MEMORANDUM

Date: 2019-07-08
Permit: PS-7894

RE: Candorado Mines LTD. Proactive Review

Review of Historical Reports and Data from Candorado Mines Ltd. by Leilane Ronqui, Auxiliary Environmental Impact Assessment Technician - Biologist, Mining Operations

1. Introduction

The intent of this memo is to provide a summary on the progression of Candorado Mine permits for the past 30 years (1989 to 2019), including receiving environment information supplied by Candorado Mines Ltd. in relation to the Candorado Mine operations, and to outline an updated baseline monitoring program for surface water and sediment samples. Information and recommendations from this review may be used to inform future field monitoring programs in the Candorado mine area by the Ministry of Environment and Climate Change Strategy (ENV, previously MOE) and compliance action.

The following permits, report and documents were reviewed:

Permits

- The *Permit PS-7898* issued under the provisions of the *Waste Management Act*, dated January 31, 1989 (MOE, 1989).
  The *Suspension of Permit (File: 76750-10 / PS-07894)* dated October 4, 1999 (MOE, 1999).
- The *Special Waste Storage Permit PS-7894* dated February 11, 2019 (MOE, 2019).

Reports & Documents

- The *Candorado Hydrogeological Assessment Report Hedley, B.C.*, dated May 24, 2007 (AMEC, 2007).
- The *Candorado Heap Leach Project (Sunrise Resources) – Hydrogeological Assessment in support of Information Order*, dated October 2, 2018 (Alloisio, 2018).

- Green, Jack (personal communication, June 6, 2019) on *Candorado Heap Leach Project (Sunrise Resources) – Hydrogeological Assessment in support of Information Order* (October 2, 2018).

❖ **Summary of Key Dates**

Jan 31st, 1989 - Permit issued (PS-7894)
Oct 4th, 1999 - Special Waste Storage permit suspended (PS-7894)
Feb 11th, 2019 – Special Waste Storage permit cancelled (PS-7894)

2. Project & Receiving Environment Monitoring Description

2.1 Background

As described in Piteau (1988), Candorado Mine Ltd. planned to reprocess tailings from former gold mining operations on Nickel Plate Mountain, located approximately 1.6 Km northeast of Hedley, BC (Appendix A – Figure 1). The tailings in that time existed as two tailings piles, one along the eastern bank of Hedley Creek, and the other on the northern bank of the Similkameen River. In addition, Candorado proposed to carry out a heap leaching operation on the level area located across the No. 3 highway from the tailings piles. This will necessitate transporting the tailings from the piles to lined pads so that the cyanide solution could be introduced to the tailings in a closed system (Piteau, 1988).

The Candorado cyanide heap leach project operated between 1988 and 1996 on Lot 2900, 1 km southeast of the Town of Hedley, B.C. (AMEC, 2007), Appendix B.

2.2 Summary on the progression of Candorado Mine permits for the past 30 years

Candorado Mines Ltd. was granted the permit PS-7894 issued under the provisions of the Waste Management Act on the 31st of January 1989 by the then Ministry of Environment, authorizing the company to store special waste, specifically, cyanide solution from a heap-leach metal recovery operation located at Hedley, British Columbia in a surface impoundment with complete waste recycle and no discharge to the environment (MOE, 1989).

However, in October 4th of 1999, the Ministry of Environment, Lands and Parks informed Candorado Mines Ltd. in a *"Suspension of Permit"* letter that the Waste Management Permit PS-7894, issued by MOE, was suspended on October 4, 1999, pursuant to Section 36 of the Waste Management Act, SBC 1982, C.41. The letter stated: *"I am prepared to consider reinstating this permit upon payment, in full, of the permit fees plus any accrued interest. In the meantime, the discharge of any authorized by the above referenced permit after the effective date of this suspension will be considered an offense under the Waste Management Act"* (MOE, 1999).

