed for the hydrogeological and geochemical understanding of the Site.

The data were used to construct a three-dimensional groundwater model, and a one-dimensional geochemical model. Together, these models were used to further a Conceptual Site Model of the Site to identify groundwater flow and contaminant transport.

Jacobs used the data collected during the 2019 field season and integrated it with previous data to further the understanding of environmental conditions (geology, hydrogeology, and the presence and migration of contamination relating to the former mining activities) at the Site. From this understanding, we have drawn conclusions and made recommendations for further work based on our technical understanding of Site conditions.

Background Conditions

- The Site is in a mining area, and as such is metal-rich. Background metals concentrations are high, and for some metals, soil, groundwater and sediment concentrations may exceed Canada Council of Ministers of the Environment (CCME) and/or Yukon-based guidelines/standards.
- Contaminant sources at the Site include tailings in the storage facility, tailings in the spill areas, tailings in the mine-made lake, sediment in the lake with elevated metals concentrations, and shallow surface soils susceptible to wind, with high arsenic concentrations.

Surface Water

- Tank Creek starts at the mine-made lake as numerous twisted and braided alignments flowing in a basin, converging to a single main channel at surface water monitoring location AGS-4.

Geology and Geochemistry

- The geological sequences at the Site include glacial overburden with fill deposits.
- Sonic drilling provided superior core samples from the boreholes, enabling identification of significant variations within the glacial geology not previously identified; discrete gravel lenses cross-cutting the bulk till and glacial outwash deposits.
- Tailings material; lack neutralization potential, are actively generating acid, and have high concentrations of arsenic, copper, iron, lead, and zinc.
- Overburden material (till) has been impacted by contamination from drainage of upgradient sources and by windblown dust or spilled tailings. The extent of surface impacts from mining activities has not been fully delineated (either laterally or vertically).
- Till materials are described as non-acid-generating, with a limited buffering capacity.
- The glacial till covers the majority of the Site with hydraulic conductivity values ranging from 2.2 to $8.3x10^{-7}$ metres per second (m/s).
- The glacial outwash underlies the glacial till and is more coarse-grained than the overlying till, comprised of silt and sand, with a hydraulic conductivity mean of $4.6x10^{-6}$ m/s.
- The glaciofluvial channel fill material are discrete intervals of coarse-grained material at or near the contact between glacial till and the underlying glaciofluvial outwash. The materials are comprised of gravel with sand, with a mean hydraulic conductivity of $1.5x10^{-5}$ m/s.
- Sulphate percentage in groundwater provides an effective contrast between background groundwater and groundwater affected by acid rock drainage. Shallow wells beneath the Tailings Storage Facility (TSF) show influence of the tailings.
- Wells screened in the deeper glacial outwash show sulphate presence while their shallow equivalents do not. This suggests the higher permeability glacial outwash serves as a preferred pathway compared to the less permeable till.
- Various geochemical interactions along the flow path result in different break through times for dissolved constituents from the tailings. Simple geochemical modelling showings that sulphate is the most mobile and is the first to emerge downgradient of the tailings. Zinc breakthrough follows, and cadmium and arsenic are next.
- Elevated zinc concentrations in the permeable channel fill deposits downgradient of the TSF indicate that contamination is reaching this unit, and based on modelling results, arsenic will follow, if sources remain unchanged.
- Despite dissolved metals concentrations that meet the standards/guidelines, MWs, and DPs near and along Tank Creek show influence of acid rock drainage with sulphate. Dilution, buffering, and attenuation are moderating the water quality impacts at present.

Groundwater

- Groundwater flow is to the west (towards the mine-made lake) and to the northwest (towards Tank Creek). There is a groundwater divide between these two flow paths that may be seasonally variable.
- Groundwater in all three units (glacial till, glacial outwash, and glaciofluvial channel fill) exceeds the Yukon *Contaminated Sites Regulation* and CCME standards/guidelines. There is geochemical evidence that indicates that the more permeable glacial outwash and channel fill are acting as preferred pathways for contaminant migration.

Summary

- The TSF is not functioning as designed. Tailings in the storage facility are being exposed to water and oxygen, are generating acid, and leaching metals.
- The full extent of contamination resulting from the TSF has not been delineated.

