Parent company of Canadian Zinc

Prairie Creek Project

MINEWATER TREATMENT CONTINGENCY PLAN FOR WATER LICENCE MV2019L2-0006

January, 2021

Preamble

This *Minewater Treatment Contingency Plan* applies to the underground activities of Canadian Zinc Corporation during exploration at the Prairie Creek Property associated with Water Licence MV2019L2-0006.

The following formal distribution has been made of this plan:

Mackenzie Valley Land and Water Board

Canadian Zinc Corporation - Prairie Creek Site Office

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1.0 INTRODUCTION

As part of the mineral exploration process of establishing, confirming and enhancing the mineral resource at the Prairie Creek property, Canadian Zinc (CZN) constructed a new decline tunnel and underground development in 2006-2007 to permit access for underground exploration, including drilling of the stratabound deposit underlying the Zone 3 quartz vein mineralization. Further delineation of the vein-type mineralization was undertaken at the same time. The new decline was planned to be accessed from a new 905 m level portal. However, at the time of decline development, it was decided to gain access via the existing portal site at the 870 m elevation. The 870 m level extends approximately 800 m into the mountain to where the collar of the Decline occurs.

During permitting, CZN undertook to also manage mine water emanating from the existing workings during the exploration Decline project. The expectation at the time of the commitment was that the settling of sediment may be required. Upon receipt of a Water Licence with Effluent Quality Criteria (EQC), it was then clear that treatment of mine water would be required to meet EQC, specifically to remove zinc. Water treatment had not occurred on the property prior to 2006.

CZN currently holds NWT Surface Lease #95F/10-5, originally issued to Procan Exploration in 1987 by Indian and Northern Affairs Canada (now AANDC). CZN assumed responsibility for the Lease when it acquired Procan's interest in the property. CZN's current liability in connection with the site is limited by the terms of the Lease and the Abandonment and Restoration Plan (ARP) attached to it as a schedule. This plan defines the required restoration actions and responsibilities of the Lessee. For example, the Lessee has the option to remove buildings and equipment, or to leave them on-site. Also, the Lessee is required to barricade the mine openings, but is not required to address mine water discharge. The existing ore stockpile is to be capped with clay and left in-place. Therefore, CZN's current liability for the site is limited. It is clear from the terms of the Lease that the majority of site liability would revert to the Crown unless mine operations proceed. CZN has every intention of eventually proceeding with mine operations and assuming all site liability.

Since the completion of the first Decline project, CZN has continued to manage water from the Decline and the old workings, although the Company believes it is not responsible for continuing to manage water from the old workings. Flows from the Decline are directed into a pipe for delivery to the 870 portal. This water does not require treatment to meet EQC. Water from the old underground workings flows along the adit to the portal. This water requires treatment due to elevated dissolved zinc.

CZN holds a Land Use Permit for a second Decline, which would also be accessed from the 870 portal. This Decline, if built, would be expected to generate water flows similar in volume and quality to the first Decline. During development of the first Decline, no sudden in-rushes of water occurred. Water flow was controlled by regulating valves on drill holes. The first Decline is presently flooded and produces ~3 L/sec in flow in summer.

CZN also has an Effluent Treatment Plan (ETP) which explains how CZN:

- collects mine water flows (section 2.1);
- plans to continue to treat mine water under Water Licence MV2019L2-0006 (sections 2.1 to 3.3, and also summarized in section 2 below); and,
- monitor treated water quality (section 3.4).

The ETP essentially describes how the mine water management and treatment system operates, and should be read in conjunction with this Mine Water Treatment Contingency Plan. This plan explains how CZN proposes to manage mine water flows and contingencies adopted for treated mine water quality in order to meet the EQC currently listed in Water Licence MV2019L2-0006.

2.0 MINEWATER TREATMENT

CZN treats mine water at a culvert which receives mine water from the 870 portal. Secondary treatment of the culvert stream is integrated with a connected delivery line to the Polishing Pond.