On February 11, 2019, MOE issued a *"Special Waste Storage Permit PS-7894"* letter with the following information: "*The special waste storage permit has been in a state of suspension since October 4, 1999, as a result of outstanding fees. Inspections of the subject facilities indicate the operation of Candorado Mines Ltd. has wound up. As the fees are still outstanding and hazardous waste storage is now regulated under the Hazardous Waste Regulation, Ministry staff has recommended cancellation of the permit. By way of this letter, Special Waste Storage Permit PS-7894 is hereby cancelled as of the date of this letter. Please note the cancellation of this permit does not absolve responsible parties from their obligations in regards to environmental liabilities associated with the property"* (MOE, 2019).

The above letter was issued due to the following requests made by Candorado Mine Ltd. owner (Rayonier Advanced Materials, Toronto, Ontario) at that time: *"On November 23, 2018, the BC Ministry of Environment and Climate Change Strategy (the Ministry) provided Rayonier Advanced Materials (Rayonier) with a letter detailing the subject file and the Ministry's intention to cancel this permit while providing Rayonier with 30 days to comment. On December 18, 2018, Rayonier sent to Ministry staff, via email, a letter request for an extension to the comment period to January 31, 2019. The extension was granted. On January 24, 2019, Ministry staff received an email requesting an extension to the comment period to February 10, 2019. The extension was granted"* (MOE, 2019).

3.3 Monitoring Programs from Candorado Mine

Regarding environmental assessment reports, the latest environmental report submitted by Candorado Mine Ltd. to ENV ("*Candorado Hydrogeological Assessment Report Hedley, B.C.")* is dated from May 24, 2007 (AMEC, 2007). This report was based on the abandoned Candorado Heap Leach pile and leachate collection ponds, approximately 2 km southeast of Hedley, British Columbia (Appendices B and C). The Candorado cyanide Heap Leach Project operated between 1988 and 1996 on Lot 2900, 1 km southeast of the Town of Hedley, B.C. The objectives of the hydrogeological assessment were to refine the conceptual model of groundwater flow beneath, and adjacent to, the heap leach pile and leachate collection ponds, and to characterize groundwater quality up-gradient, beneath and down-gradient of the heap leach pile and leachate collection ponds.

Following the above hydrogeological assessment, MOE prepared a memorandum "*Candorado Heap Leach Project (Sunrise Resources) – Hydrogeological Assessment in support of Information Order*, dated October 2, 2018 (Alloisio, 2018), which provided recommendations on groundwater and surface water monitoring for the Information Order to be issued to Sunrise Resources for the Candorado Heap Leach Project. To identify and characterize the potential groundwater contamination downgradient of the site, it was recommended that the following items be included in the Information Order:

- Conduct a one-year monitoring program (groundwater levels and sampling) using the same groundwater monitoring network employed in the 2006-2007 program conducted by AMEC.
- Inspect the well monitoring network. Unusable wells should be rehabilitated or replaced.
- If accurate coordinates and topographic elevations are no longer available or reliable, conduct a topographic survey of all the monitoring wells, so to obtain accurate coordinates and elevation of top of casing and ground surface at the well locations.
- Monitor groundwater levels and collect and analyze groundwater samples on three-month intervals that capture high and low flow seasonal conditions.
- Collect and analyze water samples from the heap pile outflow (inlet to the ponds) and collection ponds.
- Analyze for the same suite of parameters used in the 2006-2007 monitoring program, with the addition of turbidity and total metals. Compare the results with Contaminated Sites Regulations (CSR) Drinking Water and Aquatic Life benchmarks for wells located immediately downstream of the site, and with BC Water Quality guidelines for off-site wells (FN Reserve I.R. 1 and 2, and well 2 in Hedley)
- Prepare a monitoring report that includes the following:
- Monitoring location map and coordinate table;
    - ❖ Well summary table (total depth, screened intervals, lithology, water levels, etc.);
    - ❖ Map of inferred groundwater contours in high and low flow conditions;
    - ❖ Groundwater hydrographs at monitoring wells and plotted along with precipitation time series;
    - ❖ Piper plot representing hydrochemical signature;
    - ❖ Time series plots for selected analytes, including cyanide, cobalt, arsenic and manganese;
    - ❖ Summary table of exceedances and interpretation;
    - ❖ Updated hydrogeological conceptual model and a preliminary site-wide groundwater balance.
    - ❖ Assessment of potential impact on downstream groundwater receptors.
    - ❖ Discussion on options to mitigate groundwater contamination.