- Based on the geology and hydrogeology evidence, three hydrostratigraphic units are identified at the Site. These are described as glacial till, glacial outwash, and glaciofluvial channel fill.
- Site conditions indicate that the tailings in the storage facility and likely the spilled tailings both constitute a substantial source of continued acid generation and metals mobilization.
- Preliminary geochemical modelling results indicate the likelihood that further northwest migration of trace elements and low pH will continue if conditions are not changed.

As defined in the DTA, the Site is classified as Contained. The containment design at the Site was identified to have a 150-year design life. Analytical results and the subsequent conclusions drawn from the data indicate that the remedial works implemented to contain the Site are not preventing contaminant migration, containment at the Site is not functioning as designed and contamination is migrating into the environment. These conditions indicate that the site is not contained.

Contamination at the Site is not contained, and a long-term, permanent closure strategy is required to protect human health and the environment and return the Site to a land use suitable by the current owner C/TFN. This can be accomplished by invoking the Site warranty as outlined in the DTA.

To support ongoing care and maintenance activities, Jacobs recommends the following further work be completed at the Site.

- Continue monthly monitoring surface water elevations and flow at established stations – with specific focus on the seasons when surface water conditions change.
- Continue routine monthly monitoring of surface water, and groundwater, including DPs and MWs, with specific focus on months when water elevations may change substantially.

To support developing an effective containment strategy that addresses all sources of contamination at the Site, Jacobs recommend the following to further the understanding of Site conditions:

- Complete characterization of background soil and groundwater conditions to support developing Site-specific standards.
- Continue characterization and delineation of Site-related contamination on-Site and in the aquatic receiving environments (mine-made lake, Tank Creek and Bennett Lake) until sufficient data are available to support a comprehensive and final remediation plan.
- Better definition of the glaciofluvial channel fill material my help identify potential preferential pathways.
- Include meteorological monitoring to the regular monthly monitoring already underway at the Site, to address data gaps relating to the water balance (specifically addressing understanding of precipitation and infiltration through the existing cap).
- Continue to advance the understanding of the Site using the hydrogeological model and adding Site-specific meteorological information.
- Expand the geochemical model to a three-dimensional format to account for groundwater mixing, lateral dispersion, and effects of additional sources of potential contamination. This will allow proper assessment and comparison of remedial action alternatives.

Interim Site Risk Management Human Health Risk Assessment

Arctic Gold and Silver Mine Site

Final

Prepared for:

Carcross/Tagish Energy Corporation
Suite #15 – 1114 Front Street
Whitehorse, Yukon, Y1A 1A3

May 2020

Azimuth Consulting Group Partnership
218-2902 West Broadway
Vancouver, B.C., V6K 2G8

Project No. CTMC-19-02 (Task 1)

Report Version Log

Version	Date	Distribution
Draft (Rev 0)	April 22, 2020	e-copy to CTEC and Jacobs
Draft (Rev 1)	April 30, 2020	e-copy to CTEC and CIRNAC
Final (Rev 2)	May 31, 2020	e-copy to CTEC

EXECUTIVE SUMMARY

Azimuth Consulting Group Partnership (Azimuth) has been working on behalf of the Carcross Tagish Energy Corporation (CTEC) to determine if environmental contamination associated with the former Arctic Gold and Silver (AGS) mill and tailings storage facility (the Site) poses risks to human health and/or to the environment. Previous human health risk assessment for the Site reported that concentrations of metals in the soil pose unacceptable health risks for people using the Site over the long term (chronic exposure). Remedial options to address long-term health risks are being developed; however, the timeline for remediating the Site to conditions that are safe for people to use is likely several years.

At the request of the Carcross/Tagish First Nation (C/TFN), Azimuth was tasked with determining if current Site conditions pose acute public health risks between now and when the Site is remediated. If conditions do pose a risk to the health of people accessing the Site during the interim period, additional risk management measures will be required to prevent unauthorized access to areas at AGS where contaminant concentrations pose unacceptable risks to human health.

Acute Public Health Risk

If conditions pose an acute public health risk, additional risk management measures will be required.

Note: Acute exposure is defined as being exposed only once or being exposed repeatedly over a period no longer than 14 days.

Current Risk Management Measures and Risks

Historical mining and milling activities contributed to elevated concentrations of metals throughout the Site area, particularly of arsenic and lead. To warn the public that high metals concentrations exist, signs have been placed on the Montana Mountain road leading to AGS and on the tailings impoundment. A locked gate and fence partially restrict access to the Site from a popular parking area for people using Montana Mountain for recreational purposes.

