Red Mountain Underground Gold Project - Mine Area Hydrogeology

Prepared for

IDM Mining

Prepared by

SRK Consulting (Canada) Inc.
1CI019.002
August 2017

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Executive Summary

This report supports the Environmental Assessment (EA) application of the proposed Red Mountain Underground Gold Project (the Project). It presents the studies and analyses completed in the underground mine area to evaluate the hydrogeological conditions (i.e., groundwater flow system) for current, operation, closure, and post-closure periods. The study area included the underground mine and the surface infrastructure in the immediate vicinity of the mine near upper Goldslide Creek. The objectives were to establish the baseline groundwater conditions and to quantify the effects of the underground mine excavation on the groundwater flow system.

Hydrogeological Data

Between 1990 and 2016, a number of technical hydrogeological field programs were carried out in support of exploration and permitting. The field methods included borehole drilling and logging, installation and development of monitoring wells, hydraulic conductivity testing (packer tests and slug tests), measurements of groundwater levels, and measurements of inflow rates and pressure heads during dewatering events of the decline.

Thirty-three hydraulic conductivity (K) measurements were collected from 10 boreholes between 1993 and 2016. All the test intervals were completed in sub-volcanic porphyry intrusion. K ranged between 7.4×10^{-9} and 2.9×10^{-5} m/s, with a geometric mean of 3.0×10^{-7} m/s. K was generally lower at depth and at lower elevations. Three tests indicated relatively high K measurements in the JW mineralized zone, the Marc mineralized zone or the DC fault, and the Rick fault. One test suggested a relatively low K in the AV mineralized zone.

Static and dynamic groundwater levels were measured between 1993 and 2016 from three shallow surface piezometers, 37 surface exploration boreholes, and from the existing decline. Observations confirmed that groundwater flow is strongly controlled by topography, with gradients oriented from high elevations towards valleys. Groundwater levels in the upper cirque and lower cirque show clearly the influence of freshet and a peak in the water table between June and August. Water levels in the existing decline range from an average elevation of 1,800 masl, to 1,846 masl (near the Portal entrance), but have dropped as low as 1,757 masl on at least one occasion. During the rise in water levels following freshet, the average groundwater inflow rate is approximately 2,160 m^3/d.

Water levels and pumping rates were recorded during and after the dewatering events of May 1996, August 2000, and July 2016. Pumping rates were relatively low pumping rates (i.e., < 90 to 900 m^3/d) prior to the month of June or July, then increased quickly to a peak around mid-August of 2,600 m^3/d for a “cold” year, and 6,050 m^3/d for a “warm” year. Recharge from snowmelt of the Rio Blanco snowfield was interpreted to be the primary driver of the magnitude of inflow, hence a warm year leads to higher recharge and higher inflows.

Seeps at fractures and faults intersecting the existing decline were mapped and inflow rates recorded during the dewatering events of 1994 and 2016. The observations showed that inflows

tended to decrease rapidly therefore suggesting that groundwater storage is limited. Connections with surface through fractures and faults might play a secondary role in increasing inflow rates after specific precipitation events.

Conceptual Hydrogeological Model for Baseline Conditions

SRK did not identify any major aquifers in the area (MOE 2016d). There are three types of potential minor aquifers (i.e., overburden, undifferentiated fractured bedrock, and high K fractures or faults) and two types of potential aquitards (i.e., local patches of discontinuous permafrost, low K fractures or faults.

Groundwater flow is driven by the relative elevations, with the primary groundwater flow directions from the top of the Red Mountain to the Bitter Creek valley, and the secondary flow directions (i.e., localized shallow system) towards the creeks and the Cambria Ice Field. Where present and permeable, overburden units are likely draining shallow inflows. Groundwater flow paths in bedrock are controlled by fractures and joints, with no apparent distinction between lithologies (i.e., porphyry intrusions and metasediments). Faults may act as preferential conduits, impermeable barriers or both; however, none of the major structures identified to date are associated with significant discharge at surface or visible changes in water levels.

Recharge takes place above approximately 1,100 masl, in the form of snowmelt or rain infiltration. There are pronounced seasonal fluctuations in groundwater levels, and these are greater at higher elevations than at lower elevations. In the area of the existing decline, water levels peak at 1,850 masl between July and August, then slowly decrease to 1,760 m over the course of the winter season and finally, recover rapidly with recharge from snowmelt, starting around March. Discharges occur at the bottom of the Cambria Ice Field, at lower elevation in the main creeks (i.e. Goldslide Creek and Rio Blanco Creek) and possibly in smaller order streams, on the mountain slopes between approximately 950 masl and 1,100 masl (i.e., seepage zone), in gullies, breaks in slope and geologic discontinuities; and in the valley bottom.

The upper sections of Goldslide and Rio Blanco Creeks are likely ephemeral, perched above the water table, and fed primarily by glaciers, snowmelt and/or runoff. It is assumed that the lower sections of the creeks, as well as Bitter Creek in the valley, are fed by groundwater all year round. During the low-flow season (i.e., the winter period), it is assumed that groundwater contributes to nearly 100% of the base flow. During spring, summer and fall, surface runoff and quick flow generated by the snowmelt and/or precipitation dominates.

Conceptual Hydrogeological Model for the Operation Period

During mining operations, the major effects on the groundwater flow system will be underground water management, drilling, blasting, excavation, and backfilling activities. Dewatering activities will be necessary to keep groundwater out of the mine. This will result in a drawdown of the water table, centred about the underground workings that will gradually expand over time for as long as dewatering continues. The changes in groundwater levels and flow may induce a seasonal reduction of the groundwater discharges (i.e., base flow) to Goldslide and Rio Blanco Creeks. Other minor effects include drilling, blasting, and excavation activities, which may enhance the hydraulic conductivity and lead to increased drawdown, and the placement of waste rock as backfill in the underground, which may result in locally increased or decreased hydraulic conductivity of the subsurface compared to baseline conditions.

Conceptual Hydrogeological Model for the Closure/Post-closure Period

At mine closure, the ventilation shafts, adits, and portals will be sealed to limit the potential for direct mine water discharge to surface waters, and limit the ingress of oxygen. After the underground is backfilled with waste rock, and the bulkhead constructed in the lower access ramp, pumps will be shut off to allow for re-flooding of the mine. The drawdown and base flow reductions induced during operations will decrease gradually.

During the post-closure phase, the groundwater system is expected to return to baseline conditions. There may be a small zone of residual drawdown remaining due to the changes of hydraulic properties in the mine and if there are surface openings. Finally, the seasonal variations in the water table may annually expose mined-out volumes, which may result in ARD reactions and/or metal leaching/mobility and lead to changes to the groundwater chemistry.

Groundwater Predictions

Numerical groundwater models were developed to quantify the effects to the groundwater system from the underground mine excavation. The predictions included:

- The quantity of groundwater intercepted by the mine during operation and until end-of-mine;
- The maximum reduction in groundwater base flow in creeks throughout the Project life,
- The quantity of groundwater losses from the flooded mine, and the percent flow contribution of mine contact groundwater to the creeks' base flows at Post-closure;
- The groundwater pathways and travel times from the mine components to the creeks; and
- The time required to reach post-closure conditions.

These predictions served as inputs to the site-wide water and load balance, development of geochemical source terms, and water management plans. The site-wide water and load balance combined the groundwater predictions at the Red Mountain Cirque and the Bromley Humps area to evaluate the overall effects of the Project on the hydrology and water quality at local and regional scales. Results are provided in the report entitled: Red Mountain Underground Gold Project Water Quality Model Report (SRK 2017).

Modeling was conducted with the software FEFLOW, a professional software package for modeling fluid flow and transport of dissolved constituents and/or heat transport processes in the subsurface. A Base Case numerical model was constructed based on the conceptual model and calibrated to pre-mining water levels, creek base-flow estimated from regional analysis, and groundwater inflows observed during the dewatering of the existing underground decline. Two additional cases, representing Upper and Lower Case, were calibrated with alternative distributions of hydraulic conductivity and groundwater recharge. The three calibrated model cases provided the basis for assessing a range of probable responses of the hydrogeological system to mining. A sensitivity analysis assessed the effect of changes of key input parameters on the model outputs. Details on the modeling assumptions, model designs, and calibration were included in the report.

The final calibrated models reproduced the regional hydrogeological system reasonably well, with a steady-state normalized root mean squared error (NRMSE) for calculated versus observed hydraulic heads of 5.1%. NRMSE values less than 10% are commonly considered to be an acceptable level of model calibration. Seasonal water level variability at each of the four monitoring stations were consistent with the measured transient levels. The Base Case calibrated model predicted a base-flow along Goldslide Creek of 5,500 m^3/d during low-flow winter conditions, higher than the base-flow of 1,800 m^3/d inferred from a base-flow separation analysis using regional data. The simulated groundwater inflow following a 100 day dewatering event in the existing decline was approximately 2,200 m^3/d, about average compared to the observations reported during the dewatering events of 1996 and 2016.

The calibrated models were used to simulate the groundwater system during mining operations, over the proposed mine life of six years, and from closure to post-closure conditions. The key conclusions based on the modeling were as follows:

- The Base Case mine inflows are predicted to rise to an annual average inflow of about 3,810 m^3/d in Year 2 and then decrease from this point onward to about 2,640 m^3/d. The Upper Case predictions are respectively 6,400 m^3/d and 4,400 m^3/d. SRK suggests considering a conservative upper limit of 10,000 m^3/d to size peak capacity of the water management system. The extent and maximum drawdown is insignificant in terms of groundwater usage since there are no groundwater resources in use close to the site.
- The model predicts a maximum average monthly reduction in base-flow around 3 to 4% at downstream stations located in Goldslide and Rio Blanco Creeks, and 1% in Bitter Creek. The maximum reductions are calculated to occur between March and May, at the end of the low-flow winter conditions.
- For the purposes of assessing ARD reactions and/or metal leaching/mobility, it should be assumed that the full mined-out volume could be exposed to oxygen for a period ranging between 20 and 40 years. After this period, the system will have recovered to baseline conditions and the groundwater level in the mine will be expected to fluctuate seasonally.
- In terms of potential discharge of mine contact groundwater into surface water receptors, the Base Case model predicts that about 1,430 m^3/d will flow through the mined-out volumes and discharge to Goldslide, Rio Blanco, or Bitter Creeks after a minimum of about 5 years for Goldslide Creek, 40 years for Rio Blanco Creek, and 90 years for Bitter Creek. The maximum contributions to creeks' base-flow, assuming that the source had an infinite time to reach the receptor, are 55.6% in Goldslide Creek at GSC09, 10.4% in Goldslide Creek at GSC02, 5.6% in Rio Blanco Creek at RBC02, and 1.8% in Bitter Creek at BC08.

- The sensitivity analysis indicates that the uncertainty of the model outputs is tied to the characterisation of the hydraulic conductivity field, the seasonal recharge rate, and the determination of structures acting as major conduits.
  - The installation of additional groundwater level monitoring points away from the mine would provide an opportunity to confirm the hydraulic conductivity field and to obtain additional level data, and validate the current model predictions. It would also be valuable to confirm the elevation of the groundwater table at or near the mine during the winter low-flow conditions with a piezometer installed at surface or drilled in the existing decline.
  - Measurements of the snow pack thickness above the mine would be the best way to confirm the current recharge assumptions and to reduce uncertainty with respect to this parameter.
  - There are significant uncertainties with respect to groundwater recharge or discharge below areas covered with glaciers and the presence of geological structures (i.e., if and where large-scale fractures and faults are connected and where they act as a conduit or as a barrier to flows). These uncertainties are tied to the physical constraints of the site and cannot be easily verified from field investigations.

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3D	three dimensional
°C	degree Celsius
BC ALG	British Columbia Aquatic Life Guidelines
CCME	Canadian Council of Ministers of the Environment
CSR	*Contaminated Sites Regulation* (British Columbia)
d	day
EA	environmental assessment
ET	evapotranspiration
EOM	end-of-mine
EPM	Equivalent Porous Media
K	hydraulic conductivity
km	kilometer
LSA	local study area
LTC	long-term closure
m	meter
mabh	meter along borehole
MAP	mean annual precipitation
MAR	mean annual runoff
masl	meters above sea level
ML/ARD	metal leaching / acid rock drainage
mm/yr	millimetre per year
MMER	*Metal Mining Effluent Regulations* (federal)
MSE	mean square error
NAR	net available recharge
NRMSE	normalized root mean square error
PMP	annual probably maximum precipitation
QA	quality assurance
QC	quality control
RSA	regional study area
s	second
Ss	specific storage
Sy	specific yield
SWE	snow water equivalent
T	tonne
TMF	tailings management facility
TSA	technical study area

1 Introduction

This report presents the results of hydrogeological studies, including numerical modelling, for the underground mine area completed in support of an Environmental Assessment (EA) for the proposed Red Mountain Underground Gold Project (the Project). The report was prepared by SRK Consulting (Canada) Inc. (SRK), on behalf of IDM Mining Ltd. (IDM).

The hydrogeological studies for the underground mine area include the underground mine and surface infrastructure in the immediate vicinity of the mine near upper Goldslide Creek. Baseline conditions and potential changes to the groundwater system in the vicinity of the mill and tailings management facility (TMF) at the area referred to as "Bromley Humps" are presented in an accompanying report and letter reports, prepared by Knight Piésold (KP) (KP 2017a, b, c).

Recent hydrogeological baseline data collection activities at the site were completed by Avison Management Services (Avison), under the direction of SRK. The data collection program was designed to meet the requirements for submission of an EA application, the technical requirements of which are described in the document: "*Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators"* (BC MOE, 2016). Useful baseline data were also available from historical studies completed in the mid-1990s. SRK reviewed all the available hydrogeological data for the mine area and surrounding region to develop a hydrogeological conceptual model. This information was used to construct and calibrate a three-dimensional (3D) numerical model, which was then used to predict the Project's potential effect on groundwater for the end-of-mine (EOM) and long-term closure (post-closure) phases.

The main objective of this work was to establish baseline groundwater conditions and quantify any potential changes to the underground mine area groundwater system that could occur as a result of the Project. These included estimates of: the quantity of groundwater intercepted by the mine during operations; the reductions to groundwater base flow in the creeks; the contribution to the creeks of groundwater potentially influenced by the mine; the time required to reach post-closure conditions; and, the range of post-closure water levels within the mine workings. Although this work included characterization of groundwater quality, the methods and results from the baseline groundwater quality studies are presented in the companion report: *Red Mountain - Baseline Surface and Groundwater Quality Report* (SRK 2016b).

The predictions developed herein served as an input to the site-wide water and load balance (SRK 2017), development of geochemical source terms (SRK 2017), and water management plans (SRK 2017). The site-wide water and load balance was used to evaluate the overall effects of the Project on the hydrology and water quality both at local and regional scales. Results of the water and load balance are provided in the report entitled: *Red Mountain Underground Gold Project Water Quality Model Report* (SRK 2017).

The report is organized as follows:

- Section 2 presents background information relevant to hydrogeological studies, including: a description of the Project components, definition of spatial boundaries for the study area, and physical conditions of the Project that are linked to the understanding of the groundwater system;

- Section 3 summarizes the baseline study methods, including: regulatory guidelines consulted to complete the study, lists of the available desktop and field information, and details pertaining to the field data collection, data management and QA/QC methods;
- Section 4 reviews the hydrogeological dataset that supports the characterization of the groundwater system;
- Section 0 presents the hydrogeological conceptual model at the mine;
- Section 6 describes of the numerical groundwater model and presents the groundwater quantity and quality predictions; and,
- Section 7 presents the study conclusions.

2 Background

2.1 Project Description

The hydrogeological evaluation presented herein is based on a preliminary project description, adapted from the *NI 43-101 Preliminary Economic Assessment Technical Report* (JDS 2016), and summarized below. Additional mine planning and design is currently underway in support of a feasibility study (FS) for the project. The FS mine design (as of April 2017) is comparable to the PEA mine design in terms of access, depths, and geographical locations, and modifications to the mine production and associated designs are not expected to significantly change the groundwater model predictions.

The Project is a proposed underground gold mine being developed by IDM, which is located approximately 18 km east-northeast of Stewart in northwestern British Columbia. It is located west of the Cambria Ice Field and north of the Bromley Glacier (Figure 1). The ore deposit is located under the summit of Red Mountain, at elevations ranging between 1,500 and 2,000 meters above sea level (masl).

The underground mine is envisioned to produce from four mineable mineralized deposits (Marc, AV, JW and 141), ranging in thickness from < 2 m to 40 m and averaging 16 m. The mine plan (Figure 2) commences with the mining of the Marc zone, followed by the AV, and then the JW and 141 zones. There are two crown pillars (Upper and Lower Crown), which have economic potential and which may be mined in the future.

Access to the deposits will be via three Portals:

- An existing portal at about 1,850 masl, which was constructed in 1993 to allow for bulk sampling of the mineralized Marc zone. The bulk sampling zone is approximately 1,500 m long with a 4.5 x 4.5 m profile, reaches a bottom elevation of 1,760 masl, and has an estimated void volume of approximately 33,000 m^3;

- A second portal at about 1,870 masl, which will access the top level of the mine, and which will also be used for ventilation exhaust and as secondary escape way; and,
- A third lower access at about 1,710 masl, which will be added in Year 1 of the mine life and will be used for haulage.

Dewatering of the underground mine will be achieved using gravity, where possible, via the lower access ramp. Pumping will be used, as needed, to assure positive dewatering in decline headings, and to route water to settling sumps and holding ponds prior to discharge or further treatment, as required. The portal sites will also contain disturbed areas for support equipment and rock stockpiles. Runoff will be diverted from entering these areas using berms and ditches. Contact water will be collected and routed to settling/holding ponds prior to discharge.

The mine will create both waste rock from mine development and tailings as a by-product of mineral processing. All the development waste will be used as mine backfill. All the development waste (i.e., 598,200 t) will be used as mine backfill. Temporary waste rock storage areas will be developed prior to being re-handled into the underground workings as backfill. The existing historical waste stockpile (approximately 90,000 t), located near the existing portal, will also be consumed as backfill. No development waste will remain on surface at the end of mine life.

The processing plant and the TMF will be located at about 500 masl at the Bromley Humps location, approximately 4 km northeast of the deposit, adjacent to the processing plant. It has been designed to store 1.76 Mt of tailings, process water, storm storage and freeboard. The facility will be bounded by a series of perimeter dams, and will be fully lined to minimize seepage losses. It will also include basin underdrain and foundation drainage systems, a tailings distribution system, a reclaim water system and non-contact water diversion ditches.

It is proposed that the mine will operate for eight months a year, from April through November. The Project phases will be as follows:

- Operations phase: 6 years (Year 1 to 6);
- On-going reclamation: during operations phase;
- Decommissioning phase: 1 year (Year 7); and,
- Post-closure phase: from year 7 onward.

As part of the restoration activities leading to post-closure, the stockpiles and all development waste will be placed underground during mining as stope backfill, and cemented where necessary. The portals will be sealed with an engineered bulkhead. The TMF will be covered with a geomembrane liner and a soil cover to minimize infiltration. A permanent spillway from the TMF will be established. At the end of the operations phase, all infrastructure will be removed and disturbed sites will be re-graded to natural slopes.

2.2 Physical, Climate and Hydrology Setting

The Project is located in rugged mountainous terrain with steep slopes and elevations ranging from between 500 and 2,700 masl. High peaks in close proximity to the Project include Otter Mountain at 2,700 masl, and Bromley Peak at 2,300 masl. The Cambria Range and valley are heavily glaciated by the Bromley, Bear River, Kitsault and Sutton Glaciers, and the Cambria Icefield dominates the area. At elevations greater than 600 masl, glacial ice persists year round in the Bitter Creek valley and the treeline occurs at about 900 masl in elevation (Klohn 1994b).

The region has undergone several stages of glaciation and local glaciers are currently in active retreat. Within the last century, the Bromley Glacier has retreated at an average rate of 45 m/yr with a total vertical thinning of approximately 300 m. As a result of the glaciation, exposed rock outcrops are well rounded with steep sides. Above 1,600 m elevation, the peaks have been modified by alpine glaciers and display sharp jagged crests. In general, the lower north and east facing slopes are steeper than south and west facing slopes, reflecting the general direction of glacial advance. The topographic map, dated 1927, of the Nass River Cassiar District (Nass River 103P, Edition 2) indicates that the Red Mountain Cirque was not glaciated at that time.

The region has cold weather and warm summers, but no dry seasons. Climatic conditions at Red Mountain are dictated primarily by its altitude (i.e., 1,742 masl at the centre of the deposit) and proximity to the Pacific Ocean. Temperatures are moderated year-round by coastal influence; with more than four months with an average temperature of greater than 10°C, and an average temperature below 22°C in the hottest month (Peel, Finlayson, & McMahon, 2007). Precipitation is significant in all months, with October being the wettest. The area is characterized by significant snow accumulation in the winter (i.e., +2 m snow accumulation). Even at sea level, over one-third of the annual precipitation falls as snow. This proportion is greater at higher elevations, where snow may fall at almost any time of year.

Detailed baseline climate conditions are summarized in: *"Red Mountain Environmental Assessment: Climate, Hydrology Baseline and Analysis Report"* (SRK 2016a). The key findings that support the characterization of the groundwater system are the monthly and annual averages provided in Table 1, and the estimates of Mean Annual Runoff (MAR). Runoff is defined as the total amount of water that is discharged from a watershed (i.e., balance between precipitation, snowmelt, evaporation, groundwater losses and glacier discharges). Two runoff models were developed for areas with different glacier cover: watersheds with less than 10% glacial cover have a MAR of 1,584 mm/yr (i.e., Goldslide Creek) and watersheds with more than 10% glacial cover have a MAR of 2,981 mm/yr (i.e., Otter and Bitter Creeks).

Table 1: Mean Monthly and Annual Precipitation at Red Mountain

Parameter	Monthly Average [mm]												Annual [mm/yr]
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Precipitation	219	137	121	90	72	66	77	121	212	293	226	214	1,847
SWE (1)	570	750	880	980	970	580	110	0	0	20	160	360	-
Actual Evapotranspiration	0	3	19	44	65	65	71	60	30	14	5	0	376

Source: SRK 2016a

Note:

(1) SWE, Snow Water Equivalent

The proposed underground mine is in the Red Mountain cirque, a short, westerly-trending hanging valley above the Bitter Creek Valley where Bitter Creek flows. The Goldslide, Rio Blanco, and Otter Creeks are the three uppermost tributaries to Bitter Creek. All three tributaries are small alpine creeks characterized by very steep gradients and strong seasonal fluctuations in flow.

- Goldslide Creek drains the Red Mountain cirque, where the existing portal is located. The flow in Goldslide Creek is highest during freshet (typically in June) and is not influenced by glacial melt.
- Rio Blanco Creek drains the catchment where the Rio Blanco Snowfield is located into Bitter Creek downstream of the Goldslide/Bitter Creek confluence. The flow in Rio Blanco Creek is highest during freshet and flow appears to be glacially-influenced and dominated by snowmelt.
- Otter Creek drains into Bitter Creek downstream of the Rio Blanco/Bitter Creek confluence. The flow in Otter Creek is highest during freshet and flow appears to be glacially-influenced and dominated by snowmelt.
- Bitter Creek originates from the Bromley Glacier. It is a tributary to the Bear River, which flows into the Portland Canal near Stewart, BC.

2.3 Geomorphology and Surficial Geology

Geomorphological features in the Red Mountain area include: landslides, outwash channels, debris torrent deposits, alluvial fans and avalanche chutes. These features reflect the very steep terrain and high precipitation in the Bitter Creek valley (Klohn 1994b).

A map of the surficial geology in the vicinity of the Project is shown in Figure 3. Within the cirque and generally throughout the high mountain valleys, surficial deposits consist of thin and discontinuous basal moraine, talus and slopewash, generally containing small percentages of fines due to the short glacial transport distance and water runoff. The talus and slopewash extend from the ridge crest to the floor of the valley, and a neoglacial till blanket is mapped (McCuaig 2003) lower down the cirque. In the Bitter Creek valley, surficial deposits consist of neoglacial till veneer, described as discontinuous, with numerous areas of exposed bedrock and thickness between 1 to 2 m.

2.4 Bedrock Geology

The following summary of the Project geology was adapted from the *NI 43-101 Preliminary Economic Assessment Technical Report* (JDS 2016), the memo: *Major Structures Study for Brittle Structure Fault Model* (SRK 2016c) and the *Red Mountain Project Geochemical Characterization of Waste Rock, Ore, and Talus DRAFT Report* (SRK 2016d).

2.4.1 Regional Geology

Red Mountain is near the western margin of the Stikine terrain in the Intermontane Belt. The three primary stratigraphic units are the Middle and Upper Triassic Stuhini Group clastic rocks, the Lower and Middle Jurassic Hazelton Group volcanic and clastic rocks, and the Upper Jurassic Bowser Lake Group sedimentary rocks. There are several suites of intrusions in the region from the Late Triassic through the Eocene, including the Stikine plutonic suite that is coeval with the Stuhini Group and plutons that are roughly coeval with the Hazelton Group.

2.4.2 Site Geology

A map of the bedrock geology at the property scale is shown in Figure 4. Middle and Upper Triassic Stuhini Group mudstones, siltstones, and chert outcrops cover about two-thirds of the mapped area. Lower Jurassic Hazelton Group clastic and volcanoclastic rocks outcrop in the northeastern portion of the mapped area. Three Early Jurassic intrusions are exposed in the mapped area:

- The Hillside Porphyry exposed near the summit of Red Mountain and along the ridge southeast of the summit;
- The Goldslide Porphyry exposed along the Goldslide Creek valley; and,
- The McAdam Stock intruding exposed on the western side of Red Mountain.

The Hillside porphyry is a fine- to medium-grained hornblende and plagioclase porphyry that contains rafts of sedimentary rocks one to tens of meters across. The Goldslide porphyry is a medium- to coarse-grained hornblende, biotite, and quartz porphyry that is distinguished from the Hillside porphyry by mineralogy and phenocryst size. The McAdam Stock is a medium- to coarse-grained biotite quartz monzonite.

The ore body at Red Mountain is hosted mainly in the Hillside and Goldslide porphyry intrusions. Four main ore zones have been delineated. As indicated above, these include the Marc, AV, JW and 141 zones, which strike northwesterly and show a distinctive right-stepping map pattern due to faulting.

2.5 Structural Geology

Structurally, Red Mountain is on the western edge of a complex, northwest-southeast trending, double-plunging Cretaceous structure in which the Stuhini, Hazelton, and Bowser Lake Groups were folded and/or faulted by the Skeena fold belt. The Red Mountain deposits are in the core of the Bitter Creek antiform, which was created during this deformation event.

Brittle faulting has affected all rock units at Red Mountain. Rhys et al. (1995) recognized two phases of faulting: northeast striking, steeply northwesterly dipping faults, and north to northwest trending faults. Faults of the former group, such as the Rick Fault, are those that offset the mineralized zones. The latter group contain more gouge and have broader alteration envelopes than the former (Rhys et al. 1995).

In 2016, SRK characterized the geotechnical properties of the rock mass in the Red Mountain deposits, and mapped the major faults structures in accessible sections of the existing decline (Figure 5). Rock mass quality can be described as fair to good. Analysis suggests consistent fair to good quality rock in the AV and JW zones, with more variability within the Marc zone. This variability is mostly due to a higher number of modelled faults through the deposit. Isolated zones of poor ground conditions are usually, but not always, found along modelled fault zones. Faults typically are gouge-filled structures with gouge between 1 and 20 cm in thickness. Damage zones are typically between 0.2 and 1 m in thickness.

Structural analysis of the deposit suggests similar fabric throughout the deposits, with minor orientation changes due to slight rotations of joint sets. Structural domains typically include two sub-vertical joint sets, one intermediate set, and one flat set. The main orientations of the major structures (SRK 2016c) are as follows:

- A NE trending set –are typically chlorite-polished and gouge-filled structures that dip moderately to steeply to the NW. Conjugate NE trending and SE dipping faults may also be present. These are typically strike slip faults.
- EW faults – these are less steeply-dipping but are also strike slip structures. Fault surfaces are typically chlorite-polished and faults are gouge-filled structures.
- NNW faults – These are mostly dip slip reverse structures and are characterised by shear-foliated faults.

2.6 Description of the Local, Regional and Technical Study Areas

The local study area (LSA) and regional study area (RSA) are defined by the surface water catchments in the project area.

- The LSA is the Bitter Creek watershed up to the glacial extent, including Goldslide and Otter Creeks.
- The RSA is the Bitter Creek watershed including the glacial extent and the Bear River watershed from American Creek to the town of Stewart and the northern end of the Portland Canal.

A third study area was defined to look at the specific site conditions around the underground mine; this was referred to as the Red Mountain Cirque technical study area (TSA). This area is bounded by the Cambria Ice Field to the east and south, and the tongue of the Bromley Glacier to the north. It includes the mine and the areas where the water originates, at or near the Project, to where it drains or discharges. The TSA is drained by Bitter Creek, and its three uppermost tributaries: Goldslide Creek, Rio Blanco Creek, and Otter Creek.

The extent of the LSA, RSA, and Red Mountain Cirque TSA are shown on Figure 6. The baseline surface water monitoring locations within the RSA and their respective watersheds are shown in Figure 7.

2.7 Historical Baseline Monitoring

Historical hydrogeological baseline monitoring was completed from 1990 to 1992 by Hallam Knight Piésold (HKP 1992) for Bond Gold and then Lac Minerals, from 1993 to 1994 by Klohn-Crippen (Klohn 1994a, 1994b) and from 1993 to 1995 by Rescan (Rescan 1994, 1995) for Lac Minerals, and finally in 1996 by Golder (Golder 1996a, 1996b) for Royal Oak Mines. Further details on these studies are provided in Section 3.3.

2.8 Groundwater Users

There are no groundwater resources in use and no groundwater users close to the site (MOE 2016e, 2016f). Due to its remoteness and the rugged terrain of the area, groundwater resources will not likely be developed close to the mine except as a potential mine site water supply.

3 Baseline Study Methods

3.1 Regulations and Guidelines

The environmental regulations and guidelines listed below were consulted to help with the characterization of groundwater baseline conditions and the assessment of potential Project influence on the groundwater system:

- *Canadian Environmental Assessment Act*, 2012 (Government of Canada 2012).
- *Water Sustainability Act*, Groundwater Protection Regulation (includes amendments up to *B.C. Reg. 152/2016*, June 10, 2016).
- *Framework for a Hydrogeologic Study in support of an Application for an Environmental Assessment Certificate under the Environmental Assessment Act and Regulations*. Prepared by the BC Ministry of Environment, Water Stewardship Division. Available at http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/envass.html.
- *Draft Guidelines for the Preparation of an Environmental Impact Statement*, December 2015. Prepared by the Canadian Environmental Assessment Agency. Available at http://www.ceaa.gc.ca/050/document-eng.cfm?document=103961#_Toc041. Accessed on August 2016.
- *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* Version 1 (2012) and Version 2 (2016). Prepared by the BC Ministry of Environment.
- *Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities*, prepared by BC Ministry of Environment (2012).

3.2 Desktop Information

As part of the desktop study, SRK reviewed the following information:

- High-resolution LIDAR Digital Elevation Model.
- E.W. Grove, 1986. *Geology and Mineral Deposits of the Unuk River-Salmon River-Anyox Area, British Columbia*.
- McCuaig, S., 2003. *Surficial geology, Nass Valley and Kitsault Valley, British Columbia*. Geological Survey of Canada, Open File 3901, scale 1:100 000.
- *Aquifer Classification Database, Well Record Database, And Water Licences Query Tool* available on the MOE website (MOE 2016d, e, f).
- *Environmental Baseline Data Report* prepared by Hallam Knight Piesold for Lac Minerals Ltd. (HKP 1992).
- *Synopsis of Environmental Programs Undertaken and Draft Project Application* prepared by Rescan for Lac North America (Rescan 1994, 1995).
- Hydrogeological assessments prepared by Klohn Crippen (Klohn 1994a, b).
- Field investigations at the proposed underground mine and tailings impoundment documented by Golder (Golder 1996a, b).
- 1996 Project development review and correspondences on underground discharges from the exiting decline prepared by Royal Oak for the EAO (Royal Oak 1996, 1998).
- *NI 43-101 Preliminary Economic Assessment Technical Report for the Red Mountain Project* prepared by JDS in 2016 (JDS 2016).

3.3 Field Investigations

Between 1990 and 2016, a number of technical field programs were conducted in support of exploration and permitting of the Red Mountain property. The programs that reported hydrogeological information are briefly summarized in the following sections. The groundwater baseline monitoring locations (historical and current) are shown on Figure 8. As stated previously, details on the baseline groundwater quality studies are presented in SRK (2016b). However, since there is often overlap between the hydrogeological investigations and groundwater sampling activities, the latter have been included in the summaries.

3.3.1 Hallam Knight Piésold, Early 1990s

Hallam Knight Piésold (HKP 1992) collected groundwater samples at two locations, W6 and W12, in 1990 and 1991. W6 was a borehole located in the upper cirque near the existing portal (i.e., BZ89-02). W12 was a seep near the middle reaches of Rio Blanco Creek.

3.3.2 Klohn Crippen, 1993 - 1994

Between July and October of 1993, Klohn Crippen obtained, nine hydraulic conductivity measurements in fractured rock within the study area; four falling head tests in two surface piezometers (i.e., TD93-158 and TD93-159) located in the Red Mountain cirque, and five packer tests in one underground exploration borehole (i.e., MC93-124) drilled into the Marc zone ore body (Klohn 1994b). Klohn Crippen also conducted surveys of inflows in the existing decline and completed several campaigns of groundwater sampling between July and November 1993, and in March 1994. A total of 24 locations were sampled, including two underground boreholes (i.e., MC-92-124, MC92-76), two surface piezometers (i.e., TD93-159, TD93-160), two discharge locations from the existing decline, and 18 groundwater seeps or springs (Klohn 1994a, 1994b).

3.3.3 Rescan, 1993 - 1995

Rescan sampled six springs between July 12th and October 4th, 1994. Locations SS-I, SS-II, and SS-III were located near Rio Blanco Creek within the Bitter Creek valley and locations SS-IV, SS-V, and SS-Va were located within the cirque (Rescan 1994); these seeps were sampled again in 1996. Rescan also re-sampled the two Hallam Knight Piésold locations (i.e., W6 and W12): W6 in 1993, 1994, and 1996 and W12 in 1993 and 1994 (Rescan 1995).

3.3.4 Golder, 1996

Golder conducted 14 packer tests between July and October 1996 in three underground boreholes, specifically: R96-241, R96-244, and R96-U1169 (Golder 1996a). They also completed two surveys, as follows:

- A survey of the exploration boreholes completed during previous site investigations to determine the static water table and to determine possible points for groundwater sample collection. The results indicated that 38 of the 207 exploration holes surveyed had accessible water levels that likely represented the local water table.
- Mapping and sampling of the groundwater seeps in the existing decline and measurement of groundwater inflows into the decline from 34 existing underground exploration boreholes.

3.3.5 SRK, 2003 to 2016

Starting in 2003, SRK completed various activities in support of on-going compliance monitoring for the site (SRK 2004 to 2014). These included:

- Collection and analysis of waste rock seep and crib drainage water samples (2003 – 2013); and,
- Monitoring of seasonal changes in static water levels, flow and water quality in the existing decline (2003 – 2006) by SRK during annual site visits.

In 2014, SRK collaborated with Avison to review the historical groundwater quality monitoring locations in light of the current proposed mine infrastructure. Based on that review, an updated baseline monitoring program was established and re-initiated on August 24, 2014. Four groundwater quality monitoring stations were established near the historical waste dumps and around the underground workings to provide baseline data for the area in which the underground mine will be located. Groundwater levels were also recorded at each of these stations. In September 2014, three artesian locations were capped, and pressure transducers were installed to measure variations in groundwater levels over time.

