

GRASSY MOUNTAIN MINE PROJECT

Ecological Risk Assessment for Proposed Tailings Storage Facility

Prepared for:
Calico Resources USA Corp.

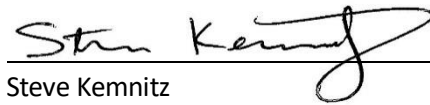
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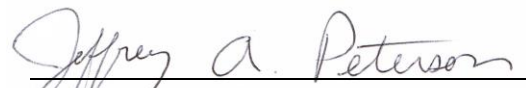
Grassy Mountain Mine Project Ecological Risk Assessment for Proposed Tailings Storage Facility

Prepared for:
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This document has been prepared by SLR International Corporation (SLR). The material and data in this report were prepared under the supervision and direction of the undersigned.



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CONTENTS

1.	INTRODUCTION	1
1.1	Tailings Storage Facility.....	1
1.2	Screening-level Ecological Risk Assessment.....	2
1.3	Report Organization	2
2.	EXPOSURE ASSESSMENT	3
2.1	Conceptual Site Model	3
2.2	Exposure Point Concentrations.....	4
3.	SCREENING-LEVEL ECOLOGICAL RISK EVALUATION	5
3.1	Risk-Based Screening Levels.....	5
3.2	Risk Characterization Approach	6
3.3	Results.....	6
4.	CONCLUSION	7
5.	REFERENCES	8

TABLE

Table 1	Ecological Screening Evaluation
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ACRONYMS

Calico	Calico Resources USA Corp.
CSM	Conceptual Site Model
DEQ	Department of Environmental Quality
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
HI	hazard index
HQ	hazard quotient
LANL	Los Alamos National Laboratory
RBC	risk-based concentration
SLR	SLR International Corporation
T&E	threatened or endangered
TSF	Tailings Storage Facility
TWRSF	Temporary Waste Rock Storage Facility
USEPA	United States Environmental Protection Agency
WAD	Weak Acid Dissociable

1. INTRODUCTION

SLR International Corporation (SLR) has prepared this Ecological Risk Assessment (ERA) on behalf of Calico Resources USA Corp. (Calico) for the proposed Grassy Mountain Mine Project (Project) in Oregon. Calico proposes to construct an underground mine and precious metal processing facilities at a site in eastern Oregon, approximately 22 miles south-southwest of Vale, Oregon. In addition to the underground mine, the proposed mining and processing operation will include a conventional Mill, Tailings Storage Facility (TSF), Temporary Waste Rock Storage Facility (TWRSF), as well as other support facilities.

The TSF will contain supernatant that has partitioned from the tailings slurry from the processing plant and overlies the finely ground ore solids (i.e., the tailings). The supernatant water contains residual inorganic chemicals from processing the ore. Although fencing and other types of barriers will be used to prevent wildlife (birds and mammals) from contacting water in the TSF, this ERA assumes that wildlife may consume supernatant over an extended period of time. This ERA characterizes potential risks that chemicals in supernatant may pose to wildlife. Results of the ERA will be used to guide potential ecological risk management actions.

1.1 TAILINGS STORAGE FACILITY

Calico proposes to extract ore and waste rock from an underground mine using conventional mining techniques (e.g., drilling, blasting, mucking, loading, and hauling). Mined ore will be transported, stockpiled, crushed, and then leached in a carbon-in-leach processing plant. Leached tailings will be pumped as a slurry to the TSF. Material in the TSF will be allowed to settle, and the supernatant solution in the pond will be recovered and recycled back to the Mill circuit for processing more ore. The proposed TSF is designed to have zero discharge. It will have geomembrane-lined primary and secondary containment, along with leak detection systems.

There is also a Reclaim Pond associated with the TSF. The Reclaim Pond is also a double-lined containment facility. The Reclaim Pond collects water that drains from the leachate collection system in the TSF, and from the TSF leak detection system and the TWRSF (also a double-lined containment facility, although it does not store water). The leachate collection system is a layer of drain rock and piping between the underlying liner system and the overlying tailings mass that is designed to minimize the hydraulic head on the liner system. Reclaim Pond water is estimated to have approximately the same chemistry as supernatant pond water, and water that collects in the pond is recycled to the Mill like the supernatant water. The volume of water in the Reclaim Pond is much smaller than the volume of the supernatant pond.