The current risk management measures do not, however, prevent people from accessing areas of the Site where metals concentrations are high. The gate does not restrict foot traffic, and the fence does not surround all the areas where concentrations of metals in soil are high. In addition, segments of the extensive trail network CTEC developed for hiking and mountain biking on Montana Mountain lead past northern areas of the Site where access is unrestricted.

Site Use

Members of the C/TFN were surveyed in November 2019 about their past and present use of the Site. This information, along with anecdotal evidence of how the public uses the surrounding area, was used to develop *exposure scenarios*. The scenarios were broadly classified as either *unauthorized public access* or *invited guest visits* and were used to assess acute risks from Site-related contaminants.

Unauthorized public access was the catch-all term for any person accessing the Site without formal consent of the C/TFN. Members of the C/TFN who participated in the Site-Use Survey indicated that AGS was an important area for activities ranging from mountain biking and hiking to hunting and gathering country foods.

Among the activities, berry picking and picnicking were the two activities that questionnaire respondents most commonly engage in at AGS. Respondents indicated people of all ages were likely to participate in berry picking and picnics, including infants and young children accompanying adults. Knowing that young children are potentially accompanying adults to AGS was significant for the Interim Site Risk Management HHRA because, on average, children are more highly exposed to environmental contaminants than adults are. This is because their behaviour causes them to have closer contact with the ground and because the rate at which they ingest food and water is comparatively high relative to their body size. For the unauthorized public access exposure scenario, the critical receptors (people most at risk) are children younger than 5 years old.

Unauthorized Public Access vs Invited Public Visits

Unauthorized public access refers to people accessing the Site without consent from the CTFN. Unauthorized public access includes all age groups, including young children.

Invited public access refers to people participating in Site visits for cultural or educational purposes under the direction of the C/TFN or CTEC. Authorized visits do not include young children because they are the age group most at-risk from being exposed to contaminants in soil.

Invited guest visits was included as an exposure scenario in the Interim Site Risk Management HHRA to provide the C/TFN with information on the potential risks to people who visit the Site for cultural and education purposes. Under this exposure scenario, we assumed that member(s) of the CTEC or C/TFN would provide access and supervision while invited public are on Site, and that children younger than 5 years old would not be included.

Acute Health Risks and Recommended Interim Risk Management Measures

Approach

Previous investigations at AGS showed arsenic is both the most wide-spread contaminant of concern in soils and that it is the contaminant that exceeds soil quality guidelines for protecting human health more than any other Site-related metals. Therefore, *assessing risks from exposure to arsenic* was used to assess whether current Site conditions pose acute health risks. Implementing interim risk management actions based on risks from exposure to arsenic means that outstanding risks from other contaminants of potential concern (COPCs) will also be addressed.

Incidental Soil Ingestion

Based on the available toxicological data, soil arsenic concentrations higher than 450 µg/g are enough to pose acute (short-term) health risks to children younger than 5 years old. Previous studies at AGS showed that soil arsenic concentrations in excess of 450 µg/g are wide-spread at AGS, and the highest concentrations of arsenic are found in soils surrounding the former mill and between the tailings impoundment and Mine-Made Lake. We recommend additional fencing to prevent unauthorized public access to areas where soil arsenic concentrations exceeded 450 µg/g.

Adults and older children who visit AGS as invited guests for cultural, educational, or other CTFN sanctioned events are at low risk of acute health effects from incidental soil ingestion. We recommend that invited guests not include young children because they are more likely to be in contact with soil and are more prone to frequent hand-to-mouth contact.

Dust Inhalation

Acute health risks from inhaling dust were evaluated using 1-hour and 24-hour exposure scenarios, assuming dusty conditions on Site. Dusty conditions are defined as 250 µg/m^3 of respirable particulate matter. The soil screening value—defined as the concentration below which no additional regulatory attention is needed to protect human health—for the acute dust inhalation pathway was calculated by dividing the air quality screening value for arsenic (0.2 µg As/m^3) by the concentration of respirable matter under dusty conditions. The lowest air quality screening value for soil arsenic was 800 µg/g (or parts per million) for 1 hour of exposure.

