Adaptive Management Plan, Sä Dena Hes Mine - DRAFT

Prepared for

Teck Resources Ltd.

Prepared by

SRK Consulting (Canada) Inc.
1CT008.043
October 2014

Adaptive Management Plan, Sä Dena Hes Mine - DRAFT

October 2014

Prepared for

Dormant Properties
Teck Resources Ltd.
601 Knighton Road
Kimberley, BC V1O 1C7

Tel: +1 250 427 8423
Web: www.teck.com

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: 1CT008.043

File Name: Adaptive_Management_Plan_1CT008_043_DRAFT_LC_LB_TRS_20141023

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Attachment 1: Sä Dena Hes Mine Post-Reclamation Water Quality Environmental Monitoring Plan

List of Abbreviations

AMP	Adaptive Management Plan
CCME	Canadian Council of Ministers of the Environment
WQMP	Water Quality Monitoring Plan
M-K	Mann-Kendall
SDH	Sä Dena Hes Mine
SWQO	Site Water Quality Objective
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
WUL	Water Use Licence

1 Introduction

The Sä Dena Hes lead/zinc mine (SDH) operated from 1991 to 1992 and is currently owned by Teck Resources Limited and Korea Zinc. The mine was in care and maintenance from 1992 to 2013. Permanent closure of the mine is currently underway in 2014 and 2015. Closure activities completed in the summer of 2014 include demolishing of the mill and other site buildings, backfilling of portals, removing the South Dam and Reclaim Dams, reconstructing a portion of the Camp Creek channel and selectively covering portions of the site. Work in 2015 includes decommissioning site roads, final resloping and capping, and revegetation. Following reclamation, the site will be monitored to ensure objectives have been met.

1.1 Regulatory Context

Operation and closure of the site is authorized by a Quartz Mining Licence issued by the Yukon Department of Energy, Mines and Resources. The Quartz Mining Licence expires December 31, 2015. A Detailed Decommissioning Reclamation Plan (Teck 2013) describes closure objectives and activities.

Water use and discharge is regulated by the Yukon Territory Water Board under the Water Use Licence (WUL) QZ99-045, which expires on December 31, 2015. Water quality and flow have been monitored according to the licence since 1991. The licence requires monthly data reports and an annual report. The most recent annual report was submitted to the Yukon Water Board in April 2014 (SRK 2014a).

A WUL will continue to govern water discharge after closure. The application for a new licence or renewal of the existing WUL will include this adaptive management plan (AMP) and a water quality monitoring plan (WQMP). The WQMP for surface water and groundwater is presented in Attachment 1. Biological monitoring of the site will also occur and is described in the YESAB Project Proposal for Post-Reclamation Activities, in Section 7 (Access, 2014)

The AMP and WQMP are companion documents. The WQMP describes the monitoring locations, frequency, and parameters for the post-reclamation WUL application. Monitoring locations for the WQMP and referenced in the AMP are shown on Figure 1. The WQMP provides the data necessary for evaluating if water quality conditions are changing. The AMP describes how these data are evaluated, thresholds that trigger additional action, potential management actions and reporting requirements for the AMP. The connection between the WQMP and the AMP is presented in Figure 2.

1.2 Problem Statement

Water quality monitoring has been conducted as a condition of the current water licence since 1991. The ongoing monitoring dataset has been used to identify existing loading sources that discharge water with elevated concentrations of zinc, cadmium, and lead. These sources are:

- North Tailings Dam Seepage (MH-02)

- Burnick Portal (MH-22)
- 1380 Portal (MH-25)

Figure 3 is a conceptual loading diagram for each of these sources, including flow paths, attenuation mechanisms and AMP water quality monitoring stations. Water from these sources infiltrates to groundwater near the source and then migrates downgradient as groundwater to areas of groundwater discharge (i.e., surface water features). Discharge from both the 1380 Portal and the Burnick Portal drainage flow through the downgradient waste rock dumps, after which the flow infiltrates into the ground. Monthly and quarterly water quality monitoring results currently meet the effluent quality limits in the WUL at the receiving water bodies (Camp Creek, False Canyon Creek, and Tributary E).

SRK conducted previous investigations (SRK 2014b) that demonstrated that the loads (mass per time or kg/day) of dissolved zinc, cadmium, and lead from the Burnick and 1380 portals are not observed at the downstream monitoring locations, indicating that these loads are attenuated along the migration pathway or have not yet arrived at the monitoring location. Additional information about the attenuation mechanisms and water quality predictions is provided in the Water Quality Loading Assessment report (SRK 2014b).

Drainage from all three loading sources travels as groundwater ultimately discharging to False Canyon Creek. Consequently, the rate at which surface water concentrations change is a function of reactive transport along the groundwater flowpath. Any potential concentration increase in the receiving waters would be gradual and would depend on many factors, including mixing with other groundwater, dispersion, attenuation, the subsequent consumption of attenuation capacity, and the travel time between the source and discharge locations. The lag time between the initial increase in concentration and the maximum predicted concentration could be tens to hundreds of years (SRK 2014b).

1.3 Purpose

Surface water quality will be monitored after reclamation to observe any potential changes indicative of indicative of loading from the North Dam, Burnick Portal and 1380 Portal. The objective of the AMP is to detect changes from existing conditions and ensure that water quality does not exceed post-reclamation WUL limits.

1.4 Approach

Site water quality has remained relatively constant over the last twenty years and is expected to remain the same as in the past. The AMP is a tool to identify changes in water quality from current and historical conditions. It provides a framework describing the process to identify, evaluate, and manage/mitigate potential changes to water quality. If water quality changes from current conditions, the AMP describes the process for developing a plan to understand why the change has occurred and how it may be addressed.

Monitoring data is collected and evaluated relative to prescribed thresholds to assess if additional action is warranted. Changes in water quality that exceed thresholds trigger action as described in Section 2.