Tailings from the carbon-in-leach processing plant will be treated for cyanide destruction prior to being pumped to the TSF. Chemicals that will be added to tailings to degrade cyanide will include lime, copper sulfate, and sodium metabisulfate. The TSF will allow for the natural degradation of remaining cyanide through exposure to ultraviolet sunlight and natural microbiota that metabolize cyanide.

1.2 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT

To promote efficiency, ERAs are typically performed in a tiered manner (DEQ, 2001). Tiered evaluations increase efficiency because conservative, relatively simple, and inexpensive assessment methods are used in the initial evaluation. More realistic, complex, and expensive higher-tiered evaluations are only performed as needed. This screening assessment is an initial tier that characterizes potential risks by comparing chemical concentrations in water with conservative screening-level values. Specifically, chemical concentrations in supernatant water are compared to risk-based screening levels protective of birds and mammals that may have long-term exposure to water through drinking. If concentrations are below screening levels, it can be inferred with high confidence that chemicals are unlikely to cause unacceptable risks to birds or mammals. Alternatively, chemicals present in the environment at concentrations above screening levels are likely to require additional evaluation.

1.3 REPORT ORGANIZATION

This ERA is organized as follows:

- Section 2 presents the exposure assessment describing the process by which ecological receptors may be exposed to chemicals in the environment. This section includes the Conceptual Site Model (CSM) describing ecological (wildlife) exposure scenarios and Exposure Point Concentrations (EPCs), which are conservative estimates of the chemical concentrations in water that wildlife may contact.
- Section 3 presents the screening-level risk evaluation. This section includes a description of risk-based screening levels protective of wildlife, risk characterization methods, and screening-level risk results.
- Section 4 presents ERA conclusions.

2. EXPOSURE ASSESSMENT

The exposure assessment describes the process by which ecological receptors may contact chemicals in the environment. The exposure assessment includes a CSM that identifies the ecological receptors that may contact an environmental medium and the pathways by which chemicals may enter the body of a receptor. Other aspects of the exposure assessment include estimates of concentrations or doses that a receptor may experience, chemical contact rates (e.g., drinking water ingestion rates), exposure frequency and duration, and other factors that influence the amount of chemical an organism may uptake. The CSM and estimates of the concentrations that receptors may contact in supernatant water are described below.

2.1 CONCEPTUAL SITE MODEL

The CSM describes potential chemical sources, release mechanisms, environmental transport processes, exposure routes, and receptors. According to United States Environmental Protection Agency (USEPA) risk assessment guidance (USEPA, 1989), a complete exposure pathway consists of four necessary elements: (1) a source and mechanism of chemical release to the environment, (2) an environmental retention or transport medium for a released chemical, (3) a point of potential contact with the impacted medium (referred to as the exposure point), and (4) an exposure route (e.g., water ingestion) at the exposure point. If any of these four components are not present, then a potential exposure pathway is considered incomplete and is not evaluated further. If all four components are present, a pathway is considered potentially complete.

Chemical sources include the parent ore materials from which metals leach into water, along with chemicals in the treatments that promote leaching from ore materials. Although many of the chemicals leached to water are recovered during processing, some are present in the material discharged to the TSF. These are the chemicals that ultimately reside in the supernatant within the TSF, which is the retention medium.

The TSF and Reclaim Pond will be engineered features designed to temporarily manage materials used in proposed mining operations. When mining operations end, these features will be appropriately decommissioned. By design, the TSF and Reclaim Pond will not be operated in a manner that would promote the establishment of natural or semi-natural aquatic ecosystems. For example, the TSF and Reclaim Pond will be intensively managed and frequently disturbed. Tailings will be regularly discharged into the TSF, and water from the supernatant pool and other areas of the TSF will be regularly extracted via pumping and delivered back to the Process Plant for reuse. These regular disturbances to media within the engineered TSF are likely to preclude development of a semi-natural aquatic system.