Sodium sulphide is the primary treatment chemical which converts dissolved zinc to a solid sulphide form. The sulphide dose (12 mg/L) is mainly determined by the mine water flow rate, which is monitored at the outflow of the Polishing Pond. This is followed by secondary treatment with iron (4 mg/L) in the form of ferric sulphate which acts as a coagulant, and a flocculant before the water is delivered to the first cell in the Polishing Pond. The Polishing Pond provides retention time for the settlement of fine particles, followed by discharge. CZN is proposing to add sand filtration to Polishing Pond discharge to further lower total zinc concentrations before the Catchment Pond and final discharge to Harrison Creek.

Monitoring of zinc concentrations in mine water after treatment is performed on-site using a portable ultra-violet spectrophotometer which determines zinc content by colourimetry, with a quoted test range of 0.2-3.0 mg/L.

3.0 CONTINGENCY PLAN

3.1 2020 ACTIVITIES AND PERFORMANCE

3.1.1 2020 Performance

In our April 2020 Effluent Treatment Plan, approved by the Board on June 30, 2020 we detailed some changes that we intended to implement to improve secondary treatment. These were the installation and reorientation of baffles in the Polishing Pond, and use of a new flocculant. In our April 2020 Mine Water Treatment Contingency Plan (MTCP), we said that if the implemented changes did not result in compliant effluent in 2020, we would investigate other methods to reduce sediment concentrations, such as sand filtration, which would reduce total zinc concentrations. Following review comments on the MTCP, CZN agreed to investigate other methods immediately (within the 2020 season) if effluent remained non-compliant. Also, in response to the NDDB-LKFN review comments dated May 25, 2020 CZN agreed to collect data with which to potentially apply to change the zinc EQC from total to dissolved.

CZN's site activities, which are currently seasonal, were delayed in 2020 due to access complications caused by COVID-19. Zinc concentrations in Polishing Pond discharge in 2020 are summarized in Table 1, along with comments relating to times when the effluent exceeded EQC.

We note that there were six instances when effluent quality exceeded the maximum total zinc EQC. The reasons for these instances and our responses to them are as follows:

- The July 23 sample was taken just after seasonal start-up and Polishing Pond filling. We believe there is some zinc diffusion/dissolution from the sediments already in the pond that occurs during pond filling. We noted this during start-up in 2019 when we initially filled the pond with fresh water. We plan to combat this in future by filling the pond with water containing enough sodium sulphide to counteract the process;
- The samples taken on August 13 and 20 correlated with mine water flow peaks that we had not experienced previously. Site had experienced multiple intense rainfall events. System capacity was increased twice over the period, and we have added additional redundancy since that time to avoid a recurrence;
- On September 2, a new technician prepared an incorrect dose of sodium sulphide, leading to insufficient treatment overnight. Additional oversight and checks were added to avoid a repetition;
- On September 10, the flocculant delivery system was reconfigured for improved mixing using a new flocculant. There was a flocculant dosing pause while this occurred;
- On November 5, the flocculant pump failed overnight due to ice in the mix. Additional heat was applied and the system was re-started.

Table 1: Summary of Zinc Concentrations in Polishing Pond Discharge, 2020

Sample Date	Zinc (mg/L)		Reason for EQC Exceedance
	Total	Dissolved	
EQC Max Avg	0.4	-	
EQC Max Grab	0.8	-	
Jul 23	1.480	1.520	Suspected diffusion from sediments in Polishing Pond during start-up
Jul 30	0.749	0.327	
Aug 6	0.654	0.127	
Aug 13	11.300	9.850	Flows exceeded system capacity
Aug 20	3.210	2.490	Flows exceeded system capacity
Aug 27	0.592	0.131	
Sep 3	1.870	0.905	Incorrect dose of primary chemical
Sep 10	1.130	0.383	Reconfiguration of flocculant delivery system
Sep 17	0.409	0.088	
Sep 25	0.258	0.044	
Oct 1	0.686	0.030	
Oct 8	0.450	0.006	
Oct 15	0.317	0.024	
Oct 23	0.698	0.006	
Oct 29	0.400	0.002	
Nov 5	0.880	0.006	Flocculant pump failure overnight
Nov 12	0.667	0.001	
Nov 19	0.561	0.003	

We believe we have resolved the origins of the six instances when effluent quality exceeded the maximum total zinc EQC. Table 1 results indicate that dissolved zinc concentrations in effluent were below 0.4 mg/L, except for four of the six instances when effluent quality exceeded the maximum total zinc.