As of December 2016, Avison had collected nine groundwater samples from flowing artesian boreholes located within the Red Mountain cirque TSA and three from the existing decline under baseline conditions. An additional 14 samples were collected from the existing decline during dewatering activities associated with the 2016 exploration program.

In 2016, SRK conducted a hydrogeological field investigation program to test the hydraulic properties of the bedrock around the JW and AV mineralized zones. Ten packer tests were successfully completed in four underground geotechnical boreholes. Underground seeps and inflows were mapped and recorded. During the dewatering of the existing decline, the pumping rates and variations of water levels were recorded by JDS. Avison collected water quality samples of the water discharged at surface.

3.4 Field Data Collection Methodology

Field data collection methodologies for packer testing and piezometer installations by Golder and SRK are provided in Appendices A, B and C. Methodologies associated with the packer tests and piezometer installations completed by Klohn Crippen were not available in the existing documentation.

3.5 Data Management and QAQC

As recommended by guidelines (Section 3.1), SRK reviewed all the historical information and compiled the data into excel spreadsheets, ACCESS and GIS databases (ArcMap and Leapfrog) for analyses and mapping. All SRK's test analyses were reviewed and verified internally including: methodology, input values, calculations and interpretations. The groundwater levels from automatic data loggers were compensated for atmospheric pressures and checked against manual groundwater depth measurements. All monitoring locations (hydraulic conductivity (K) tests intervals, groundwater heads or pressure, seep locations and inflows) were plotted in 3D space based on the high-resolution LIDAR or surveyed collar elevation, and IDM's database of drillhole surveys.

4 Hydrogeological Data

This section presents historical and recent groundwater data collected by Golder, Klohn Crippen, Rescan and SRK. It provides the current framework for understanding and characterizing the groundwater system at the Red Mountain cirque TSA.

4.1 Hydraulic Conductivity

Thirty-three hydraulic conductivity (K) measurements were collected in 10 boreholes between 1993 and 2016. The tests were completed in two surface piezometers, three surface boreholes, and five underground boreholes. All the test intervals were completed in the sub-volcanic porphyry intrusion. Table 2 provides a compilation of the entire K dataset and Figure 9 illustrates the K distributions in 3D views.

K in bedrock ranges between 7.4×10^{-9} and 2.9×10^{-5} m/s, with a geometric mean of 3.0×10^{-7} m/s, and is interpreted to be primarily related to fractures. SRK analyzed for correlations between K and depths, elevations, specific mineable zones, and the available geotechnical data (i.e., RQD, fracture frequency, core photos, and major structures). With the exception of a trend of K reduction with depth and elevation (Figure 10 and Figure 11), no strong correlation emerged from the analysis. Measurements showed:

- There are three tests that potentially show the JW mineralized zone, the Marc mineralized zone or the DC fault, and the Rick fault are characterized by relatively high K:
  - Test #3 in U16-1207 (3.6×10^{-6} m/s) intercepted the JW mineralized zone;
  - Test #5 in MC93-124 (3.0×10^{-6} m/s) intercepted the Marc mineralized zone and the DC fault; and,
  - Test #2 in U16-1202 (9.9×10^{-7} m/s) intercepted the Rick fault.
- There is one test that suggests that the AV mineralized zone is characterized by a relatively low K:
  - Test #3 in U16-1216 (8.5×10^{-9} m/s) intercepted the AV mineralized zone.
- The two tests conducted in U16-1209 measured a K value of approximately 3×10^{-5} m/s in intervals logged with fault/broken zones that are not identified in the current structural model.

Table 2: Summary of Hydraulic Conductivity Tests conducted between 1993 and 2016

Hole ID	Drilled from	Hole Length	Az	Dip	Date	Test Type	Test #	Interval Top	Interval Bottom	K	Comments on Analysis	Source
-	(1)	m	deg	deg	mm-yy	(2)	-	mabh	mabh	m/s	-	-
961169	UG	546	98	61	Dec-96	CH	1	1.9	167	$2x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	2	164.4	289.5	$2x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	3	286.5	437.4	$7x10^{-8}$	Hvorslev Time Lag Method.	Golder 1996a
M93124	S	198	91	84	Jul-93	n/a	1	96.6	106.4	$4x10^{-7}$	n/a	Klohn 1994b
					Jul-93	n/a	2	107.3	122.6	$3x10^{-7}$	n/a	Klohn 1994b
					Jul-93	n/a	3	122.6	141.8	$1x10^{-7}$	n/a	Klohn 1994b
					Jul-93	n/a	4	136.9	155.2	$2x10^{-6}$	n/a	Klohn 1994b
					Jul-93	n/a	5	153.4	166.8	$3x10^{-6}$	n/a	Klohn 1994b
R96241	S	1,030	166	52	Dec-96	CH	1	457.3	1029.7	$2x10^{-8}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	2	457.3	1029.7	$4x10^{-8}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	3	792.6	1029.7	$3x10^{-8}$	Hvorslev Time Lag Method.	Golder 1996a
R96244	S	978	197	55	Dec-96	FH	1	9.5	102.1	$6x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	2	97.8	230.7	$3x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	3	229.9	325.2	$5x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	4	320.4	399.6	$7x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	RH	5	402.7	770.2	$7x10^{-9}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	6	544.1	785.4	$8x10^{-9}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	7	399.4	910.4	$2x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
					Dec-96	CH	8	399.6	977.4	$2x10^{-7}$	Hvorslev Time Lag Method.	Golder 1996a
T93158	S	29	46	90	Oct-93	n/a	1	0	21	$1x10^{-6}$	n/a	Klohn 1994a,b
					Oct-93	n/a	2	0	25	$5x10^{-7}$	n/a	Klohn 1994a,b
T93159	S	46	46	90	Oct-93	n/a	1	0	8.23	$5x10^{-6}$	n/a	Klohn 1994a,b
					Oct-93	n/a	2	0	33.23	$3x10^{-7}$	n/a	Klohn 1994a,b
U16-1202	UG	230	103	29	Sep-16	ST	1	73.5	121.5	$1x10^{-7}$	Theis Recovery Analysis	SRK 2016
					Sep-16	ST	2	118.5	181.5	$1x10^{-6}$	Theis Recovery Analysis	SRK 2016
U16-1207	UG	155	92	61	Oct-16	ST	1	22.5	61.5	$1x10^{-6}$	Theis Recovery Analysis	SRK 2016
					Oct-16	ST	2	55.5	118.5	$1x10^{-6}$	Theis Recovery Analysis	SRK 2016
					Oct-16	ST	3	118.5	154.5	$4x10^{-6}$	Theis Recovery Analysis	SRK 2016
U16-1209	UG	161	90	41	Oct-16	ST	1	49.5	82.5	$2x10^{-5}$	Theis Recovery Analysis	SRK 2016
					Oct-16	ST	2	82.5	118.5	$3x10^{-5}$	Theis Recovery Analysis	SRK 2016
U16-1216	UG	138	129	45	Oct-16	I	1	19.3	51	$2x10^{-7}$	Theis Recovery Analysis	SRK 2016
					Oct-16	I	2	52.3	84	$9x10^{-8}$	Theis Recovery Analysis	SRK 2016
					Oct-16	I	3	91.3	138	$9x10^{-9}$	Theis Recovery Analysis	SRK 2016

Notes:

(1) S, Surface; UG, Underground

(2) CH, Constant head; FH, Falling head, ST, Shut-in; I, injection

n/a not available

4.2 Groundwater Levels and Pressures

Static groundwater levels were measured between 1993 and 2016 from three shallow surface piezometers, 37 surface exploration boreholes, and from the existing decline. Of the 41 locations, two pressure transducers were installed in piezometers, two in exploration boreholes, and one in the decline to record the seasonal changes in groundwater levels during baseline conditions. In addition to levels, pressures were recorded in eight underground exploration boreholes between August and September of 1994, and in 16 underground exploration boreholes in September of 1996. Pressure measured in underground boreholes provided anecdotal information on the dynamic levels surrounding the decline during dewatering. A map showing the locations of groundwater level and pressure measurements is provided in Figure 12 and the compiled data are provided in Appendix E and Appendix F.

Observations of groundwater levels confirmed that groundwater flow is strongly controlled by topography, with gradients oriented from high elevations towards valleys. The groundwater table at the vicinity of the Red Mountain peak has an elevation of at least 1,875 masl or 252 mbgs (M93124 measured on July 7th, 1993). The groundwater table near Goldslide Creek, within the lower cirque area, is close to the ground surface, with an average elevation of approximately 1,425 masl or 3 mbgs (T93159 measured between September 2014 and September 2016). Among the monitoring locations, seven surface exploration holes (i.e., 8902, M94172, M94173, M94217, T93162, T93163) were noted to have flowing artesian conditions; five of those have water level information available. These conditions are believed to result from the inclination of the borehole underneath areas of higher elevation relative to the collar location or the interception of fractures connected to higher elevation (Figure 13) and not by confined pressures below an impermeable feature or unit, although the latter cannot be ruled out.

Seasonal changes in water levels observed in the upper cirque (i.e., Portal, M94217, and M94173) and in the lower cirque (i.e., T93159, T93160) are summarized in Table 3. Plots of the baseline seasonal groundwater levels are shown on Figure 14, Figure 15, and Figure 16. The gaps in the seasonal dataset were caused by lack of regular downloads due to difficulty of access (i.e., risk of avalanche and thick snowpack) and technical issues such as water level dropping below the sensor, or displacement of the transducer to shallower depths followed by freezing of the water.

The transducer located in the existing decline between 2003 and 2006 provides information on the range of water level elevations between low- and high-flow seasons and the magnitude of groundwater inflows during the rise in water levels between June and August.

- The transducer could not be placed low enough in the decline to record levels during the winter period, but the low levels were inferred by extrapolating levels with a linear trend (Figure 14). The analysis indicated that groundwater levels can potentially drop down to average elevations ranging between 1,795 and 1,805 masl. Levels may even reach lower elevations occasionally; IDM communicated that the bottom of the decline (at approx. 1,757 masl) was reached on one occasion during historical exploration activities without dewatering (pers. comm.; Rob McLeod, IDM, Sep 2016).

- During the high-flow season, the levels peaked between 1,844 masl and 1,848 masl. Discharges of water were observed at the Portal (approximately 1,850 masl) in August 2014.
- During the rise in water levels, the average groundwater inflow rate is approximately 2,160 m^3/d. This rate is estimated from the changes in levels recorded in July 2004, 2005, and 2006.

Table 3: Summary of Seasonal Changes in Water Levels at the Red Mountain TSA

Location [period range]	Minimum Water Level (masl)	Maximum Water Level (masl)	Comments
Existing Decline [1993 – 2006] *Upper Cirque*	1,760 (1) 1,795 (2)	1,850 (3)	Relatively rapid increases of the water table in the months of June or early July with a peak from mid to end of August. Peak does not show singular recharge event but volume of the decline likely dampens the response. Freshet, snowmelt and summer precipitations cause the rise of the water table. Decline can be fully flooded occasionally (3).
M94217 [2015 – 2016] *Upper Cirque*	NA	1,778	Peaks occur mid to end of July 2015 and 2016. Sudden changes in level were observed between September 3rd and October 17th 2016 that potentially show effects of pumping in decline.
M94173 [2015 – 2016] *Upper Cirque*	1,667	1,686	Relatively rapid increases of the water table the month of July 2015 with a peak at the end of July through August 2015 and responses of single recharge events.
T93159 [2014 – 2016] *Lower Cirque*	NA	1,422	Two peaks observed per year in 2015 and 2016. One in June and a second in October associated with spring freshet and summer precipitation events.
T93160 [2014 – 2016] *Lower Cirque*	1,423	1,427	Two peaks observed per year in 2015 and 2016. One in June/July and a second in October associated with spring freshet and summer precipitation events.

Note:

(1) IDM communicated they had been able to reach the bottom of the decline (approx. 1,760 masl) on one occasion during historical exploration activities without dewatering it (pers. comm.; Rob McLeod, IDM, Sep 2016). In May 24th 2016 prior to starting pumps, the water level was measured at 1,780 masl).

(2) Water level extrapolated from the 2003-2006 records.

(3) Discharges of water observed at the portal in August 2014.

NA Not Available

4.3 Pumping Rates and Water Levels during Dewatering Events (1996, 2016)

Water levels and the pumping rates were recorded between May 1996 and August 2000, and between July 2016 and October 2016, during and after the dewatering of the existing decline. Pumping rates were estimated based on records of cumulative volumes of water discharged at surface (1996) or from the stage capacity curve of the pumps (2016) rather than flow measurements; therefore, both the 1996 and 2016 pumping rates are considered uncertain. The rates inferred from pump stage curves, in particular, likely overestimate the actual pumping rates[1]. In addition to these records, on five occasions in July, October, and November of 2016, JDS measured the changes in water levels after the pumps had been shut off. These observations were used to estimate the actual groundwater inflow rates to the decline.

Overall, the dewatering events of 1996 and 2016 indicate that pumping rates are relatively low (i.e., < 90 to 900 m^3/d) until the month of June or July, then increasing quickly as a result of recharge from snowmelt and summer precipitation to a peak around mid-August ranging between 2,600 m^3/d for a "cold" year, and 6,050 m^3/d for a "warm" year. Recharge from snowmelt of the Rio Blanco snowfield is interpreted to be the primary driver of the magnitude of inflow, hence warmer years lead to higher recharge and higher inflows. Connections with surface through discrete features may play a secondary role in increasing inflow rates after specific precipitation events. Inflows from groundwater underneath the Cambria Ice field or a deep groundwater source are highly unlikely, because: 1) the bottom elevation of the decline is above the elevations of the top of the ice field; and, 2) a significant flux of groundwater flowing upward is unlikely considering that flows in the Project area are driven by topography and that the decline is located near the peak of Red Mountain.

Observations specific to each dewatering event are summarized below.

1996 Dewatering Event

Plots of the water levels in the decline and pumping rates are illustrated on Figure 13, Figure 17 and Figure 18 for the 1996 dewatering period.

The Portal was entered on May 8th, 1996 with a water level measured at an elevation of 1,786 masl. The level decreased naturally down to 1,780 masl until the pumping system started on May 24th, 1996. The decline was fully dewatered after only one week, with an average pumping rate of 1,380 m^3/d (i.e., 8 days of pumping, flooded volume approximately 11,000 m^3). Once dewatered to the bottom (at 1,757 masl), pumping could easily keep up with groundwater inflows and rates were progressively decreased down to less than 90 m^3/d. Then, between August 7th and 24th, 1996, the pumping rates were increased up to 3,460 m^3/d to respond to an increase in groundwater inflows. The timing of the increase closely matched the timing of the peak water levels observed in the decline after freshet between 2003 and 2006 (Figure 14). Finally, in the second half of September 1996, inflows started to decrease and discharge rates were adjusted to about 2,590 m^3/d until pumping ceased on October 18th, 1996.

2016 Dewatering Event

Plots of the water levels in the decline, pumping rates, and estimated groundwater inflow rates are illustrated on Figure 19 for the 2016 dewatering period.

Dewatering started on July 3rd, later than initially planned, when the water table had already reached an elevation of 1,851 masl and was expected to peak within a month. At the start, between July 11th and August 4th, the pumping system discharged approximately 2,590 m^3/d on

[1] On October 9th, 2016, a pumping rate of 4,750 m^3/d was estimated based on a stage curve; whereas on October 10th, 2016, a pumping rate of approximately 3,890 m^3/d was measured by JDS (*pers. comm*.; Dinesh Devathasan, JDS Jan 2017).

average, decreasing the level in the decline from 1,851 down to 1,812 masl. On August 5th, the system was upgraded with bigger pumps to improve the dewatering progress and thereafter, discharge rates ranged between 8,640 and 9,500 m^3/d. Once dewatering was achieved on October 1st (i.e., bottom level at approximately 1758 masl), it was possible to progressively reduce the pumping rate. On October 20th, the pumping rates were down to approximately 3,900 m^3/d, and the pumps were shut off on November 5th, 2016. Compared to the average discharge rates reported in 1996 for the months of August and September (approximately 2,590 m^3/d), the 2016 dewatering event achieved significantly higher average discharge rates (approximately 7,780 m^3/d).

Since the aim of pumping was to dewater the decline to the bottom, the pumping rates were higher than the groundwater inflow. The flow rates estimated from changes in water levels after pump shut-offs should, therefore, be more representative of actual groundwater inflow to the decline. Estimates from changes in water level after pump shut-offs are compiled in Table 4 and plotted in Figure 19.

Table 4: Estimated Groundwater Inflow Rates to the Decline (2016)

Date	Water Intake	Pump Shut-off Duration	Inflow	Min Daily Temperature	Max Daily Temperature
	m^3	hr	m^3/d	°C	°C
7/29/2016	399	2	4,750	11	18
10/10/2016	102	0.8	3,020	3	7
11/05/2016	66	- (1)	1,380	-3	1
11/05/2016	477	8.4 (1)	600	-3	1
11/06/2016	581	22.1 (1)	780	-3	1
11/08/2016	1602	47.8 (1)	9	-3	1

Note:

(1) Dewatering stopped on November 5th, 2016 and decline allowed to re-flood.

The groundwater inflow rates to the decline were about 4,750 m^3/d at the end of July, 3,020 m^3/d at the beginning of October, and 1,380 m^3/d immediately after the permanent shut off of the pumps. Rates dropped to less than 860 m^3/d after only a day after the pumps were shut off. These rates were higher than the groundwater inflow rates estimated from the 2003-2006 records (i.e., about 2,160 m^3/d of groundwater inflow in July during baseline conditions – See Section 4.2) but still within the same order of magnitude.

SRK believes that the differences between the 1996 and 2016 dewatering events described above are the result of the differences in surface temperatures and the potential effect on the amount of snowmelt that recharges the groundwater system. A comparison of the temperatures for the period 1981-2016 (Appendix G) indicates that the 2016 mean annual temperature was the highest of this period, whereas in 1996, it was the lowest. It is assumed that the higher temperature in 2016 resulted in an increase of snowmelt, which led to a higher recharge to the groundwater system, and resulted in higher groundwater inflow rates.

A rapid transfer of recharge from precipitation infiltrating through discrete features may also play a role in increasing inflow rates over short time periods (i.e., within a few hours or a few days after single precipitation events). JDS communicated to SRK in 2016 that while working in the decline, warmer temperature or surface precipitations led to an increase in inflows within a couple of hours.

4.4 Discrete Inflows in the Existing Decline

Observation of seeps and inflow rates associated with fractures and faults intersecting the existing decline were recorded during the dewatering events of 1994 and 2016. SRK analysed these observations using a broad classification with six categories, shown below in Table 5. The findings were indicative of the potential discrete rock fractures that could act as conduits to groundwater flow, as well as the order of magnitude of the inflow associated with discrete features. It must be noted, however, that observations are strongly dependant on the moment in time they were recorded, generally decreasing quickly over time, suggesting that fractures and faults have a limited groundwater storage.

Table 5: Qualitative System of Water Inflow Classification

Code	Description
1	Dry (0 litres/hour)
2	Moist (<1 L/hr)
3	Dripping (1-5 L/hr)
4	Seeping (5-20 L/hr)
5	Flowing (20-100 L/hr)
6	Pouring (>100 L/hr)

Major structures and faults are shown in Figure 20 with seep observations from 1994 and 2016, and the 1994 inflow rates are plotted over time in Figure 21, where locations had been monitored several times.

The inflow observations varied greatly from less than 1 L/hr to greater than 100 L/hr (Figure 21). The specific structures associated with flowing or pouring water inflows in 1996 and/or 2016 are listed in Table 6.

Table 6: List of Structures Associated with Flowing or Pouring Inflows

ID	Dip	Dip	Comments on Structure	Comments on Damage Zone	Comments on Inflows
R3	181	62	Strongly sheared, laminated qtz-carb veins. 1-2cm, open vugs, smooth Chl fault surface. Strike slip, strong persistence.	2 m damage zone	Pouring in 1994 and 2016
R5	-	-	Major structure, 10 cm gouge	4 m damage zone	Pouring in 1994 and 2016.
R7	-	-	-	-	Pouring in 1994 but categorized as moist, dripping in 2016.
R10	-	-	Secondary fault, Chlorite polished surface, 2.5mm vein filled fault with 1m damage zone.	0.2-0.5 damage zone	Pouring in 1994 but categorized as moist, dripping in 2016.
R14	97	45	Secondary structure, Smoothed polished surface, vein filled surface. Some roof support.	0.5 m damage zone	Pouring in 1994 but categorized as moist, dripping in 2016.
R15	0	0	Major structure, 20 cm gouge.	4 m damage zone	Pouring in 1994, seeping in 2016.
R18	24	60	Secondary structure, thin gash veins. Major structure, strike slip system.	1-2 m damage zone	Pouring in 1994; no flow noted in 2016.
R19	18	80	Calcite veining and a shear foliation zone of 5 cm wide.	2 m wide zone	Pouring in 1994 and 2016
R22	154	45	Secondary structure, bounded by R23 and R37 (Rick fault). 30 cm damage zone, Chlorite polished surface, 1 cm veinlets, wavy surface.	0.5 m damage zone	Pouring in 1994; no flow noted in 2016.
R23	-	-	Secondary structure, 20 m persistence, Chlorite polished surface, anastomosing fault, 10 cm fault width.	0.5 m	No flow noted in 1994; pouring in 2016.
R64	166	74	Major secondary structure, 5cm gouge fill. Strike slip, bifurcates from R63.	1 m damage zone	Pouring in 1994; seeping in 2016.
R58	342	71	Rick fault. Multiple calcite veinlets, chlorite polished surfaces, 30 cm fault zone of sheared rock.	1-3 m damage zone	No flow noted in 1994; more than 10 seeps noted in 2016 including 4 pouring ones.
R68	4	86	Major structure, 30 cm breccia and gouge fill.	-	Pouring in 1994 and 2016.

5 Conceptual Hydrogeological Model

This section presents conceptual models of the groundwater flow system within the Red Mountain cirque TSA, for baseline conditions, and during mining operations and post-closure phases. The hydrogeological conceptual models are simplified representations of the essential features of the physical hydrogeological system and its hydraulic behaviour. The development of the models is an iterative process; therefore, it should be updated as new data becomes available, as the understanding of the system is improved, or as questions and modelling objectives evolve (Wels et al. 2012).

5.1 Hydrogeological Units

There are no major aquifers identified in the area (MOE 2016d). SRK identified three types of potential minor aquifers and two types of potential aquitards:

Minor aquifers:

- The overburden cover consists of glacial, eolian, and fluvial deposits, with a colluvium cover on many of the steeper slopes. In the Red Mountain cirque, basal moraine, talus and slopewash, generally contain small percentages of fines due to the short glacial transport distance and water runoff. From literature data, K in glacial till material can vary widely from less than $1x10^{-8}$ to $5x10^{-6}$ m/s (Freeze and Cherry 1979). Depth to bedrock is shallow, specifically, 1 to 2 m in thickness.
- The bedrock is grouped into one hydrogeological unit, which encompasses all the lithologies encountered at the site (i.e., porphyry intrusion and metasediment) without distinction. K has a geomean of $3x10^{-7}$ m/s and tends to decrease with depth.
- High K fractures or faults are potentially present but not well defined with the current dataset. A number of structures listed in Table 6 (Section 4.4) were reported to have relatively high inflows (>100 L/hr). A K of $1x10^{-6}$ m/s was measured for the Rick fault.

Aquitards (impermeable units):

- Local patches of discontinuous permafrost could be present, although not identified. Where present, they will act as an aquitard (impermeable unit) that can limit groundwater recharge.
- Low K fractures or faults are potentially present but not specifically identified with the current dataset. If present, low K fractures or faults could create local impermeable barriers and compartments.

5.2 Groundwater Flow

5.2.1 Baseline Conditions

Groundwater flow is primarily influenced by relative elevations with the primary groundwater flow directions from the top of Red Mountain to the Bitter Creek valley, and the secondary flow directions (i.e., localized shallow system) towards the creeks and the Cambria Ice Field. Plan view and cross-sections of groundwater flow conceptual models of the Red Mountain cirque TSA are shown in Figure 22.

Groundwater flow paths are controlled by fractures and joints that penetrate the bedrock, with no apparent distinction between lithologies (i.e., porphyry intrusions and metasediments). Faults may act as preferential conduits, impermeable barriers or both; however, none of the major structures identified to date are associated with significant discharge at surface or visible changes in water levels. The influence of fault zones are therefore assumed to be limited at this stage. Where present and permeable, overburden units are likely draining shallow inflows but this influence is considered to have negligible impacts on the Project.

Recharge to the groundwater system takes place above approximately 1,100 masl, in the form of snowmelt or rain infiltration. There are pronounced seasonal fluctuations in groundwater levels, and these are greater at higher elevations than at lower elevations. In the area of the existing decline, water levels peak at 1,850 masl between July and August, then slowly decrease to 1,760 m over the course of the winter season and finally, recover rapidly with recharge from snowmelt, starting in in March or June.

Discharges occur:

- At the bottom of the Cambria Ice Field;
- At lower elevation in the main creeks (i.e., Goldslide and Rio Blanco Creeks) and possibly in smaller order streams;
- On the mountain slopes between approximately 950 and 1,100 masl (i.e., seepage zone);
- In gullies, breaks in slope and geologic discontinuities; and,
- In the valley bottom.

The upper sections of Goldslide and Rio Blanco Creeks are likely ephemeral, perched above the water table, and fed primarily by glaciers, snowmelt and/or runoff. It is assumed that the lower sections of the creeks, as well as Bitter Creek in the valley, are fed by groundwater all year round. During the low-flow season (i.e., the winter period), it is assumed that groundwater contributes to nearly 100% of the base flow. During spring, summer and fall, surface runoff and quick flow generated by the snowmelt and/or precipitation dominates.

A base-flow separation analysis was prepared in order to estimate the proportion of groundwater contributing to creek flows (SRK 2016a). Stream discharge was separated into two components, specifically: quick-flow and base-flow. *Quick-flow* is defined as the portion of streamflow that comes from either surface runoff or interflow. *Base-flow* is the portion of streamflow that comes from the sum of deep subsurface flow and delayed shallow subsurface flow. The runoff separation was conducted using the Nathan and McMahon (1990) technique. The results of the analysis are plotted and illustrated in Figure 23 and Figure 24, and summarized in Table 7.

Table 7: Unit Base-Flow for Bitter, Otter and Goldslide Creeks

Location	Base Flow [l/s/km²]											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bitter and Otter Creeks	1.6	3	5.3	7.7	18	69	165	135	62	28	7.2	2.2
Goldslide Creek	1.9	3.2	5.3	7.7	19	64	82	41	28	21	7.2	2.6

5.2.2 Mining Operations

During mining operations, the major effects on the groundwater flow system will likely be dominated by underground water management, drilling, blasting, excavation, and backfilling activities.

- The deepest mine excavation is proposed to be at an elevation of approximately 1,636 masl. The lower portal will provide access to the lower levels of the underground workings, located at an approximate elevation of 1,710 masl. Dewatering activities will be necessary to keep groundwater out of the mine. This will result in a drawdown of the water table, centred about the underground workings that will gradually expand over time for as long as dewatering continues. The changes in groundwater levels and flow may induce a seasonal reduction of the groundwater discharges (i.e., base flow) to Goldslide and Rio Blanco Creeks.
- Drilling, blasting, and excavation activities may enhance the hydraulic conductivity and lead to increased drawdown. Some of these activities may use variable amounts of groundwater, but the only groundwater expected to leave the system is moisture exported from the mine in the blasted ore.
- Placement of temporary waste rock piles may modify the hydraulic conductivity at the ground surface and lead to a change in recharge.
- Placement of waste rock as backfill in the underground may result in locally increased or decreased hydraulic conductivity of the subsurface compared to baseline conditions.

5.2.3 Closure and Post-closure

At mine closure, the ventilation shafts, adits, and portals will be sealed to limit the potential for direct mine water discharge to surface waters, and limit the ingress of oxygen. After the underground is backfilled with waste rock, and the bulkhead constructed in the lower access ramp, pumps will be shut off to allow for re-flooding of the mine. The drawdown and base flow reductions induced during operations will decrease gradually.

During the post-closure phase, the groundwater system is predicted to return to baseline conditions. There may be a small zone of residual drawdown remaining due to the changes of hydraulic properties in the mine and if there are surface openings at the Upper Crown, and Lower Crown pillars (Figure 2). For this study, it was assumed that the backfilled stopes will be more permeable than the bedrock fabric. Finally, the seasonal variations in the water table may annually expose mined-out volumes, which may result in ARD reactions and/or metal leaching/mobility and lead to changes to the groundwater chemistry.

6 Groundwater Predictions

In general, groundwater is a key component of the biophysical environment, based on linkages to other ecosystem components, including: surface water quantity, surface water quality, human health, aquatic resources, and wetlands. This section describes the 3D-groundwater numerical model used to assess the effects of the Project on groundwater quantity and quality, and presents the results of model simulations.

6.1 Objectives of Groundwater Modeling

The objectives of the predictive simulations and temporal boundaries are presented in Table 8 and Table 9.

Table 8: Groundwater Modeling Objectives - Predictive Simulations

Objectives	Temporal Boundary
Estimate the groundwater inflow rate into the underground developments during the dewatering periods.	Mining Operation: Year 1 to Year 6.
Maximum reductions of groundwater base flow in creeks	Mining Operation: Year 6
Estimate the re-flood time.	Closure: Beginning of Year 7 to Post-closure.
Estimate the groundwater losses from the mine.	Post-closure
Estimate the groundwater pathways and travel times from the mine components to the creeks.	Post-closure.
Estimate the contribution to the creeks (base flow) of groundwater potentially influenced by the mine.	Post-closure.

Table 9: Groundwater Modeling Objectives - Temporal Boundaries

Temporal Boundary	Description
Mining Operation: Year 1 to 6	Underground excavation and waste rock piles are progressively developed. Progressions of the mine components are assessed by one-year increments. Dewatering pumps are on.
Closure Year 7	The mine is fully excavated. Waste rock piles are no longer present at surface. Cemented backfill is placed in the primary stopes and un-cemented run-of-mine waste in the secondary stopes, filling 62% of the mine development. Ramps are sealed with engineered bulkheads. Dewatering pumps are shut off and workings are allowed to re-flood.
Post-Closure	The mine is flooded and the groundwater system has returned to equilibrium.

6.2 Model Software

Numerical groundwater modeling was completed using the software, FEFLOW v7.0 (Update 9) (DHI, November 2016). FEFLOW is a professional software package for modeling fluid flow and transport of dissolved constituents and/or heat transport processes in the subsurface. This program is used extensively for groundwater mining projects around the world. The code is based on a finite element solution of the partial differential equations for flow and transport.

6.3 Model Assumptions

The model assumptions are as follows:

- For the purposes of the assessment, the entire rock/surficial package may be treated as a homogeneous, anisotropic medium (i.e., different properties in different directions);
- The unconsolidated material is assumed to have properties similar to that of the shallow bedrock within the upper model layer;
- On the scale of the assessment, groundwater system flow, which is expected to occur dominantly via fracture flow, can be approximated by an Equivalent Porous Media (EPM) model;
- K is largely anisotropic, with a lower vertical K (K_V) compared to horizontal K (K_H). In general terms, K, in all orientations, decreases with depth, according to the model proposed by Jiang et al. (2010); and,
- Recharge is spatially constant throughout the model region.

6.4 Groundwater Model Setup

6.4.1 Model Domain

The groundwater model domain was set to match the Red Mountain cirque TSA, which encompasses the potential catchment area of the proposed underground mine and is based on surface drainage patterns. Boundaries of the TSA are sufficiently far from the mining area, to exert minimal influence of the boundary conditions on model predictions. The upper surface of the model was defined based on a high-resolution digital elevation model. The base of the model was set at a constant depth of 1,000 mbgs projected downward from the surface topography. The model domain covers an area of approximately 5.5 x 5.7 km, with a total area of 19 km^2 (Figure 25).

6.4.2 Model Mesh

The finite element mesh comprises 129,060 nodes. The horizontal mesh refinement varies from 100 x 100 m at the edges of the model to 25 x 25 m near the proposed underground workings (Figure 25, Figure 26). The vertical grid comprises 15 layers increasing in thickness from 20 m in the near surface to 190 m at depth.

Following model calibration, the mine infrastructure was incorporated into the simulation by restructuring the mesh around the mine workings using tetrahedron elements. Mesh was designed to have a 5 m nodal spacing around the proposed mine, increasing the overall number of nodes from 129,060 to 154,516.

6.4.3 Model Properties

Initial parameter values for model construction were estimated based on the hydrogeological conceptual model and assigned based on field test interpretations. Using these initial estimates, the model parameters were adjusted to match the average annual and seasonal water level fluctuations, dewatering behaviour at the existing decline, and low-flow, winter base-flow conditions. The results of the model calibration are presented in Section 6.5.

The overburden and bedrock were simulated using an equivalent porous media approach with the following properties:

- Horizontal hydraulic conductivities (K_H) were estimated from the steady-state calibration. K_H is constant within a given layer.
- The K field is anisotropic with a conductivity tensor where the horizontal hydraulic conductivity (K_H) is greater than the vertical hydraulic conductivity (K_V).
- K decreases with depth due to increases in the lithostatic stress. Jiang et al.'s (2010) model was used to estimate the hydraulic conductivity decrease, using the following equation:

$$K(z) = K_0 \left(\frac{1 + \frac{b_r}{b_0} \frac{z}{z_c}}{1 + \frac{z}{z_c}} \right)^3$$

Where: K_0 is the hydraulic conductivity near the ground surface; b_r/b_0 is the ratio of the minimum expected aperture at depth compared to that at the ground surface, and z_c is a depth constant. Model constants (b_r/b_0 and z_c) were derived from hydraulic test data using a least squares analysis. Results suggest a best fit with a z_c of 600 m and a b_r/b_0 of 2%.

- The values for specific storage were estimated from the transient calibration.
- The longitudinal and transverse dispersivities are assumed to be 60 m and 20 m, respectively, based on published literature on fractured rock systems (Singhal 2010). Dispersivities are only assigned to the models that solve the mean lifetime expectancy and the exit probabilities (Refer to Section 6.6 for details).

6.4.4 Boundary Conditions

Boundary conditions are described below and are illustrated in Figure 25.

External Boundaries

- The western edge of the model is simulated as a constant head boundary defined by the elevation of Bitter Creek;
- The northern edge of the model is defined by seepage nodes along Otter Creek;
- The eastern edge is defined by a no-flow (or zero-flux) boundary condition, to correspond with surface water divides;

- The southeast boundary is simulated using transfer flux (Cauchy) boundary conditions to simulate flow from the Cambria Ice Field; and,
- Finally, the base of the model is defined as a no-flow boundary, in view of the expected low permeability at this depth (>1,000 m).

Internal Boundaries

Recharge

Recharge from precipitation and snowmelt is applied on the top slice and estimated based on the baseline climate conditions established in the document: *"Red Mountain Environmental Assessment: Climate, Hydrology Baseline and Analysis Report"* (SRK 2016a). Recharge estimates were derived using the following water balance approach:

- Monthly net available recharge (NAR) was estimated using the equation:

$$NAR = P - ET - \Delta SWE$$

  Where P is the precipitation, ET is the actual evapotranspiration, and ΔSWE is the monthly change in snow-water equivalent (i.e., positive valves correspond to snowpack gains; negative values correspond to snowpack losses). A summary of the monthly NAR is presented in Table 10.