The TSF and Reclaim Pond will not be connected to natural surface waters, and fish or other wholly aquatic organisms will not be able to colonize these features through water. Although it is possible that the volant life stage of invertebrates with a separate aquatic life stage (e.g., mosquitos) could fly into the pond, due to frequent disturbance and other factors, the TSF is unlikely to represent good breeding habitat for aquatic insects. Similarly, seeds of aquatic plants could potentially migrate into the TSF, but again,

disturbances to media within the TSF are likely to prevent the establishment of a semi-natural aquatic plant community.

The TSF (including the Reclaim Pond located at the toe of the TSF embankment) will be located within an enclosure with fencing 8 feet in height and armoring extending 18 inches above and below the ground surface to exclude wildlife, including burrowing mammals (MB&G, 2023). Despite these wildlife exclusion features, this CSM assumes that local birds and mammals will be able to access the TSF. Appendix E of the Wildlife Resources Baseline Report (EMS, 2020) lists the wildlife observed during field studies near the site. This list includes 62 birds, 26 mammals, 11 reptiles, and 1 amphibian. It is assumed that birds such as the horned lark (*Eremophila alpestris*) or western meadowlark (*Sturnella neglecta*), and local small mammals such as the western deer mouse (*Peromyscus sonoriensis*) or Belding's ground squirrel (*Urocitellus beldingi*), may access the TSF. Furthermore, it is assumed that birds and mammals may use supernatant in the TSF as a source of drinking water and have chronic (long-term) exposure to chemicals in water through ingestion. Although it is likely that wildlife drinking supernatant would also have dermal contact with water, this exposure route is considered insignificant relative to water ingestion. It should be noted that DEQ ERA guidance (DEQ, 2001) and guidance from other institutions (LANL, 2017) do not report models that estimate dermal uptake of chemicals in water by wildlife. The TSF and Reclaim Pond are unlikely to support significant populations of aquatic plants and invertebrates. As a result, birds and mammals that may drink from the TSF are not expected to forage on aquatic organisms from these features, and dietary exposure to chemicals is expected to be minimal.

2.2 EXPOSURE POINT CONCENTRATIONS

Ecological receptors do not constrain exposure to activities to a single sample location, and instead move over the environment and are likely to be exposed at a variety of locations within an exposure unit. The EPC is an estimate of the average chemical concentration in an environmental medium that a receptor may contact on a long-term basis (USEPA, 1989). For the purposes of this ERA, the EPC that wildlife may contact on a chronic basis is the maximum estimated concentration in supernatant reported in the SRK (2021) tailings geochemical modeling report.

SRK (2021) used a geochemical model to estimate concentrations of chemicals in supernatant of the TSF. They modeled concentrations expected under wet, dry, and average conditions during three different phases of mining operations. The geochemical model used by SRK considered the effects of evaporation and precipitation on supernatant pond water chemistry. SRK (2021) performed a sensitivity analysis on the geochemical model where certain assumptions used in the base model were relaxed, and they found few significant effects on estimated supernatant chemical concentrations. Supernatant chemical concentration estimates in Table 4-1 of SRK (2021) were used in this ERA. To be conservative, the maximum estimated concentration during any season or mining operation phase was used as the EPC for a chemical.

The form of cyanide in the TSF and Reclaim Pond is total cyanide. As mentioned previously, tailings are treated to degrade cyanide before they are pumped to the TSF. As a result, most Weak Acid Dissociable (WAD) cyanide and free cyanide are removed from tailings before they enter the TSF. Also, WAD cyanide in the TSF will be readily degraded by sunlight and natural bacteria. The EPC for supernatant is for total cyanide.

3. SCREENING-LEVEL ECOLOGICAL RISK EVALUATION

This screening-level ERA compares EPCs representing the maximum estimated chemical concentrations in supernatant water to risk-based screening levels protective of birds and mammals. If the EPC for a chemical is below a conservative screening level, it can be inferred that exposure to the chemical in water is unlikely to cause unacceptable risks to ecological receptors. Ecological screening levels and screening-level risk estimates are described below.