Under dusty conditions, dust from Site areas with arsenic concentrations greater than 800 µg/g could pose health risks to people if the exposure was 1 hour or longer. Research on dust dispersion suggests people could be exposed to up to 250 µg/m^3 of dust as far away as 200 m from the source, depending on the wind speed and direction.

The primary objective of risk management measures to protect the public against acute health effects caused by inhaling dust is to prevent them from being continuously exposed to dust originating from the Site for 1 hour or more. For invited guests, we recommend restricting vehicle access to avoid creating dusty conditions. Where invited guests with mobility issues require vehicle support (ATV or truck), we recommend other invited guests keep a safe distance away and stay downwind from vehicles that can create dust emissions. There is no risk of acute health effects to the general public exposed to dust for a few minutes while transiently passing the Site or using the trail network in the area.

Berry Collection

Concentrations of arsenic in berry samples collected from AGS do not pose acute health risks to toddlers or adults, even if atypically large quantities of berries are consumed (more than 800 g for toddlers and 3,500 g from adults).

Installing additional fencing to restrict public access to areas where soil arsenic is greater than 450 µg/g will also limit access to areas of the Site used for collecting berries and other country foods/traditional medicines (e.g., spruce pitch).

CTEC Land Steward collecting berries for metals analysis

Drinking Water Consumption

Water quality guidelines that address acute risks from inorganic substances in the short term are not well developed. To our knowledge, only nitrate, nitrite, and copper have guidelines meant to protect against potential effects from short-term exposure. The available data from Mine-Made Lake and the outlet to Tank Creek show concentrations of metals and other constituents are below health-based guidelines for short-term and long-term (chronic) exposure. In general, guidelines to protect against long-term health risks are more conservative (i.e., the acceptable limits are lower) than guidelines meant to protect short-term effects. This means people who fill a water bottle from Mine-Made Lake or Tank Creek are not at risk of effects to their health from Site-related contaminants.

Summary

AGS will eventually be remediated to ensure that human exposure to residual environmental contamination will not present a public health risk. In the interim, it is imperative that

unauthorized access to the Site be restricted to prevent potential health risks from acute exposure to contaminants:

- Children less than 5 years old must be prevented from contact with arsenic-contaminated soil or sediment at the Site, even for very brief periods of time.
- Children and adults must be prevented from inhaling airborne dust from arsenic-contaminated soil at the Site for durations of 1 hour or longer.

It is ultimately up to CTFN and CTEC to determine suitable risk management measures to address the acute health risks identified in this report. These measures may include:

- Expanding the existing fence infrastructure to prevent the public from accessing arsenic-contaminated soil or sediment at the Site and installing a more secure gate, and
- Implementing policies and procedures
    - to prevent children less than 5 years old from visiting the Site, and
    - to prevent invited older children and adults from being exposed to dusty conditions at the Site.

Annual Environmental Monitoring Summary Report (April 2021 to March 2022) Arctic Gold and Silver Mine, Carcross, Yukon

Prepared for:

Crown Indigenous Relations and Northern Affairs Canada
300 Main Street
Whitehorse, Yukon Y1A 2B5

Project No. 105121-01

Prepared by:

Hemmera Envirochem Inc.
2237 2nd Avenue, Suite 230
Whitehorse, YT Y1A 0K7
T: 867.456.4865
F: 604.669.0430
hemmera.com

May 6, 2022

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS IV

1.0 INTRODUCTION 1
1.1 Objectives 2
1.2 Scope of Environmental Monitoring 2

2.0 MONITORING STATIONS 4

3.0 METHODS 4
3.1 Health and Safety 4
3.2 Field Schedules and Staff 4
3.3 Groundwater and Surface Water Monitoring 5
3.3.1 Guidelines and Standards 7
3.3.2 Field Measurements 8
3.3.3 Groundwater Monitoring 8
3.3.4 Surface Water Quality Monitoring 9
3.3.5 Surface Water Level and Flow Monitoring 10
3.3.6 Seep Survey 10
3.3.7 Quality Assurance/Quality Control (QA/QC) Sampling 11
3.3.8 Deviations from Prescribed Sampling Program 12
3.4 Geotechnical Visual Inspection 12
3.5 Air Monitoring 12