- The actual groundwater recharge (R) was then estimated from the NAR by fitting models to the mean annual observed hydraulic heads and seasonal fluctuations. Models were fit by varying the percentage of NAR which reaches the groundwater system as actual recharge (R). The remaining NAR which does not reach the groundwater system is assumed to be removed as near-surface runoff.

Calibrated recharge values are presented in the transient calibration section (Section 6.5.2). The NAR estimates suggest the peak of recharge occurs between May and June as a result of freshet melt. A secondary peak occurs in early fall (i.e., September and October).

Table 10: Estimation of Net Available Recharge (NAR)

Month	Precipitation (mm)	Actual Evapotranspiration (mm)	SWE (mm)	Change in SWE (mm)	NAR (mm)
January	219	0	570	180	39
February	137	3	750	130	4
March	121	19	880	100	2
April	90	44	980	-10	56
May	72	65	970	-390	397
June	66	65	580	-470	471
July	77	71	110	-110	116

Month	Precipitation (mm)	Actual Evapotranspiration (mm)	SWE (mm)	Change in SWE (mm)	NAR (mm)
August	121	60	0	0	61
September	211	30	0	20	161
October	291	17	20	140	134
November	227	5	160	200	22
December	214	0	360	210	4

Rivers/Creeks

- Bitter Creek was simulated as a constant head (Dirichlet) boundary condition. Constant head boundary conditions imply that an unimpeded hydraulic connection exists between the rivers and the underlying groundwater system, freely allowing watercourses to function as sources and/or sinks to the groundwater flow system[2]; and,
- The smaller creeks and headwaters (i.e., Goldslide, Rio Blanco, and Otter Creeks) are simulated using seepage boundary conditions[3]. The seepage boundary conditions allow for discharge to the creeks where the water table is above surface, but do not allow these creeks to add water to the groundwater system.

Underground Workings

- The existing decline and the proposed underground mine were simulated using seepage boundary conditions[3], with the assumption that all water reaching the underground mine will be actively removed during the life of operations.

6.5 Model Calibration

6.5.1 Steady-State Calibration

The numerical groundwater model was initially calibrated to the pre-mining steady-state conditions by varying the horizontal surface hydraulic conductivity (K_H), vertical to horizontal K ratio (K_V/K_H), recharge (R), and transfer distance (TD) parameters to match measured *in situ* water levels and inflow/outflows. The calibration was conducted by independently varying the four parameters until the global difference between the observations and model predictions was minimized. Recharge estimates were calibrated by varying the %NAR that recharges the groundwater (Section 6.4.4). Water levels used for calibration were based on mean annual water levels from data collected by Klohn Crippen, Golder, and SRK between 1993 and 2016 from a total of 34 stations. Base-flow in Goldslide Creek were calibrated to low-flow winter conditions inferred from the base-flow separation analysis (SRK, 2016; Section 5.2.1).

[2] This boundary type was selected in consideration of the dominantly rocky creek beds observed.
[3] A seepage condition is a constant head (Dirichlet) boundary condition with a maximum flow constraint that behaves only as an exit point (drain) for water, i.e. the boundary condition is only active in cases where the water table exceeds the level of the creek and the flow direction is out of the model (into the creek bed).

Steady-state calibration of the Red Mountain model indicated a best-fit with a K_H at surface of 8.4×10^{-7} m/s, K_V/K_H of 0.05, %NAR of 37.0% (equates to a %MAP of 29.4%), and a transfer distance of 2,500 m. The final distribution of K_H with depth is illustrated in Figure 27.

The calibration plots are presented in Figure 28. This set of input parameters equates to a normalized root mean squared error (NRMSE) of 5.1% for the steady-state hydraulic heads, which is considered to be “good”, based on an acceptance threshold of 10% (Smith 2015). Large hydraulic head errors (i.e., ~100 m) are found to occur in drill holes MC90-35, MC90-41, and MC90-42. These measurements were collected by Golder (1996) in abandoned drill holes and, as a result, are largely uncertain due to the inability to determine the location of groundwater inflow into the abandon wells. These points remain incorporated into the calibration statistics; if removal of these could be justified, the calibration statistics would improve significantly.

Two secondary calibrations were conducted to test alternative conceptual models. The first subdivided the groundwater model into two hydrogeological domains, based on the regional geology. Specifically, two domains were simulated: metasediments and porphyry intrusions. Calibration was conducted by allowing the hydrogeological parameters to vary independently within the domains. The best fit was obtained by minimizing the misfit ($S(m)$) between the model and observed hydraulic levels and base-flow, where:

$$S(m) = \frac{1}{2}\sum(Model - Observation)^2$$

Results of the simulation converged on a near identical answer to the single hydrogeological domain model. Summary statistics were also similar with the NRMSE indicating that an improved calibration cannot be achieved through incorporation of the regional geology over the simplified single hydrogeological model.

The second alternative conceptual model subdivided the groundwater model into two separate domains: general rock mass, and Rick fault. Calibration was again conducted by allowing the hydraulic properties of the two units to vary independently and minimizing the misfit between the model and the observed groundwater systems. Results of the simulation indicated an improved fit to the transient response (i.e., NRMSE reducing from 30% to 20%); however, the steady-state fit became “worse” with the NRMSE increasing from 6.5% to >25%. This was due to a reduction in predicted head values near the existing decline resulting from increased depressurization along the Rick Fault. This suggested that the Rick Fault was not likely to be hydraulically connected to the rock mass, and/or did not act as a conduit over its entire length, such that it would drain the mountain.

6.5.2 Transient Calibration

Following the steady-state calibration, the numerical groundwater model was further calibrated to reproduce transient groundwater conditions, by estimating the diffusivity (K/S) of the groundwater system. Transient conditions were calibrated by varying specific storage (S_s) and specific yield (S_Y) to fit three datasets, namely:

- Low-flow, winter base-flow conditions at Goldslide Creek;
- Seasonal groundwater level fluctuations observed at M94173, M94217, TD93-159, and TD93-160; and,
- Groundwater inflows reported to the existing decline during the dewatering periods of 1996 and 2016.

For the transient calibration, the horizontal surface hydraulic conductivity (K_H), vertical to horizontal K ratio (K_V/K_H), recharge (R), and transfer distance (TD) parameters were fixed at the steady-state calibrated values. Seasonal variability in recharge was estimated based on the estimation of NAR presented in Table 10 (Section 6.4.4). The simulated recharge profile and associated water budget components are provided in Figure 29.

The final storage parameters were $4x10^{-5}$ m^{-1} for the storage compressibility (S_s) and 1% for the specific yield (S_y), which are both reasonable values for fractured rock. Examination of seasonal water level variability at each of the four monitoring stations suggested a good agreement between the simulated and measured levels. Comparison of the simulated and measured levels is presented in Figure 30.

The model predicted a base-flow along Goldslide Creek of 5,500 m^3/d during low-flow winter conditions, and a groundwater inflow to the existing decline of approximately 2,590 m^3/d, following a dewatering period of 100 days starting in the month of July. A comparison of the simulated and estimated flows is presented in Figure 31.

6.6 Predictive Simulations

The predictions are based on a model termed "Base Case" that uses the same parameters as the model calibrated to current conditions. Table 11 lists the predictive scenarios.

Table 11: List of Predictive Scenarios

Predictive Simulations	Description
Mining Operation: Year 1 to 6	Dewatering starts on March 1st with the activation of the seepage nodes assigned to the underground mine volume, assuming all water reaching the mine will be actively removed. Dewatering is assumed to use gravity via the lower access ramp and to continue during the seasonal closure of the mine (i.e., November to February). The seepage nodes are adjusted on a yearly basis to account for the progressive excavation of the mine with a one-year time step.
Closure Year 7	The initial head conditions are set to the head predictions at the end of year 6 when the mine reaches its full development. The seepage nodes assigned to the mine volumes are deactivated since the ramps are sealed with engineered bulk heads. Cemented backfill is placed in the primary stopes and un-cemented run-of-mine waste in the secondary stopes. The stopes are assigned with a K of 3.5×10^{-6} m/s (K_h=K_v) and a specific yield of 7% (equivalent to a void volume of 162,000 m^3 as indicated by the mine production and backfill schedule; JDS 2016). The developments are represented as high-permeability conduits. Dewatering pumps are shut off and workings are allowed to re-flood.
Post-Closure	The mine is characterized as for Closure (Year 7). Developments and stopes are re-flooded and the groundwater system is predicted to return to baseline conditions.

The results of the Base Case model have been compared to upper and lower bound scenarios (Upper Case and Lower Case, respectively), and to models modified to assess the sensitivity of the predictions. The modifications to the Base Case model were as follows:

- K_H, K_V, R , Ss, and Sy were adjusted concurrently to simulate a recharge equivalent to 50% MAP (Upper Case) and 10% MAP (Lower Case) while keeping the calibration to baseline hydraulic heads;
- K_H, K_V, R , Ss, and Sy were increased or decreased individually to assess the sensitivity of the model to each parameter; and,
- Specific major structures were added to the model to test their effect on model predictions.

The predictive simulations evaluated the underground inflow rates and changes to groundwater base-flows. The simulations also evaluated lifetime expectancy and exit probabilities[4] to estimate the flow contribution of the underground mine to the base-flows of Goldslide, Rio Blanco, and Bitter Creeks.

The Red Mountain Cirque TSA and the Bromley Humps TSA delineate the area of the LSA and RSA where the Project components (i.e., underground mine and TMF) are anticipated to affect the groundwater and surface water systems. The groundwater model results for the two TSAs were formatted for the Project site-wide WLBM (SRK 2017), which then combines the two TSA's predictions and assess the overall effects of the Project via groundwater on the LSA and RSA.

[4] *FEFLOW solves standard mass-transport equations to calculate lifetime expectancy and exit probability, which provide the means to analyze flow dynamics, estimate risk vulnerability and evaluate outlet capture zones and the origin of water. Lifetime expectancy is defined as the average time for groundwater still needed before exiting the domain via an outlet. It therefore corresponds to the expected travel time from the current location to an outflow boundary. The parameter exit probability can be used to calculate the probability of water exiting the model domain at specific locations. Compared to standard particle tracking, exit probability can provide much more information on a capture zone: Heterogeneity effects are considered via dispersion and flow times are determined through temporal spreading of the probability plume.* – Adapted from the FEFLOW User Manual (DHI-WASY).

6.7 Model Results

6.7.1 Application of Model Results

The British Columbia Groundwater Modeling Guidelines (Wels et al., 2012) define three levels of modeling complexity, based on: potential impacts, modeling objectives, hydrogeological framework and data availability. The model developed to undertake this assessment may be classified as of moderate complexity, defined as follows:

> *"These are conceptual or numerical models based on a reasonable, though limited, dataset and having limited calibration. These models may be used to determine the potential range of change or to "bracket" potential effects that may occur due to a given stress."*

Hence, while specific results are calculated during the modelling process, there always remains a degree of uncertainty associated with these estimates. Quantification of the uncertainty may be a laborious and expensive process. SRK has attempted to quantify the uncertainty by providing a range of estimates; however, these ranges should not be viewed as definitive.

6.7.2 Mining Operations

Table 12 presents a compilation of the predicted annual averages and Figure 32 plots the mine inflow predictions for the Base Case, Upper Case and Lower Case scenarios. The Base Case model predicts that mine inflows will rise gradually to a peak of about 3,810 m^3/d in Year 2 and then decrease from this point onward to about 2,640 m^3/d. At Year 2, the developments have almost reached their full extent and in subsequent years the mining of the stopes remains within the bound of the developments; excavation does not extend deeper.

Table 12: Predicted Average Annual Underground Inflows during Mining Operations

Operational Year #	Groundwater Inflow (m^3/d)		
	Base Case	Upper Case	Lower Case
1	3,200	5,400	1,500
2	3,800	6,400	1,900
3	3,200	5,300	1,500
4	2,900	4,900	1,300
5	2,700	4,600	1,100
6	2,600	4,400	1,100

Figure 33 illustrates the extent of the drawdown at the end of year 6 (EOM). The drawdown cone is approximately 3.8 km^2 in area and the maximum drawdown is about 110 m at the vicinity of the Lower Portal entrance.

The model predicts that groundwater flow to the mine will induce losses of base-flow groundwater contributions in the Bitter Creek catchment. Table 13 shows the calculated base-flows and the

Relative Percent Difference (RPD) between Year 6 (EOM) and baseline conditions for Goldslide Creek at GSC09 and GSC02, Rio Blanco Creek at RBC02, and Bitter Creek at BC08. The modeling results indicate that the maximum reduction to surface water base-flows will occur between March and May, at the end of low-flow winter conditions. The Base Case model predicts a maximum reduction of 36% at GSC09, located on Goldslide Creek at close proximity with the mine, 4% at GSC02, located further downstream on Goldslide Creek, 3% at RBC02 on Rio Blanco Creek, and 1% at BC08 on Bitter Creek.

The predictions of drawdown and groundwater base-flow reductions are identical for the Base Case, Upper Case and Lower Case models due to the fact that K, R, Ss, and Sy are increased or decreased concurrently and in the same proportions.

Table 13: Predicted Baseflows and Relative Percent Difference (RPD) between Year 6 (EOM) and baseline conditions

Station	Type	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
GSC09	Baseline	m³/d	330	320	310	320	390	440	400	360	370	370	350	330
	Model Year 6	m³/d	220	210	200	210	270	320	290	240	250	260	230	210
	RPD	%	-34%	-35%	-36%	-35%	-31%	-26%	-27%	-32%	-31%	-31%	-34%	-35%
GSC02	Baseline	m³/d	5,450	5,240	5,090	5,200	6,530	7,660	6,870	6,170	6,350	6,370	5,870	5,540
	Model Year 6	m³/d	5,340	5,150	4,990	5,080	6,240	7,480	6,870	6,030	6,210	6,220	5,720	5,390
	RPD	%	-2%	-2%	-2%	-2%	-4%	-2%	0%	-2%	-2%	-2%	-3%	-3%
RBC02	Baseline	m³/d	6,300	6,060	5,890	6,020	7,550	8,820	7,920	7,150	7,380	7,380	6,800	6,430
	Model Year 6	m³/d	6,300	6,060	5,890	5,990	7,330	8,730	8,030	7,100	7,320	7,320	6,720	6,350
	RPD	%	0%	0%	0%	0%	-3%	-1%	1%	-1%	-1%	-1%	-1%	-1%
BC08	Baseline[1]	m³/d	36,620	35,220	34,280	35,120	44,400	52,160	46,120	41,260	42,760	42,780	39,200	37,020
	Model Year 6	m³/d	36,610	35,240	34,290	35,080	43,800	51,950	46,560	41,210	42,700	42,710	39,100	36,930
	RPD	%	0%	0%	0%	0%	-1%	0%	1%	0%	0%	0%	0%	0%

Note:

Inflows rounded off to the nearest 10.

[1] Baseline baseflow predictions at BC08 are doubled to account for the groundwater discharges coming from the west side of the Bitter Creek valley, outside the model domain. The potential groundwater baseflow originating from underneath the Cambria Icefield is not accounted.

6.7.3 Closure

The time necessary for the groundwater system to recover its initial state (i.e., re-flood) is a function of the volume of the mine, the inflow to the mine, the decay in groundwater inflow over time related to the decrease in head difference between the mine water level and the surrounding groundwater levels, and groundwater losses out of the mine area.

The recovery period is estimated based on the water balance calculated by the model for the mined-out volume. In the early stage, after closure, the water balance indicates a positive net gain of water into the mined-out volume. This reflects the fact that groundwater is still in disequilibrium and undergoing re-flood conditions. The net gain is progressively reduced as the groundwater system returns to an equilibrium state, at which point the net gain over a one-year recharge cycle is equal to zero (i.e., gains equal to losses), as follows:

$$[dQ]_{over\ one\ year\ cycle} = Q_{IN} - Q_{OUT} = 0$$

Where dQ is the net gain of water, Q_{IN} is the flow into the slope, and Q_{OUT} is the flow out of the stopes.

Figure 34 plots the predictions of net gain of water in the mined-out volumes for the Base Case, Upper Case and Lower Case scenarios. Table 14 summarizes the predicted recovery periods in years.

Table 14: Predicted Re-flood periods

% Recovery	Predicted Re-flood Periods (in Years)		
	Base Case	Upper Case	Lower Case
95%	23	17	40
99%	57	48	>80

6.7.4 Post-Closure

Once the groundwater system has recovered to an equilibrium condition, the Base Case model predicts a flow rate through the mined-out volume (i.e., stopes) of 1,430 m^3/d. Flows are oriented towards lower elevations and discharge to Goldslide, Rio Blanco, or Bitter Creeks. Figure 34 illustrates the calculated forward pathlines representing the complete steady-state flow path from source to final receptor. The Base Case model predicts that it will take a minimum of about 5 years before the first particle reaches Goldslide Creek in the Upper Cirque area, about 40 years to reach Rio Blanco Creek, and about 90 years to reach the Bitter Creek valley. The mean life time expectancy (LTE) of groundwater originating from the stopes before it reaches a surface water receptor is at least 40 years. Figure 36 shows a map of the predicted mean LTE at ground surface (i.e., the time it takes for water to travel from ground surface to the nearest receptor) as well as a 3D view of the mean LTE applied to the volumes of the stopes.

The maximum contributions to the creeks' base-flow, as calculated by the Base Case model, of groundwater potentially influenced by the mine are compiled in Table 15. These results assume steady-state conditions, i.e., the source has an infinite amount of time to reach the receptor.

Table 15: Predicted Maximum Contributions from Mine Contact Groundwater to the Creek Base-flows at Post-Closure

Receptor	Groundwater Base-Flow	Portion of Groundwater Base-flow Potentially Influenced by the Mine	
	m^3/d	m^3/d	%
Goldslide Creek at GSC09	420	230	55.6%
Goldslide Creek at GSC02	6,510	680	10.4%
Rio Blanco Creek at RBC02	7,660	430	5.6%
Bitter Creek at BC08	42,000 [1]	740	1.8%
All Surface Water nodes within the Model Domain	73,080 [1]	1420	1.9%

Note:

Inflows rounded off to the nearest 10.

[1] Baseline baseflow predictions at BC08 are doubled to account for the groundwater discharges coming from the west side of the Bitter Creek valley, outside the model domain. The potential groundwater baseflow originating from underneath the Cambria Icefield is not accounted.

6.8 Model Sensitivity

6.8.1 Methodology

Multiple simulations were conducted to assess the sensitivity of the model predictions to changes of K_H alone, R alone, K_V, Ss, Sy and the explicit modeling of geological structures as important hydrogeological features. These parameters were varied without re-calibration of the model (i.e., sensitivity simulations do not represent alternative conceptualizations of the site). The results of the sensitivity runs were analyzed by comparing the sensitivity models to the Base Case (calibration) model under Baseline, Mining, Closure and Post-closure conditions. The sensitivity of the model outputs were evaluated through review of changes in:

- Hydraulic head calibration (%NRMSE) for baseline model as RPD between Base Case and sensitivity models;
- Seasonal water level variability (amplitude and timing) compared to Base Case and baseline observations;
- Creek base-flows at stations GSC02, GSC09, RBC02 and BC08 as RPD between Base Case and sensitivity models;
- Mine inflow predictions at year 6 (EOM) as RPD between Base Case and sensitivity models;
- Re-flood time as RPD between Base Case and sensitivity models; and,
- Average potential flow contributions to base-flow from the mine at stations GSC02, GSC09, RBC02 and BC08 as RPD between Base Case and sensitivity models.

Then, the following qualitative sensitivity definitions were applied to rate the significance of effects to the model calibration and prediction:

- High: more than 30% RPD;
- Medium: 15 to 30% RPD;
- Low: 5 to 15% RPD; and,
- Null: less than 5% RPD.

The list of sensitivity scenarios is compiled in Table 16.

Table 16: Descriptions of Sensitivity Scenarios

ID	Descriptions
Kh1, Kh2	K_H alone increased and decreased by 67%
Kv1, Kv2	K_V alone increased and decreased by 67%
R1, R2	R alone increased and decreased by 67% (equivalent to 50% and 10% MAP respectively)
F	Explicit modeling of the structures labelled R3, R5, R8, R15, R19, R23, R23, R35, Rick fault, R63, R68 and R99a. These structures were assigned with Kh = Kv = 5x10^{-6} m/s
Ss1, Ss2	S_S alone, increased and decreased by one order of magnitude
Sy1, Sy2	S_Y alone, increased and decreased by one order of magnitude

6.8.2 Results of the Sensitivity Simulations

Table 17 and Table 18 summarize the sensitivities of the baseline, EOM/closure, and post-closure model outputs to changes in model parameters. The significance of effects to the model calibration and prediction are indicated by the format of the cell, with dark grey indicating a high sensitivity, light grey a medium sensitivity, pale yellow a low sensitivity, and white not sensitive.

Hydraulic Head

The simulated heads at the target locations are sensitive to all the parameters with the exception of the specific yield, Sy.

Creek Base-Flows

Base-flow estimates simulated for baseline conditions are sensitive to K_H, to a decrease of K_V or S_S, and to recharge. Estimates are insensitive to the explicit modeling of the structures added to the model, to an increase of K_V or S_S, or the specific yield, Sy.

The predictions of the effects to creek base-flows from mine dewatering are sensitive to all the parameters. However, the actual effect magnitude remains low (i.e., between 1 to 8%) in all cases, with the exception of the decrease in S_S (i.e., 14% reduction at GSC02 compared to 2% for the Base Case model).

Mine Inflows

Predictions of mine inflows during baseline conditions or the operations phase are sensitive to all the parameters, with the exception of the specific yield, S_y.

Potential Contribution from Mine Contact Groundwater to Base-Flow

Predictions of mine contact groundwater contributions are sensitive to K_H, K_v, R, and explicit modeling of faults, and insensitive to S_s and S_y; the most sensitive parameter being the modeling of faults. However, in terms of actual contributions to base-flows (i.e., the predictions) the magnitude remains low in all cases (i.e., between 2 and 6% contribution at GSC09, 0 and 3% at GSC02, 0 and 2% at RBC02, and 0 and 1% at BC08).

Re-flood Time

Predictions of re-flood time during Closure and Post-Closure conditions are sensitive to all the parameters, with the exception of the specific yield, S_y.

Table 17: Sensitivity of Baseline Model Outputs

Parameter	Parameter Variation	Head % NRMSE	Monthly Average Base Flow in Goldslide Creek (GSC02)		Monthly Average Base Flow in Rio Blanco Creek (RBC02)		Monthly Average Base Flow in Bitter Creek (BC08) (note 1)		Dewatering Inflows
			Low flow period	High flow period	Low flow period	High flow period	Low flow period	High flow period	
		%	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	m^3/d
Base Case	-	5%	6,530	7,660	7,550	8,820	44,400	52,160	3,950
K_H	Increased by 67%	7%	9,720	11,160	11,270	12,900	64,640	74,300	5,440
	Reduced by 67%	25%	6,030	6,850	7,480	8,420	36,700	42,540	7,050
K_V	Increased by 67%	9%	6,040	7,290	7,920	9,330	46,120	54,280	1,720
	Reduced by 67%	42%	7,590	8,830	8,690	10,090	44,820	53,380	10,510
R	Increased by 67%	32%	12,260	14,320	14,400	16,730	66,980	81,220	17,630
	Reduced by 67%	24%	1,050	1,220	1,350	1,570	21,880	23,740	0 (note2)
K Fault	$K_h = K_v = 5x10^{-6}$ m/s	26%	6,860	8,180	7,830	9,320	45,820	54,860	10
S_S	Multiplied by 10	-	6,240	6,770	7,280	7,920	43,100	47,080	7,770
	Divided by 10	-	6,780	10,120	8,420	11,960	66,840	101,060	3,540
S_Y	Increased by 67%	-	6,360	7,610	7,360	8,770	43,260	51,780	3,910
	Reduced by 67%	-	6,360	7,610	7,360	8,770	43,280	51,880	3,910

Note:

(1) Baseline baseflow predictions at BC08 are doubled to account for the groundwater discharges coming from the west side of the Bitter Creek valley, outside the model domain.

(2) When recharge is set to 10% of MAP, the water table is predicted to fall below the existing decline; hence, no groundwater mine inflow is predicted.

Table 18: Sensitivity of Closure to Post-Closure Model Outputs

Parameter	Parameter Variation	Max. Annual Mine Inflow (note 1)	Monthly Average Reduction of Base-Flow in Goldslide Creek (GSC02) (note 2)	Monthly Average Reduction of Base-Flow in Rio Blanco Creek (RBC02) (note 2)	Monthly Average Reduction of Base-Flow in Bitter Creek (BC08) (note 2, 5)	Contributions from Mine to Base-Flow in Goldslide Creek (GSC02)	Contributions from Mine to Base-Flow in Rio Blanco Creek (RBC02)	Contributions from Mine to Base-Flow in Bitter Creek (BC08)	Re-flood Time (Note 4)
		m^3/d	%	%	%	m^3/d	m^3/d	m^3/d	yr
Base Case	-	3,810	-2%	-1%	-1%	680	430	740	23
K_H	Increased by 67%	1,220	-3%	-2%	0%	680	430	740	12
	Reduced by 67%	2,380	-4%	-1%	-1%	520	270	580	18
K_V	Increased by 67%	2,380	-5%	-4%	-1%	430	270	550	13
	Reduced by 67%	7,660	-5%	-4%	-1%	950	630	990	>50
R	Increased by 67%	5,030	-8%	-6%	-2%	680	430	740	6
	Reduced by 67%	*See note (3)*				70	20	70	680
K Fault	$K_h = K_v = 5x10^{-6}$ m/s	3,060	-2%	-1%	0%	220	180	290	>50
Ss	Multiplied by 10	9,980	-5%	-5%	-3%	680	430	740	15
	Divided by 10	2,380	-14%	-10%	-3%	680	430	740	19
Sy	Increased by 67%	3,800	-2%	-1%	-1%	680	430	740	23
	Reduced by 67%	3,790	-2%	0%	-1%	680	430	740	23

Note:

(1) Model output at End of Year #6 (EOM)
(2) Reduction of base-flows during low-flow conditions at year 6 of mining
(3) When recharge is set at 10% of MAP, the water table is predicted to fall below the existing decline; hence, no groundwater mine inflow is predicted.
(4) 95% recovery
(5) Baseline baseflow predictions at BC08 are doubled to account for the groundwater discharges coming from the west side of the Bitter Creek valley, outside the model domain.

Results of the sensitivity analyses are summarized in Table 19, according to sensitivity types as defined by Brown (1996). Sensitivity types are defined as follows:

- Type I: There are insignificant effects for both model calibration residuals and predictive model results (relative to modeling objectives). In other words, within a reasonable range of values the parameter is varied, but nothing significant happens as a result. This parameter type does not need further data collection or monitoring;
- Type II: There is a significant effect on model calibration, but an insignificant effect on predictive model results (relative to modeling objectives). The model calibration is affected (residuals increase for some part of the parameter range being tested) so the parameter has an effect on calibration goodness of fit. However, the results of the predictive model are still insensitive to this parameter;
- Type III: There are significant effects on both model calibration and model prediction results (relative to modeling objectives). The parameter has an effect on calibration goodness of fit and a corresponding effect on predictive model results; and,
- Type IV: There is an insignificant effect on model calibration, but a significant effect on predictive model results (relative to modeling objectives). The model calibration is not affected and does not help constrain this parameter value, while the results of the predictive model are sensitive to this parameter.

Table 19: Sensitivity Types of the Red Mountain cirque TSA Groundwater Model

		Change in Calibration	
		Insignificant	Significant
Change in Prediction Results	Insignificant	**Type I** *Sy*	**Type II** *none*
	Significant	**Type IV** *none*	**Type III** *Kh, Kv, R, Fault, Ss*

The sensitivity analysis indicates that:

- Type I and II sensitivities are of little concern because the impact on predictions is insignificant. Only Sy falls into this category;
- Type III sensitivity is of concern only for an uncalibrated model, or where a wide range of calibrations is possible, and a proper calibration of this parameter is the solution. The sensitivity is important but it is known and can be avoided by model calibration. K_H, K_v, R, Ss and the modeling of geological structures fall into this type; and,
- Type IV sensitivity is cause for concern because non-uniqueness in a model input might allow for a range of valid calibrations, but the choice of value significantly impacts model prediction.

It is important to determine the actual value of this parameter and not rely on model calibration to estimate this parameter. It should be measured with robust data (model field audit), and ideally, the data should represent the same stresses as in the predictive model simulations. There is no parameter categorized as Type IV.

6.9 Limitations of the Groundwater Model

The model was developed based on the available data. At the scale of the mine site, the model simulates reasonably well the site observations and the regional behaviour of the groundwater system. Model results have highest confidence in the vicinity of the mine area, where there is relatively more data.

It is clear from the sensitivity analysis that the uncertainty of the model outputs is tied to the characterisation of the hydraulic conductivity field, the seasonal recharge rate R, and the determination of structures acting as major conduits. The uncertainty for each of these parameters is discussed below:

- The hydraulic conductivity field is best characterized for the porphyry intrusion, at and around the ore deposit; whereas data further from the mine are limited. Hydraulic conductivity field testing provides a good characterisation of K along the primary direction of flow and is generally biased towards more permeable features (i.e., lower permeability geological units or structures are masked by the higher permeability features). Actual conditions may vary locally due to variations in K or other material properties where data are not available.
- Recharge rate varies seasonally and annually according to climatic conditions. It is conceivable that values range between 10% and 50% MAP. Recharge mechanisms have been hypothesized based on climate and site groundwater data, but uncertainty remains on how the combination of temperature, precipitation and snowmelt affects the magnitude of groundwater inflow reporting into the mine during freshet and the summer seasons.
- There is also significant uncertainty with respect to groundwater recharge or discharge below areas covered with glaciers. It is believed that these glaciers may contribute recharge to the groundwater system year round; however, the magnitude of this contribution is unknown. Discharge of groundwater originating from higher elevation likely occurs locally.
- While geological structures have been mapped, it is not possible to confirm, with the available data, where large-scale fractures and faults are connected and where they act as a conduit or as barrier to flows.

7 Conclusions

The final calibrated models reproduced the regional hydrogeological system reasonably well, with a steady-state normalized root mean squared error (NRMSE) for calculated versus observed hydraulic heads of 5.1%. NRMSE values less than 10% are commonly considered to be an acceptable level of model calibration. Seasonal water level variability at each of the four monitoring stations were consistent with the measured transient levels. The Base Case calibrated model predicted a base-flow along Goldslide Creek of 5,500 m^3/d during low-flow winter conditions, higher than the base-flow of 1,800 m^3/d inferred from a base-flow separation analysis using regional data. The simulated groundwater inflow following a 100-day dewatering event in the existing decline was approximately 2,200 m^3/d, about average compared to the observations reported in 1996 and 2016.

The calibrated models were used to simulate the groundwater system during mining operations, over the proposed mine life of six years and from closure to post-closure conditions.

The primary conclusions of this work are as follows:

- The Base Case model predicts that mine inflows will rise gradually to an annual average inflow of about 3,810 m^3/d in Year 2 and then decrease from this point onward to about 2,640 m^3/d. For the Upper Case model, the annual average inflow is about 6,400 m3/d and the final inflow is about 4,400 m^3/d.
- The model also predicts a maximum monthly peak inflow of 6,000 m^3/d (Base Case) and 10,000 m^3/d (Upper Case) when new developments and/or stopes are added to the model on a yearly time step. Although these inflow rates are an artefact of the model simplifications, SRK suggests considering a conservative upper limit of 10,000 m^3/d to size peak capacity of the water management system.
- The extent of the mine drainage-induced drawdown cone is 3.8 km^2 in area and the maximum drawdown is about 110 m at the vicinity of the Lower Portal entrance. The magnitude of the drawdown is insignificant in terms of groundwater usage since there are no groundwater resources in use close to the site (MOE 2016e,f).
- The model indicates that the Project could cause a maximum average monthly reduction in base-flow of 36% (110 m^3/d) at GSC09, located in close proximity with the mine, 4% at GSC02 (290 m^3/d), located further downstream, 3% (220 m^3/d) at RBC02, and 1% (600 m^3/d) at BC08. The maximum reductions are calculated to occur between March and May, at the end of the low-flow winter conditions.
- The groundwater system is predicted to have reached a 95% recovery after 23 years for the Base Case Model, 17 years for the Upper Case model and 40 years for the Lower Case model. For the purposes of assessing ARD reactions and/or metal leaching/mobility, it should be assumed that the full mined-out volume could be exposed to oxygen for a period ranging between 20 and 40 years. After this period, the system will have recovered to baseline conditions and the groundwater level in the mine will be expected to fluctuate seasonally. During winter low-flow conditions, the water table will be expected to drop to an average elevation of about 1,790 masl, as indicated by the 2003-2006 groundwater level

records within the existing decline, leaving about 30% of the mine-out volume exposed to the mine atmosphere. During the freshet and summer periods, the water table will rise and will be expected to flood almost all the mined-out volume.

- In terms of potential discharge of groundwater affected by the mine into surface water receptors, the Base Case model predicts that about 1,430 m^3/d will flow through the mined-out volumes, and move topographically downhill on Red Mountain. The particle path analysis, which represents the complete steady-state flow path from source to final receptor, indicates that the first particle (i.e., earliest discharge of mine-affected groundwater) will travel for a minimum of about 5 years before it reaches Goldslide Creek in the Upper Cirque area, about 40 years to reach Rio Blanco Creek, and about 90 years to reach Bitter Creek in the valley. The mean LTE of groundwater originating from the south end of the stopes is a minimum of 40 years before it reaches a surface water receptor.
- The maximum contributions of groundwater potentially influenced by the mine to the creeks' base-flow, assuming the source had an infinite time to reach the receptor, are 55.6% in Goldslide Creek at GSC09, 10.4% in Goldslide Creek at GSC02, 5.6% in Rio Blanco Creek at RBC02, and 1.8% in Bitter Creek at BC08.
- The sensitivity analysis indicates that the uncertainty of the model outputs is tied to the characterisation of the hydraulic conductivity field, the seasonal recharge rate R, and the determination of structures acting as major conduits. The model was developed based on the available data. At the scale of the mine site, the model simulates reasonably well the site observations and the regional behaviour of the groundwater system. Model results have highest confidence in the vicinity of the mine area, where there is relatively more data.
- Actual conditions may vary locally due to variations in K or other material properties where data are not available. The installation of additional groundwater level monitoring points away from the mine would provide an opportunity to confirm the hydraulic conductivity field and to obtain additional groundwater level data. This information would serve to validate the current model predictions. It would also be valuable to confirm the elevation of the groundwater table during the winter low-flow conditions with a piezometer installed at surface or drilled in the existing decline.
- Recharge mechanisms have been hypothesized, based on climate and site groundwater data but uncertainty remains regarding how the combination of temperature, precipitation and snowmelt affects the magnitude of groundwater inflow reporting into the mine during the freshet and the summer seasons. Site measurements of the snow pack thickness above the mine would be the best way to confirm the current recharge assumptions and to reduce uncertainty with respect to this parameter.
- There are significant uncertainties with respect to groundwater recharge or discharge below areas covered with glaciers and the presence of geological structures (i.e., if and where large-scale fractures and faults are connected and where they act as a conduit or as a barrier to flows). These uncertainties are tied to the physical constraints of the site and cannot be easily verified from field investigations.

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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.