3.1 RISK-BASED SCREENING LEVELS

The Oregon Department of Environmental Quality (DEQ) has identified risk-based concentrations (RBCs) protective of birds and mammals exposed to chemicals in water through ingestion (see Table 1b, <https://www.oregon.gov/deq/hazards-and-cleanup/env-cleanup/pages/era.aspx>). These particular DEQ RBCs were originally developed by Los Alamos National Laboratory (LANL, 2017). The RBCs are calculated assuming that birds and mammals have a reasonable maximum exposure (i.e., high exposure but not unreasonable) to chemicals in water through drinking. Data from chronic toxicity studies (i.e., tests involving a substantial fraction of an organism's life or a critical life stage) where effects on test organism mortality, reproduction, or growth were measured are used to develop the toxicity reference values used in RBC derivations (LANL, 2017).

LANL (2017) developed ecological screening values for indicator species representative of three common bird and mammal feeding guilds: herbivores, invertivores, and carnivores. Indicator species were relatively small-bodied members of a guild. Small-bodied birds and mammals have relatively high food and water ingestion rates (when normalized by body mass), and screening values for indicator species are intended to be protective of other members of the guild. The bird RBC selected by DEQ was the lowest of the drinking water values developed by LANL (2017) for the American robin (*Turdus migratorius*), American kestrel (*Falco sparverius*), or Mexican spotted owl (*Strix occidentalis lucida*). Similarly, the mammal RBC was the lowest of the LANL (2017) drinking water values for the deer mouse, mountain cottontail (*Sylvilagus nuttallii*), montane shrew (*Sorex monticolus*), or gray fox (*Urocyon cinereoargenteus*). Although some of these species are unlikely to be present near the TSF (e.g., Mexican spotted owl), they have similar body sizes, behaviors, and exposure conditions to birds or mammals observed near the site that may contact supernatant water in the TSF (see Appendix E of EMS, 2020). RBCs for these birds and mammals represent conservative, but relevant, ecological screening values.

The Oregon cleanup rules specify the protection of individual organisms of species listed as threatened or endangered (T&E) under state or federal laws established to protect T&E species (e.g., Endangered Species Acts). For species not listed as T&E species, populations, not necessarily each individual, must be protected. None of the Oregon bird or mammal species listed as threatened or endangered (https://www.dfw.state.or.us/wildlife/diversity/species/threatened_endangered_candidate_list.asp) are likely to be present near the site. As a result, the RBCs in Table 1b for non-T&E species were used as ecological screening values.

3.2 RISK CHARACTERIZATION APPROACH

As mentioned above, this ERA assumes that wildlife (birds and mammals) may have long-term exposure to the maximum estimated chemical concentrations in supernatant water via drinking. For each chemical, a hazard quotient (HQ) is calculated as follows for both birds and mammals:

$$HQ = \frac{EPC}{RBC}$$

The hazard index (HI), an estimate of the cumulative risks associated with exposure to multiple chemicals, is estimated as the sum of chemical-specific HQs for both birds and mammals. This cumulative risk estimate conservatively assumes that the toxicity of all chemicals are additive. The HI is estimated as follows:

$$HI = \sum HQ$$

The DEQ acceptable risk level for ecological receptors is an HI < 1.

3.3 RESULTS

Table 1 presents RBCs, EPCs, HQs, and HIs for both birds and mammals that may be exposed to supernatant water in the TSF. Based on results of this screening-level ecological risk evaluation, chemicals in supernatant water are not expected to pose unacceptable risks to wildlife. As shown in Table 1, when it is assumed that wildlife have long-term drinking exposures to the maximum predicted concentrations of chemicals in supernatant water, the HI for birds (0.99) and mammals (0.22) are below the target acceptable risk level of 1.

4. CONCLUSION

Based on the results of this conservative screening-level risk evaluation, chemicals in supernatant water of the TSF are not expected to pose unacceptable risks to wildlife. Given the conservative nature of this risk assessment, additional ecological risk evaluations do not appear to be warranted.