The most recent owner of Candorado Mines Ltd., Sunrise Resources, received the Information Order from ENV; however, after discussions with the Judge Advocate General (JAG) it was determined that there was no legal entity to serve the information order be bind. Furthermore, Sunrise Resources went into liquidation on May 7, 2019. According to that and with the cancellation of the permit, no options were left for the Compliance Section at ENV to enforce any action (Green, J. pers. Comm. 2019).

RECOMMENDATIONS

The following section describes L. Ronqui's review of the Candorado Mine based on the documents assessed. A specific issue was identified, and the pertinent recommendations, including rationale to address the associated issue were provided at the end of this section. A detailed description of the baseline monitoring program for surface water and sediment samples is provided in Table 2.

1. Recommendations for MAS receiving environment monitoring

- Regarding the surface water monitoring conducted in 2006 reported by Candorado Mine in AMEC (2007):

> *"The locations of each surface water elevation monitoring point (staff gauges and boom gauge) are referred to as SG #1 through SG #4 and are presented in Figure 5 (Appendix C). Stations SG #1 (WSC boom gauge) and SG #2 are located on Hedley Creek, while stations SG #3 and SG #4 are on the Similkameen River. Surface water samples were collected and analyzed for physical tests, dissolved anions, total metals, cyanides and nutrients during the March (2006) monitoring event"* (AMEC, 2007).

However, the above statement encompasses four surface water sampling stations; only two were sampled and presented surface water results (SG1 upstream – Hedley Creek and SG4 – downstream of the heap leach pad in Similkameen River).

The table below (Table 1) presents a summary of all sampling stations (surface water) encompassed into the *"Candorado Hydrogeological Assessment Report Hedley, B.C."* (AMEC, 2007), and lists all parameters of potential concern (POPC) identified in this review, and the lack of water quality objectives (WQO's) information, biological analyses performed and CABIN monitoring.

Table 1: Candorado Mine surface water sampling stations and additional information:

Matrices	Waterbody Name	Site Name/ EMS	Rationale	[2]Data	POPC	WQO's[1] exceedances	Biological Analyses/ CABIN
Candorado Mine							
SURFACE WATER SAMPLES[3]	Hedley Creek (HC)	***SG #1**	Reference station: Upstream of Candorado Heap	Yes	Cyanide, thiocyanate, cobalt, ferrocyanide,	None	No

			Leach site and Hedley Town		arsenic, manganese		
		SG #[2]	Downstream of Hedley City, upstream of Candorado Heap Leach site.	No	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese	None	No
	Similkameen River (SR)	SG #3[2]	Near-field stations, after the confluence of Hedley Creek with Similkameen River	No	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese	None	No
		*****SG #4	Downstream of Heap Leach Pad, New Tailings Pile, Process Ponds and Groundwater Wells	Yes	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese	None	No

-Not applicable.

[1]**Metals Exceeding:** None metal exceedances reported regarding AMEC (2007). However most of the parameters were below the method detection limit (MDL); it was collected one sample for each station with one duplicate. Also, the latest report from Candorado (AMEC, 2007) did not compare the results with WQO's for Hedley Creek and Similkameen River Watershed.

[2]**Date:** No = data absent regarding AMEC (2007), Yes = data existent regarding AMEC (2007).