3.1.2 Sand Filtration

In early September, we collected a bulk sample and proceeded with off-site treatment testing in Vancouver to seek further water treatment improvements. Later in the month we confirmed sand filter efficacy and proceeded with procurement. A filter was shipped to site, arriving in mid-October. However, with the on-set of freezing temperatures, it was considered to be too late to install and operate the filter. We believe we can improve effluent quality so that the average maximum total zinc EQC is not exceeded by the use of sand filtration.

3.1.3 Dissolved Zinc EQC

We note that adoption of sand filtration to meet EQC would not be necessary if the Board agrees to change the zinc EQC from total to dissolved, consistent with the 2018 Canadian Council of

Ministers of the Environment (CCME) Guidance for zinc for the protection of freshwater aquatic life. CZN will be making an application to make this change shortly.

3.2 MITIGATION OF EXCESS WATER

The water treatment system was not prone to inundation from excess flows resulting from 'in-rushes' of water. Mine drainage flows vary according to season and rainfall. Since 2007, the volume of this discharge during summer months has typically been in the range of approximately 5-15 L/sec. However, flow peaks likely exceeding 25 L/s occurred in 2020, all related to intense rainfall events. These peaks exceeded treatment system capacity (culvert and reaction tank overflow). System capacity was increased twice at the time of the peaks, and we have added additional redundancy since that time to avoid an overflow recurrence.

The higher flows did not exceed chemical treatment capacity since doses of chemicals can be increased to maintain treatment efficiency. In terms of polishing the high flows after treatment, the size of the Polishing Pond remains large enough to provide settling time within prescribed levels.

Water flows did not pose any significant issues during the period that included the development of the first decline (2006-2007). If a second decline is developed, no issues would be expected either. However, we will ensure that adequate system contingency is available before commencing decline dewatering

Apart from infiltration primarily during the summer months, the mine water management and treatment system is not affected by surface water runoff. Only mine water reports to the culvert where primary treatment occurs (see photo below). Treated water is then delivered to the Polishing Pond by a pipeline. The Polishing Pond is a raised structure with four berms. There is no run-on into the pond. The pond does receive incident precipitation, but this does not negatively affect pond function, which is the settling of sediment, and pond volume stays constant as inflows are matched by outflows which occur over a weir at a constant elevation below freeboard.

Site surface water runoff collects in pre-existing ditches which drain to the Catchment Pond. There, surface water co-mingles with treated mine water before discharge to Harrison Creek via a culvert which has a gate weir control point.

Mine water flows are monitored at SNP Station 3-4, Polishing Pond outflow, via a calibrated weir gauge and recorded daily when site is open.

3.3 TREATMENT SYSTEM MALFUNCTION

In 2019 in particular, difficulties were experienced with treatment system pump failures and the clogging or freezing of chemical delivery lines. In 2020, CZN has added redundancy in terms of spare pumps and parts, duplicate lines to allow clean-out without interrupting treatment, and heat tracing to counter freezing. **No such malfunctions occurred in 2020.**

3.4 WATER QUALITY

The rate of sodium sulphide addition is based on the flow rate, measured at the weir downstream of the Polishing Pond.

During prolonged periods of intense rainfall, which increases the volume of mine water flowing by gravity from the 870 adit, a flow-based sulphide dose alone is not sufficient to reduce metal concentrations sufficiently. It appears the metal load during such periods also increases, although there appears to be a lag between the flow and load increases. At times when the tested zinc concentration from on-site monitoring using colourimetry (see the ETP for details) of water in the Polishing Pond exceeds 0.3 mg/L, the dose is increased to match the demand and reduce zinc concentrations. However, the dose increase occurs after zinc concentrations have increased.