5. REFERENCES

- Department of Environmental Quality (DEQ). 2001. Guidance for Ecological Risk Assessment: Levels I, II, III, IV. November 1998, Updated December 2001.
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- SRK Consulting (SRK). 2021. Technical Memorandum: Numerical Prediction of Tailings Supernatant Pond and Reclaim Pond Chemistry for the Grassy Mountain Project.
- U.S. Environmental Protection Agency (USEPA). 1989. Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Part A), Interim Final. EPA/540/1-89/002. Office of Emergency and Remedial Response. December.

TABLE

Table 1
Ecological Screening Evaluation
Grassy Mountain Mine Project

Analyte	Ecological Screening Levels ¹		Predicted Supernatant Pond Concentration ²	Hazard Quotient (HQ)	
	Birds (mg/L)	Mammals (mg/L)	Maximum (mg/L)	Bird HQ	Mammal HQ
Alkalinity	NE	NE	42.5	--	--
Aluminum	4,500	86	0.344	7.6E-05	4.0E-03
Antimony	52	2.3	0.054	1.0E-03	2.3E-02
Arsenic	760	5.6	0.217	2.9E-04	3.9E-02
Barium	770	8.8	0.038	4.9E-05	4.3E-03
Beryllium	82	29	0.0005	6.1E-06	1.7E-05
Boron	71	1,200	0.018	2.5E-04	1.5E-05
Cadmium	71	17	0.0006	8.5E-06	3.5E-05
Calcium	NE	NE	153	--	--
Chloride	NE	NE	7.59	--	--
Chromium	2	630	0.002	1.0E-03	3.2E-06
Cobalt	1.6	2.2	0.099	6.2E-02	4.5E-02
Copper	500	33	2.40	4.8E-03	7.3E-02
Cyanide	640	3,000	0.024	3.8E-05	8.0E-06
Fluoride	24,000	210	0.295	1.2E-05	1.4E-03
Iron	NE	NE	0.0008	--	--
Lead	0.78	16	0.0007	9.0E-04	4.4E-05
Lithium	0.26	700	0.062	2.4E-01	8.9E-05
Magnesium	NE	NE	3.01	--	--
Manganese	160	63	0.918	5.7E-03	1.5E-02
Mercury	10,000	0.71	0.007	7.0E-07	9.9E-03
Molybdenum	220	120	0.049	2.2E-04	4.1E-04
Nickel	14	1.4	0.002	1.4E-04	1.4E-03
Nitrate	NE	NE	1.00	--	--
pH	NE	NE	8.00	--	--
Phosphorous	NE	NE	0.008	--	--
Potassium	NE	NE	21.8	--	--
Selenium	45	1,100	0.026	5.8E-04	2.4E-05
Silver	4,900	0.31	0.0003	6.1E-08	9.7E-04
Sodium	NE	NE	256	--	--
Strontium	0.57	700	0.386	6.8E-01	5.5E-04
Sulfate	NE	NE	883	--	--
Thallium	14	0.31	0.002	1.4E-04	6.5E-03
Tin	NE	NE	0.028	--	--
Uranium	3,200	3,100	0.008	2.5E-06	2.6E-06
Vanadium	45	3,100	0.001	2.2E-05	3.2E-07
Zinc	4,900	4,400	0.099	2.0E-05	2.3E-05
Hazard Index (HI)				9.9E-01	2.2E-01

Notes:

- 1 Drinking water screening levels for non-threatened or endangered wildlife
From: Table 1B, Oregon Department of Environmental Quality,
<https://www.oregon.gov/deq/hazards-and-cleanup/env-cleanup/pages/era.aspx>
- 2 Maximum estimated concentration in Table 4-1,
SRK Consulting, 2021, Technical Memorandum, Re: Ecological Risk Assessment:
Numerical Prediction of Tailings, Supernatant Pond and Reclaim Pond Chemistry
for the Grassy Mountain Project, December 7.
NE = Not Established (i.e., no screening value)
HQ = Maximum Concentration/Screening Level
HI = Sum of chemical-specific HQs