The general method and objectives are the same for the three potential loading sources (North Dam seepage, Burnick Portal discharge and 1380 Portal discharge), and is described as follows:

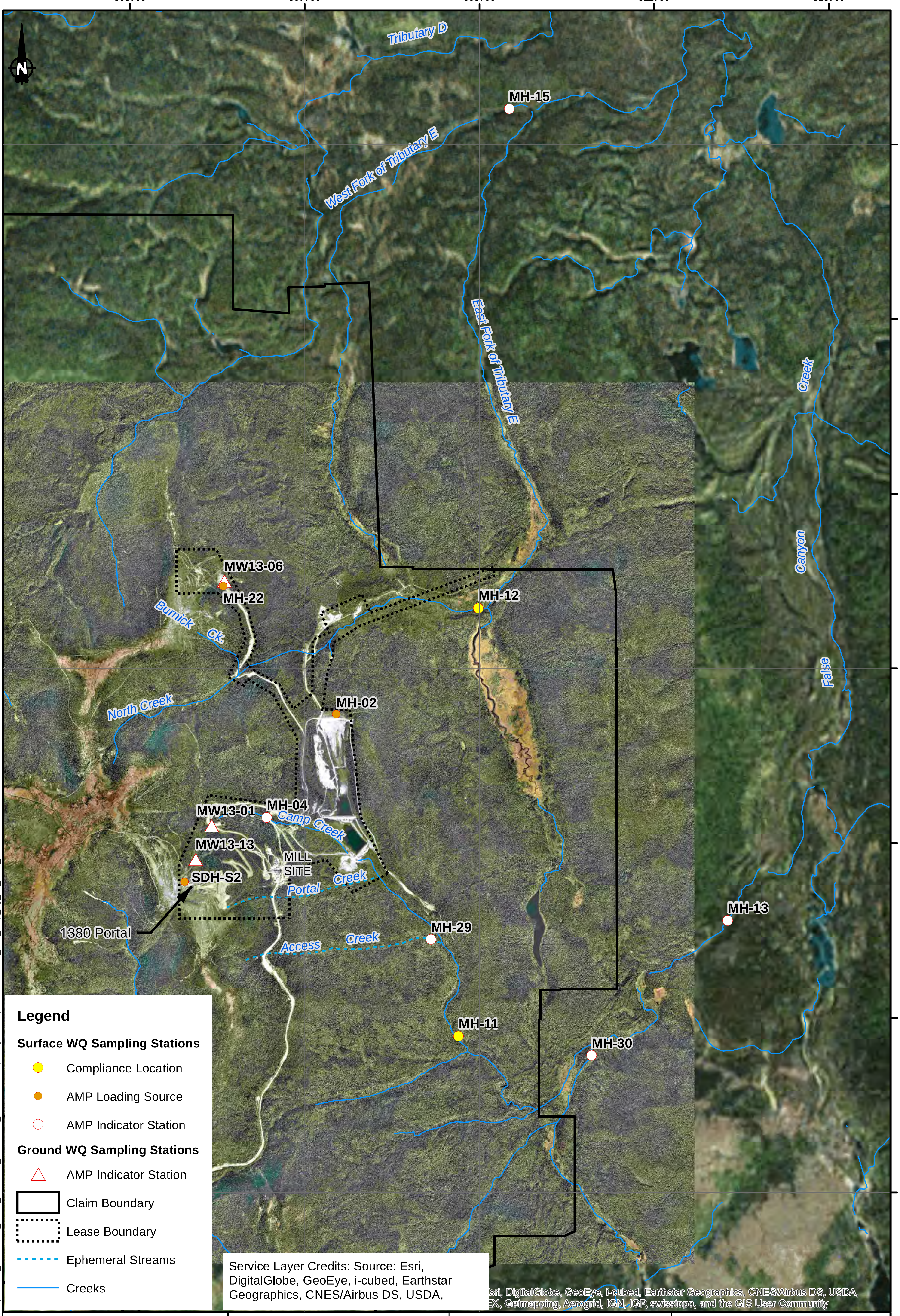
1. Description of AMP Loading Sources and Objectives of the AMP monitoring (developed from the conceptual model for each source),
2. Identification of specific indicators to be monitored,
3. Establishing thresholds for triggering action,
4. Evaluation of monitoring results, and
5. Description of a framework for escalating response if thresholds are exceeded.

1.5 Implementation Process

This AMP will be in effect for the duration of the post-reclamation water licence. It is a living document and can be revised as additional data and information become available over time. The AMP was prepared in support of the application to renew the water licence. It is anticipated that the AMP will be revised to incorporate other relevant permit requirements as the regulatory process proceeds to the water use licensing phase.

1.6 Annual Reporting

Reporting of the results of the WQMP monitoring and interpretation and recommendations from the AMP will be included in the annual report, submitted to the Water Board each March.



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Water Quality Monitoring Plan