To rectify this problem, when a flow increase is measured coincident with prolonged rainfall (i.e. a more sudden increase rather than a steady increase due to a change in season), the sulphide dose will be increased by the same amount over the normal range. For example, if the flow rate increases by 10%, the sulphide dose will be increased 20%, 10% for the new flow rate and 10% for the anticipated higher load. Monitoring will still be conducted in the Polishing Pond using

colourimetry, and the dose further increased if zinc concentrations are too high. The dose will return progressively to the normal range once flows stabilize or drop.

Sulphide treatment produces fine sediment that can be very difficult to settle. Total zinc concentrations related to this sediment have been the cause of the majority of non-compliance events.

Testing indicated that 4 mg/L iron as ferric sulphate is required as a coagulant followed by flocculant to promote settling and achieve compliant effluent. On-site testing of zinc by colourimetry is not well suited to detecting zinc in sediment, and therefore settling performance is based on the weekly samples collected for laboratory analysis. As noted, in the ETP, recent assessment by water treatment consultants indicated that settling could be enhanced by using a different flocculant. In addition, adjustments to the baffles in the Polishing Pond were made to maximize settling and minimize space not contributing to settling. In the event these measures were not sufficient to produce compliant effluent, further testing and the use of sand filtration on Polishing Pond outflow was recommended. CZN had proposed to acquire two months of treatment data before considering further changes. Concerns were expressed that this could mean unauthorized discharges for this period of time. Consequently, CZN agreed to seek additional treatment enhancements if initial results were not promising. As explained in the updated ETP, initial results were not promising, and CZN proceeded with further testing which resulted in the definition of a better flocculant, and with procurement of a trial sand filter. The new flocculant was brought on-line in mid-October, but it was too late to trial a sand filter (capacity 5 L/s).

Regarding the consideration of alternative options that are viable and that will prevent the release of effluent that does not meet EQC, it is important to note that it has been demonstrated that the use of sodium sulphide is effective in significantly reducing dissolved zinc concentrations, converting the zinc to a total form. Laboratory testing has indicated that it is feasible to settle the resulting zinc particles such that total zinc concentrations meet the current EQC. However, 2020 results proved this was not the case. It is also important to note, that because of the limitations of colourimetric analysis in total zinc concentration determination, it is not possible to know if effluent is in fact compliant until the results of laboratory analysis are received. It is not feasible to retain treated water for that length of time as the Catchment Pond has limited capacity. As such, laboratory results are received after the treated water has been released.

CZN previously proposed that the results of a superior flocculant and revised baffle orientation be awaited to assess compliance with EQC before considering other more significant alternatives. After the 2020 treatment season, CZN proposed to evaluate results and further consider options to consistently achieve effluent discharge that meets requirements. Laboratory tests indicated that sand filtration would be able to remove the majority of particulates and it should be feasible for effluent to meet the current total zinc EQC consistently. However, multiple filters (4-5) would be needed. The vessels are bulky (each vessel requires two plane trips, one for the vessel and one for the sand), and a sizable building would need to be erected to house the filters and provide heating, as well as heat tracing of all water lines.

Alternatively, sand filtration would not be required if the Board changes the EQC from total zinc to dissolved zinc. As noted above, the majority of the unauthorized discharges have been due to inadequate settling and elevated total zinc values, whereas dissolved values have usually been

low. CZN collected water samples from Prairie Creek downstream of the Mine (SNP Station 3-11) every two weeks in 2020 and had them analyzed for total and dissolved zinc, hardness, pH and dissolved organic carbon in order to apply to the Board to change the EQC from total zinc to dissolved zinc.

In 2019, the site experienced intense rainfall events in June leading to significantly higher sulphide consumption which ultimately resulted in a temporary exhaustion of supply. We have instituted enhanced inventory tracking and advanced ordering to avoid the exhaustion of supply in future.

4.0 RESPONSE FRAMEWORK

This section provides a description of the response framework that will be implemented to link the results of monitoring to those corrective actions necessary to ensure that the objectives listed in the Licence are met. Note that during water treatment operations and when the Polishing Pond is in use, all facilities are inspected by site personnel on a daily basis.

4.1 GEOTECHNICAL STABILITY

The water treatment apparatus includes a culvert, delivery pipes, metal-fame reaction tanks and the Polishing Pond. With respect to geotechnical stability, only the Polishing Pond is appropriate for consideration.