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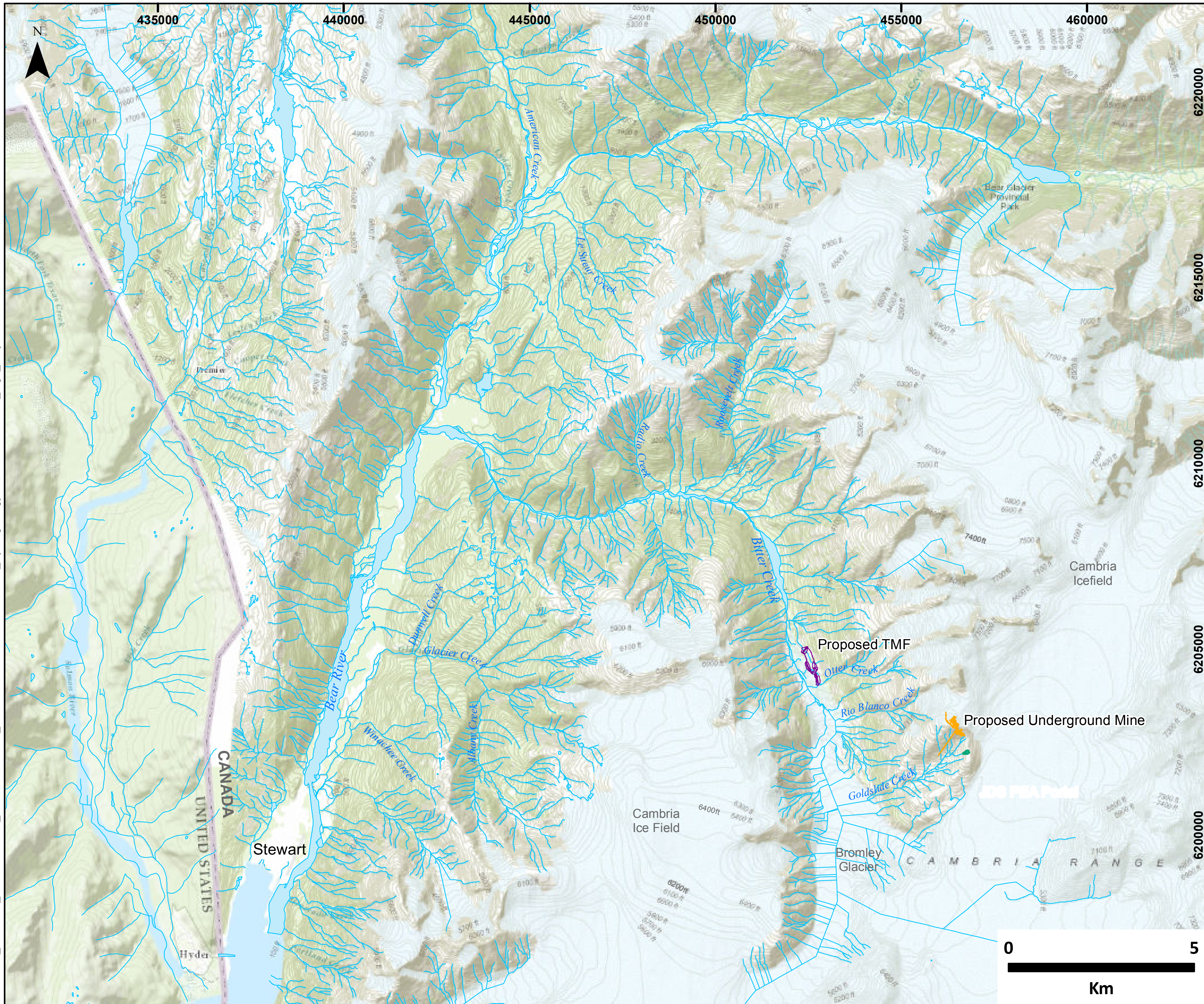
Figures



Legend

- Proposed TMF (PEA Design)
- Existing Waste Rock Dump
- Proposed Underground Mine Projected to Ground Surface
- Watercourse
- Waterbody

Site Location

Notes:
Coordinate System: NAD 1983 UTM Zone 9N

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Red Mountain Hydrogeology

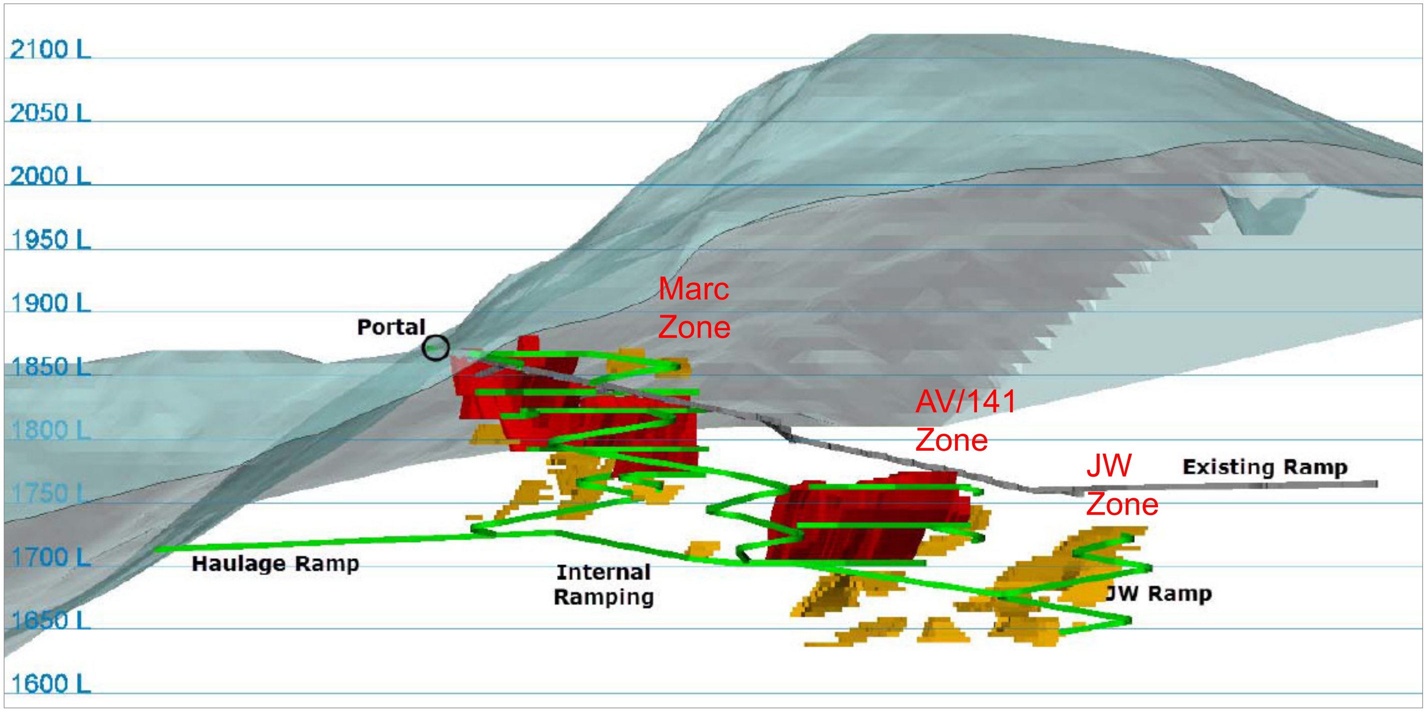
Project Location

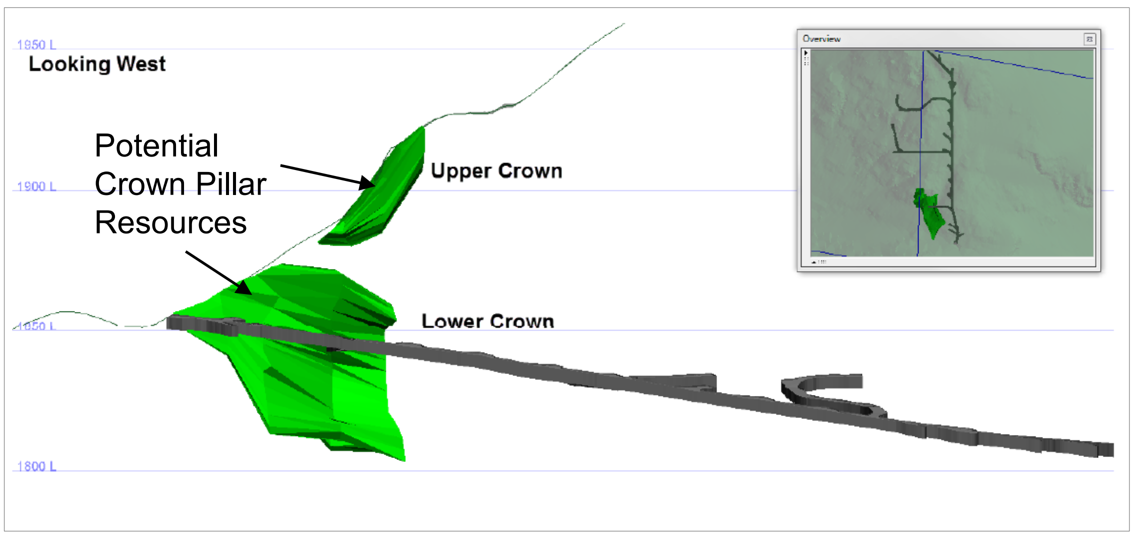
Red Mountain Underground Gold Project

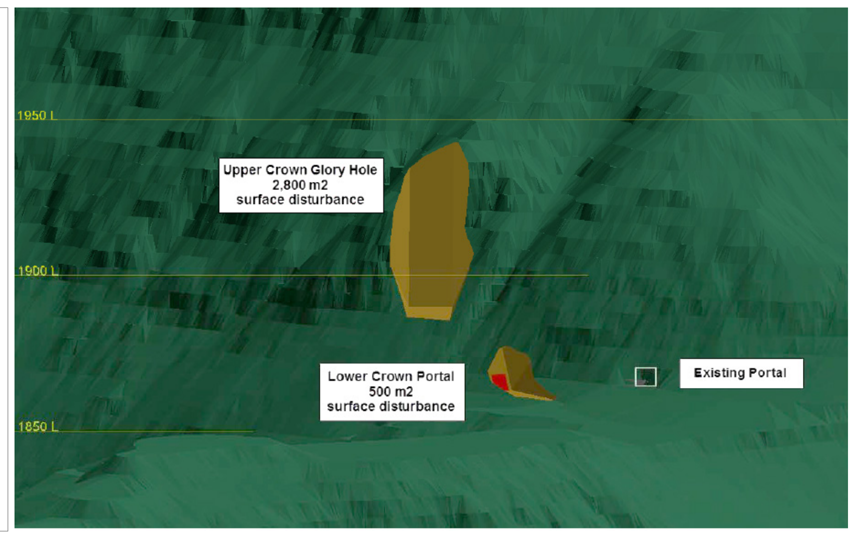
Job No: 1CI019.200.03
Filename: 1CI019.002.200.03_Fig1_ProjectLocation

Date:	Approved:	Figure:
Jan. 2017	GF	1

\\VAN-SVR0\Projects\01_SITES\Red_Mountain_BC\1CI019.002_Phase 2 EA\!040_AutoCAD\GIS\!MXD\2016-12-23_Hydrogeology\1CI019.002.200.03_Fig1_ProjectLocation.mxd







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Job No: 1CI019.002 Filename: Fig_2_UG-3D-View_1CI019-001.pptx	Red Mountain Underground Gold Project	Red Mountain Hydrogeology **3D views of the Proposed Underground Mine** Date: Dec 2016 · Approved: GF · Figure: 2

POST-FRASER GLACIATION
- O, Organic deposits
- Cb, Colluvial blanket
- Ca, Colluvial Apron
- Cf, Colluvial Fan
- Cl, Landslilde Sediments
- Cv, Colluvial Veneer
- Cu, Undivided Colluvial Sediments
- Ap, Alluvial Plain
- Af, Alluvial Fan
- Afd, Fan Delta

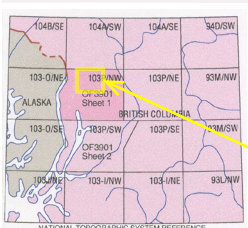
GLACIAL DEPOSITS
- Tnb, Neoglacial Till Blanket
- Tnv, Neoglacial Till Veneer

FRASER GLACIATION (Wisconsinian)
POST GLACIAL DEPOSITS
- Ln, Glaciolacustrine Blanket
- Mb, Glaciomarine Blanket
- Mv, Glaciomarine Veneer
- Gp, Glaciofluvial Plain
- Gd, Glaciofluvial Delta
- Gb, Glaciofluvial Blanket
- Gv, Glaciofluvial Veneer
- Gu, Undivided Glaciofluvial Sediments

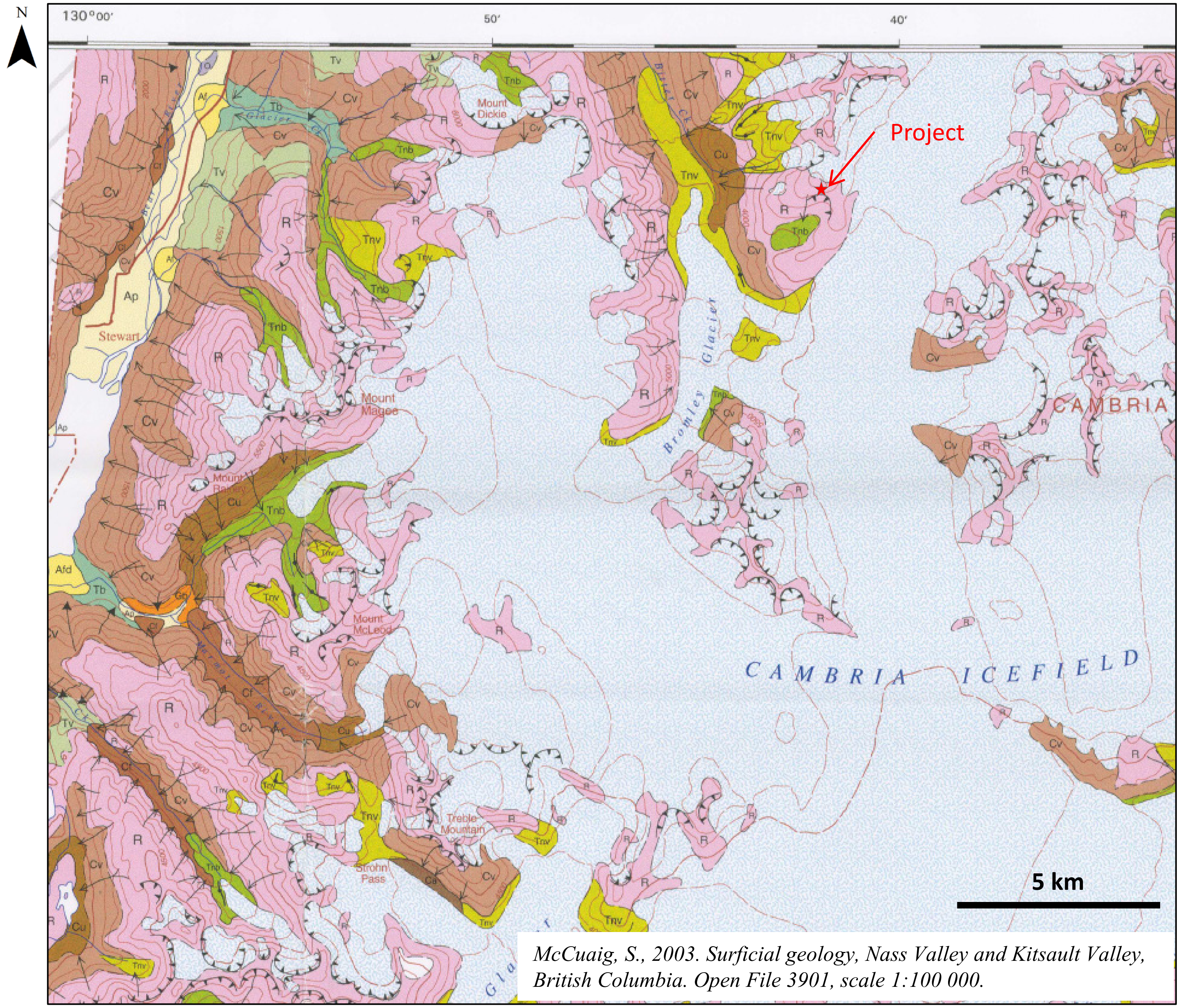
GLACIAL DEPOSITS
- Tb, Till Blanket
- Tv, Till Veneer

BEDROCK
- R Triassic-Jurassic volcanic and sedimentary bedrock

Unit Boundary…...
Avalanche track….
Debris flow track…
Terrace scarp……..
Cirque……………
Meltwater channel..
Drumlin…………..
Moraine…………..



Area of the Kitsault valley surficial map shown to the right



McCuaig, S., 2003. Surficial geology, Nass Valley and Kitsault Valley, British Columbia. Open File 3901, scale 1:100 000.

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Red Mountain Hydrogeology

Extract of Kitsault Valley Surficial Geology Map (McCuaig 2003)

Job No: 1CI019.002

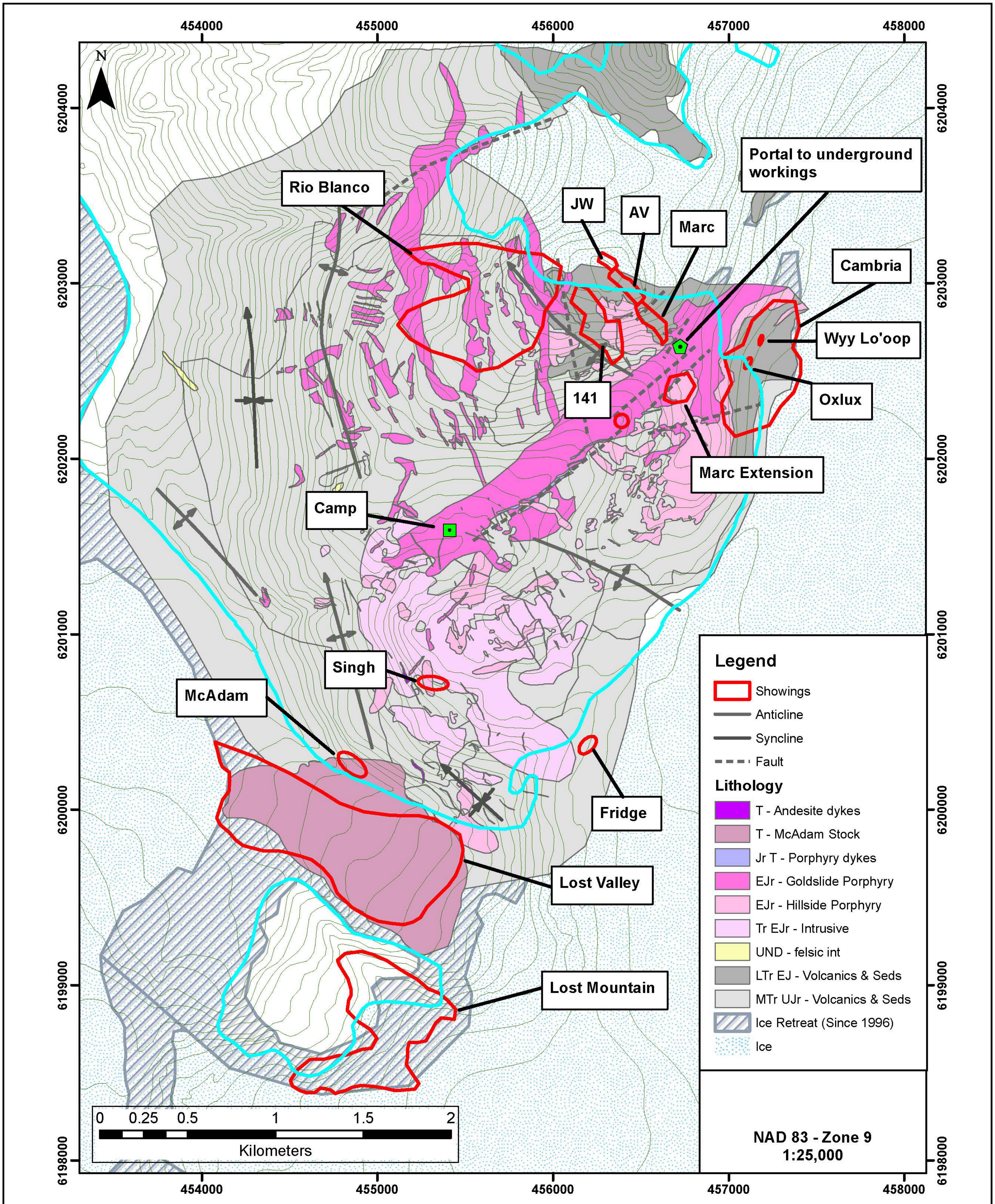
Filename: Fig_3_Surficial_Geology_1CI019-001.pptx

Red Mountain Underground Gold Project

Date: Dec 2016

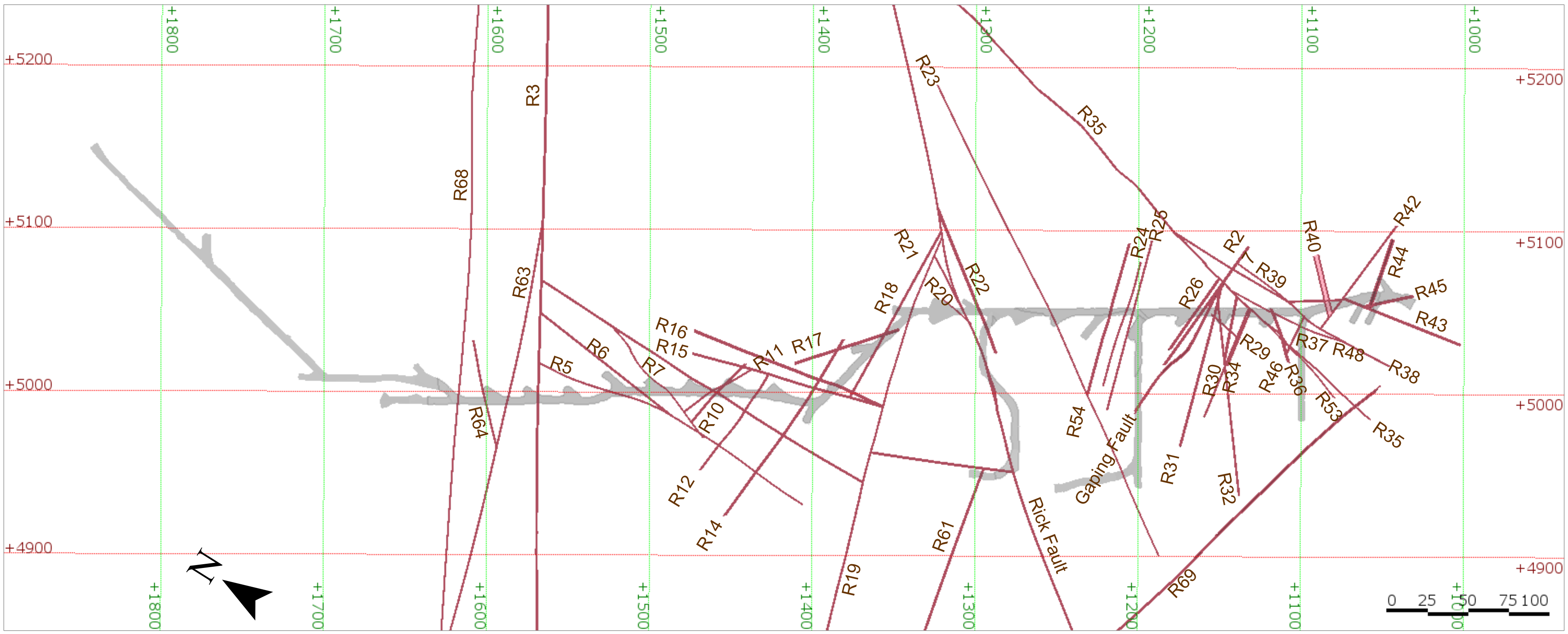
Approved: GF

Figure: 3



srk consulting	IDM MINING	Red Mountain Hydrogeology **Property Scale Bedrock Geology Map**		
Job No: 1CI019.002 Filename: Fig_4_Bedrock_Geology_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016	Approved: GF	Figure: 4

Major Structures and Faults in Plan View



Mine Grid coordinate system

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Job No: 1CI019.002

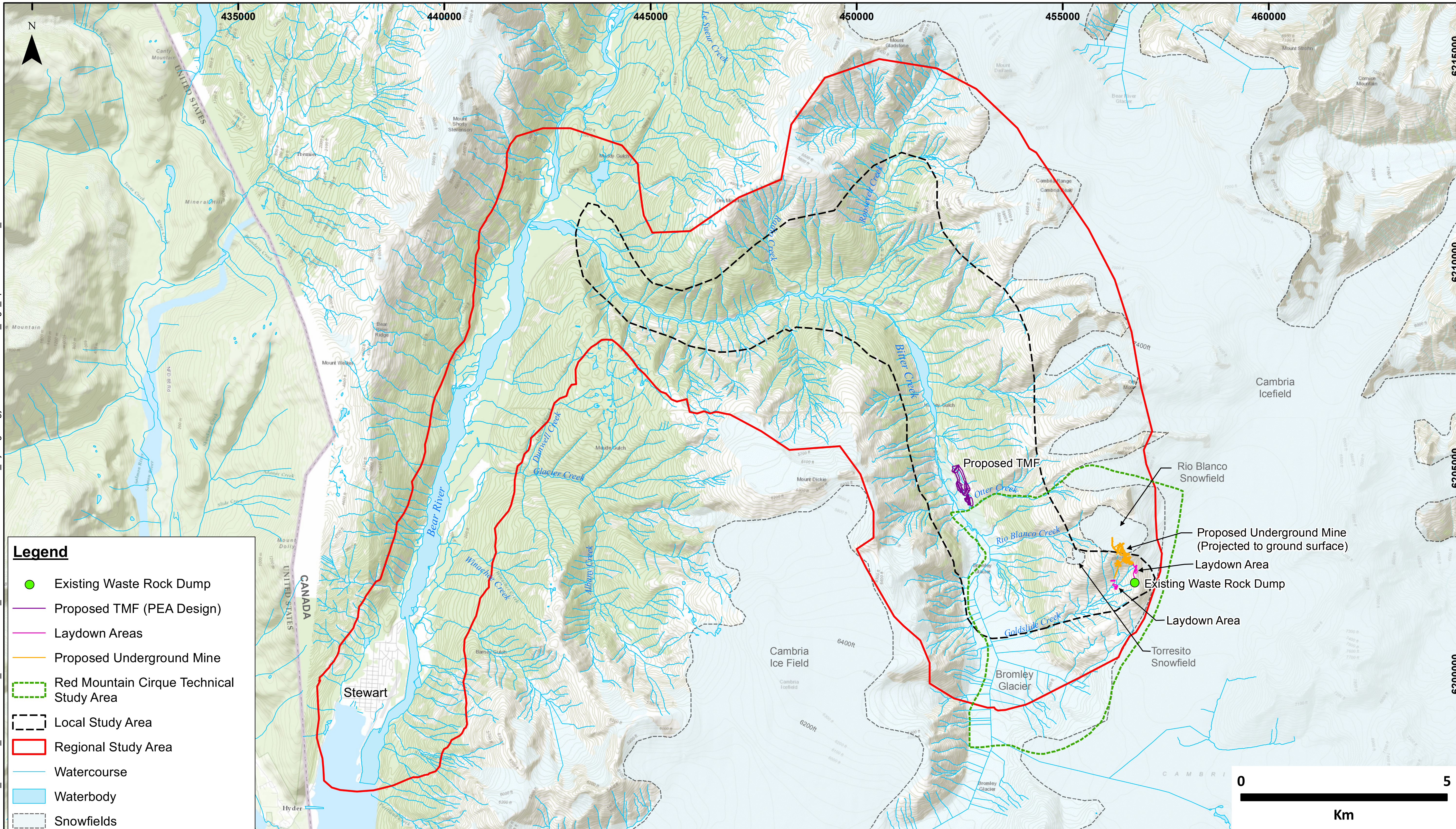
Filename: Fig_5_Major Structure and Faults in Portal.pptx

Red Mountain Underground Gold Project

Red Mountain Hydrogeology

Major Structure and Faults identified in the Existing Decline

Date:	Approved:	Figure:
Dec 2016	GF	5



Notes:
Coordinate System: NAD 1983 UTM Zone 9N

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Red Mountain Hydrogeology

Spatial Boundary

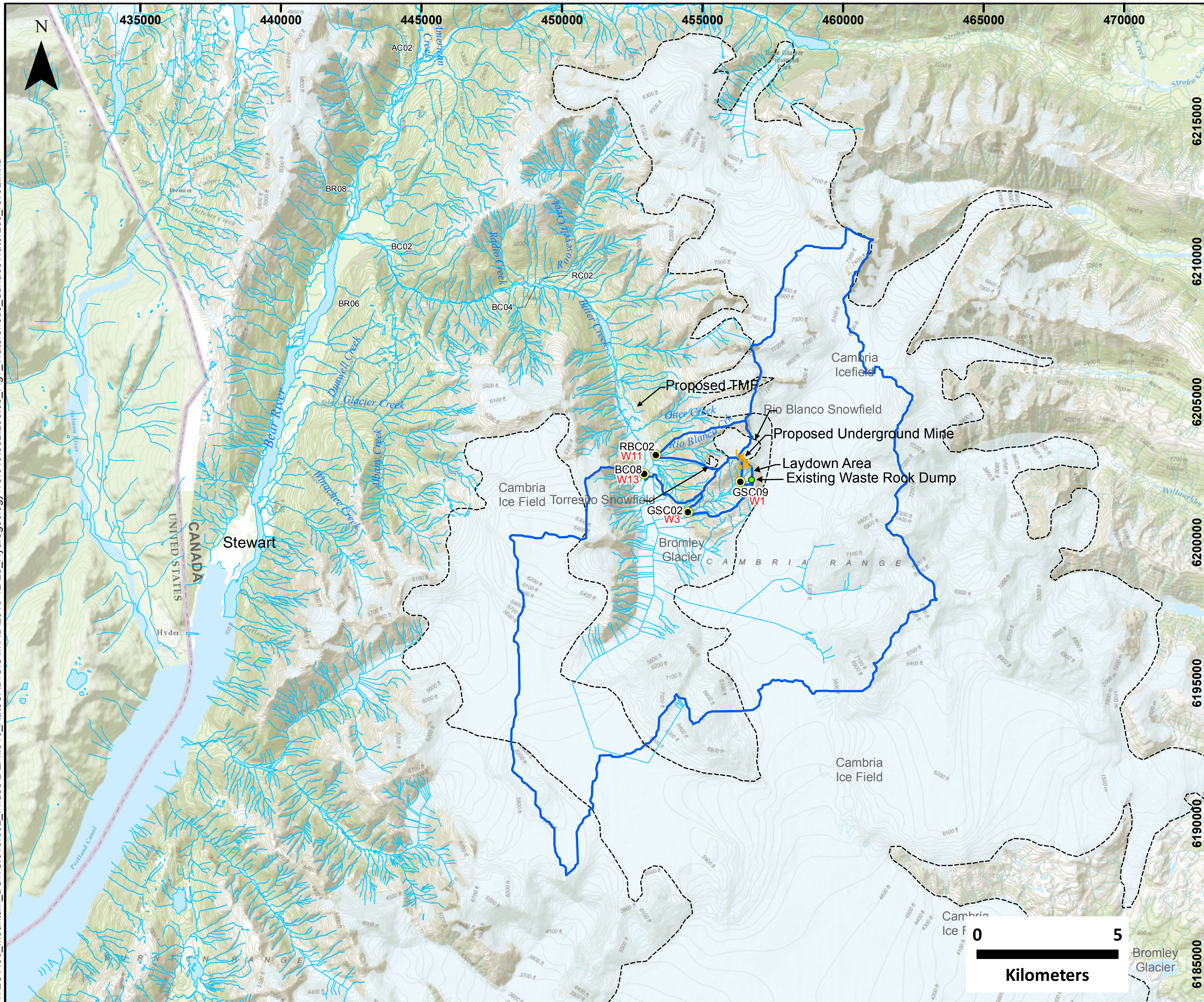
Job No: 1CI019.200.03

Filename: 1CI019.002.200.03_Fig6_SpatialBoundaries_rev01

Red Mountain Underground Gold Project

Date: Jan. 2017 | Approved: GF | Figure: 6

\\VAN-SVR0\Projects\01_SITES\Red_Mountain_BC\1CI019.002_Phase 2 EA\!040_AutoCAD\GIS\!MXD\2016-12-23_Hydrogeology\1CI019.002.200.03_Fig6_SpatialBoundaries_rev01.mxd



RC02

W18 **Legend**

- Surface Water Locations
- Historical Surface Water Locations
- Existing Waste Rock Dump
- Proposed Underground Mine
- Watershed boundaries
- Snowfields
- Watercourse
- Waterbody

Watershed Areas and Glacier/Snowfield Cover

Station	Watershed Area [km²]	Glacier / Snowfield Area [km²]	Glacier / Snowfield Cover [%]
BC08	151.9	133.7	88%
GSC02	2.7	0	0%
GSC09	0.3	0	0%
RBC02	3.2	0.9	28%

Notes:
Coordinate System: NAD 1983 UTM Zone 9N

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Job No: 1CI019.200.03

Filename: 1CI019.002.200.03_Fig7_Watersheds_SurfaceWaterLoc_rev02

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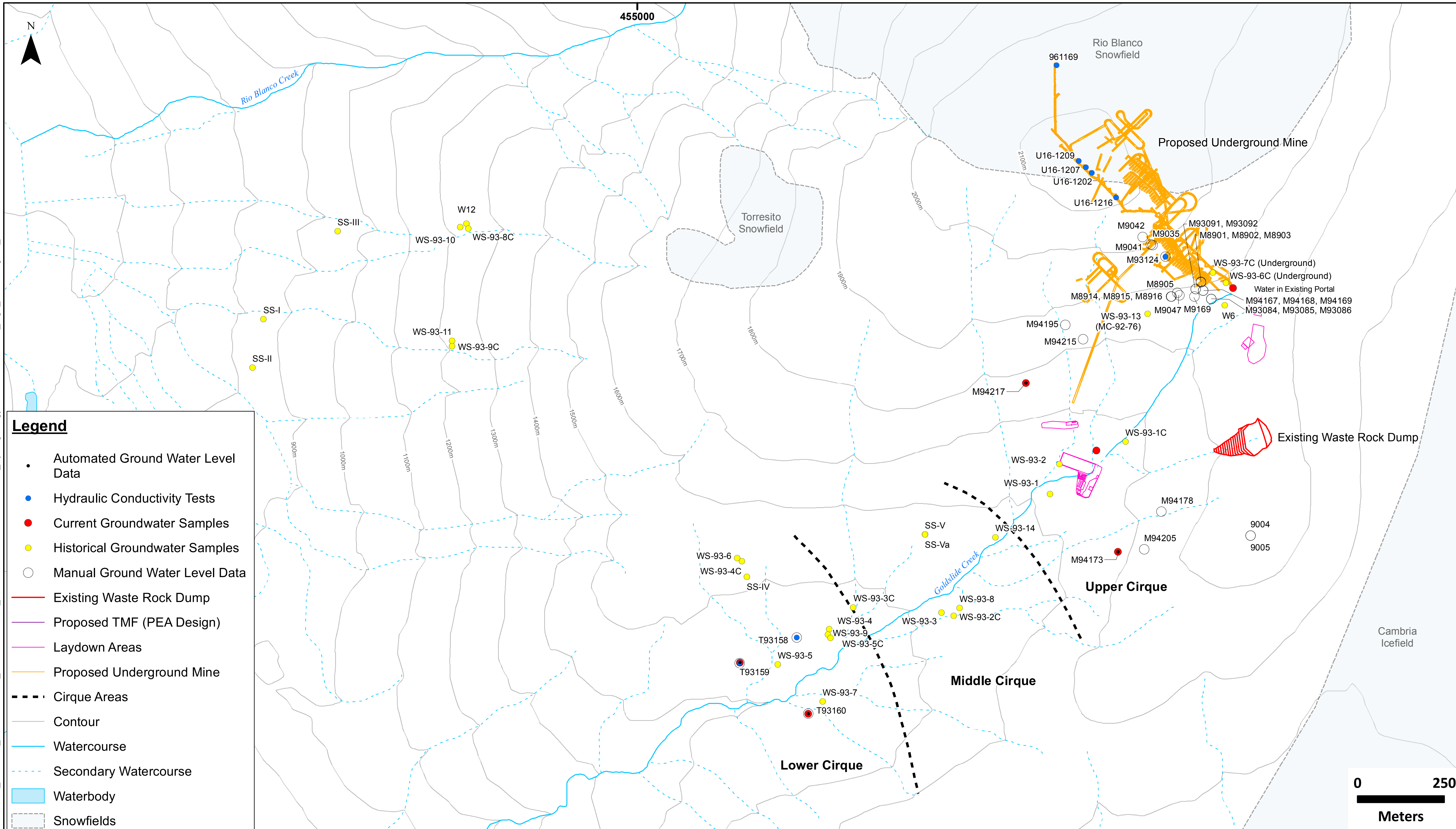
Red Mountain Underground Gold Project