4.0 RESULTS AND DISCUSSION 15
4.1 Site Groundwater and Hydrogeological Characteristics 15
4.1.1 Exceedances of Applicable Environmental Thresholds: Groundwater 16
4.1.2 Groundwater Elevations and Gradients 22
4.1.3 Near-continuous Groundwater Elevation Records 23
4.1.4 Spatial Trends in Groundwater Quality 24
4.1.5 Temporal Trends in Groundwater Quality 25
4.2 Surface Water Quality 27
4.2.1 Exceedances of Applicable Environmental Thresholds: Surface Water 28
4.2.2 Spatial and Temporal Trends in Surface Water Quality 28
4.3 Water Chemistry Quality Assurance/Quality Control 30
4.4 Stream Flow Monitoring and Staff Gauge Readings 30
4.5 Seep Survey 37
4.6 Review of Visible Geotechnical Parameters 39
4.7 Air Monitoring 40

5.0 CONCLUSION AND RECOMMENDATIONS 41
5.1 Conclusions 41
5.2 Recommendations 42
6.0 CLOSURE 43
7.0 REFERENCES 44

LIST OF TABLES (WITHIN TEXT)

Table A Monitoring schedule and C/TMC staff attendance summary 5
Table B Stations not sampled during monitoring events 6
Table C Deviations from proposed monitoring plan 13
Table D Summary of exceedances in groundwater 17
Table E Observed range of groundwater below the ground surface 22
Table F Summary of temporal trends in groundwater quality along a transect through the consolidated tailings area 26
Table G Summary of exceedances in surface water 29
Table H Average COPC concentrations in Unnamed Lake/Tank Creek watershed 30
Table I QA/QC Results for Monitoring Events 31
Table J Stream Flow and Staff Gauge Readings 34
Table K Summary of Unnamed Lake Shoreline Survey Results 37
Table L Summary of Water Quality Field Parameters from“SEEPS”at other Site locations 39
Table M Air Monitoring Data Summary 40

LIST OF APPENDICES

TABLES (APPENDED)

Table 1 Groundwater Analytical Results
Table 2 Surface Water Analytical Results
Table 3 Water Quality Assurance/Quality Control Results

FIGURES (APPENDED)

Figure 1 Site Location and General Mining Related Features
Figure 2 Monitoring Locations
Figure 3a Groundwater Elevation Contours (April 2021)
Figure 3b Groundwater Elevation Contours (July 2021)
Figure 3c Groundwater Elevation Contours (October 2021)
Figure 3d Groundwater Elevation Contours (January 2022)

Figure 4 Continuous Groundwater Elevation Records from Pressure Transducers
Figure 5a Spatial Distribution of Sulphate in Groundwater (June 2021)
Figure 5b Spatial Distribution of Sulphate in Groundwater (January 2022)
Figure 5c Spatial Distribution of Fluoride in Groundwater (June 2021)
Figure 5d Spatial Distribution of Fluoride in Groundwater (January 2022)
Figure 5e Spatial Distribution of Iron in Groundwater (June 2021)
Figure 5f Spatial Distribution of Iron in Groundwater (January 2022)
Figure 5g Spatial Distribution of Manganese in Groundwater (June 2021)
Figure 5h Spatial Distribution of Manganese in Groundwater (January 2022)
Figure 5i Spatial Distribution of Cadmium in Groundwater (June 2021)
Figure 5j Spatial Distribution of Cadmium in Groundwater (January 2022)
Figure 5k Spatial Distribution of Cobalt in Groundwater (June 2021)
Figure 5l Spatial Distribution of Cobalt in Groundwater (January 2022)
Figure 5m Spatial Distribution of Zinc in Groundwater (June 2021)
Figure 5n Spatial Distribution of Zinc in Groundwater (January 2022)
Figure 6a Temporal Trends in Groundwater Flouride Concentrations (mg/L)
Figure 6b Temporal Trends in Groundwater Iron Concentrations (mg/L)
Figure 6c Temporal Trends in Groundwater Manganese Concentrations (mg/L)
Figure 6d Temporal Trends in Groundwater Cadmium Concentrations (mg/L)
Figure 6e Temporal Trends in Groundwater Cobalt Concentrations (mg/L)
Figure 6f Temporal Trends in Groundwater Zinc Concentrations (mg/L)

APPENDICES

Appendix A Site Photographs
Appendix B Monitoring, Sampling and Elevation Data
Appendix C Field Forms
Appendix D Laboratory Certificates of Analysis
Appendix E Monitoring Plan