***Parameters analysed in 2006 (AMEC, 2007):** Surface Water: **physical tests** (conductivity, hardness, TDS, and pH); **dissolved anions** (total alkalinity, bromide, chloride, fluoride, sulphate); **nutrients** (ammonia nitrogen, total Kjeldahl Nitrogen, nitrate, nitrite, dissolved ortho-phosphate, total dissolved phosphate, total phosphate); **Cyanides** (total cyanide, cyanate, thiocyanate, weak acid dissociable cyanide – WAD); **total and dissolved metals** (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, titanium, uranium, vanadium, and zinc). **EMS information absent.**

Based on the information above, I recommend that:

1. That a detailed surface water quality and sediment baseline assessment be performed with consideration to the findings of the hydrogeological assessment made by Alloisio (2018), and outlined in Table 2 below.
2. Conduct the monitoring program mentioned above in Hedley Creek and Similkameen River near Candorado Mine footprint, and whether possible, to include the same sampling area of the surface water and groundwater monitoring survey conducted in the 2006-2007 program completed by AMEC (AMEC, 2007) as described in Table 2.
3. Include two new sampling stations in Similkameen River: Annies Beach and SR, described in Table 2 and Appendix D.
4. All parameters analyzed must be compared against the Water Quality Objectives (WQO's) for Hedley Creek and Similkameen River Watershed and the BC Water Quality Guidelines

(WQG's) for protection of aquatic life. ***The parameters recommended are listed below Table 2.***

Table 2: Candorado Mine surface water and sediment sampling stations recommendations for the next water quality monitoring program:

Matrices	Waterbody Name	Site Name/ EMS	Rationale	*Data	POPC
SURFACE WATER AND SEDIMENT SAMPLES	Hedley Creek (HC)	SG #1	Reference station: Upstream of Candorado Heap Leach site and Hedley Town	*	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese
		SG #[2]	Downstream of Hedley City, upstream of Candorado Heap Leach site.	*	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese
	Similkameen River (SR)	SG #3[2]	Near-field stations, after the confluence of Hedley Creek with Similkameen River	*	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese
		SG #4	Downstream of Heap Leach Pad, New Tailings Pile, Process Ponds and Groundwater Wells	*	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese
	Addition of two sampling stations				
		Annies Beach / E207463	Downstream of Candorado Mine, Hedley Creek, Hedley Town and Similkameen River	**	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese
		SR / E207461	Reference: located approximately 1 km upstream from Hedley Creek, Hedley Town, Similkameen River, and Princeton	**	Cyanide, thiocyanate, cobalt, ferrocyanide, arsenic, manganese

-Not applicable.

***Parameters to be analysed:** Surface Water: **physical tests** (conductivity, hardness, TDS, and pH); **dissolved anions** (total alkalinity, bromide, chloride, fluoride, sulphate); **nutrients** (ammonia nitrogen, total Kjeldahl Nitrogen, nitrate, nitrite, dissolved ortho-phosphate, total dissolved phosphate, total phosphate); **Cyanides** (total cyanide, cyanate, thiocyanate, weak acid dissociable cyanide – WAD); **total and dissolved metals** (aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, thallium, titanium, uranium, vanadium, and zinc); **biological analyses** (periphyton biomass as chlorophyll a, periphyton communities composition, CABIN, benthic invertebrates communities, biotic indexes and endpoint measures (Bray Curtis Index, Hilsenhoff Biotic

Index – HBI, Simpson's Evenness, Simpson's Diversity, and Ephemeroptera-Plecoptera-Trichoptera %EPT).
****Personal communication:** Devan Oldfield (Dated July 7, 2019).

Rationale: The current conceptual model in the *Candorado Hydrogeological Assessment Report Hedley, B.C.* dated May 24, 2007 (AMEC, 2007) suggests that the heap leach pile and ponds are the most likely source of the groundwater contamination downgradient of the site detected in the past (until December 2007). This is supported by the very high concentration of thiocyanate, cyanate, cyanide and cobalt identified in the water sampled at the heap leach pile outflow and collection ponds. However, due to the outdated data set available at the site, it is not possible to determine whether and to what extent this source is currently causing groundwater contamination (Alloisio, 2018).