Red Mountain Hydrogeology

Watersheds and Surface Water Locations

Date:	Approved:	Figure:
Jan. 2017	GF	7

\\VAN-SVR0\Projects\01_SITES\Red_Mountain_BC\1CI019.002_Phase 2 EA\!040_AutoCAD\GIS\!MXD\2016-12-23_Hydrogeology\1CI019.002.200.03_Fig7_Watersheds_SurfaceWaterLoc_rev02.mxd



Notes:
Coordinate System: NAD 1983 UTM Zone 9N

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Red Mountain Hydrogeology

Monitoring Location Map for the Red Mountain Cirque TSA

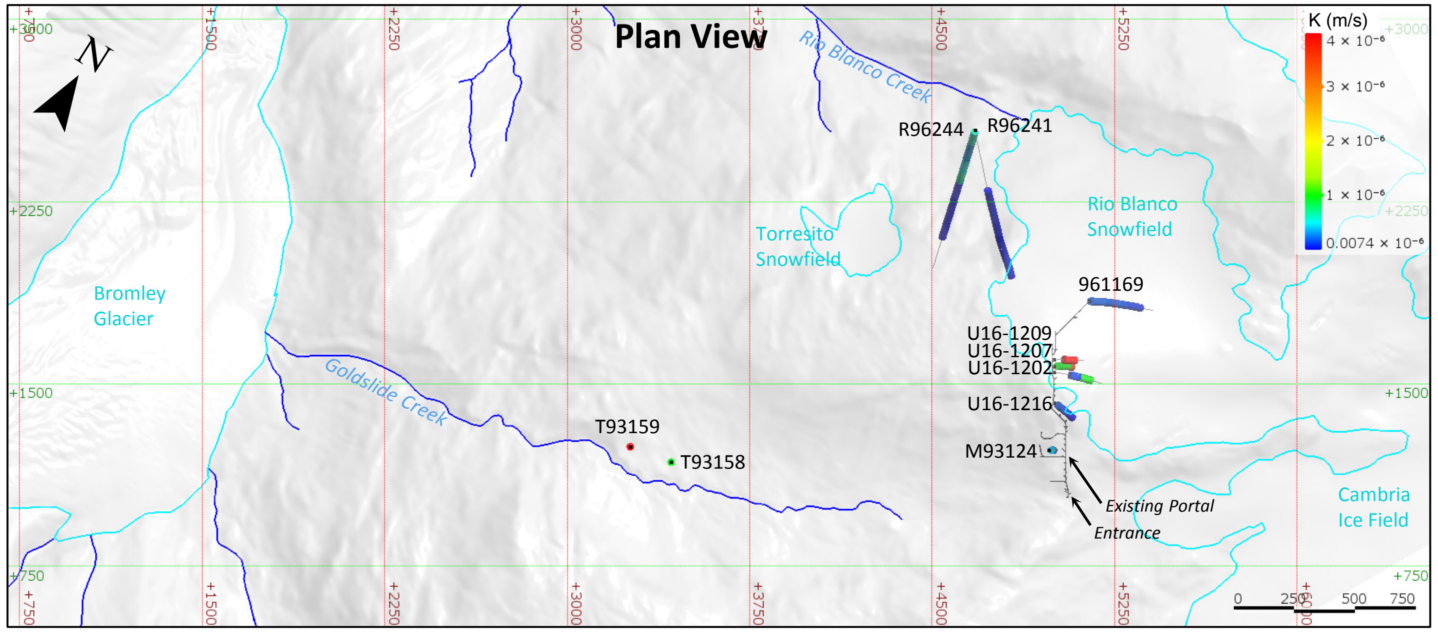
Job No: 1CI019.200.03

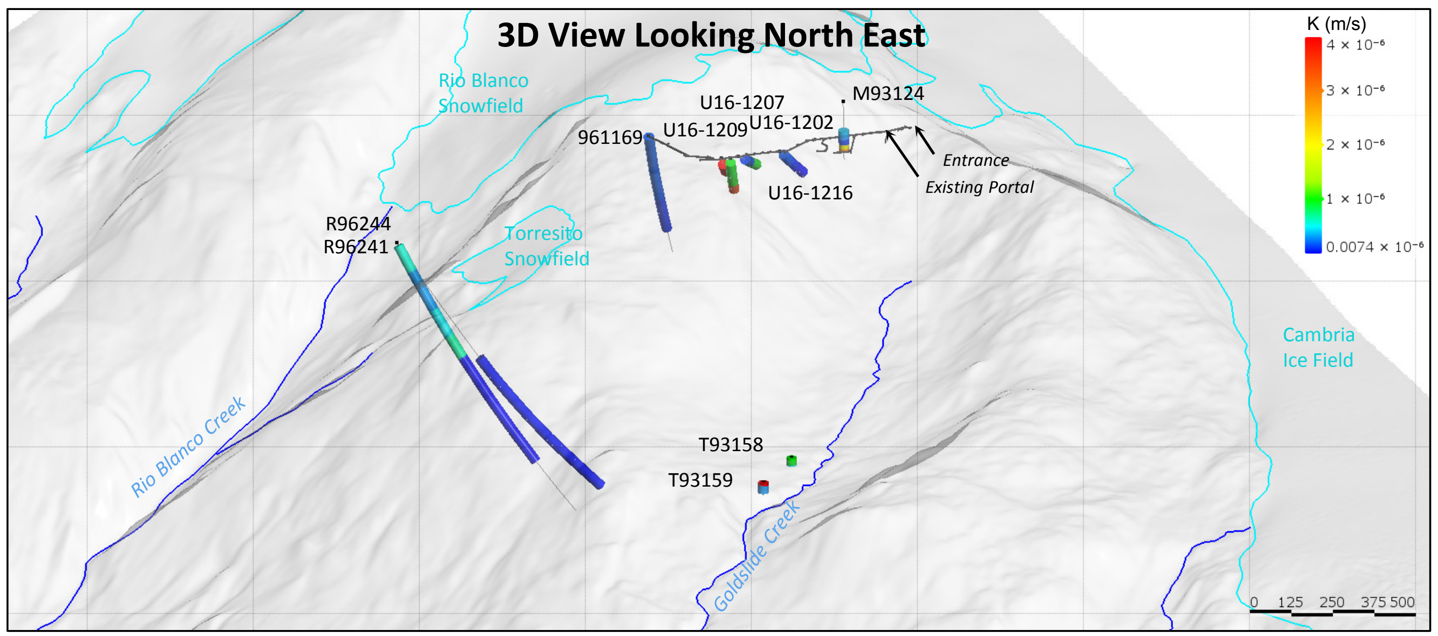
Filename: 1CI019.002.200.03_Fig8_MonitoringLoc_rev01

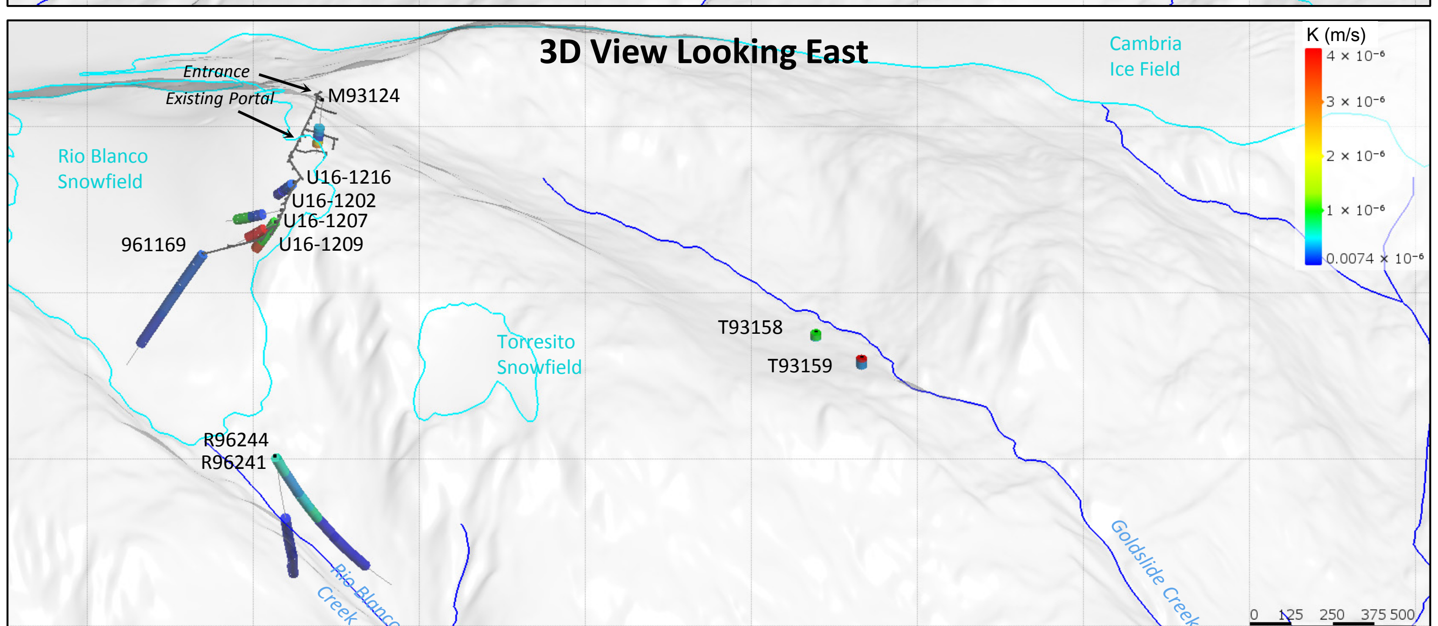
Red Mountain Underground Gold Project

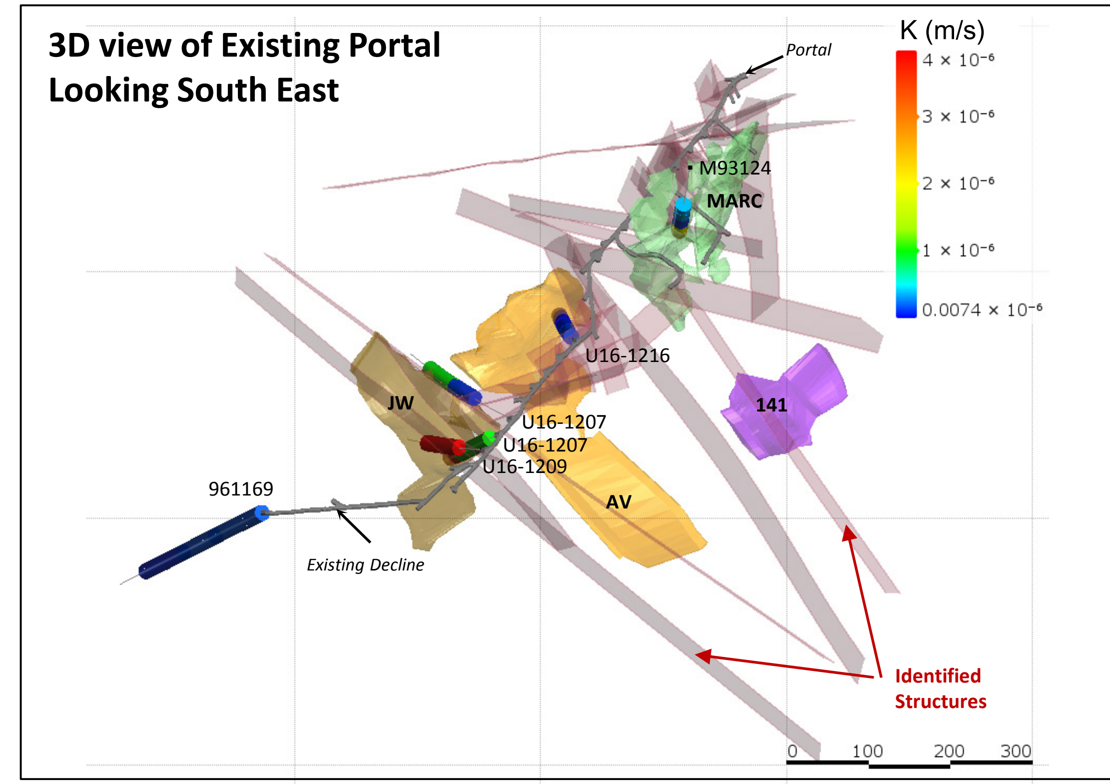
Date:	Approved:	Figure:
Jan. 2017	GF	8

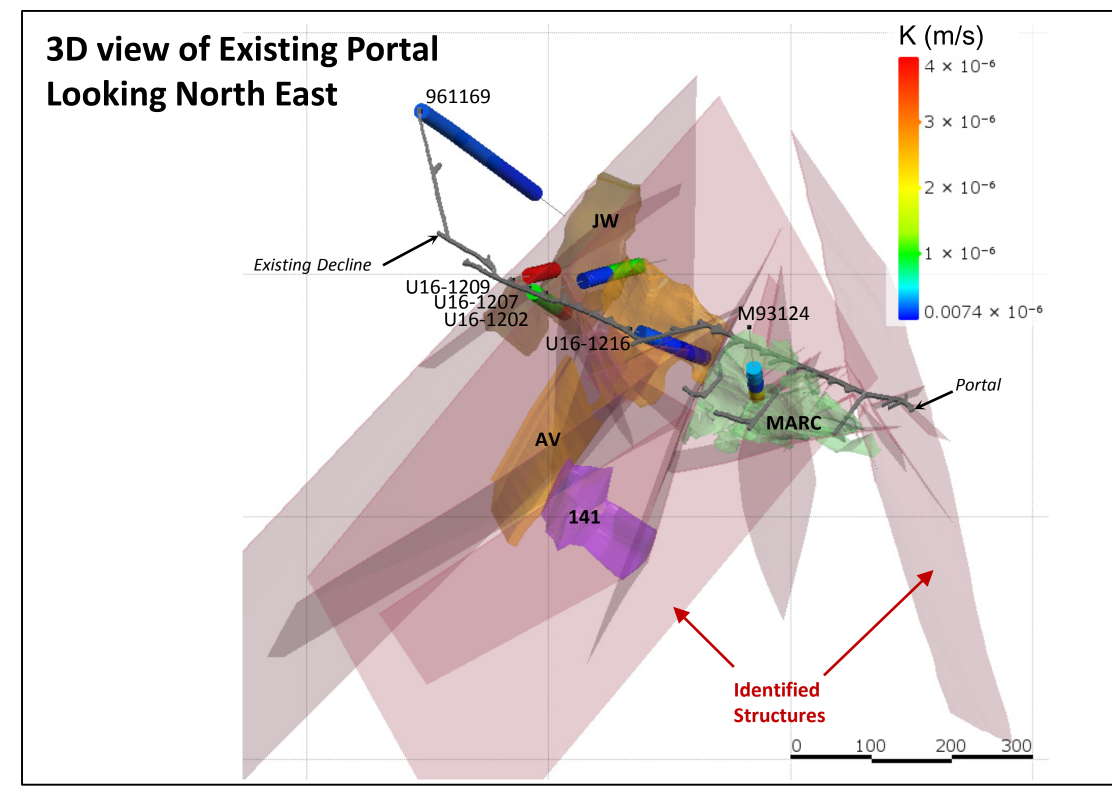
\\VAN-SVR0\Projects\01_SITES\Red_Mountain_BC\1CI019.002_Phase 2 EA\!040_AutoCAD\GIS\!MXD\2016-12-23_Hydrogeology\1CI019.002.200.03_Fig8_MonitoringLoc_rev01.mxd











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Red Mountain Hydrogeology

K tests in 3D views

Job No: 1CI019.002

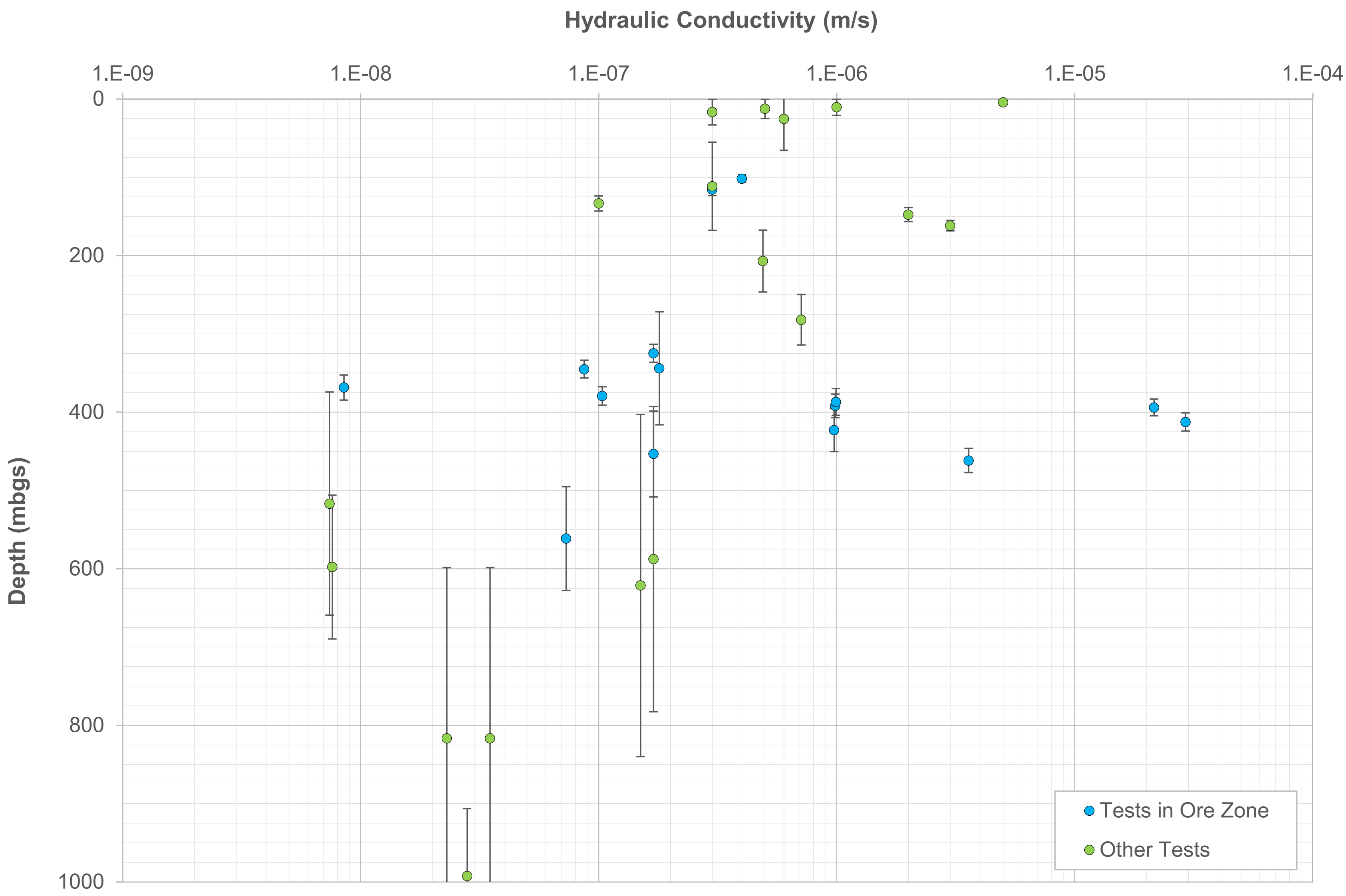
Filename: Fig_9_K-Tests-3D_1CI019-001.pptx

Red Mountain Underground Gold Project

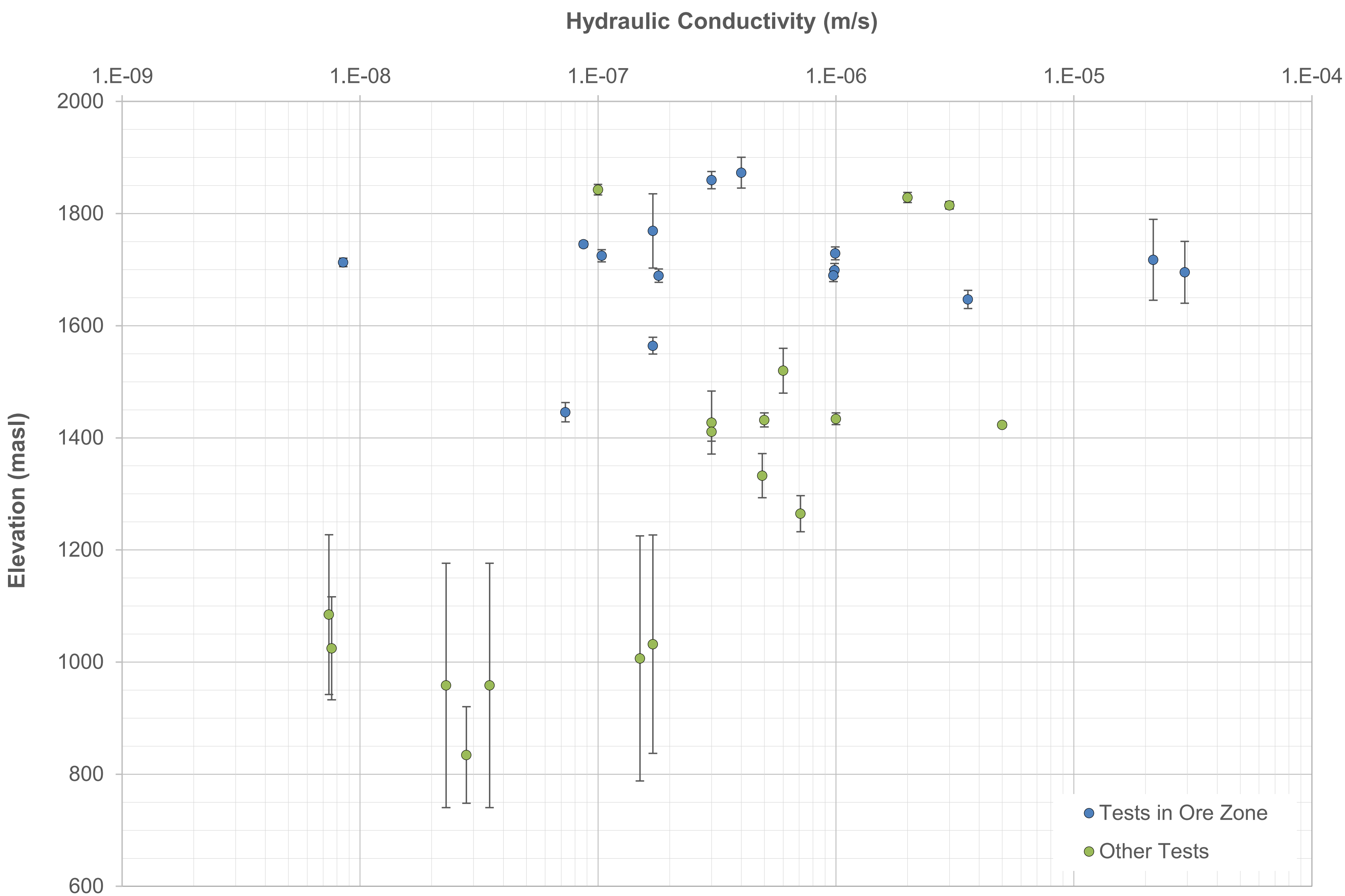
Date: Dec 2016

Approved: GF

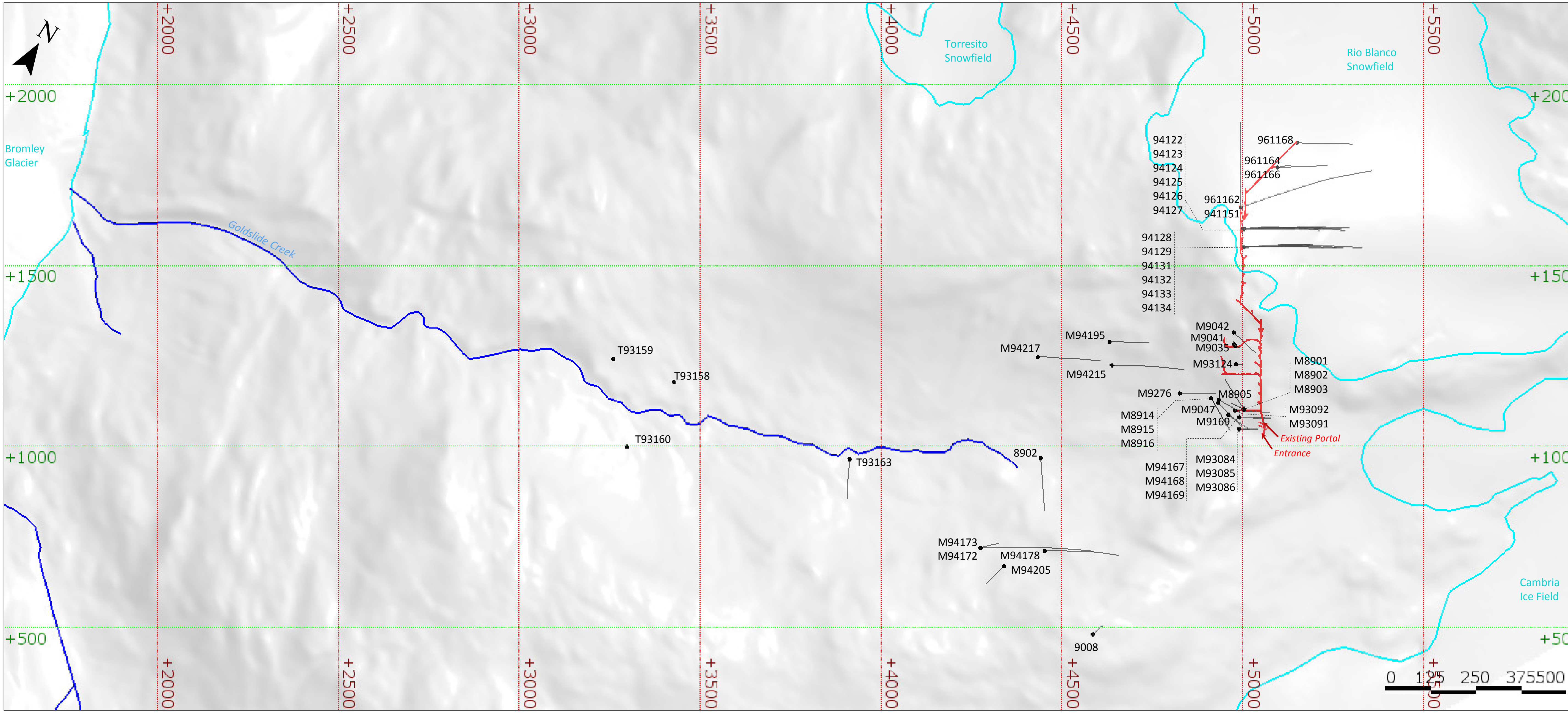
Figure: 9

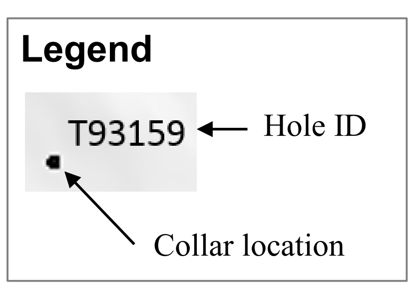


srk consulting	IDM MINING	Red Mountain Hydrogeology **K Versus Depth**
Job No: 1CI019.002 Filename: Fig_10-11_KvsDepth_KvsElev_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 / Approved: GF / Figure: **10**



srk consulting	IDM MINING	Red Mountain Hydrogeology
		K Versus Elevation
Job No: 1CI019.002 Filename: Fig_10-11_KvsDepth_KvsElev_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 · Approved: GF · Figure: **11**





srk consulting

IDM MINING

Job No: 1CI019.002

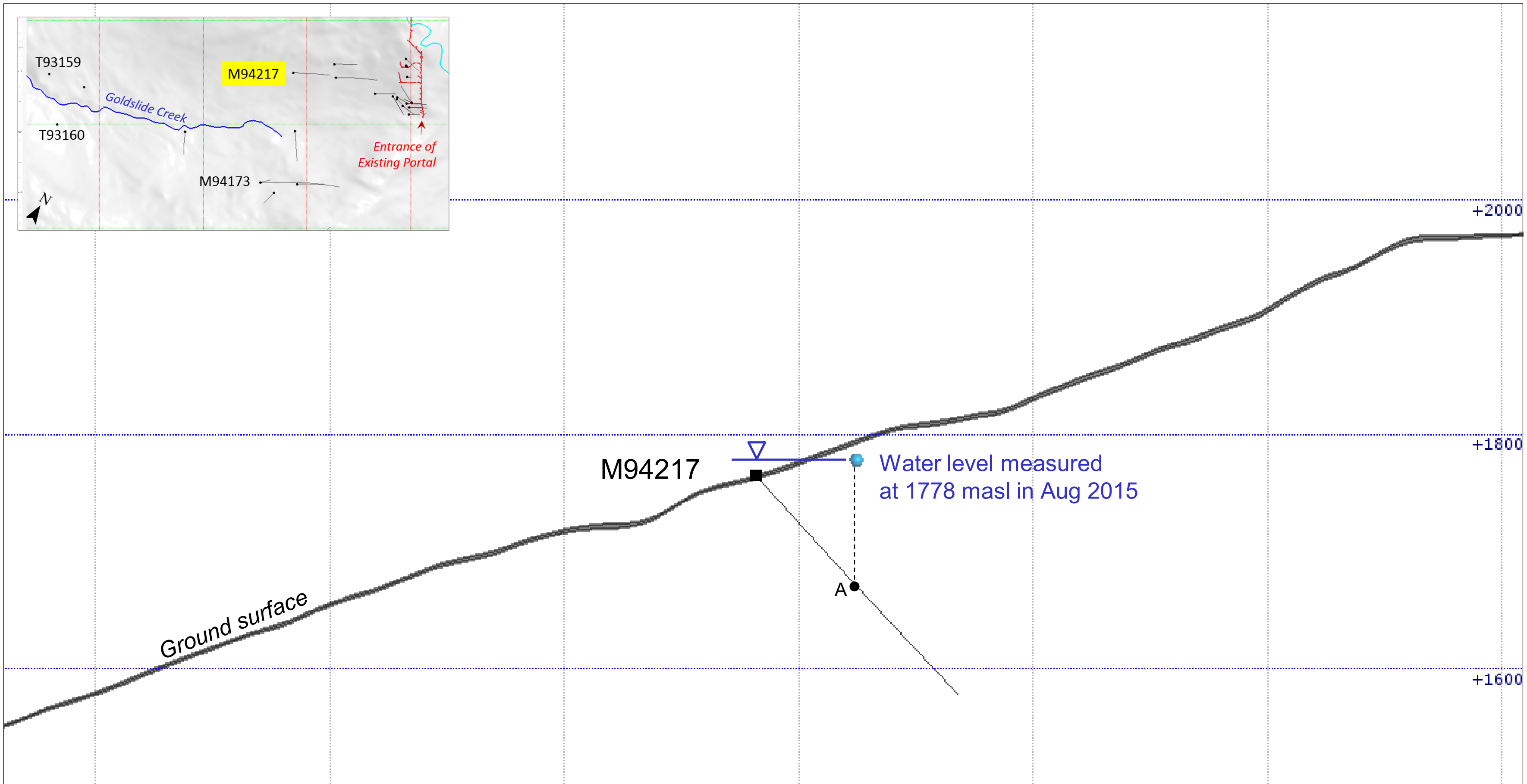
Filename: Fig_12_Map_GW-Head&P_1CI019-001.pptx

Red Mountain Underground Gold Project

Red Mountain Hydrogeology

Location map of groundwater heads and pressure measurements

Date:	Approved:	Figure:
Dec 2016	GF	12

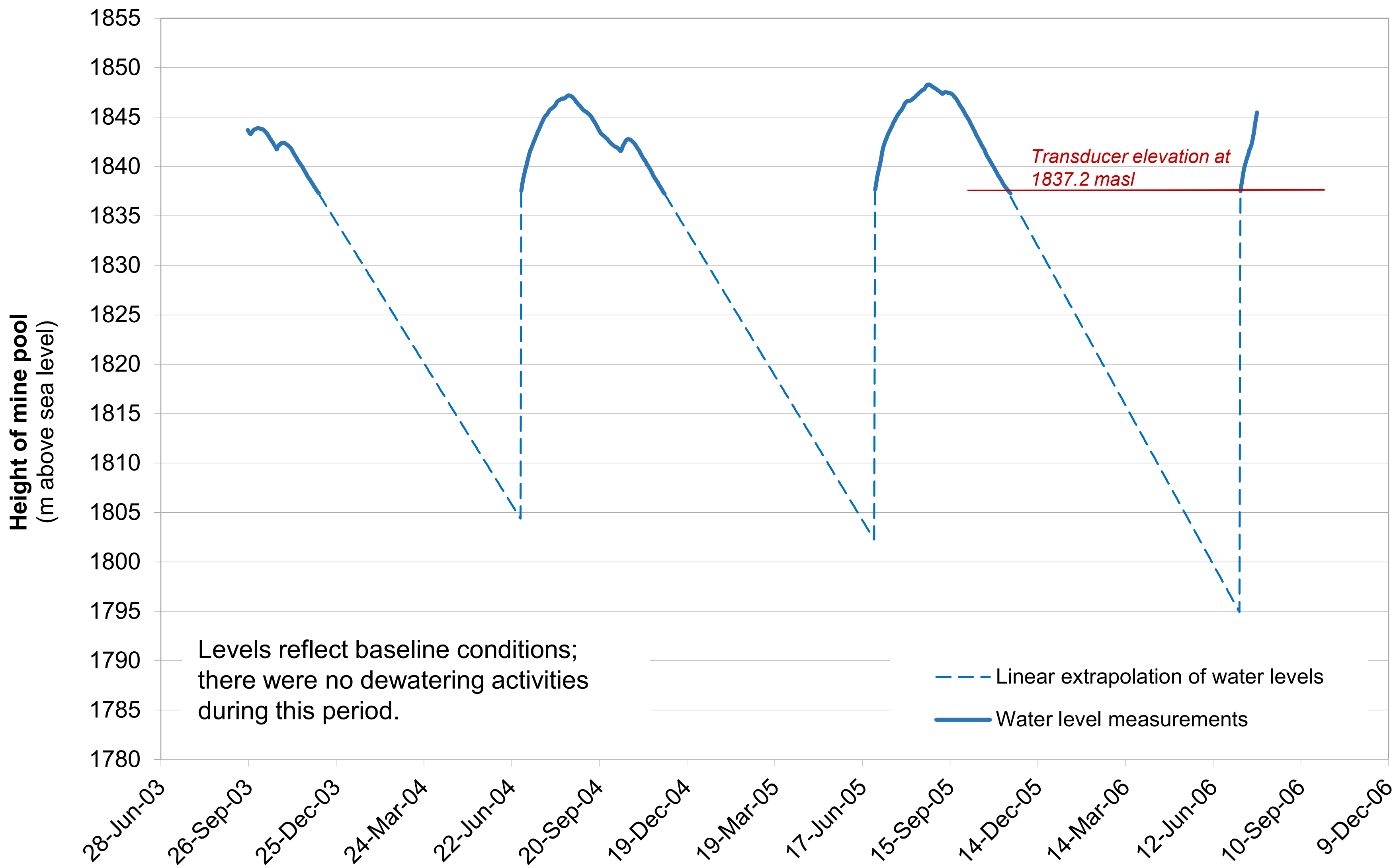


Note:
M94217 is an open exploration borehole capped at surface and installed with a transducer down hole. Since it is not possible to determine the location of groundwater inflow, measurements are assigned to the mid-interval length of the borehole (point A).