Post-Reclamation Water Quality AMP Monitoring Stations

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Sä Dena Hes Mine

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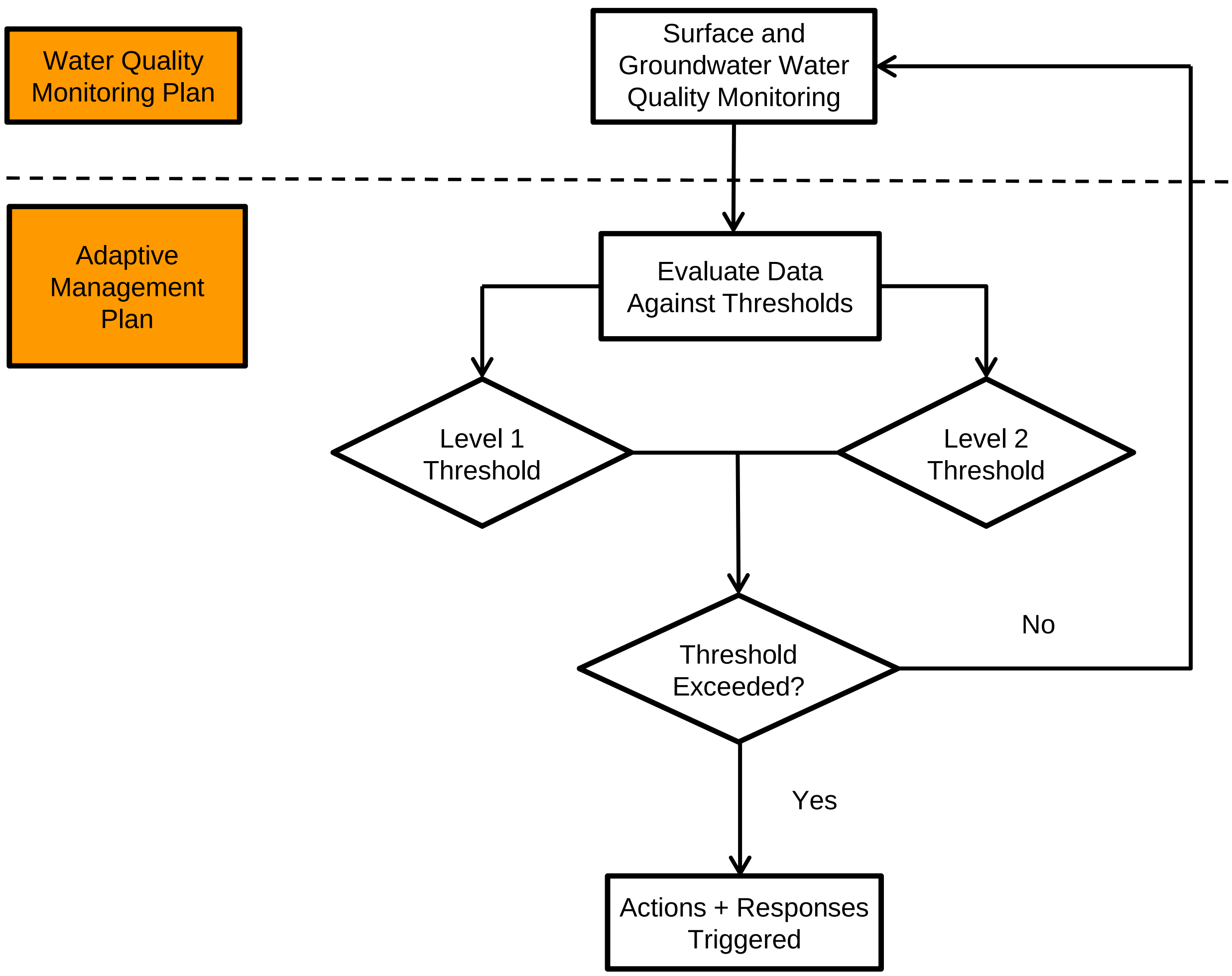

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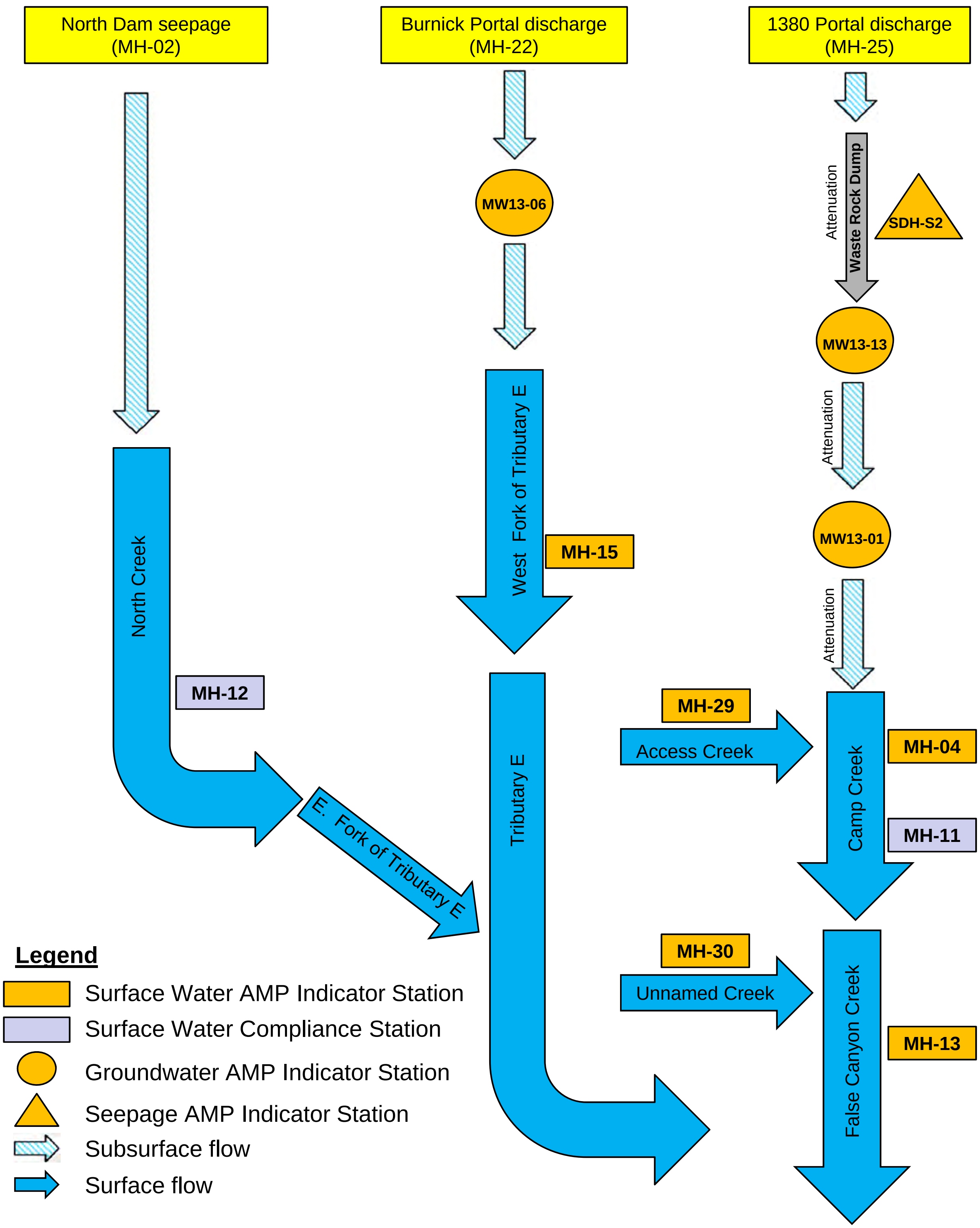
Job No: 1CT008.043 Filename: AdaptiveManagementPlanFigures_1CT008.043_Rev01_LMC_LNB.pptx	Sä Dena Hes	Date: October 2014 · Approved: LNB · Figure: **2**



srk consulting	Teck	Adaptive Management Plan Conceptual Loading Diagram
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2 Adaptive Management Plan

As discussed in Section 1.2, the AMP applies to three loading sources from the mine site, specifically:

- North Dam Seepage (MH-02)
- Burnick Portal (MH-22)
- 1380 Portal (MH-25)

2.1 Description of AMP Loading Sources and Flow Paths

Loading from each of the three mine site loading sources (North Dam Seepage, Burnick Portal and 1380 Portal) could increase mining related constituent concentrations. Currently geochemical attenuation, groundwater transport and mixing with other surface water and groundwater limit these potential changes. This section describes each loading source, the geochemical conceptual model and the drainage/seepage flow path.