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Definition
AGS	Arctic Gold and Silver
ASTM	American Society for Testing and Materials
AW	Aquatic life water use
CCME	Canadian Council of Ministers of the Environment
CIRNAC	Crown Indigenous Relations and Northern Affairs Canada
COC	chain of custody
COPC	contaminants of potential concern
C/TFN	Carcross Tagish First Nation
C/TMC	Carcross/Tagish Management Corporation
DO	dissolved oxygen
DP	Drive points
DW	Drinking water use
FAL	Freshwater Aquatic Life
FIGQG	Federal Interim Groundwater Quality Guideline(s)
HASP	Health and Safety Plan
kPa	Kilopascal
L	litre
LDL	Laboratory detection limit
L/s	Litres per second
m	metres
mbgs	metres below ground surface
masl	metres above sea level
ML/ARD	Metal leaching / acidic rock drainage
NM	Not measured
ORP	oxidation-reduction potential
PPE	Personal Protective Equipment
QA/QC	Quality Assurance/Quality Control
RPD	relative percent difference
Salt	Sodium and chloride
SPC	Specific conductivity
TDS	Total dissolved solids
TSS	Total suspended solids
TWA	Time weighted average
YCSR	Yukon Contaminated Sites Regulations

1.0 INTRODUCTION

Hemmera was retained by Crown Indigenous Relations and Northern Affairs Canada (CIRNAC) to complete the 2020-2022 monthly environmental and geotechnical monitoring programs at Arctic Gold and Silver (AGS) and Venus abandoned mine sites. Both mines are in their closure phases, and the associated monitoring and maintenance requirements are managed by CIRNAC. This report summarizes the objectives, scope, deliverables, and methodologies that were used to carry out the program between April 2021 and March 2022 at the AGS mine near Carcross, Yukon (the Site) (excluding May 2021: please see below). An evaluation of temporal and spatial trends in groundwater and surface water quality is also provided.

The AGS mine is located approximately 4 km south of Carcross, Yukon, near the base of the eastern slope of Montana Mountain, on Category A Settlement Land in the traditional territory of Carcross Tagish First Nation (C/TFN). The Site is located at Zone 8N, 6666370 North and 515344 East. The current and historical Site layout is shown in **Figure 1**. Photographs from the monitoring events are presented in **Appendix A**.

Milling of ore occurred intermittently during the late 1960s (Hemmera 2013). Silver and gold concentrates were extracted from ore sourced from the Arctic Caribou and Big Thing underground mines, developed in an “altered Montana Mountain Pluton granite of the Mt. McIntyre Plutonic Suite” (Mann 1998; Nicholson 2002). The crushed ore was processed using a basic flotation method without cyanide, and the tailings were discharged into a trapezoidal tailings impoundment of approximately 1.8 hectares in size. Over a two year period of operation, the milling of ore generated approximately 27,000 cubic metres of tailings. The mill was closed in September 1969 due to low commodity prices and poor metals recovery. The mill and tailings impoundment were abandoned soon afterwards.

Limited field studies were completed at the Site in 1996 and 1997. These studies confirmed that the tailings were prone to acidic mine drainage, and that there is a potential for dissolution and transport of arsenic and other metals/metalloids toward the small unnamed lake located approximately 80 m to the west and downslope from the lower toe of the tailings deposit. Following completion of a remedial options analysis in 1999, remediation was carried out in 1999 and 2000, based on the “consolidate and cap” remedial option.

As summarized by SRK (2017) and EBA (2001), the Site remediation comprised the following actions and features, which were generally intended to limit future metal leaching / acidic rock drainage (ML/ARD) by placement of mine wastes beneath a low permeability cover to limit water and oxygen ingress, and “thereby keeping them from becoming acid-generating” (SRK 2017):

- Consolidation into the impoundment of various disseminated mine wastes including windblown tailings, relocated ore piles, and other inert Site waste.
- Enhancement of the perimeter berm around the consolidated tailings area with well-graded sand-till.
- Placement of former mill loading ramp material (sand and gravel) on top of the tailings, providing an average cover thickness of 0.5 to 0.6 m.
- Leveling and re-grading of the tailing and ramp material to backfill the former central drainage channel in the tailings deposit (leading to the former decant outlet into Unnamed Lake: **Figure 1**). According to SRK (2017), “*The drainage channel consisted of a riprapped swale running along the east-west centreline of the impoundment, through the west berm and into the decant drainage ditch. The historic decant structure was sealed with a bentonite and concrete mixture and then backfilled with sand and gravel*.”