Furthermore, a preliminary hydrogeologic conceptual model developed for the site (Piteau, 1988) and cited by Alloisio (2018) indicates that groundwater flows mainly in a northwest-southeast direction. The primary source of recharge to the aquifer is groundwater flow from beneath Hedley Creek, and groundwater flow from beneath the Similkameen River. Lesser sources of recharge occur as leakage from the Similkameen River, and local groundwater flow from the north wall of the Similkameen Valley, which is more significant during spring freshet. The groundwater flowing beneath the site (Candorado Mine footprint) is estimated to discharge into Similkameen River at approximately 2.3 km southeast of the site (Alloisio, 2018). As the heap leach pile and ponds are the most probable source of groundwater contamination in the area (detected in Dec 2007), this water could also be reaching Similkameen River changing the quality of the water and the biota.

Regarding the addition of the sampling stations E207463 (Annies beach) and E207461 (Similkameen River – SR) (pers. Commun. Devan Oldfield), as there are historical mining remnants (waste rock and tailings piles) situated along the banks of Hedley Creek from the convergence with the Similkameen River, to well beyond the townsite up the Hedley Valley, in order to have a reliable sampling station, that could represent the background of this area and downstream (Candorado Tailings Piles, heap leach pads and ponds) of the receiving environment, the sampling stations E207463 and E207461 should be included in the next water quality monitoring program for Candorado Mine.

Thank you for the opportunity to provide my technical review and summarize the current situation of *Candorado Mines Ltd.* If you have any questions regarding the content of this memo, please do not hesitate to contact me at either Leilane.Ronqui@gov.bc.ca or 604-582-5344.

Sincerely,

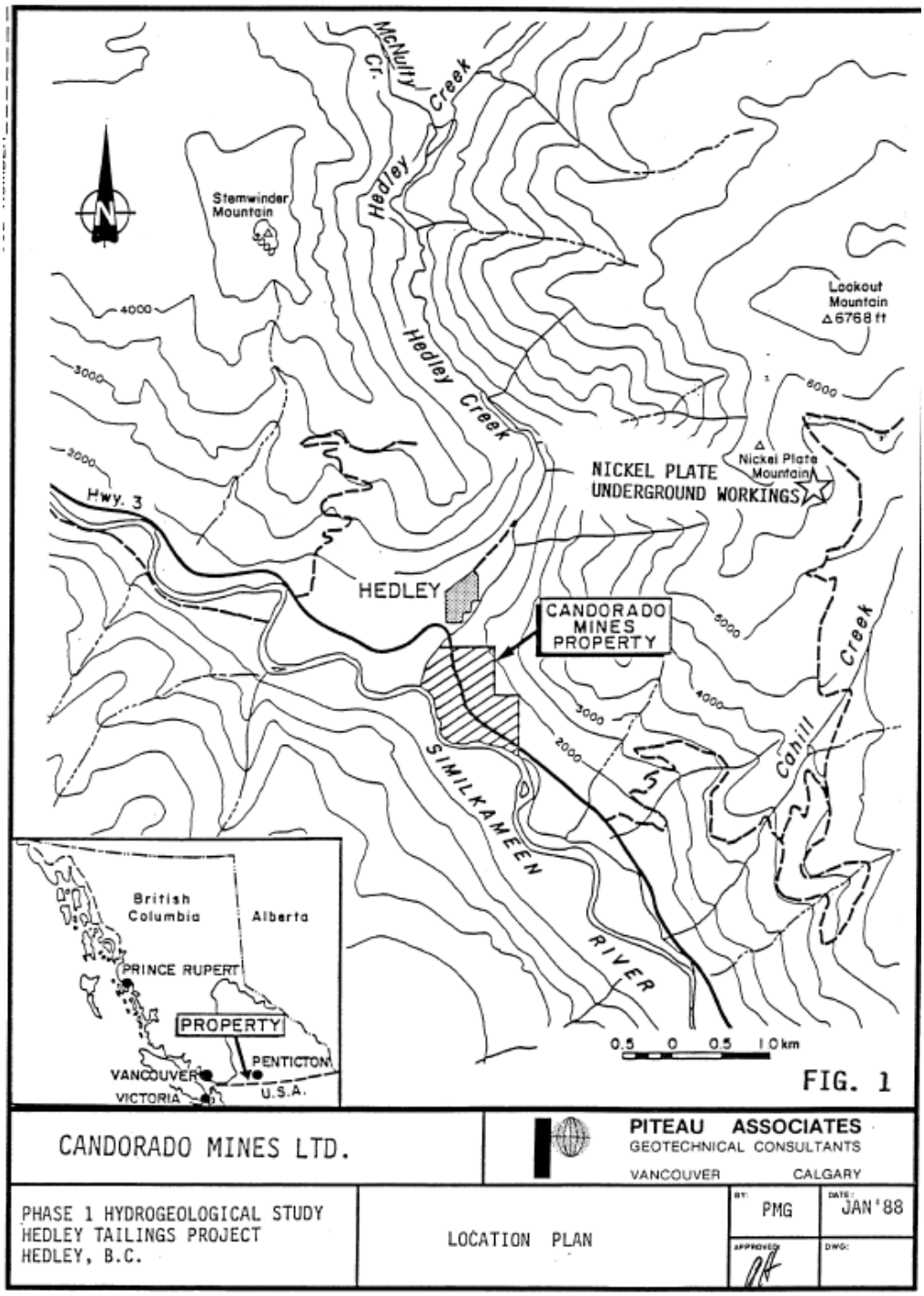
Leilane Ronqui, Ph.D.
Auxiliary Environmental Impact Assessment Technician - Biologist, Mining Operations
Ministry of Environment and Climate Change Strategy