2.1.1 North Dam Seepage

During operations, most tailings were discharged to the North Tailings Pond. Currently, there is no ponded water in the pond, but the tailings are saturated at depth. There is seepage from the toe of the North Dam, which is routinely monitored at MH-02 as required by the WUL. The seepage at MH-02 is tailings porewater that has been diluted by groundwater from the valley sides and runoff from the North Dam face (SRK 2000). The seepage quality at MH-02 is routinely in compliance for all WUL parameters.

Seepage from the North Tailings Dam flows throughout the entire year. Flow at MH-02 is highest during freshet and lowest during the winter. The seepage flows aboveground for a short distance from the North Dam before infiltrating the ground. It then flows as groundwater before discharging to North Creek and the headwaters of the East Fork of Tributary E. From the East Fork of Tributary E, the water flows to Tributary E and then to False Canyon Creek (Figure 1 and Figure 3).

Metal attenuation along this pathway has not been evaluated. The flowpath is relatively short compared to the groundwater pathways downgradient of the Burnick Portal and 1380 Portal. For the purposes of the post-reclamation water quality predictions, it was conservatively assumed that the entire constituent load from the seepage discharges to North Creek above MH-12 and that there was no attenuation of metals by the soil (SRK 2014b).

Specific Issues

The objective of the AMP for the North Dam seepage is to detect any deterioration in water quality in the tailings dam seepage and manage and mitigate these changes before any effects are observed in the downstream receiving surface waters. AMP monitoring locations include tailings seepage monitoring at MH-02 located at the toe of the dam and surface water monitoring station MH-12 in North Creek.

Monitoring MH-02 would detect any changes in water quality proximal to the loading source. Downstream of these stations, tailings seepage flows as groundwater. Any potential change in surface water quality in the receiving waters would therefore be a function of groundwater reactive transport. Any water quality changes are expected to be slow and would be detected by monitoring over multiple years for a statistically significant increasing trend.

2.1.2 Burnick Portal Discharge

The Burnick Portal is located 3 km from the SDH mill and was constructed to access the Burnick Zone ore body. There are two portals (1200 and 1300) at the Burnick Zone. The lower portal previously discharged continuously and has been routinely monitored during temporary closure at MH-22 as part of WUL QZ99-045. Now discharge from MH-22 is ephemeral (June to November). The discharge water quality exceeds the WUL limits for zinc during low flow months.

MH-22 discharge flows through a buried culvert, cascades over the crest of the Burnick waste rock dump, and then infiltrates under the waste rock dump. It then flows downgradient to the east-northeast as groundwater) to the headwaters of the West Fork of Tributary E, which is more than 1.5 km downgradient of the portal (Figure 1). The headwaters of the West Fork of Tributary E are marshy and channeled surface flow is intermittent. Surface water flows to the east-northeast from the West Fork of Tributary E to Tributary E and then to False Canyon Creek. There is currently no evidence that the zinc load from the Burnick Portal is observed in Tributary E or False Canyon Creek (SRK 2005). From this observation, SRK concluded zinc is attenuated through extensive contact with the soils between the Burnick Portal and the West Fork of Tributary E.

Column experiments using discharge from the Burnick Portal and downstream soils were used to evaluate the attenuation mechanism (SRK 2005). The testwork concluded that downgradient soils have the potential to significantly attenuate zinc concentrations at the levels observed in the discharge for much longer than 200 years. Column tests showed the attenuation capacity was not exhausted and no secondary minerals were formed. The studies confirmed that zinc is passively removed by contact with downgradient soils.

Because the zinc attenuation mechanism has more than 200 years of capacity, the attenuation capacity of the soils was considered to last for the duration of the licenced post-reclamation period.

Specific Issues

The objective of the AMP for the Burnick Portal discharge is to detect any deterioration in water quality in the drainage flowing from the Burnick Portal and downgradient surface water. AMP monitoring locations include the Burnick portal drainage (MH-22), groundwater monitoring well MW13-06 downgradient of the Burnick portal and surface water monitoring stations and MH-15 in the West Fork of Tributary E (Figure 1).

Monitoring at MH-22 and MW13-06 would detect any changes in water quality in the portal drainage or groundwater near the portal. Downstream of these stations, the drainage flows as groundwater. Any potential change in surface water quality in the receiving waters would be a function of reactive transport along the groundwater flowpath. Any changes are expected occur slowly and would be detected by monitoring over time to establish statistically significant increasing trend.

2.1.3 1380 Portal Discharge

The Main Zone Pit is a box cut located in the headwaters of Camp Creek. The 1380 Portal is located at the south end of the cut. In June 1999, drainage from the portal was observed. The drainage is routinely monitored at MH-25 as part of WUL QZ99-045. MH-25 was sampled for the first time in 1999 to support the closure plan and was found to contain 41 mg/L dissolved zinc.

Drainage from MH-25 is ephemeral (June to October) and consistently exceeds the WUL limits for zinc and cadmium and less frequently for lead. The zinc is leached from oxidizing exposed rock and talus around the portal area, which contain sphalerite. The source water is likely shallow groundwater with minor contributions from Jewelbox Pit (SRK 2000).

In 2000, MH-25 was monitored continuously for two months to assess variations in flow and chemistry. SRK (2000) reported that the drainage from the Main Zone pit portal contained elevated zinc, cadmium, and lead concentrations. Flow was estimated at 1 L/s. Flow decreased following freshet, but constituent concentrations were relatively constant. The constituent load associated with this flow was not detected in Camp Creek or False Canyon Creek at any time during the summer, suggesting attenuation along the flow path.