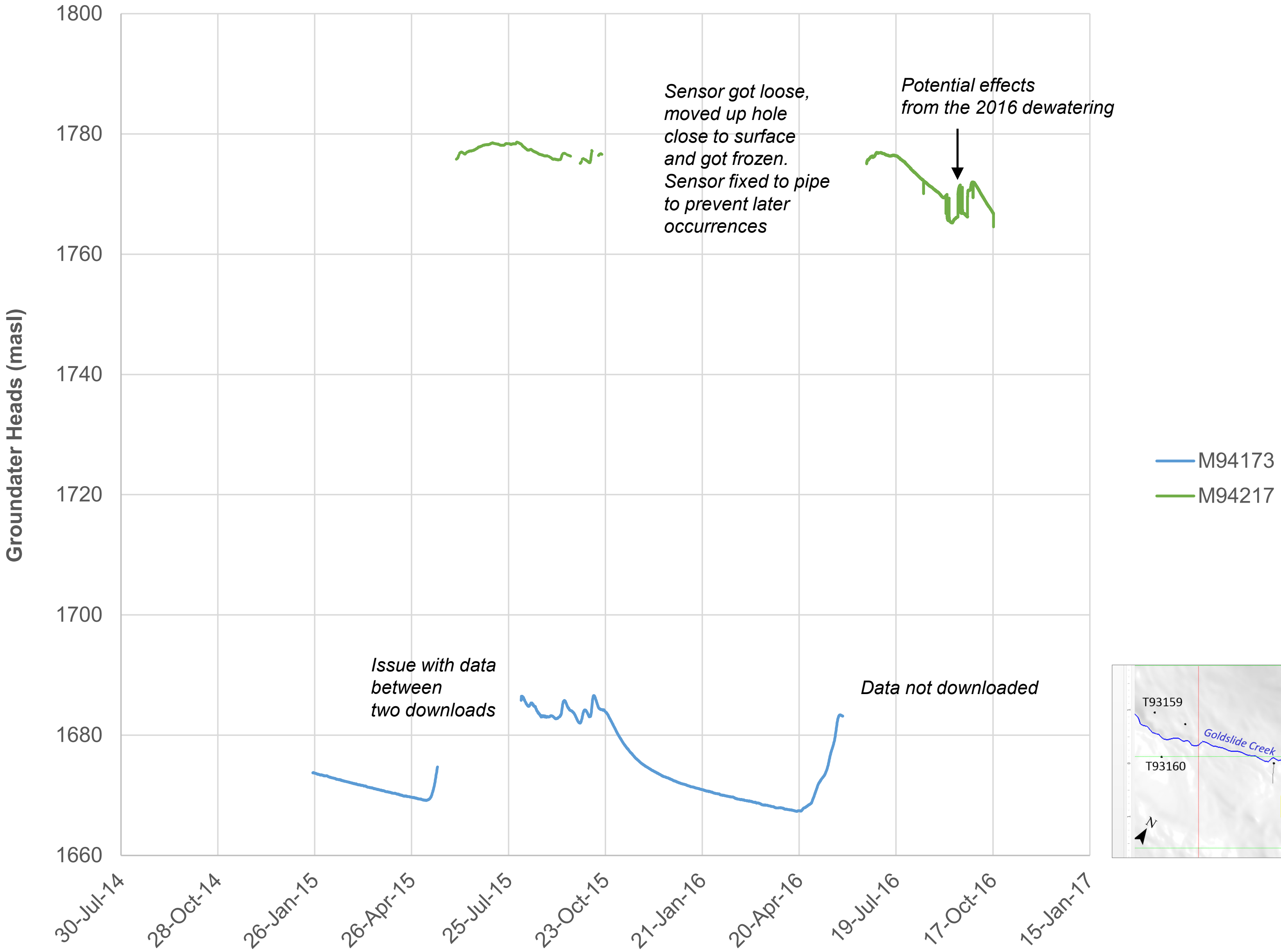
+1400

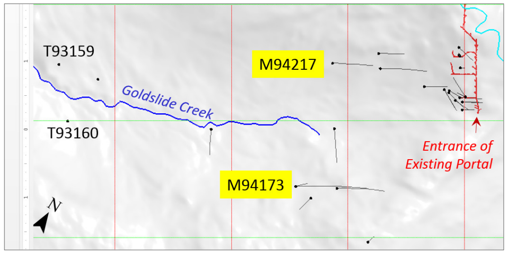
0 50 100 150 200

srk consulting	IDM MINING	Red Mountain Hydrogeology
		Section along borehole trace M94217
Job No: 1CI019.002 Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 · Approved: GF · Figure: 13



srk consulting	IDM MINING	Red Mountain Hydrogeology
		Water Level in the Existing Decline between 2003 and 2006
Job No: 1CI019.002 Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 · Approved: GF · Figure: **14**





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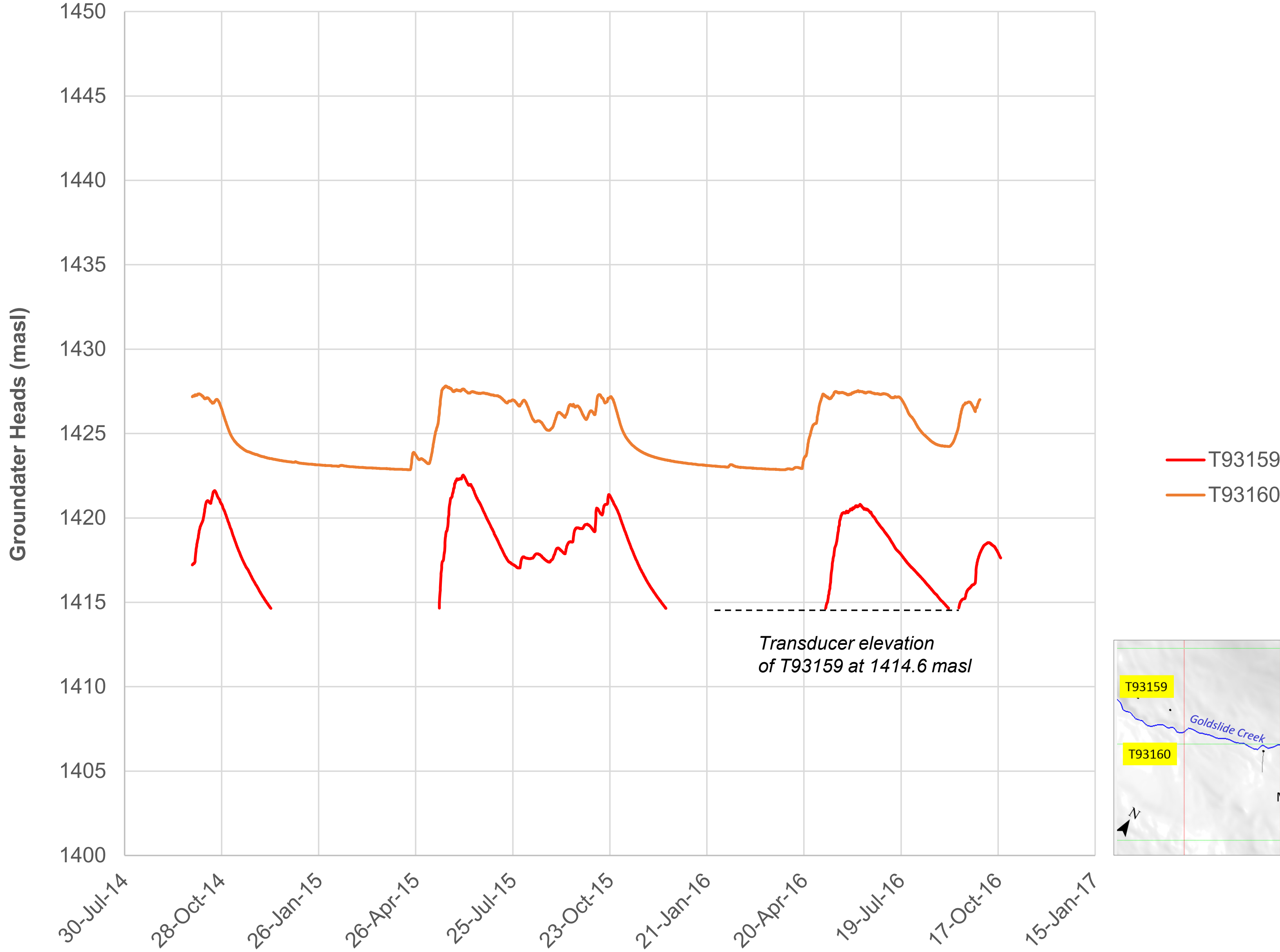
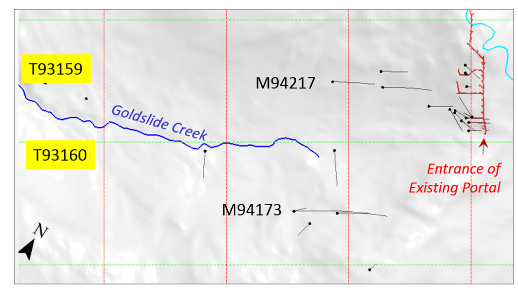
Red Mountain Hydrogeology

Water Level in the Upper Cirque between Sep. 2014 and Sep 2016

Job No: 1CI019.002 Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016	Approved: GF	Figure: 15





Red Mountain Hydrogeology

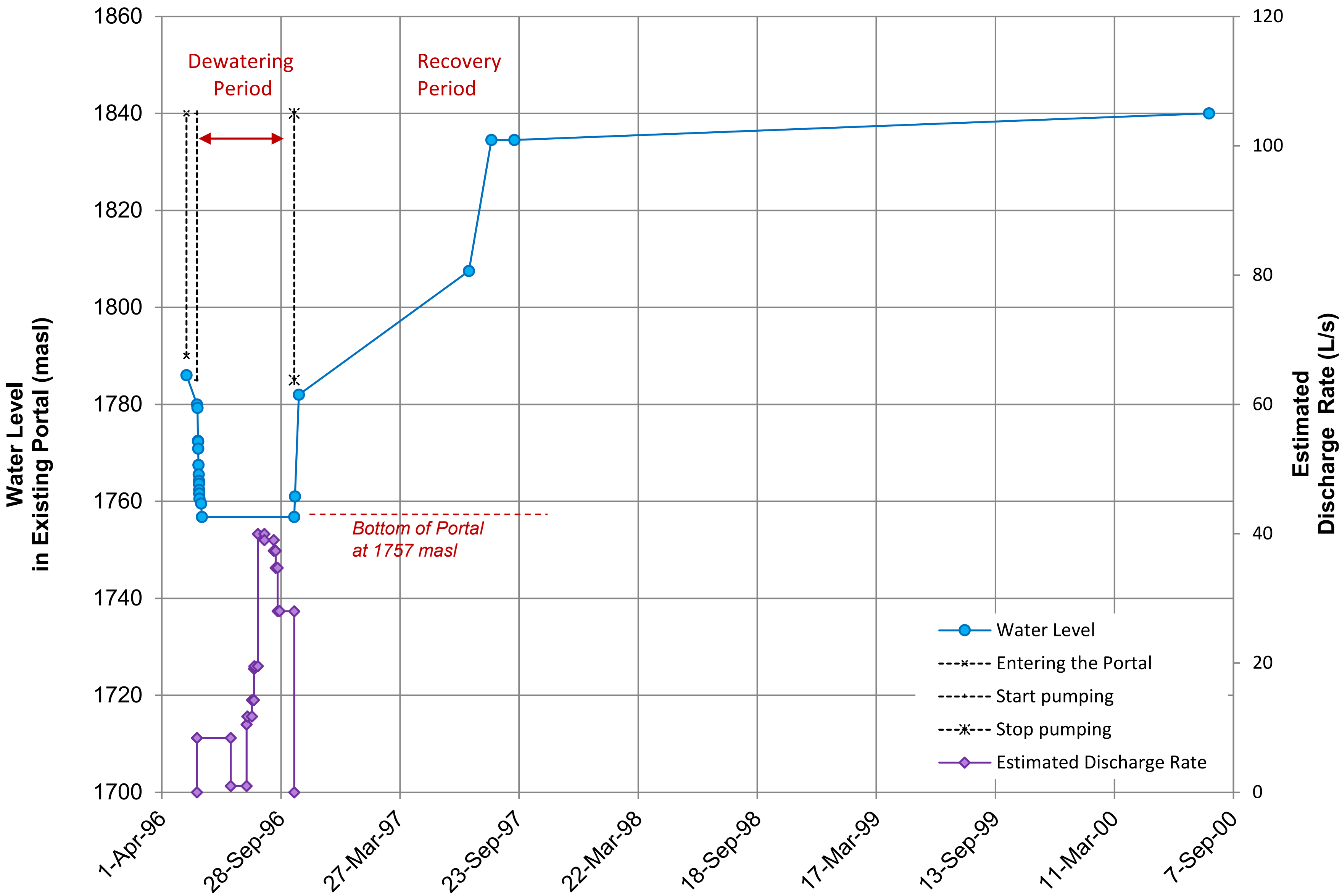
Water Level in the Lower Cirque between Sep. 2014 and Sep 2016

Job No: 1CI019.002

Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx

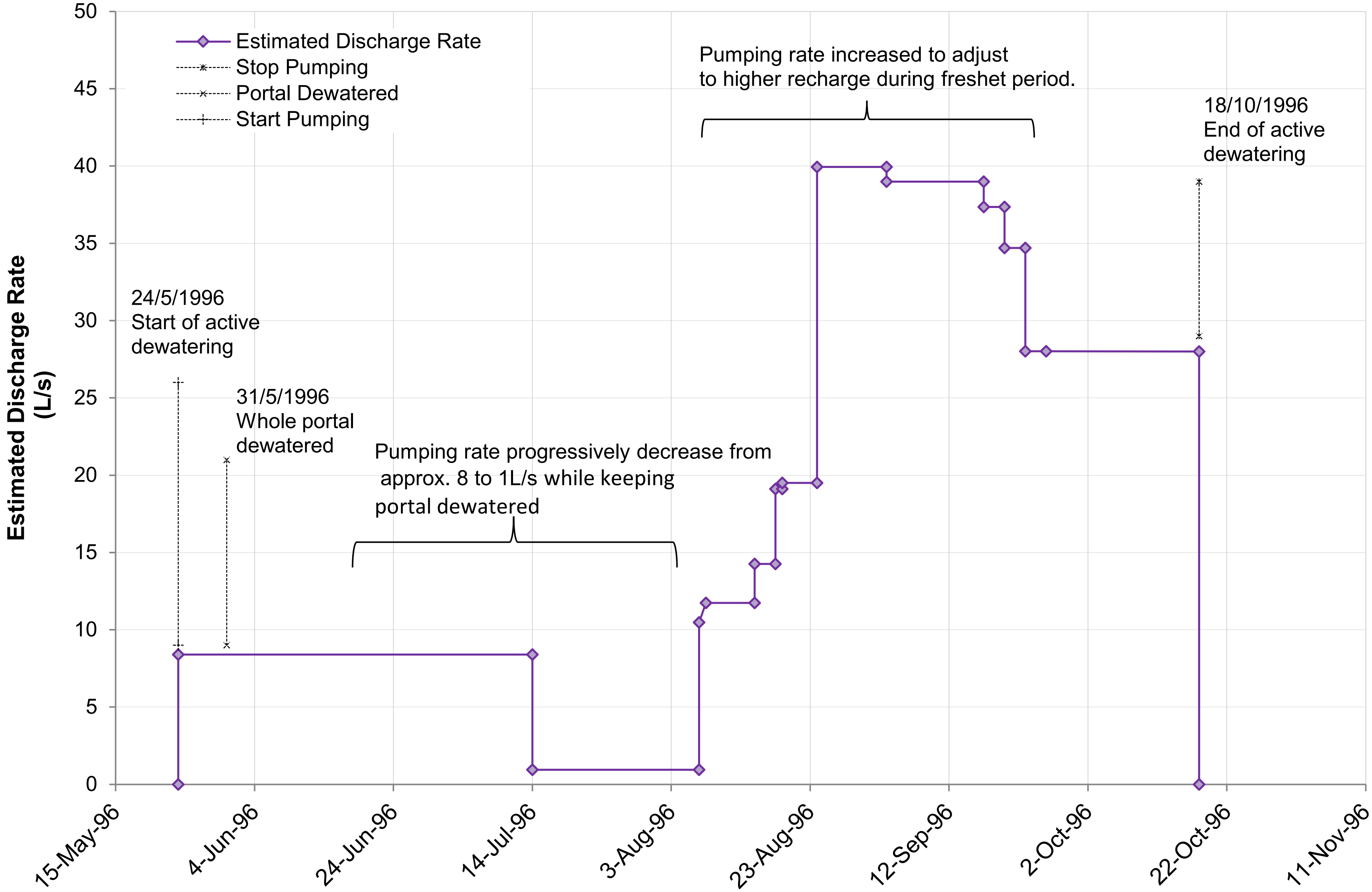
Red Mountain Underground Gold Project

Date:	Approved:	Figure:
Dec 2016	GF	16



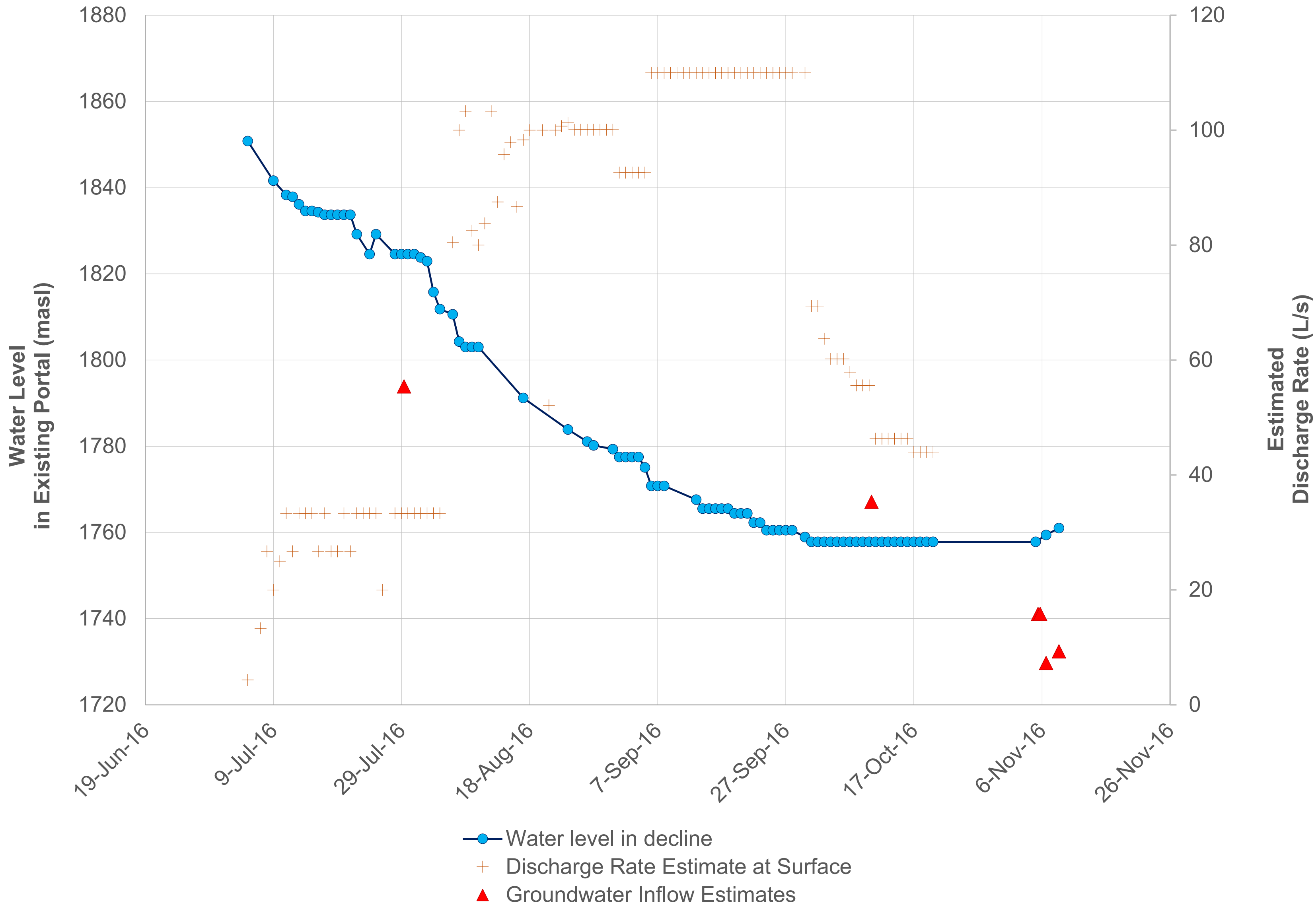
Note: Pumping rates estimated based on historical records of cumulative volumes of water discharged at surface.

srk consulting	IDM MINING	Red Mountain Hydrogeology **Water Level and Discharge Rate in the Existing Decline During the 1996 Dewatering**
Job No: 1CI019.002 Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 · Approved: GF · Figure: 17



Note: Pumping rates estimated based on historical records of cumulative volumes of water discharged at surface.

srk consulting	IDM MINING	Red Mountain Hydrogeology
		Discharge Rate Out of the Existing Decline During the 1996 Dewatering
Job No: 1CI019.002 Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 / Approved: GF / Figure: **18**



srk consulting

IDM MINING

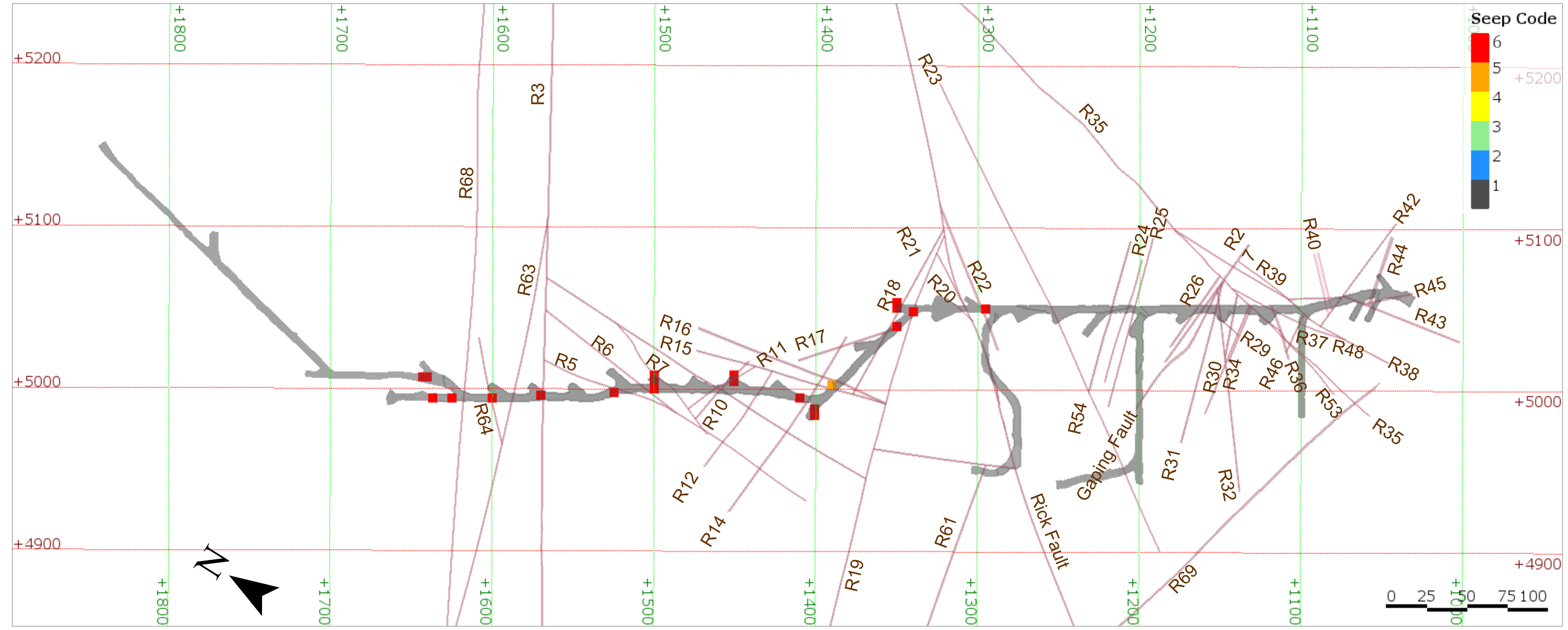
Red Mountain Hydrogeology

Water Level and Discharge Rate in the Existing Decline during the 2016 Dewatering

Job No: 1CI019.002	Red Mountain Underground Gold Project	Date: Dec 2016	Approved: GF	Figure: 19
Filename: Fig_13-to-19_Trsnt_GW-Lvls_1CI019-001.pptx				

1994 Seep mapping:

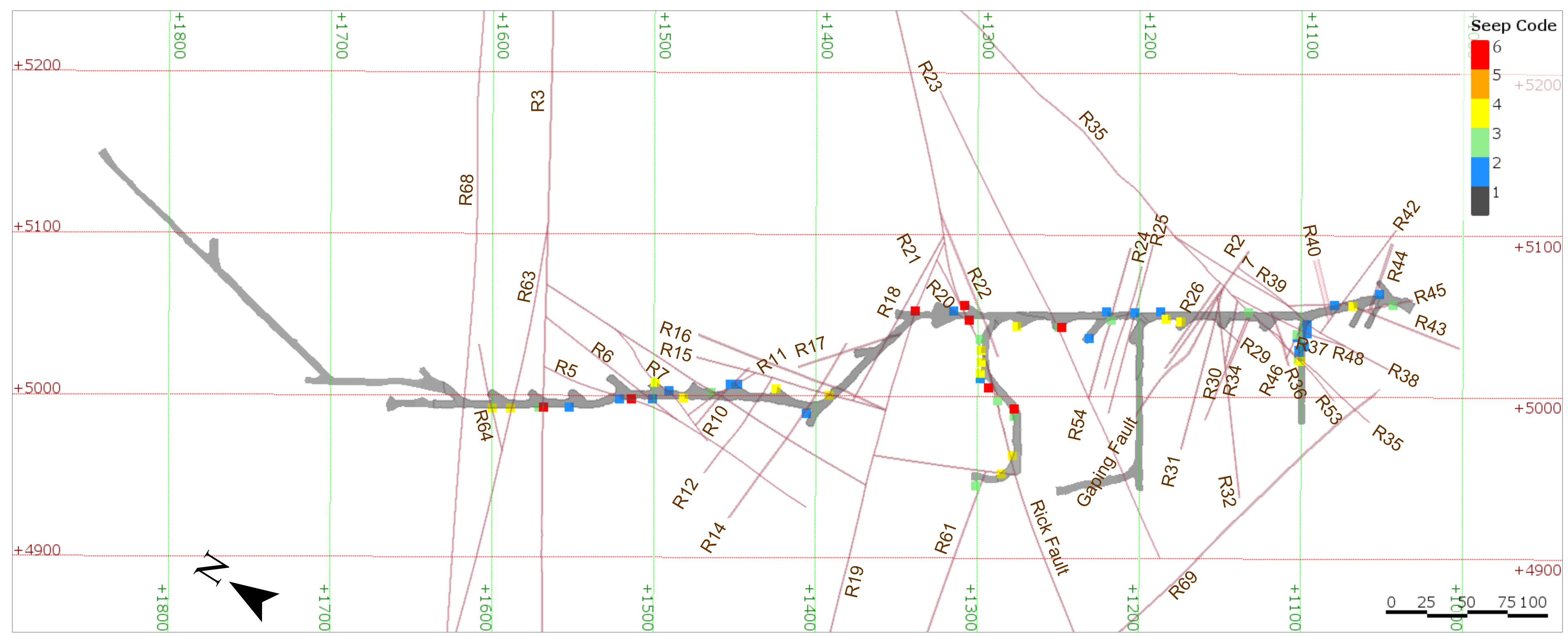
Observations collected by LAC Minerals Ltd. between May 7th and Sep. 17th 1994. Locations monitored several time, i.e. 1 to 16 times per location. Map shows only the highest inflow rates recorded



Mine Grid coordinate system

2016 Seep mapping:

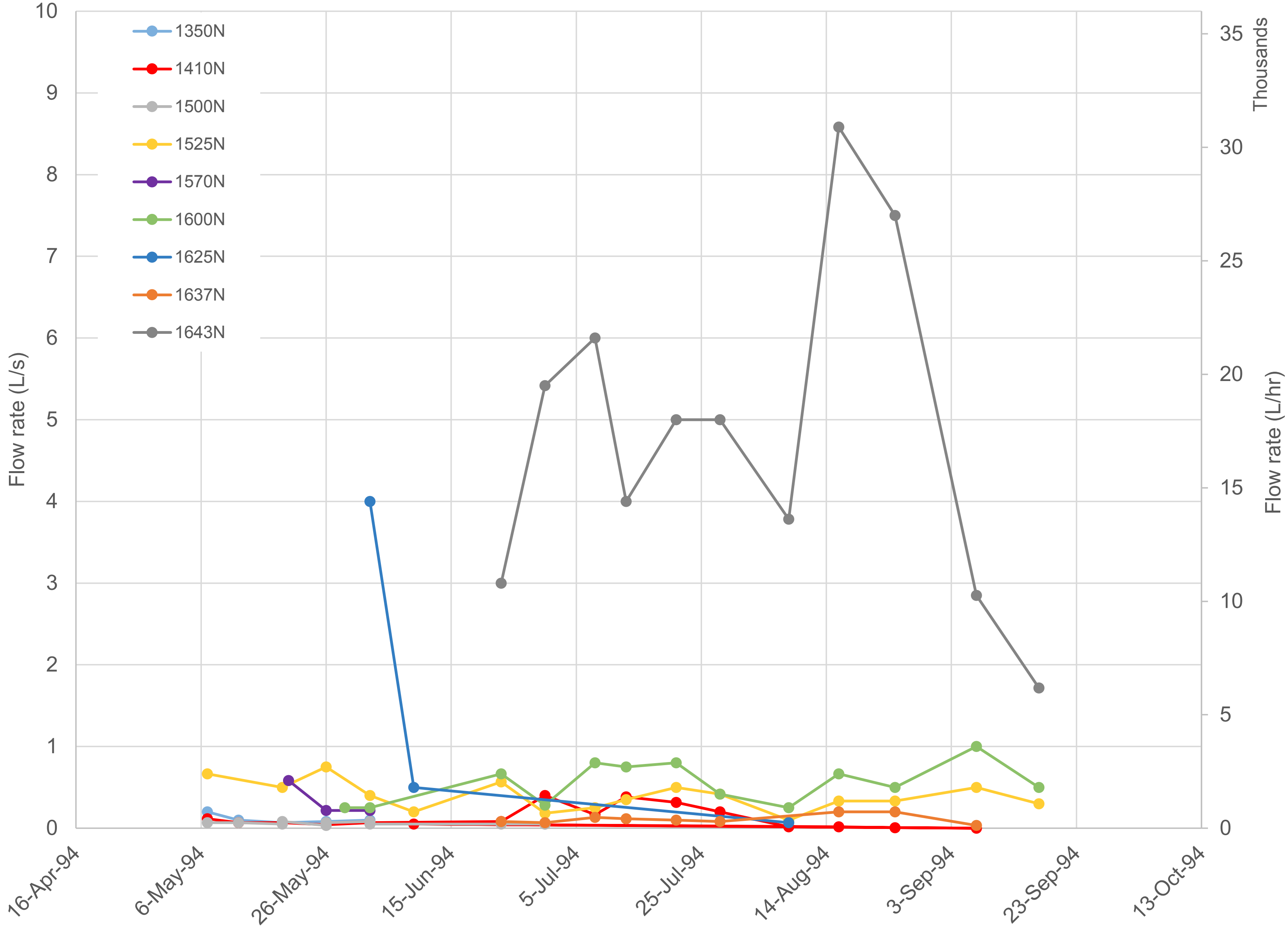
Observations collected by SRK on Sep. 8th 2016 (from Matt Vitale) and from Oct. 2th to October 6th 2016 (from Ron Uken). Map on the right shows all the inflow rates mapped by SRK.