Cc: Deb Epps, Water Quality Section Head - Monitoring and Assessment Stewardship
Gabriele Matscha, Environmental Impact Assessment Section Head – Mining Operations

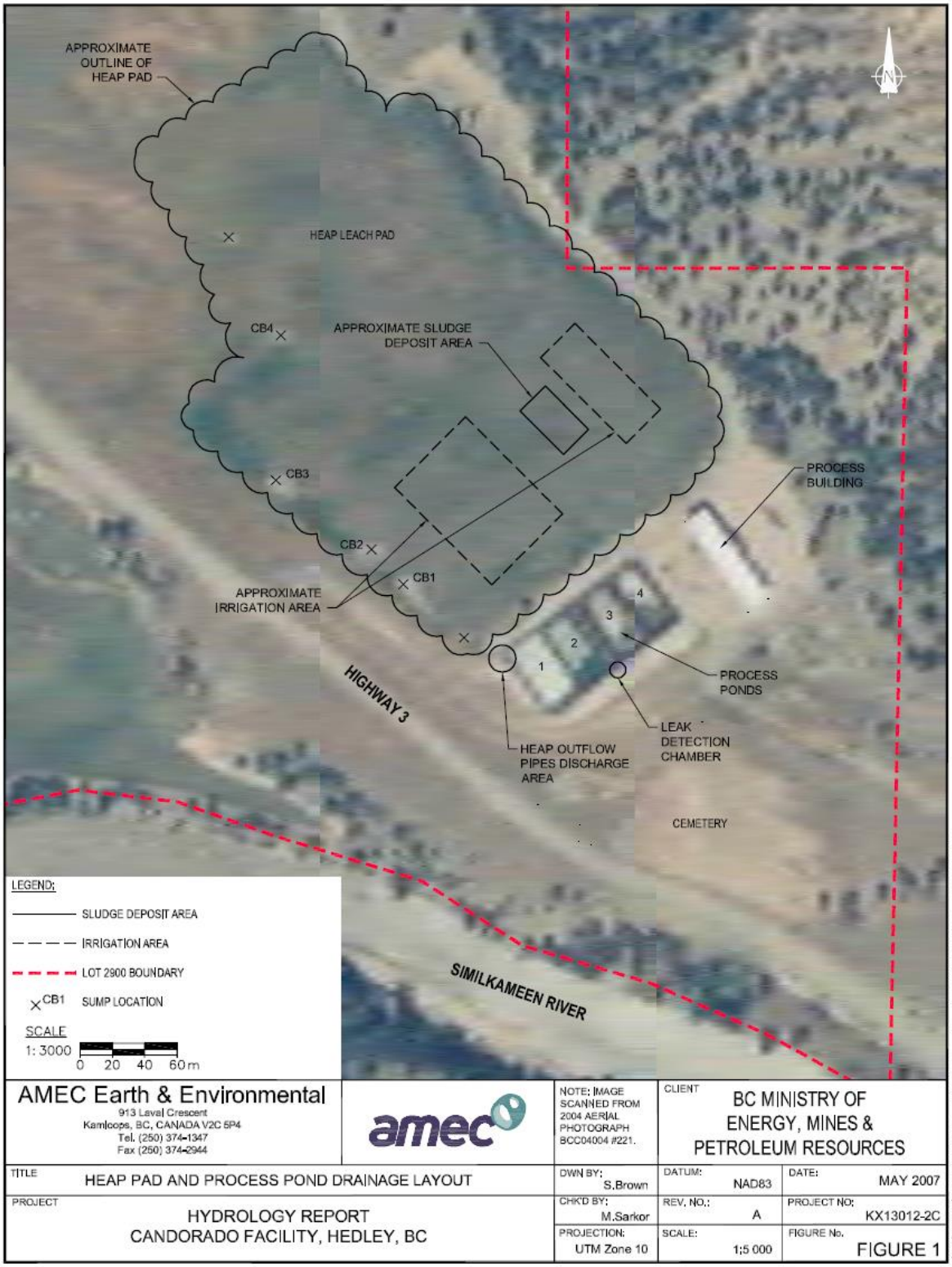
References

- Alloisio, S., "*Candorado Heap Leach Project (Sunrise Resources) – Hydrogeological Assessment in support of Information Order,"* October 2018. Prepared by Sarah Alloisio (Hydrogeologist, Mining Operations, MoE). Prepared for Jack Green (Environmental Protection Officer, Regional Operations Branch, MoE). October 2, 2018.
- AMEC Environmental (2007). Candorado Hydrogeological Assessment Report, Hedley, BC.
- AMEC (2006a). September 2006 Groundwater Monitoring Summary. Former Candorado Tailings Project. Highway No.3, Hedley, BC.
- AMEC (2006b). December 2006 Groundwater Monitoring Summary. Former Candorado Tailings Project. Highway No.3, Hedley, BC.
- BC MoE. 1989. *Permit PS-7898*. Waste Management Act, BC Ministry of Environment. January 1989.
- BC MoE. 1999. *Suspension of Permit PS-07894*. Pollution Prevention and Pesticide Management, BC Ministry of Environment, Lands and Parks. October 1999.
- BC MoE. 2019. *Special Waste Storage Permit PS-7894.* Mining Operations, BC Ministry of Environment. February 2019.
- Piteau Associates Engineering Ltd., January 1988. Phase I Hydrogeological Study for Proposed Hedley Tailings Project, Project No. 88-985, 25 p.