The 1380 Portal drainage flows through the marble Main Zone waste rock dump immediately downstream of the portal. Flow within the waste rock dump is audible but difficult to locate and/or access, resulting in infrequent monitoring. The dissolution of the marble attenuates zinc, cadmium, and lead by precipitation of metal carbonates. This attenuation mechanism of drainage from MH-25 is considered to last in perpetuity. Station SDH-S2 located within the waste rock below the 1380 Portal characterizes concentrations after attenuation by the waste rock. MH-25 and SDH-S2 have similar sulphate levels, but the zinc concentration is approximately four times lower at SDH-S2 than at MH-25, the level of cadmium is approximately five times lower, and the level of lead is approximately 1.5 times lower. Geochemical modelling indicates that that precipitation of zinc, cadmium, and lead carbonates is the probable attenuation mechanism resulting from the interaction of MH-25 drainage with marble waste rock (Day and Bowles 2005).

After passing through the waste rock dump, the 1380 Portal drainage is further attenuated downstream as groundwater flows through the soils along the flow path to Camp Creek. Studies indicate that there may eventually be a loss of attenuation capacity in the soils. The groundwater flow discharges to surface as a spring near the headwaters of Camp Creek. The length of the flow path from the 1380 Portal to the spring near the headwaters of Camp Creek is approximately 900 m. The spring is relatively large and is located where the southern fork of Camp Creek originates which mixes about 100 m downstream with water from a second groundwater spring on the southwestern flank of Mt. Hundere. Camp Creek flows to the south and is a tributary to False Canyon Creek (Figure 1 and Figure 3).

Specific Issues

The objective of the AMP for the 1380 Portal drainage is to detect any deterioration in the portal drainage water quality within the waste rock dump and monitor for the potential loss of attenuation capacity of the soils upstream of Camp Creek. AMP monitoring locations include:

- Seepage monitoring at station SDH-S2 within the Main Zone waste rock dump,
- Groundwater monitoring at MW13-01 and MW13-13 located downgradient of SDH-S2 and upstream of Camp Creek, and
- Surface water monitoring at MH-04 in lower Camp Creek and MH-11 and MH-13 in upper False Canyon Creek

All the locations are shown in Figure 1 and Figure 3.

Any potential change in surface water quality in the receiving waters would be a function of reactive transport along the groundwater flowpath. Any changes are expected to be slow and would be detected by monitoring over time to establish statistically significant increasing trend.

2.2 Indicator Parameters

The surface water and groundwater monitoring programs for the North dam seepage, Burnick portal and 1380 portal are outlined in the WQMP and include monitoring of relevant downstream stations (Figure 1). Figure 3 shows a loading schematic of the sources and each water monitoring station to the loading sources. The AMP indicator parameters for the WQMP stations are zinc, lead, cadmium, and sulphate.

2.3 Thresholds

Exceedance of a threshold triggers action. There are two threshold levels.

A Level One threshold is a statistically significant increasing trend of zinc, cadmium, lead and/or sulphate concentrations at surface water or groundwater WQMP monitoring locations. Detecting an increasing concentration trend earlier will allow for sufficient time to reduce the likelihood of exceeding a Level 2 threshold.

A Level Two thresholds are the WUL limits at surface water monitoring stations MH-11 and MH-12. These are water quality compliance points for the site. These licence limits will be defined in the post-reclamation WUL. The locations of the surface water compliance points are shown on Figure 1 and their relationship to the loading sources is shown in Figure 2. MH-11 and MH-12 define the boundary where site-influenced water enters the receiving environment, and are proposed to be specified as such in the WUL.

Exceedance of the thresholds should occur sequentially from statistically significant increasing trends at monitoring locations most proximal to the loading sources (Level 1) that may eventually lead to an exceedance of limits at the two surface water compliance point monitoring stations (Level 2).

2.4 Evaluation of Monitoring Results

This section provides the details of how the data are evaluated in the context of Level 1 and Level 2 triggers.

2.4.1 Level 1

The Level 1 trigger is a statistically significant increasing trend in concentrations of zinc, cadmium, lead and/or sulphate at surface water or groundwater monitoring locations. Trends observed at multiple monitoring locations downgradient of a loading source provide more evidence than an increasing trend at a single location. Statistical significance of the trend will be tested using a Mann-Kendall test or other predetermined criteria to assess an increasing trend in the data will be used to evaluate water quality data for surface water and groundwater monitoring locations. The large existing dataset from 1991 to 2014 supports using trend analysis to identify statistically significant changes in water quality.

The Mann-Kendall test is a statistical test that used to evaluate a dataset to test for statistically significant trends in time series data. The test does not require data to have a normal distribution. This statistical test is commonly used in monitoring data analysis programs (Helsel and Hirsch 2002). There are a variety software packages, including the publically available ProUCL software from the United States Environmental Protection Agency (USEPA 2013) that can perform the test.

A statistically significant increasing trend in concentrations may trigger further action. The results of the statistical test from multiple stations will be used to assess the appropriate level of response. An upward trend for a single AMP indicator or compliance station will trigger a lower level of response than multiple stations showing upward trends. Similarly an upward trend that continues for multiple years will trigger a greater response than if the trend were observed in a single year. The details of the response will be defined during permitting.

2.4.2 Level 2

The Level 2 threshold is the exceedance of WUL limits for surface water stations MH-11 and MH-12. Water quality at MH-11 and MH-12 will be compared to the standards for lead, zinc and cadmium as indicated in the WUL.

2.5 Response and Actions

Action is triggered when thresholds are exceeded. When a Level 1 or Level 2 threshold is exceeded, a step-wise plan of responses and actions will be followed. The sections below describe the types of action that may be taken and are presented as a framework in order of escalating action, as presented in Figure 4.

Each level of action includes documentation of the steps undertaken and resulting recommendations and responses that would result in escalation to the next level of action, as appropriate. Each section notes the type of report and distribution.

2.5.1 Verification of Data

When a threshold (Level 1 or Level 2) is exceeded, the result needs to be verified. The first step includes confirmation of the result with the lab. If the result is confirmed, the subsequent step is to verify the initial result by resampling the site within 60 days. If resampling confirms the initial result and Level 1 or Level 2 thresholds are exceeded, then the nature and extent of the exceedance needs to be investigated (Section 2.5.2).