A preliminary design of the Polishing Pond was prepared by EBA Engineering Consultants dated April 26, 2005. The design consisted of a four-sided bermed structure with height up to 3.2 m and with slopes 2.5 horizontal to 1 vertical. The structure was to include a hypalon liner consisting of welded segments retrieved from the large pond already constructed on site but not in use, an overflow weir and a drain pipe at the base of the structure.

Golder Associates were subsequently appointed to advise on pond construction requirements and inspect and approve the final structure for use. A memorandum to CZN dated August 10, 2005 provided construction directions. Following an inspection on May 18, 2006 after pond construction as per the design and construction directions, Golder approved the pond for use.

There have been no significant structural issues with the pond since construction. Some relatively minor settlement cracks in the dykes were noted in some locations, but these stabilized soon after formation. As a precaution, CZN added buttressing material in the form of loose shale rock around the downstream toe of the structure and draped up the sides of the slopes to reduce slope angle. Annual inspections have not detected any issues with dyke conditions, such as cracks, slumping or other apparent movement. If any of these items is noted, a geotechnical engineer will inspect the structure to determine any need for, and the form of, response actions.

Historically, no seepage has been noted from the pond, other than minor leakage from the drain valve below the weir when the pond is full and discharging water over the weir. The hypalon liner is inspected annually. A few relatively minor leaks at weld locations and tears from settlement have been noted and patched. This process will continue to promote structural integrity. Note that this is a structural concern, not a water quality concern. The pond receives treated water for polishing (settling of sediment). Any water leakage through the liner would be filtered by the granular material forming the pond, and/or the underlying alluvial gravels, and report to the pond discharge location where water flows into a ditch carrying the water to the Catchment Pond.

The drain valve is to allow emptying of the pond during seasonal shut-down to prevent ice formation when the site is dormant over winter. The valve is connected to a pipe through the dyke. The inner end of the pipe is attached to, and sealed into, the liner. This seal is inspected each spring before water treatment and pond use resumes. If any cracking were to be observed, sealer would be applied. The drain vale remains open during the dormant period, and closed

when treatment resumes. The pond then fills and discharge only occurs once the pond level reaches the weir.

It is physically impossible for treated mine water in the Polishing Pond to exceed the freeboard limit. The water level in the pond is determined by the weir elevation at the outflow. The flow rate of water entering the pond is the flow rate of water level leaving the pond. The water level does not change once it reaches the weir elevation.

4.2 THERMAL CHARACTERISTICS

Water treatment typically does not occur in winter when there are no activities occurring underground. Mine water flows at the 870 portal reduce to 1-2 L/sec and freeze at the portal entrance where an ice plug forms.

The Polishing Pond is drained prior to winter to avoid ice formation which would otherwise delay pond use the following spring.

When activities are occurring underground in winter, if mine water is being pumped out, treatment lines are kept open by heat tracing, and the Polishing Pond is kept operational by using compressed air bubblers to prevent the outlet from icing. These bubblers are not prone to break down since a compressor will provide air provided there is power, and the site has main and reserve power generators.

The alluvial materials underlying the Polishing Pond are too coarse to host permafrost. Similarly, frost penetration into the pond dykes has not been observed. Any type of deformity would trigger an inspection by a geotechnical engineer.

There are no other thermal considerations or issues with the water treatment system.

4.3 SEEPAGE QUALITY, QUANTITY AND RUN OFF

As noted in Section 4.1, historically no seepage has been noted from the pond. Seepage quality is also discussed in section 4.1. Run off is discussed in Section 3.1.

4.4 MONITORING

Monitoring is conducted to ensure performance. Regarding the Polishing Pond, the pond is inspected annually each spring for geotechnical stability, condition of the hypalon liner and condition of the drain line and valve and the weir. Other than the buttressing described in Section 4.1 above, and patching of the liner as needed, no other responses have been necessary. Any evidence of berm cracking or subsidence would trigger an inspection by a professional engineer. Also as noted in Sections 4.1 and 4.2 above, no significant issues have occurred of a thermal or seepage nature.