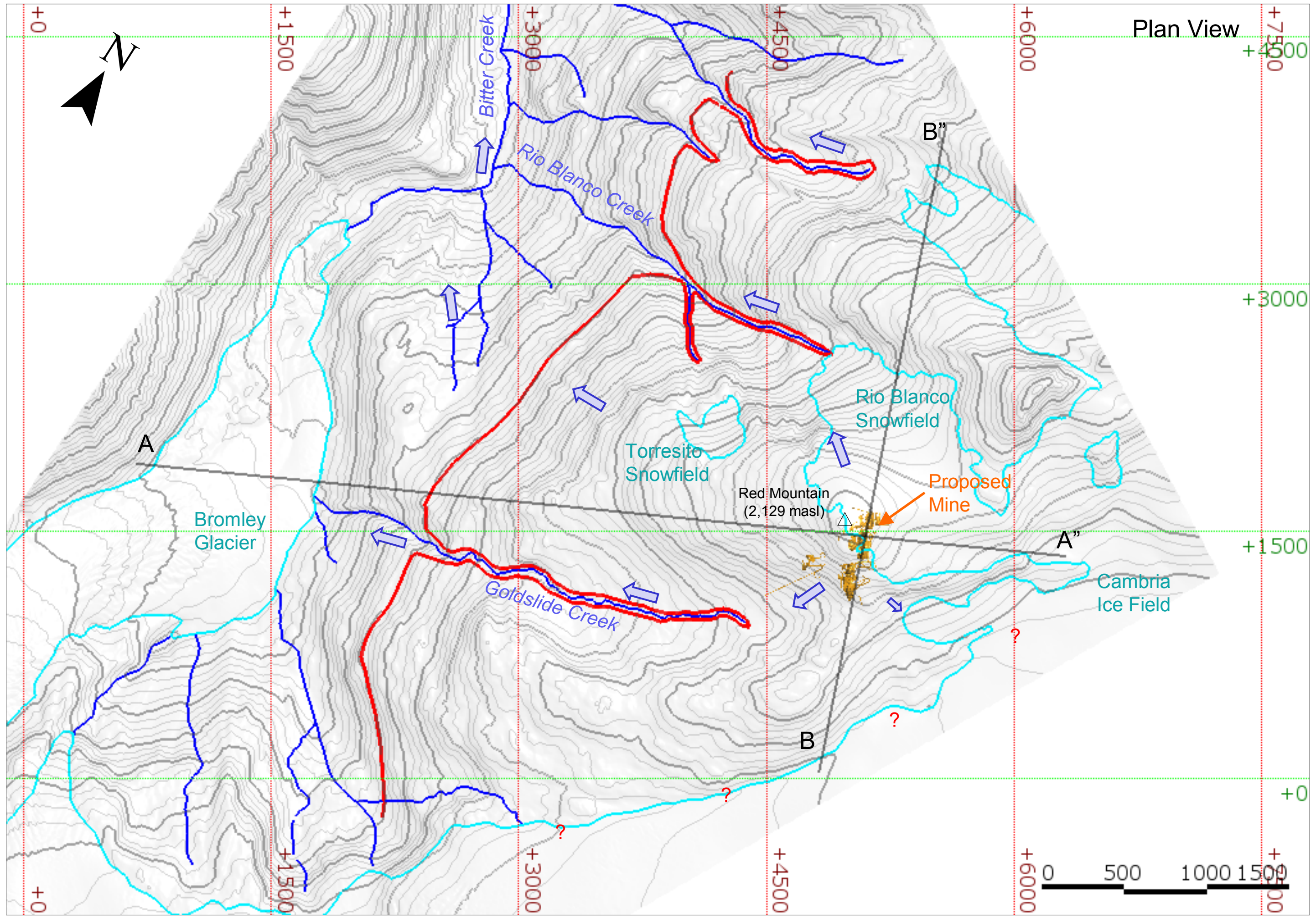
Mine Grid coordinate system

Water flow code:
1, dry (0 L/hr)
2, moist (<1 L/hr)
3, dripping (1 to 5 L/hr)
4, seeping (5 to 20 L/hr)
5, flowing (20 to 100 L/hr)
6, pouring (>100 L/hr)

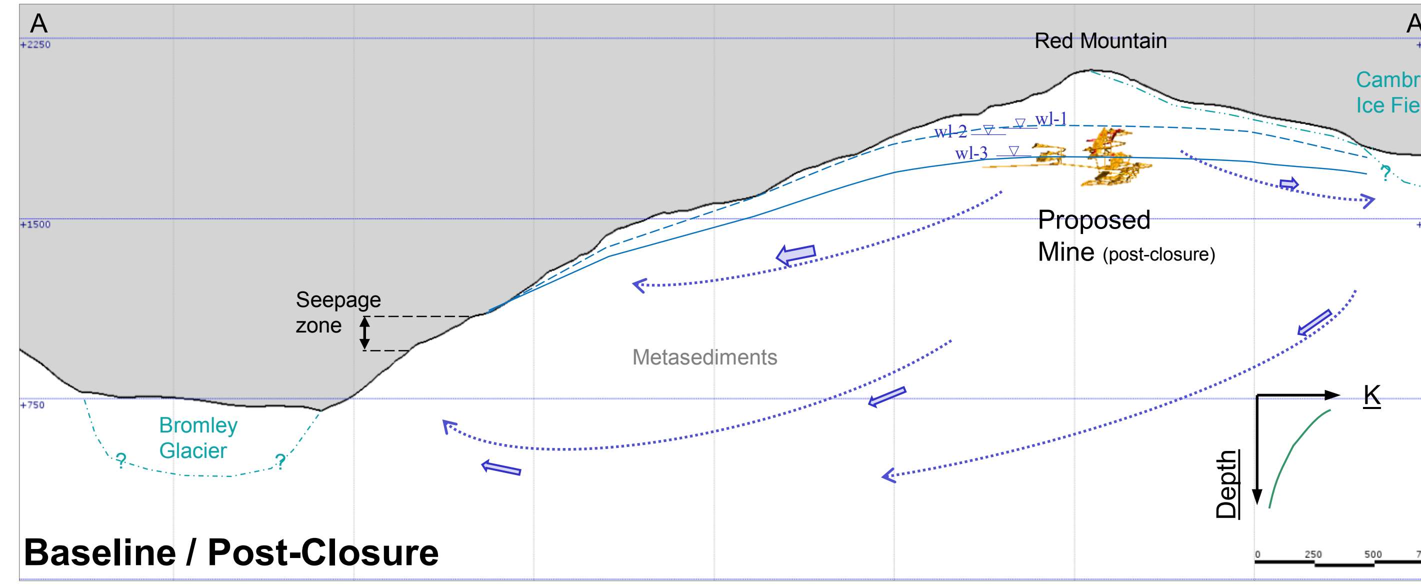
srk consulting	IDM MINING	Red Mountain Hydrogeology
Job No: 1CI019.002 Filename: Fig_20_Map_Seeps in Portal.pptx	Red Mountain Underground Gold Project	Plan views of the Existing Portal and seeps mapped in 1994 and 2016
		Date: Dec 2016; Approved: GF; Figure: 20

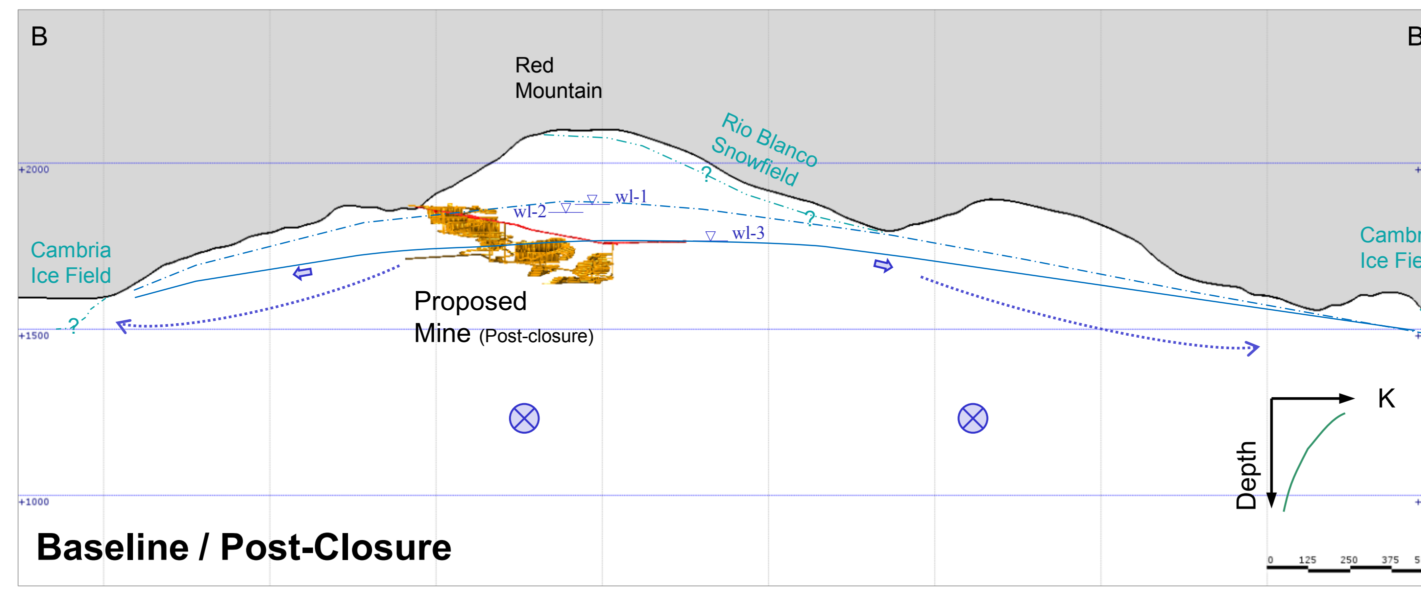


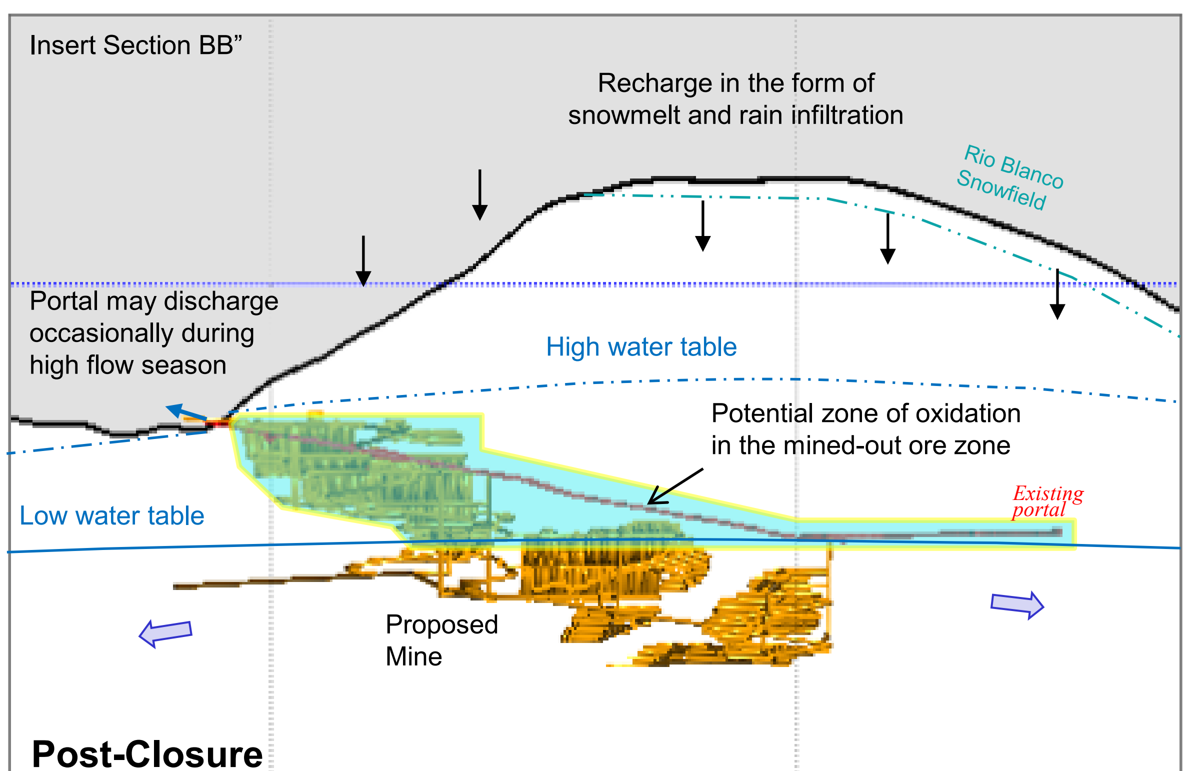
srk consulting	IDM MINING	Red Mountain Hydrogeology
		1994 Seep inflow rates mapped in Portal versus Time
Job No: 1CI019.002 Filename: Fig_21_1994_Seep inflow rates	Red Mountain Underground Gold Project	Date: Dec 2016 / Approved: GF / Figure: **21**



Coordinate system in Mine Grid







Groundwater discharge areas

Main Flow directions

Flow directions out of plane

wl-1: Level at 1875 masl (M94217 July93)

wl-2: Level at 1850 masl (Portal Aug. 2005)

wl-3: Level at 1760 masl (Bottom Portal, end of low flow season)

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IDM MINING

Red Mountain Hydrogeology

Conceptual Groundwater Model

Job No: 1CI019.002

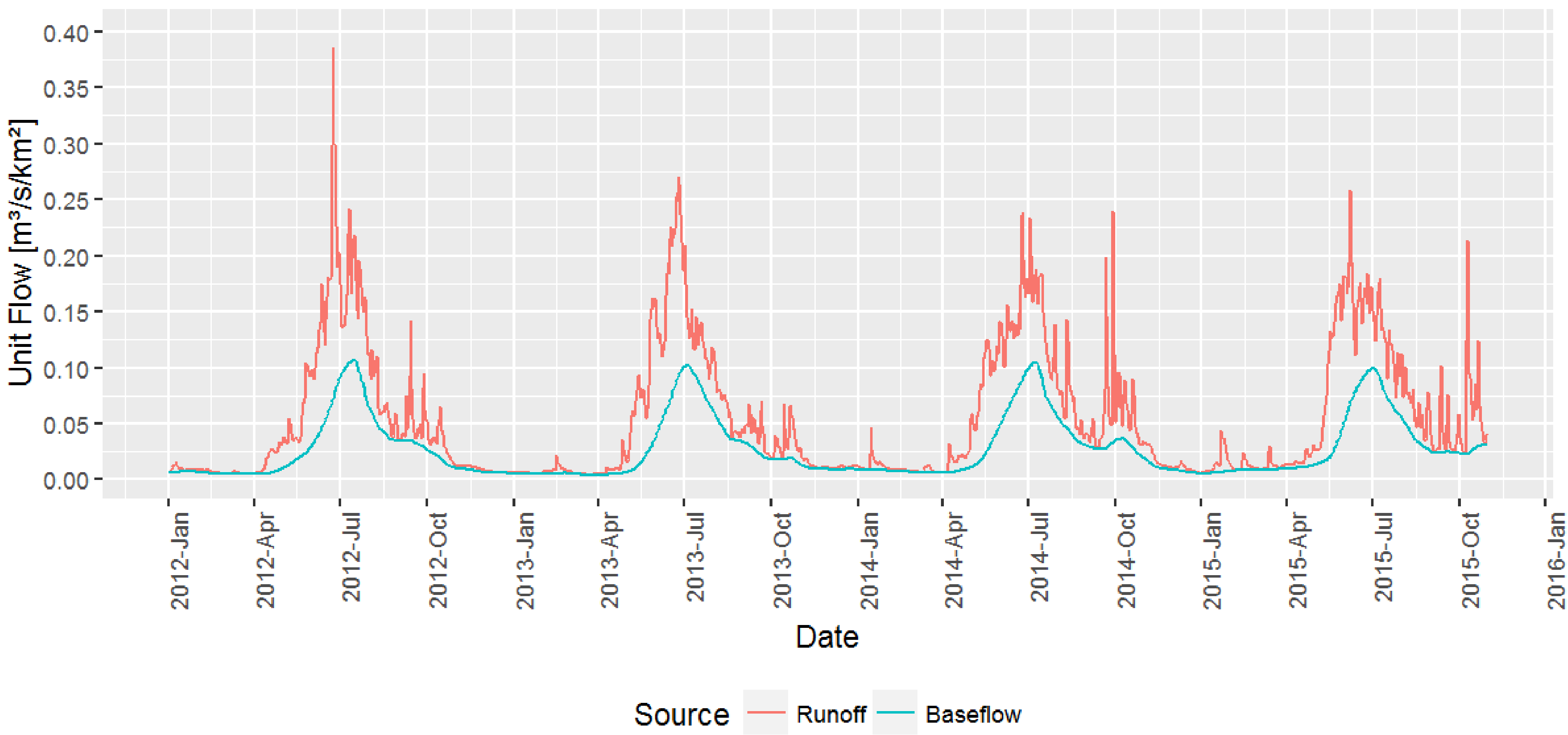
Filename: Fig_22_Conceptual Groundwater Model.pptx

Red Mountain Underground Gold Project

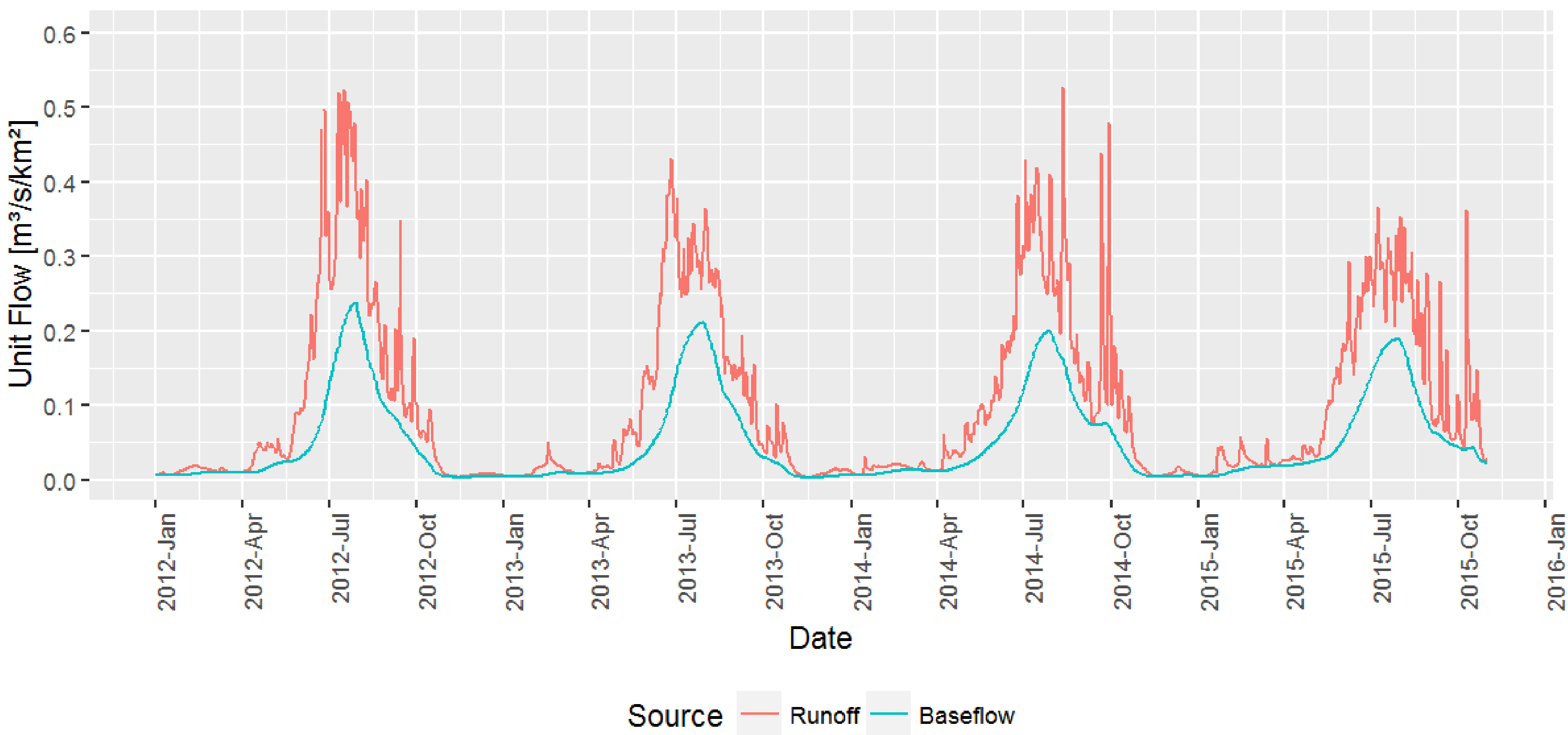
Date: Dec 2016

Approved: GF

Figure: 22



srk consulting	IDM MINING	Red Mountain Hydrogeology
		Baseflow separation for Goldslide Creek for 2012 to 2016
Job No: 1CI019.002 Filename: Fig_23-24_Baseflow Separations_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 / Approved: GF / Figure: 23



srk consulting

IDM MINING

Job No: 1CI019.002

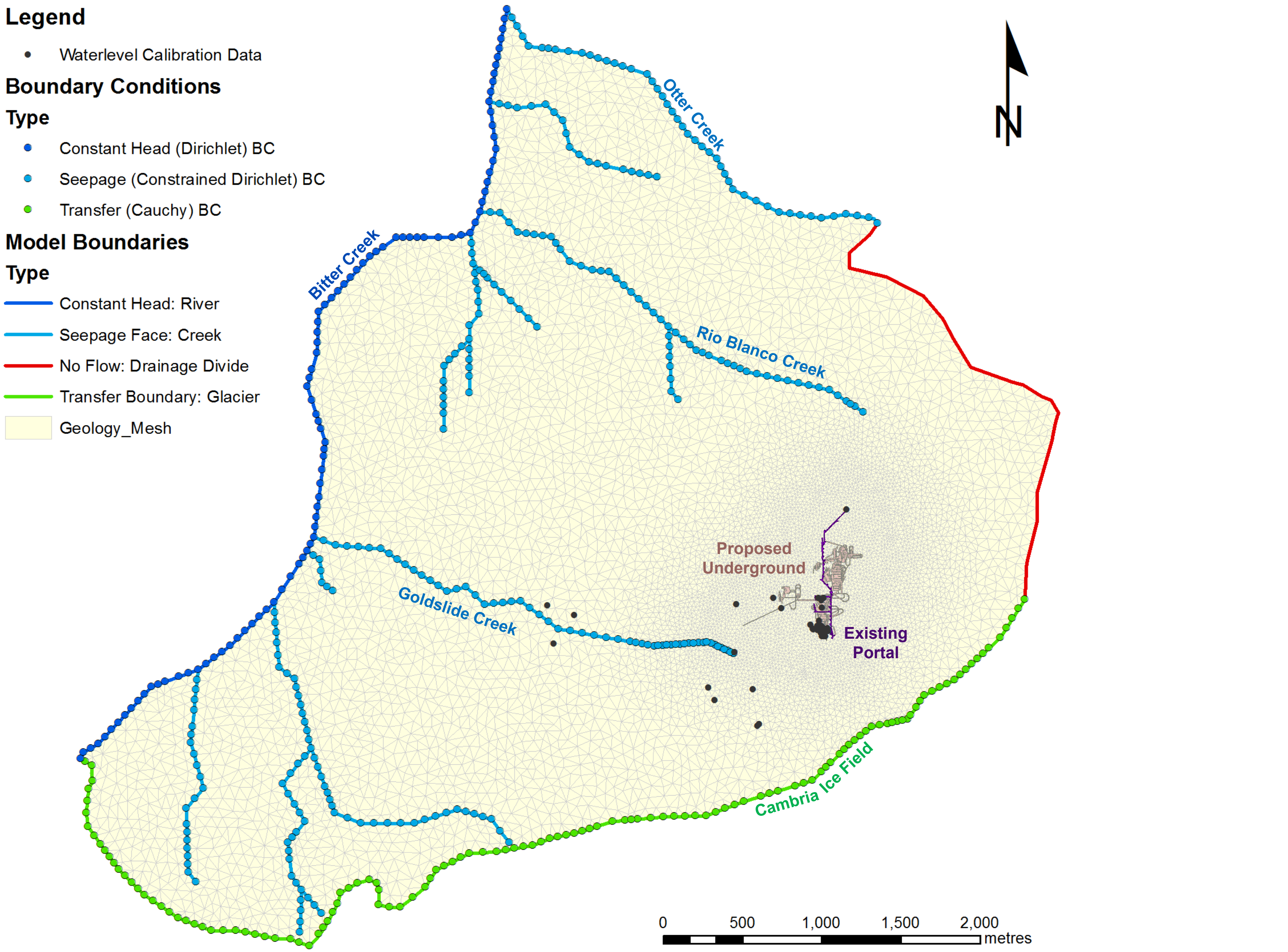
Filename: Fig_23-24_Baseflow Separations_1CI019-001.pptx

Red Mountain Underground Gold Project

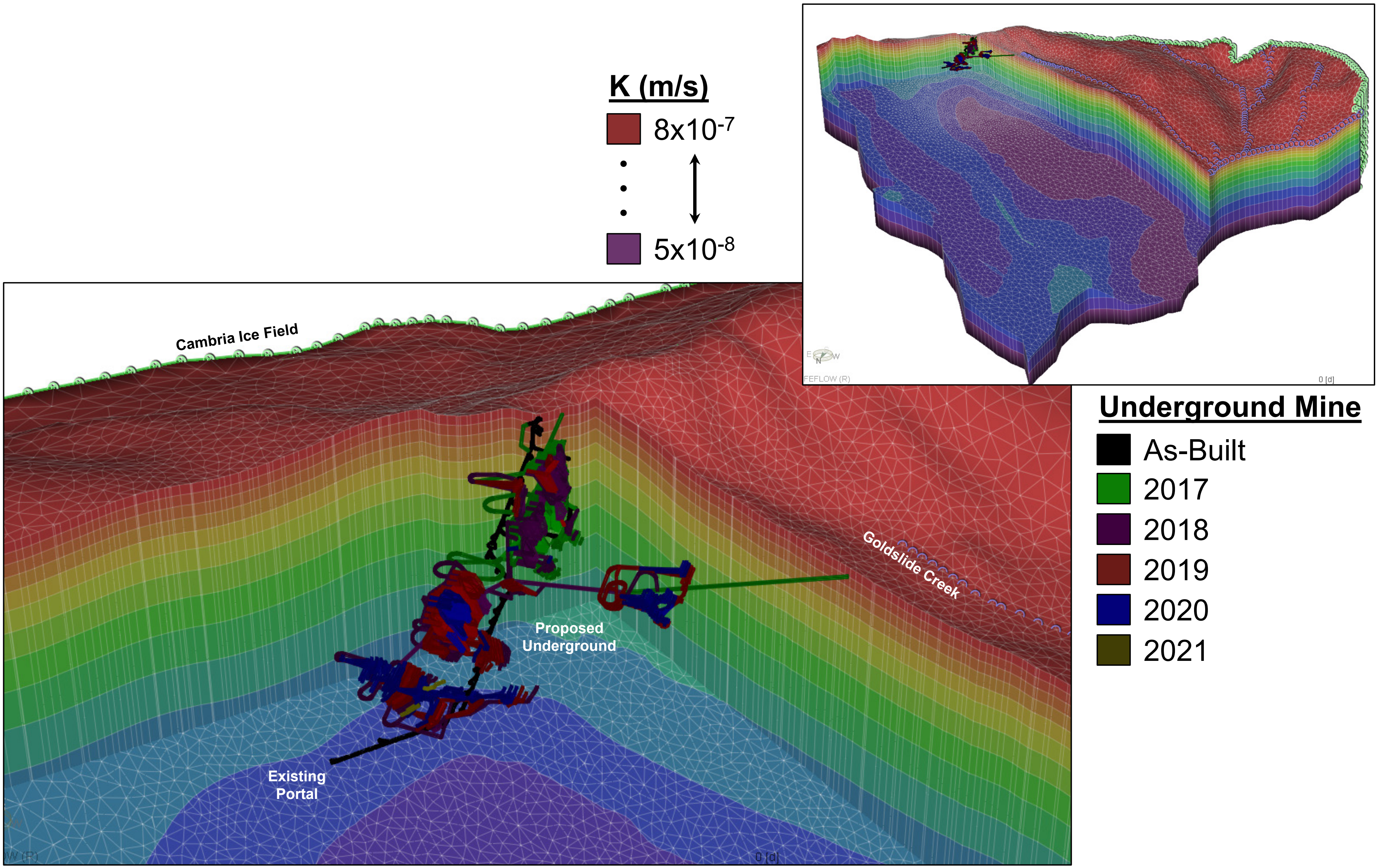
Red Mountain Hydrogeology

Baseflow separation for Bitter-Otter Creek for 2012 to 2016

Date:	Approved:	Figure:
Dec 2016	GF	24



srk consulting	IDM MINING	Red Mountain Hydrogeology
		Groundwater Model Setup: Boundary Conditions
Job No: 1CI019.001 Filename: Fig25-31_calibration_figures_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 / Approved: JM / Figure: 25



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IDM MINING

Job No: 1CI019.001

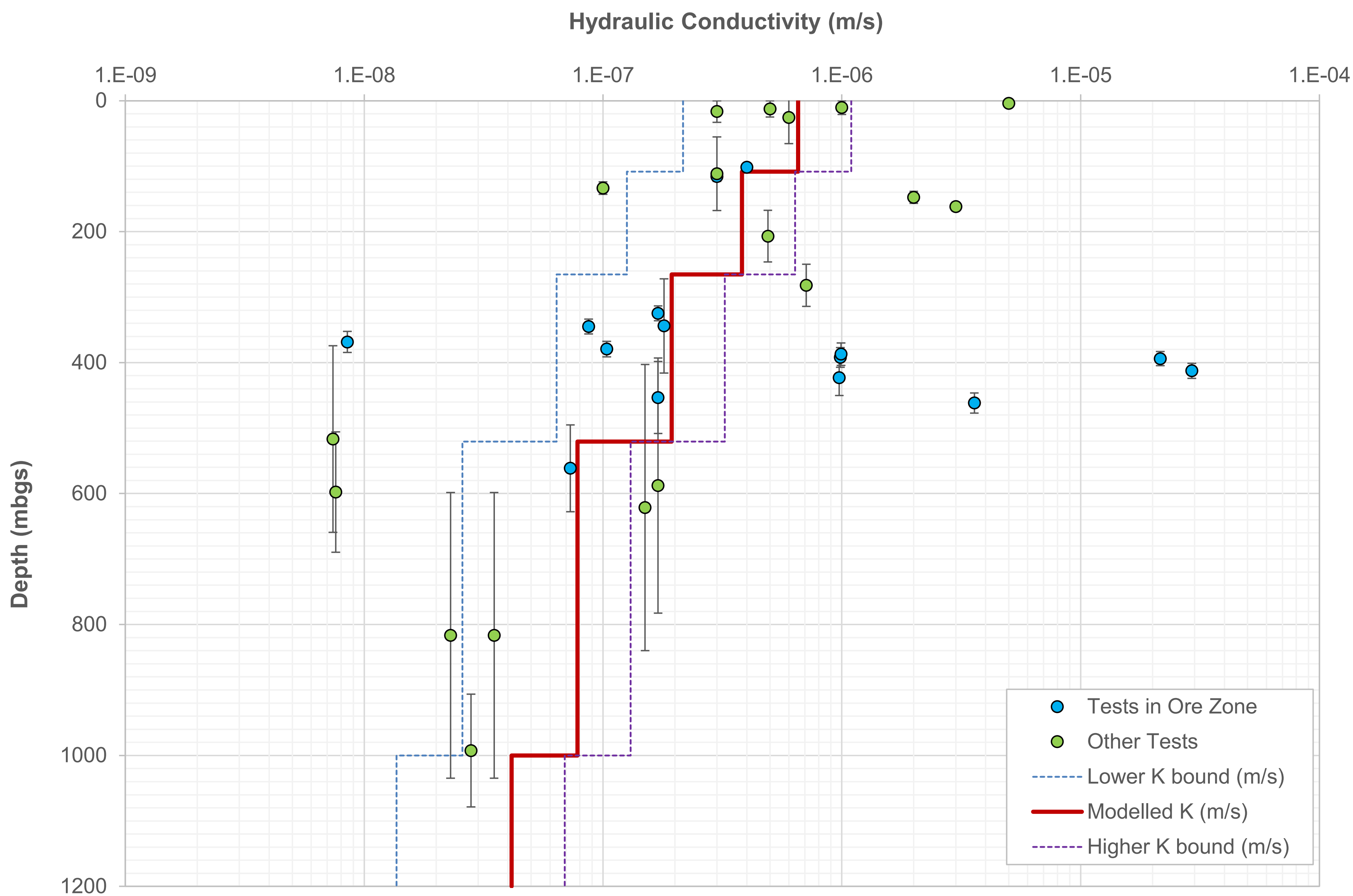
Filename: Fig25-31_calibration_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

Red Mountain Hydrogeology

Groundwater Model Setup: Red Mountain Underground

Date:	Approved:	Figure:
Dec 2016	JM	26



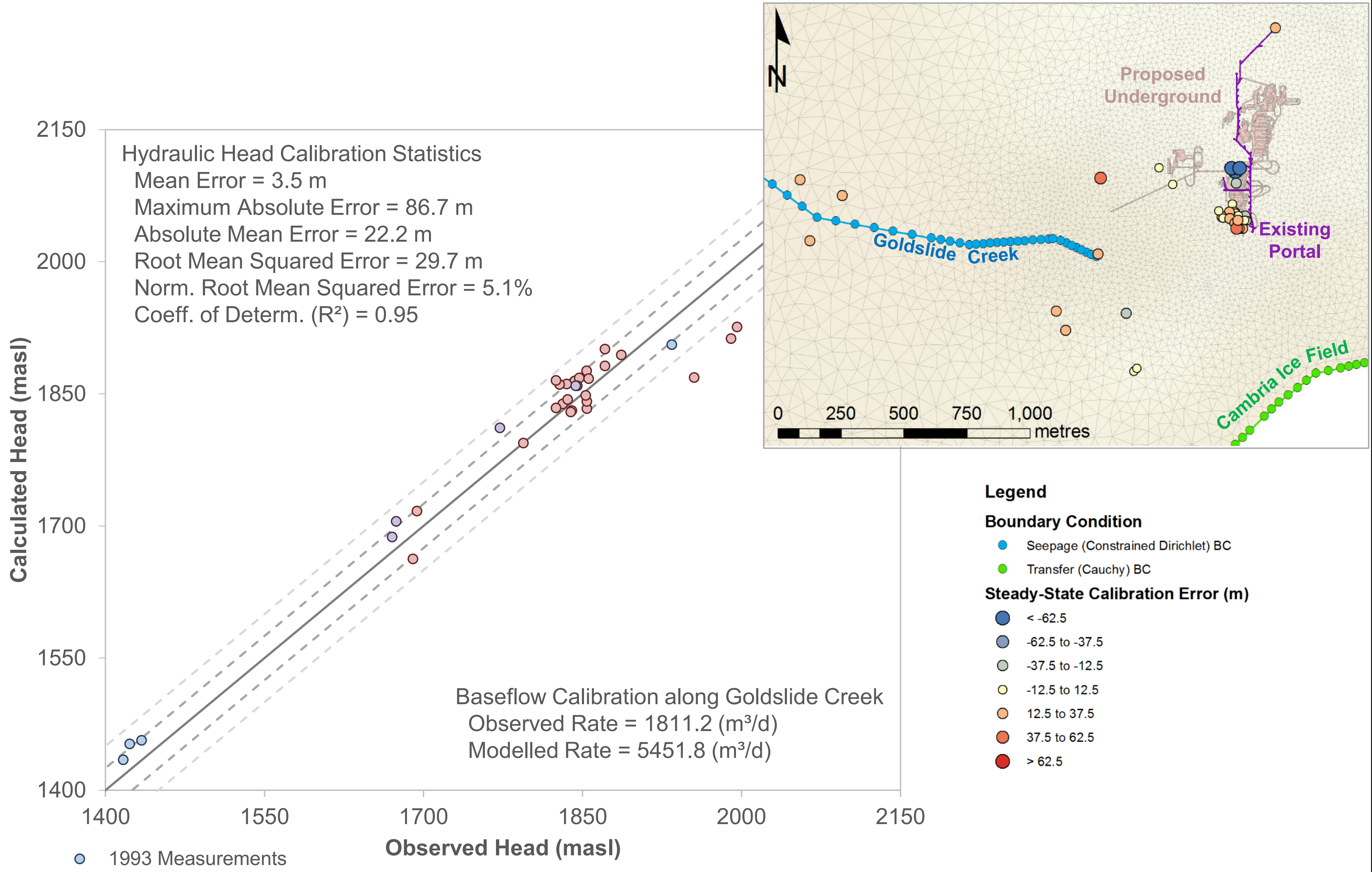
srk consulting | IDM MINING | Red Mountain Hydrogeology

Groundwater Model Setup: K distribution

Job No: 1CI019.001
Filename: Fig25-31_calibration_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