In the case of an exceedance of a Level 1 or Level 2 threshold, management will be notified in writing, including a summary of the outcome of the verification program and if escalation of action is warranted.

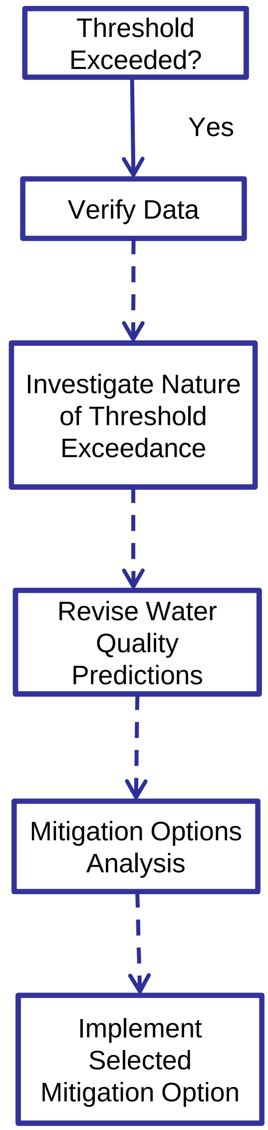
2.5.2 Investigate Nature and Extent of the Threshold Exceedance

Any threshold exceedance will be assessed and a monitoring plan created to investigate the nature and extent of the exceedance. The plan may include more frequent sampling of existing stations and/or the addition of new monitoring stations, and would take into consideration various factors, including but not limited to:

- Magnitude of threshold exceedance,
- Duration of an increasing trend for a Level 1 threshold,
- Number of stations within a source load flow path that have exceeded a threshold,
- Location of station that has exceeded a threshold (source load, groundwater, surface water, or compliance point),
- Which level of threshold has been exceeded (Level 1 or Level 2), and
- Results of biological monitoring

Depending on the findings of the investigation, the water quality model may be revised to re-evaluate potential changes to downstream water quality.

The Water Board would be notified in writing of any changes in monitoring and the outcome of the investigation.



Note: Dashed arrow denotes action escalates progressively based on recommendations from preceding response.

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2.5.3 Revise Water Quality Predictions

As additional data become available from the increased monitoring, the data could be used to validate the water quality prediction model (SRK 2014b). Model validation may indicate the conceptual model for constituent loading be re-evalated and potentially revised. The loss of attenuation capacity or more rapid groundwater transport may warrant model revision. A revised model could then be used to reassess the situation and/or develop further action plans. This could include assessing if increasing constituent concentrations could impact aquatic life. Additional biological monitoring could also be undertaken. The results from additional monitoring could be used to verify if increasing concentrations are affecting aquatic life.

A report outlining the revised water quality predictions would be submitted to the Water Board.

2.5.4 Mitigation Options Assessment

If the revised water quality predictions indicate that water quality will exceed WUL water quality limits or suggest that there could be effects to the aquatic receiving environment a plan outlining mitigation will be developed. Potential mitigation measures would include source control, migration control and treatment options. These options will be based on data collected as part of the escalating response to increasing constituent concentration and are dependent on the magnitude, timing and potential impact of increasing concentrations.

A report outlining the mitigation options analysis with mitigation recommendations would be submitted to the Water Board.

2.5.5 Implement Mitigation

If mitigation is warranted, the preferred option recommended from the options analysis would be implemented. Any proposed mitigative actions, including any associated monitoring, would be documented and reported to the Water Board before works are undertaken.

3 Conclusion

The AMP describes how to use data collected by the WQMP to identify and evaluate increasing concentrations in sources and receiving water during post reclamation at the Sä Dena Hes mine. The AMP also provides a framework to develop plans for understanding the processes responsible for increasing concentrations, their potential impact and their mitigation if needed. Results of the AMP will be reported in the WUL annual report.

The AMP is living document and is expected to be revised as needed in response to any significant changes in water quality resulting from loading sources at the site. Additional detail will be added to the AMP as it becomes available. This may include new or revised conditions (e.g. WUL water quality limits) within the WUL. Implementing the AMP will ensure post reclamation water quality in receiving water downgradient of the Sä Dena Hes mine site is protected.

This report, Adaptive Management Plan, Sä Dena Hes Mine - DRAFT, was prepared by

"DRAFT"

Lee Christoffersen, EIT, GIT
Consultant (Environmental Engineering)

"DRAFT"

Lisa Barazzuol, PGeo
Senior Consultant (Geochemistry)

and reviewed by

"DRAFT"

Tom Sharp, PhD, PEng
Principal Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

4 References

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Attachment 1:
Sä Dena Hes Mine Post-Reclamation Water Quality
Environmental Monitoring Plan

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

T: +1.604.681.4196
F: +1.604.687.5532

vancouver@srk.com
www.srk.com

Memo

To:	Michelle Unger, Teck	**Client:**	Teck Resources Ltd.
From:	Saskia Nowicki Lisa Barazzuol Tom Sharp	**Project No:**	1CT008.043
		Date:	Revised October 16, 2014
Subject:	Sä Dena Hes Mine Post-Reclamation Water Quality Monitoring Plan - DRAFT		