Surface water run off does not directly affect the water treatment system or Polishing Pond, so is not specifically monitored. Mine water flow and water treatment efficiency is monitored at Station 3-4, the outlet of the Polishing Pond. Water flow is only monitored to select chemical

dosing requirements. Mine water flows have been well within the treatment system capacity since initiation of treatment and monitoring in 2006.

Regarding water treatment performance, as explained in Section 3.3, there are two aspects to water treatment performance: removal of dissolved metals by dosing with sodium sulphide; and, settling of the resulting suspended solids. Monitoring of the first step is done primarily by the use of a colourimeter to measure zinc concentrations. This method appears to respond mostly to dissolved zinc content, and is not conducive to monitoring total zinc concentrations. CZN takes a pro-active response to sulphide dosing i.e. we increase the dose before monitoring determines that a response is necessary. When a flow increase is measured coincident with prolonged rainfall, the sulphide dose is increased by the same amount over the normal range. As explained in Section 3.3, if the flow rate increases by 10%, the sulphide dose will be increased 20%, 10% for the new flow rate and 10% for the anticipated higher load. In this respect, there are no specific low, medium or high action levels, rather the action level (percentage of increased dose) is determined by the percentage of flow increase. Plant operators are also instructed to increase the sulphide dose incrementally if the zinc concentration measured by colourimeter exceeds 0.3 mg/L. These two corrective actions usually result in over-dosing, which is gradually reduced as flow conditions and/or colourimter concentrations return to their normal range.

Regarding the second aspect of water treatment performance, settling of suspended solids, results are only available from laboratory analysis. These have indicated that settling performance is not optimal. The doses of coagulant and flocculant are not thought to be at fault, since we know from bench-scale testing that the doses are correct. The delivery of the chemicals and the arrangement of the baffles in the Polishing Pond were changed with limited improvement.

There is a lack of correlation between total zinc concentrations and TSS. TSS concentrations are generally low. However, only a small fraction of the very fine particulates from sulphide treatment reporting to the total result is enough to cause a total zinc EQC exceedance, even when dissolved zinc results are very low.

Regarding other metals, cadmium concentrations correlate strongly with zinc concentrations, and originate from the same source. When the latter are controlled, the former is also. As for zinc, dissolved concentrations, which are more toxic, are much lower.

5.0 CONFORMITY WITH JUNE 30 & OCTOBER 9, 2020 BOARD DECISIONS

Item	Outstanding items requiring updating	Reference	Plan Section
1.	Update the MTCP to include a section that discusses contingency options that could be employed during primary treatment. This could include a discussion of how the portal culvert overflow event and clogging of treatment chemical delivery lines were mitigated in 2019.	ADKFN-1	3.2, 3.3
2.	Update with details on how CZN will be more proactive in seeking additional treatment enhancements if initial results are not promising (i.e. not waiting two months).	ENR-4	3.4
3.	Update based on the understanding that conversion to lime treatment will not occur in 2020, but an evaluation of treatment plant changes will occur, along with collecting data to possibly support a future application to change the zinc EQC from total to dissolved.	ECCC-1; ENR-5	3.4
4.	Update to correctly reference the Effluent Treatment Plan.	MVLWB-3	1
5.	Update section 3.2 Water Quality to indicate that a revised Effluent Treatment Plan would be revised and submitted to the MVLWB for approval if conversion to a lime-based treatment system is to occur.	MVLWB-6	3.4
6.	Update to include details of biweekly sampling at SNP station 3-11 for pH, hardness, dissolved organic carbon, dissolved zinc, and total zinc during the discharge season.	Racher-5	3.4
	The R2 correlation between dissolved zinc and TSS at SNP station 3-4 is 0.010. The R2 correlation between total zinc and TSS at SNP station 3-4 is 0.172. These low R2 values do not indicate that the elevated zinc in the effluent is necessarily a consequence of elevated TSS.	ADKFN-5	4.4
	The Proponent must be required by the Board to maintain a 7 day contingency stockpile of all treatment chemicals to ensure this issues does not occur in future.	ADKFN-6	3.4
	The Proponent should investigate and report to the Board and ADKFN the causes of elevated cadmium in effluent.	ADKFN-7	4.4