- Capping of re-graded consolidated tailings deposit with a low permeability 0.3 m thick layer of clayey silt imported to the Site.
- Breaching the "*beaver dam containment structures*" (SRK 2017) to lower water levels in Unnamed Lake.
- Removal of subaqueous tailings from the lake where feasible and placement in a separate impoundment area to the northeast of the main facility, followed by consolidation and capping of the new cell.
- Removal of culvert structures in Unnamed Lake.
- Re-vegetation of the re-contoured Site through seeding.

The thickness of tailings in the consolidated deposit grades from less than 1.0 to 1.5 m in the eastern half of the facility to 3 to 4 m along its western perimeter, adjacent to the perimeter berm that faces Unnamed Lake (EBA 2011, as reproduced in Figure 5 of Appendix A of SRK 2017).

Hemmera (2013) completed a review of the ten-year monitoring program initiated in 2001 by CIRNAC (then Indian and Northern Affairs Canada) following the remediation. The scope of environmental monitoring at the Site has been increased several times since 2003 in consideration of the observed site conditions.

This Work was performed in accordance with Contract number 4500413475 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and Crown Indigenous Relations and Northern Affairs Canada (Client), dated July 17, 2020 (Contract). This Report has been prepared by Hemmera, based on fieldwork conducted by Hemmera, for sole benefit and use by Crown Indigenous Relations and Northern Affairs Canada. In performing this Work, Hemmera has relied in good faith on information provided by others and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

1.1 Objectives

Hemmera was retained by CIRNAC to conduct a monitoring and sampling program for surface water and groundwater quality, air quality and geohazard/geotechnical monitoring at the Site from August 2020 to March 2022. The purpose of the monitoring and sampling program is to monitor water quality (surface and groundwater), groundwater levels, surface water flow, air quality, and geohazard/geotechnical conditions at the Site. This report summarizes the results of the monitoring program from April 2021 to March 2022.

1.2 Scope of Environmental Monitoring

The Site monitoring tasks and methods used are described in detail in the 2020/21 Monitoring Plan developed by Hemmera in August 2020 (Hemmera, 2020; attached in Appendix E). Departures from the scope of work are outlined in **Section 3.3.8**. The following activities were carried out during the April 2021 to March 2022 portion of the sampling program.

Groundwater monitoring:

- Measuring groundwater levels in wells and drive point piezometers.
- Inspection of monitoring wells for damage/assessing needed repairs.
- Purging and sampling of monitoring wells and drive points.
- Measuring and recording field parameters (water temperature, pH, conductivity, oxidation-reduction potential [ORP] and dissolved oxygen [DO]).
- Collecting groundwater samples from each location for laboratory analysis.
- Downloading data from dataloggers and processing data for plotting of groundwater levels.

Surface water monitoring:

- At drive point locations installed in surface water, measuring the depth to surface water on the outside of the drive point.
- Measuring field parameters (water temperature, pH, conductivity, ORP, turbidity and DO).
- Collecting surface water samples from each location for laboratory analysis.
- Collecting flow measurements at the inlet and outlet of Unnamed Lake.
- Recording staff gauge readings at Unnamed Lake and Tank Creek.

Groundwater seeps:

The scope of work for the groundwater seep survey included a visual survey of the groundwater discharge area along the shoreline of Unnamed Lake. Where possible, the following were recorded:

- Field parameters (water temperature, pH, conductivity, ORP and DO).
- Visually estimated flow rate.
- GPS coordinates.
- Representative photographs.

Air quality:

The scope of work for air quality monitoring included a minimum of one personal air quality monitoring device collecting real-time particulate matter concentrations to determine the need for an enhanced Personal Protective Equipment (PPE) program. Air quality monitoring was not performed when the Site was covered with snow or when it was raining, as it is assumed to be a very low potential for workers to be exposed to airborne particulates under such conditions.

Geotechnical considerations:

Visual geohazard/geotechnical inspections were conducted during each monitoring event, by field staff under the direction of a senior geotechnical engineer. Field staff documented any critical observations, and the results were reviewed by a senior geotechnical engineer.