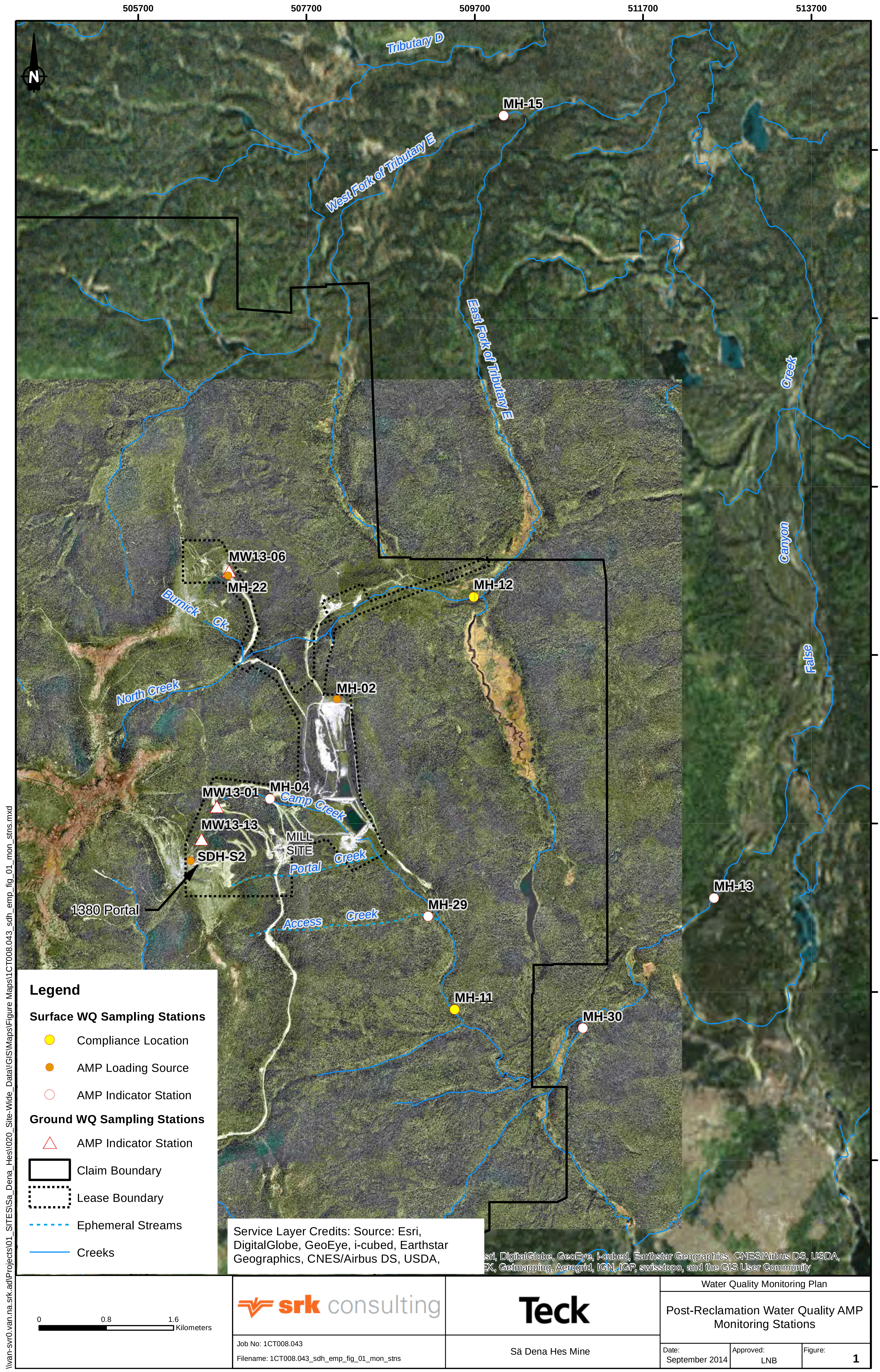
1 Introduction

This memorandum presents the post-reclamation water quality monitoring plan (WQMP) for the Sä Dena Hes (SDH) Mine property and immediate receiving environment. The WQMP collects surface water and groundwater quality data to be evaluated by Sä Dena Hes' water quality Adaptive Management Plan (AMP).

Surface water and groundwater quality monitoring is discussed in Section 2 – including sampling locations and frequency, field measurements, and laboratory analyses. Section 3 discusses the integration of the water quality monitoring program within the context of the AMP.

2 Water Quality Sampling

Figure 1 presents the post-closure surface water and groundwater monitoring locations that are within the scope of the AMP. The surface water and groundwater sampling programs are discussed separately because there are variations in the monitoring requirements.



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Sä Dena Hes Mine

Water Quality Monitoring Plan

Post-Reclamation Water Quality AMP Monitoring Stations

Date:	Approved:	Figure:
September 2014	LNB	1

2.1 Surface Water Sampling

2.1.1 Stations

Table 1 lists the location and purpose of the surface water monitoring stations.

There are three categories of surface water monitoring stations, which are described as follows:

1. Compliance Points: These locations define the boundary of where site-influenced water enters the receiving environment, and would be specified as such in the WUL. Water quality at these stations will be compared to the standards indicated in the WUL. Two stations, MH-11, and MH-12 are the proposed compliance point stations.

2. AMP Loading Source: These stations are surface water monitoring locations most proximal to the identified mine site loadings sources (SRK 2014). These three stations monitor the seepage from the North Dam (MH-02) and drainage from the Burnick Portal (MH-22) and 1380 Portal (SDH-S2).

3. AMP Indicator: These stations are downstream of the mine site loading sources and are not permitted compliance points. The objective of monitoring at stations MH-04, MH-13 and MH-15 is to provide data for evaluation by the AMP to evaluate if water quality has or is changing. Water quality data collected at MH-29 and other biological monitoring locations support the biological monitoring program of the AMP, however the data will be evaluated as described in the AMP water quality data assessment process.

Table 1: Surface Water Quality Sampling Stations

Station Category	Station ID	Coordinates		Station Description
		Northing	Easting	
Compliance Point	MH-11	509460	6707788	Upper False Canyon Creek
	MH-12	509688	6712755	East Fork of Tributary E
AMP Loading Source	MH-02	508060	6711477	North Dam seepage
	MH-22	506767	6712946	Burnick 1200 Portal discharge
	SDH-S2	506325	6709558	Drainage from the 1380 Portal, present as a seep in the downslope waste rock dump
AMP Indicator	MH-04	507267	6710292	Camp Creek
	MH-13	512541	6709113	False Canyon Creek main channel
	MH-15	510041	6718408	West Fork of Tributary E
	MH-29*	509146	6708895	Access Creek Upstream of Camp Creek
	MH-30*	510985	6707568	Unnamed Tributary Upstream of False Canyon Creek

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Notes:
*Denotes biological AMP station but the associated water quality data will be interpreted as part of the AMP.

2.1.2 Surface Water Sampling Frequency

For the first five years of post-reclamation, from 2016 to 2020, surface water sampling will be conducted semi-annually to capture freshet flow (June to July) and baseflow (September or October). In 2014, the South and Reclaim dams were removed and Camp Creek channel reconstructed. Sampling during the freshet in the first five years is proposed to monitor for erosion of the channel or runoff from these reclaimed areas, which is most likely to occur during freshet.