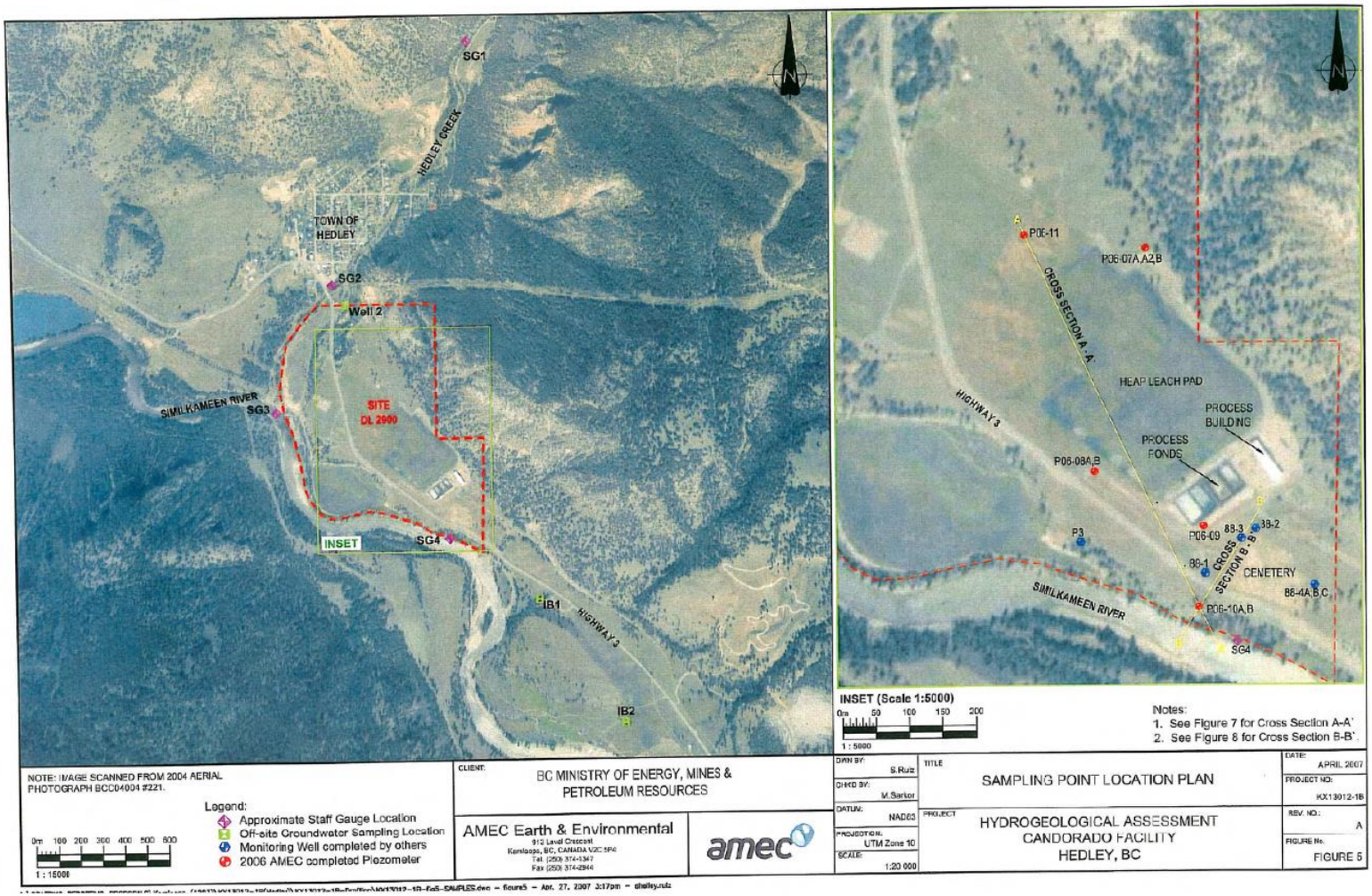
Appendix A: Figure 1: Tailings Piles – Candorado Mine.



APPENDIX B: Heap Pad and Process Pond Drainage Layout (Figure 1 from AMEC, 2007).



APPENDIX C: Sampling Point Location Plan (Surface water sites: SG1, SG2, SG3, and SG4). (Figure 5 from AMEC, 2007).



Appendix D: Localization of sampling stations in Annies Beach (E207463) and in the Similkameen River - SR (E207461): pers. Comm.: Devan Oldfield (2019).