After this initial five year period, surface water quality data will be evaluated to determine if annual sampling would be appropriate in the following years. It is anticipated that monitoring will demonstrate that water quality will be stable and annual monitoring would be appropriate. The potential effects of groundwater discharge on surface water quality are most observable during baseflow when groundwater contributes a larger portion to the flow than surface water runoff. The loading source migration pathways that can potentially impact surface water are via groundwater, so surface water would be monitored annually during baseflow after the first five years.

After 10 years of post-reclamation water quality monitoring, the data would be further assessed to determine if further reductions in the sampling frequency, e.g. every second year, are warranted.

2.1.3 Field Measurements

The following field measurements will be taken at each surface water station:

- Temperature,
- pH,
- Specific conductivity,
- Oxidation-Reduction Potential (ORP),
- Turbidity, and
- Flow rate.

2.1.4 QA/QC Program

Each sampling event will include the following QA/QC samples:

- 10% sample duplicates;
- 1 field blank; and
- 1 travel blank.

The QA/QC program for the surface water sampling can be combined with the groundwater program if conducted at the same time.

2.1.5 Laboratory Analytical Requirements

For each surface water station and QA/QC sample, multiple sample bottles will be collected and shipped to a laboratory to be analysed for general parameters, anions and nutrients, total elements and dissolved elements. Details of the analyses are provided in Table 2.

Table 2: List of Laboratory Analyses for Surface Water Stations

Category	Parameter	Method of Analysis
General Parameters	pH	Electrode
	Conductivity	
	Acidity	Potentiometric Titration
	Alkalinity	Titration
	Total Organic Carbon	Combustion
	Dissolved Organic Carbon	Combustion
	Total Dissolved Solids	Gravimetric
	Total Suspended Solids	Gravimetric
	Turbidity	Nephlometer
Anions and Nutrients	Chloride	Ion Chromatography
	Fluoride	
	Nitrite	
	Nitrate	
	Sulphate	
	Bromide	
Trace Elements	Total Concentrations	Inductively Coupled Plasma Mass Spectrometry (ICP-MS)
	Dissolved Concentrations	

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2.2 Groundwater Sampling Program

There are two post-reclamation groundwater monitoring programs for SDH. The scope of the EMP program is to monitor the groundwater downstream of the mine-influenced loading sources presented in Table 1. These data will be evaluated by the AMP. Golder (2014) also outlines a groundwater monitoring program, however the scope of monitoring is in the context of a closed contaminated site.

2.2.1 Stations

Table 3 lists the location and purpose of the groundwater monitoring stations. All groundwater stations are AMP indicator stations in that they monitor downgradient flow from the AMP loading sources identified in Table 1 and the purpose is to evaluate the data collected as described in the AMP.

Table 3: Groundwater Quality Sampling Stations

Station Category	Station ID	Station Description
AMP Indicator	MW13-06	Adjacent to Burnick Portal
	MW13-01 MW13-13	Downstream of 1380 Portal

2.2.2 Sampling Frequency

Groundwater sampling will be conducted during baseflow groundwater periods (August to September). The limited sulphate data suggest that there is dilution during freshet when there is increased groundwater flow and that concentrations are slightly higher during baseflow. Furthermore, the loading source migration pathways that can potentially impact surface water are via groundwater. The potential effects of groundwater discharge on surface water quality are most observable during baseflow when groundwater contributes a larger portion to the flow than surface water runoff.

The long-term sampling scheduling is parallel to the surface water quality monitoring program, specifically annual sampling for the first ten years of post-reclamation, after which the data would be further assessed to determine if further reductions in the sampling frequency, e.g. every second year, are warranted.

2.2.3 Field Measurements

The following field measurements will be taken at each groundwater station after purging three times the well volume:

- Temperature,
- pH,
- Specific conductivity,

- Oxygen-reduction potential,
- Turbidity, and
- Water level.

2.2.4 QA/QC Program

Each sampling event will include the following QA/QC samples:

- 10% sample duplicates;
- 1 field blank; and
- 1 travel blank.

The QA/QC program for the groundwater sampling can be combined with the surface water program if conducted at the same time.

2.2.5 Laboratory Analytical Requirements

For each groundwater station and after purging three times the well volume, multiple sample bottles will be collected and shipped to a laboratory to be analysed for general parameters, anions and nutrients, and dissolved elements. The analytical suite for the QA/QC program will be the same. Details of the analyses are provided in Table 4. The list of required analyses outlined in Table 4 differs slightly from the historical groundwater monitoring conducted by Golder.

Table 4: List of Laboratory Analyses for AMP Groundwater Stations

Category	Parameter	Method of Analysis
General Parameters	pH	Electrode
	Conductivity	
	Acidity	Potentiometric Titration
	Alkalinity	Colourimetry
	Total Dissolved Solids	Gravimetric
	Turbidity	Nephlometer
Anions and Nutrients	Chloride	Ion Chromatography
	Fluoride	
	Nitrite	
	Nitrate	
	Sulphate	
	Bromide	
Trace Elements	Dissolved Concentrations	ICP-MS

3 Integration with the Adaptive Management Plan

Surface water and groundwater quality data collected as part of the EMP will be analyzed using the methods outlined in the AMP. The sampling locations and frequencies discussed herein are subject to change based on specifications presented in Sä Dena Hes' AMP. The AMP specifies various thresholds for water quality that if exceeded, would result in the re-evaluation of the EMP in the context of the management issue identified.

4 References

Golder 2014. Long Term Groundwater Monitoring Plan, Sa Dena Hes Mine, Yukon Territory. Technical memorandum prepared for Teck Metals Ltd. By Golder Associates, July 18, 2014.

SRK 2014. Post-Reclamation Surface Water Quality Predictions. Technical Report prepared for Teck Resources Ltd. by SRK Consulting (Canada) Inc., September 2014.

SRK Consulting (Canada) Inc.

"DRAFT"

Saskia Nowicki, BSc
Staff Consultant

"DRAFT"

Lisa Barazzuol, P.Geo.
Senior Consultant (Geochemistry)

Reviewed by:

"DRAFT"

Tom Sharp, P.Eng.
Principal Consultant (Water Management)