Date: Dec 2016 | Approved: JM | Figure: 27



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Job No: 1CI019.001

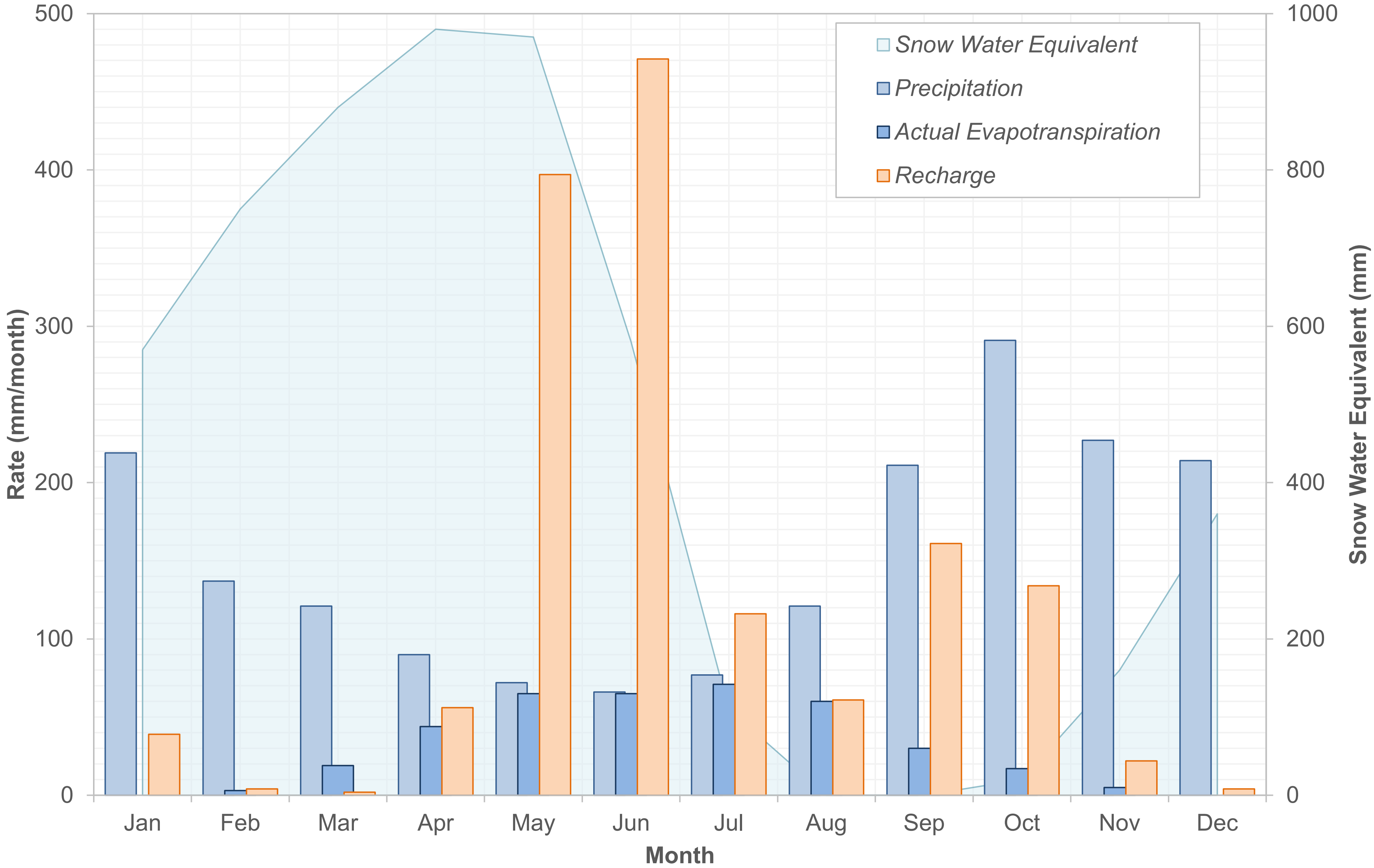
Filename: Fig25-31_calibration_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

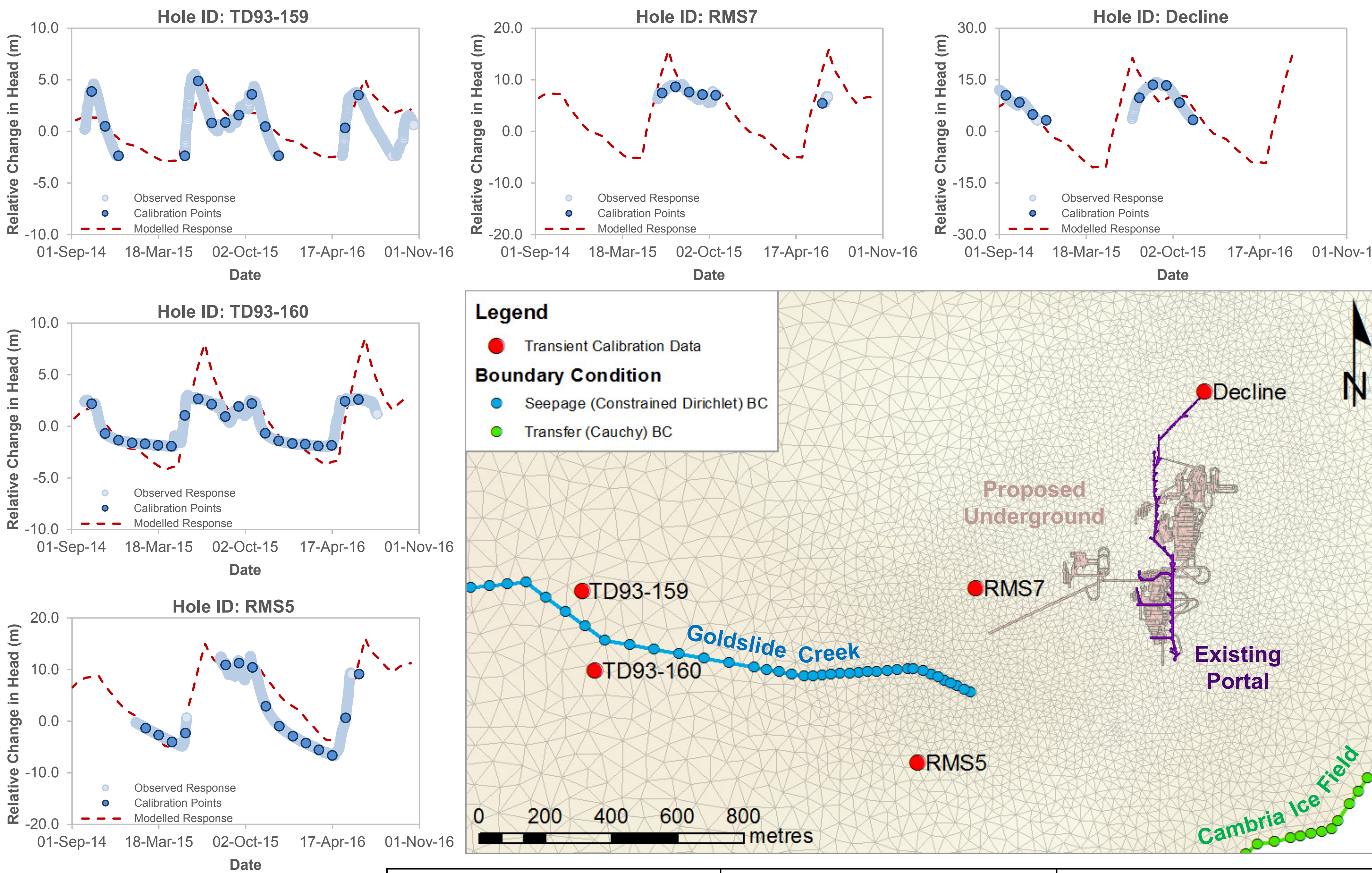
Red Mountain Hydrogeology

Steady-State Calibration: Head and Baseflow

Date:	Approved:	Figure:
Dec 2016	JM	28



srk consulting	IDM MINING	Red Mountain Hydrogeology
		Simulated Transient Groundwater Recharge Profile
Job No: 1CI019.001 Filename: Fig25-31_calibration_figures_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 · Approved: JM · Figure: **29**



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Job No: 1CI019.001

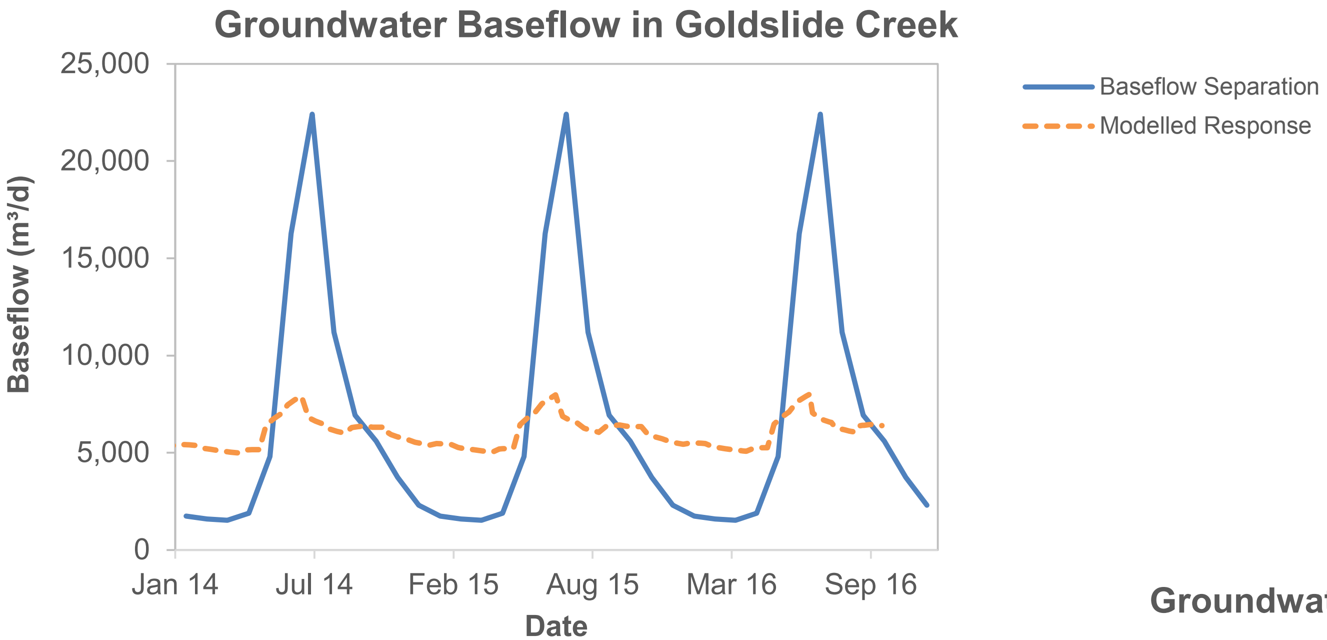
Filename: Fig25-31_calibration_figures_1CI019-001.pptx

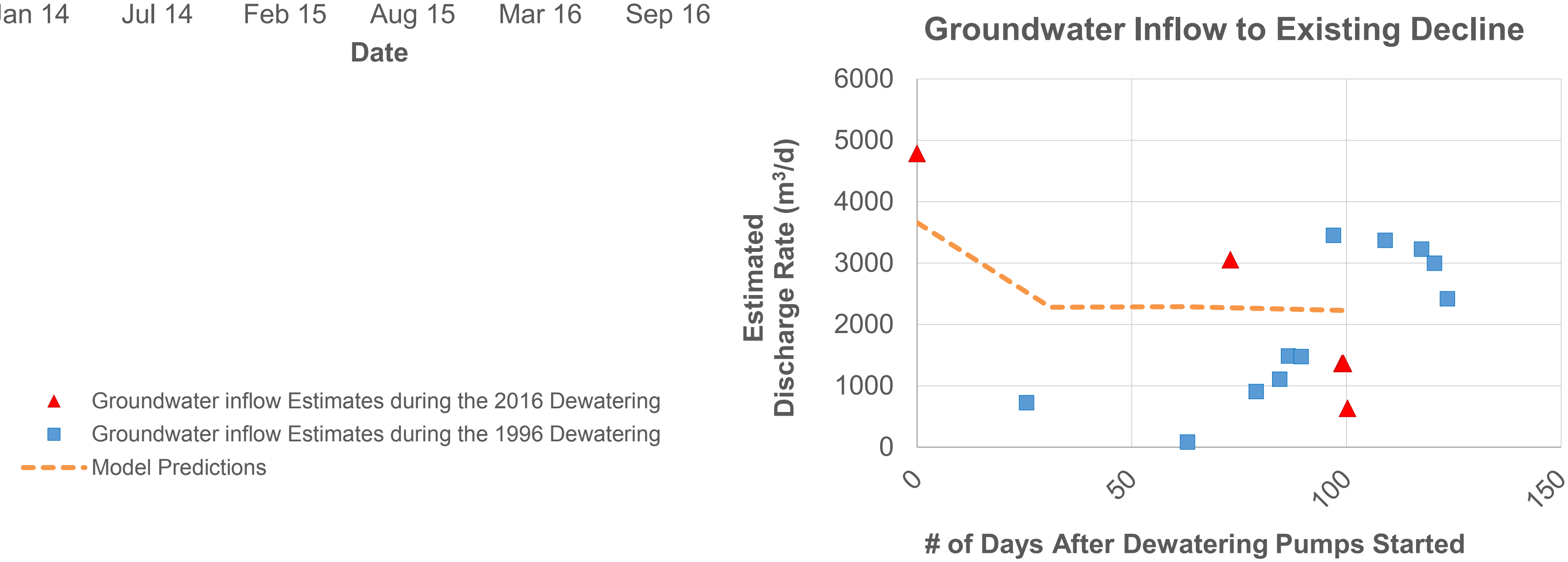
Red Mountain Underground Gold Project

Red Mountain Hydrogeology

Transient Calibration: Seasonal Water Level Variability

Date:	Approved:	Figure:
Dec 2016	JM	30





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Red Mountain Hydrogeology

Transient Calibration: Seasonal Baseflow Variability and Inflows to Existing Decline

Job No: 1CI019.001

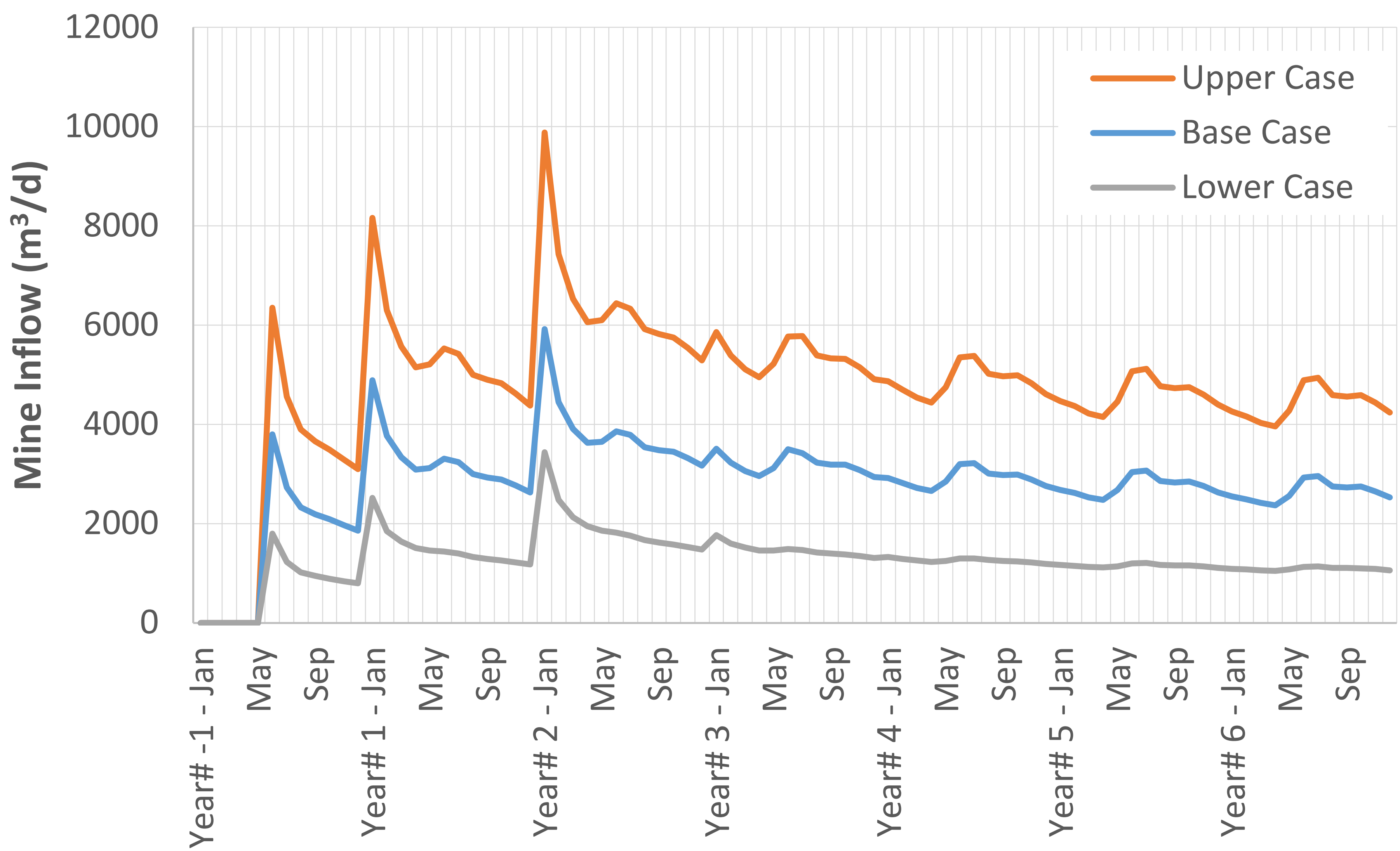
Filename: Fig25-31_calibration_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

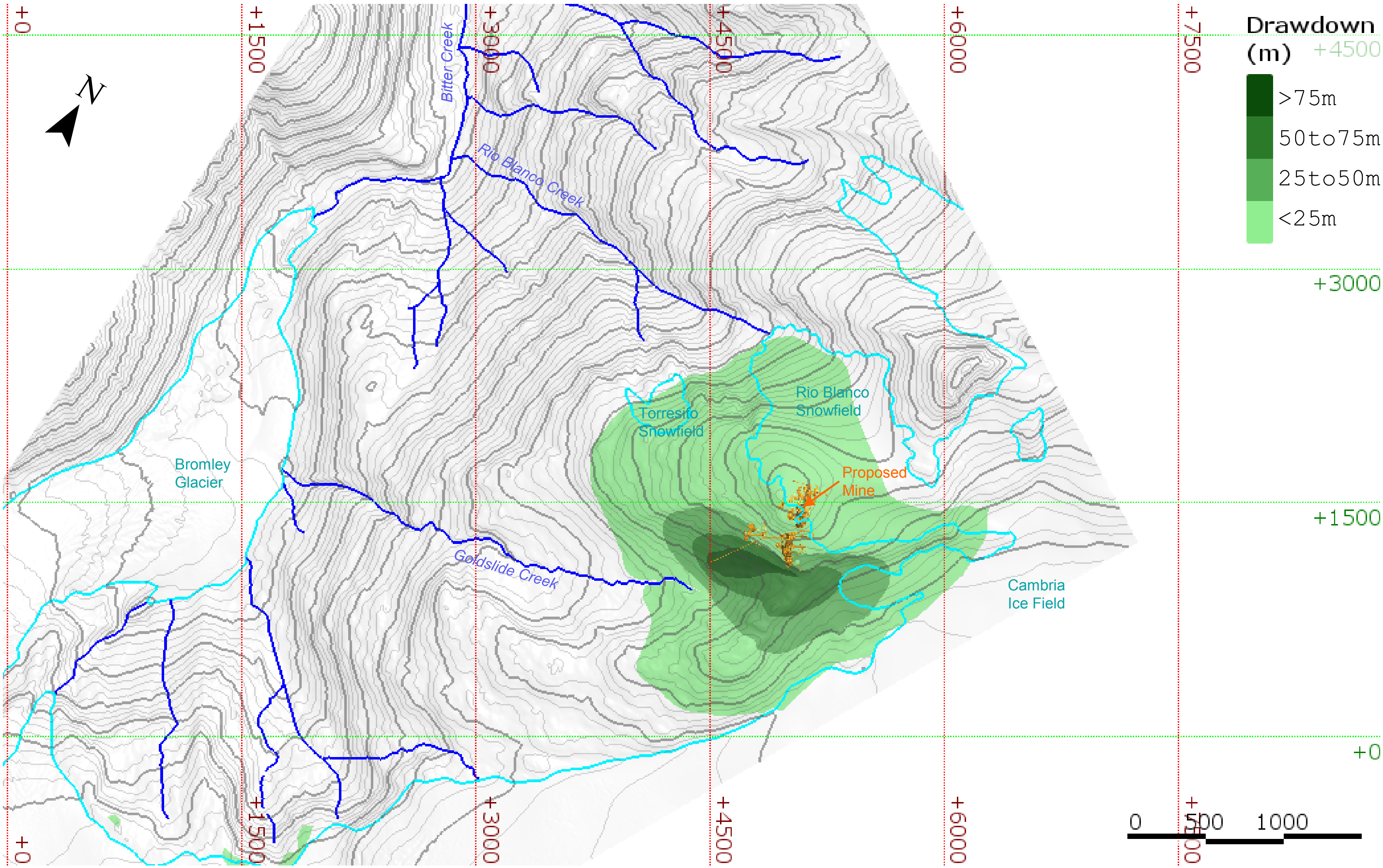
Date: Dec 2016

Approved: JM

Figure: 31



srk consulting	IDM MINING	Red Mountain Hydrogeology
		Monthly Average Mine Inflow Predictions
Job No: 1CI019.001 Filename: Fig_32-36_Prediction_figures_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 / Approved: JM / Figure: 32



srk consulting

IDM MINING

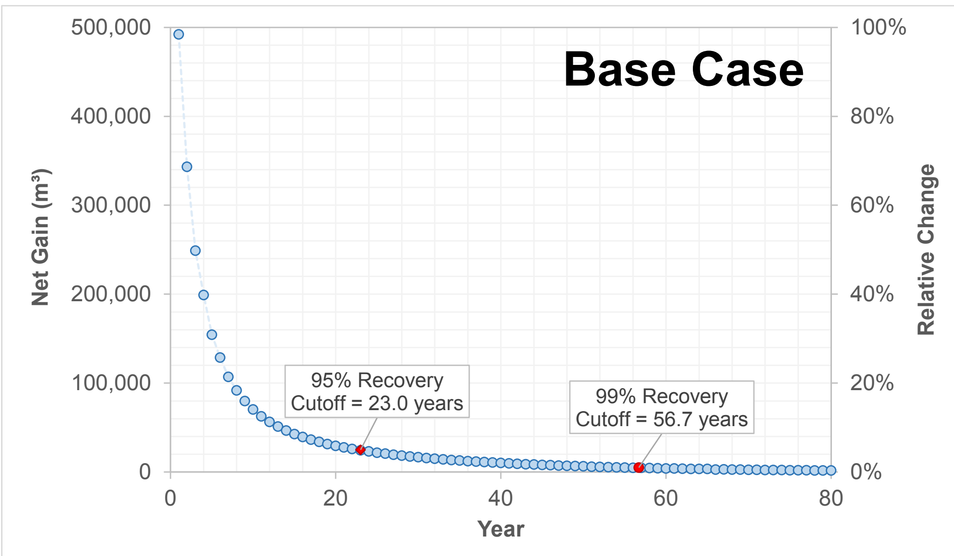
Red Mountain Hydrogeology

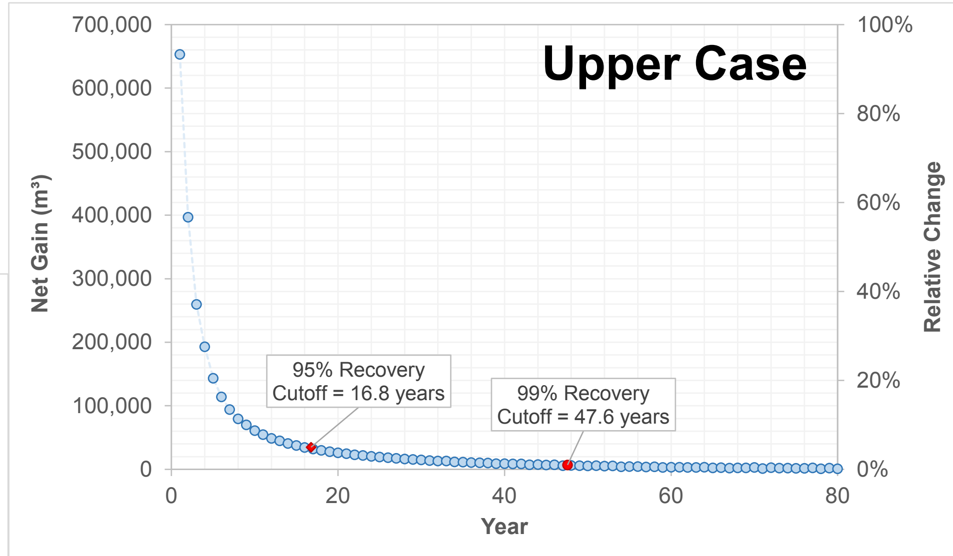
Predicted Drawdown

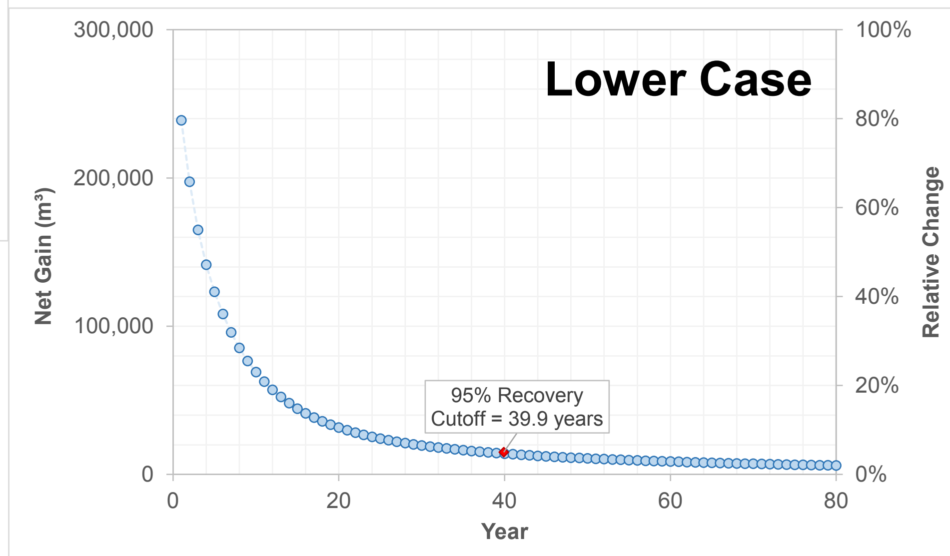
Job No: 1CI019.001
Filename: Fig_32-36_Prediction_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

Date: Dec 2016 | Approved: JM | Figure: 33







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Red Mountain Hydrogeology

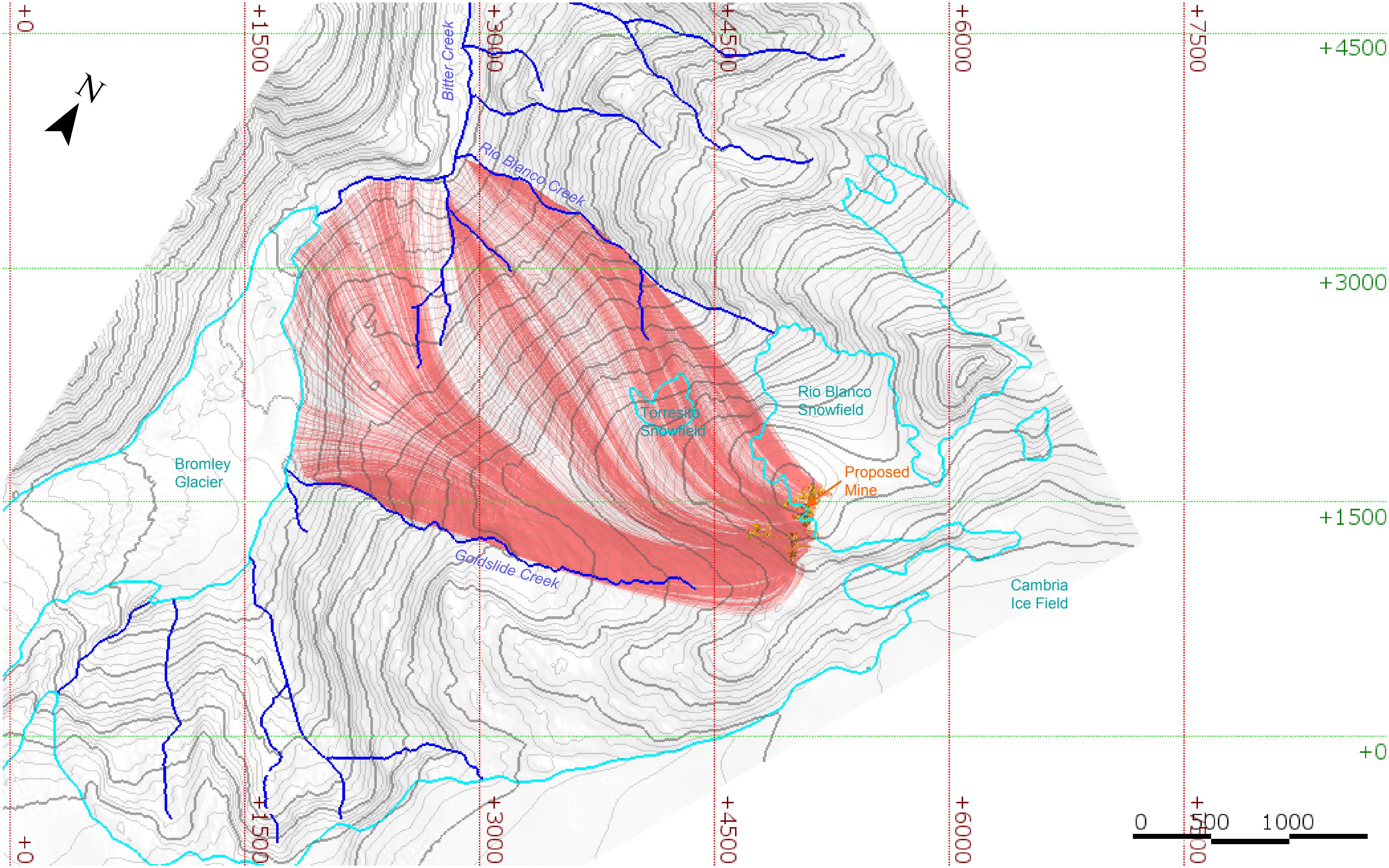
Net Groundwater Gain to Mined-Out Volumes Over Time

Job No: 1CI019.001

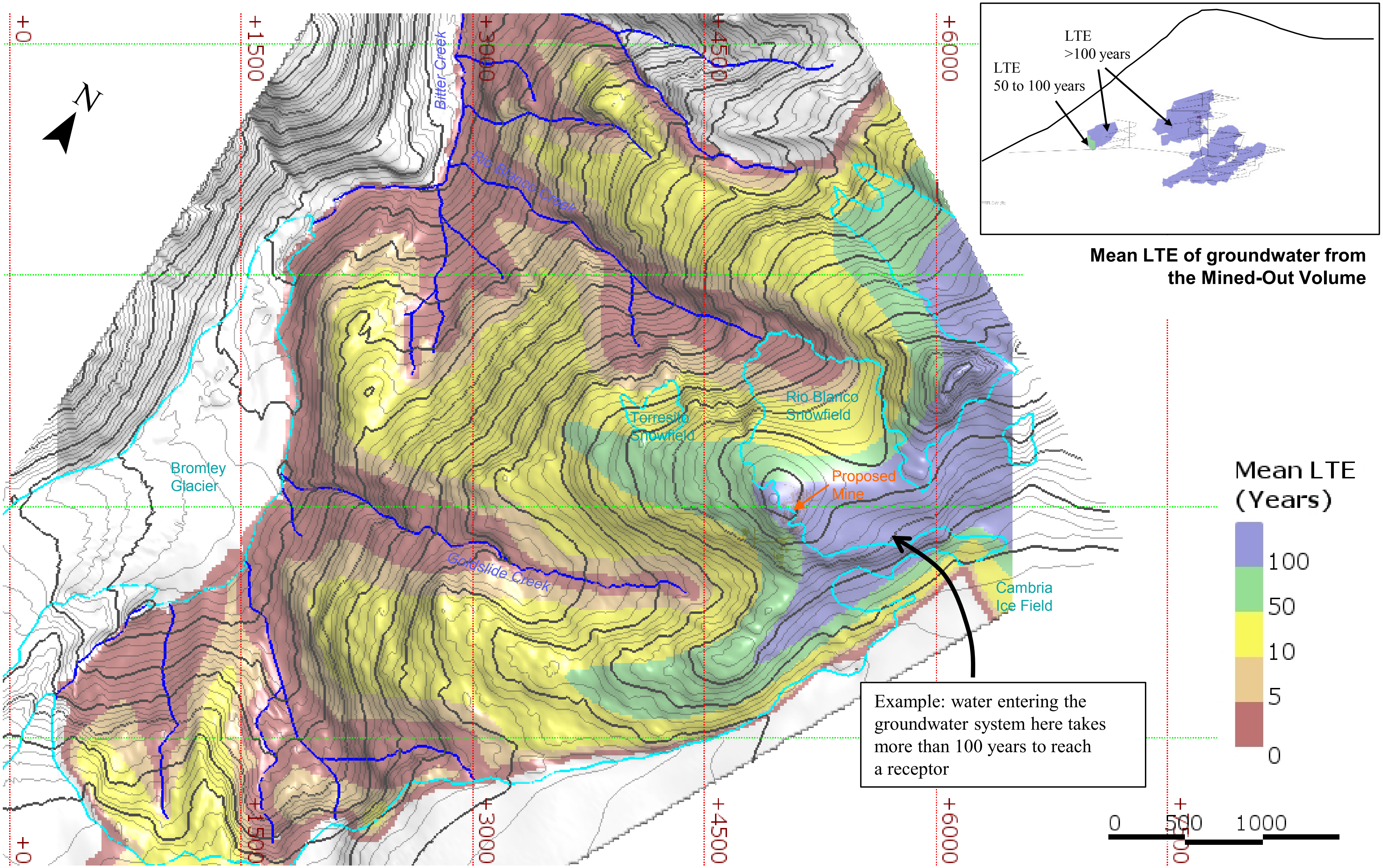
Filename: Fig_32-36_Prediction_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

Date:	Approved:	Figure:
Dec 2016	JM	34



srk consulting	IDM MINING	Red Mountain Hydrogeology
		Particle Paths to the Surface Water Receptors
Job No: 1CI019.001 Filename: Fig_32-36_Prediction_figures_1CI019-001.pptx	Red Mountain Underground Gold Project	Date: Dec 2016 · Approved: JM · Figure: **35**



Mean LTE of groundwater from the Mined-Out Volume

Mean LTE of groundwater from ground surface

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Job No: 1CI019.001

Filename: Fig_32-36_Prediction_figures_1CI019-001.pptx

Red Mountain Underground Gold Project

Red Mountain Hydrogeology

Predicted Groundwater Mean Life Time Expectancy (LTE)

Date:	Approved:	Figure:
Dec 2016	JM	36

Appendix A – Packer Test Procedure (Golder)

General procedure for packer test:

(Golder Associates Ltd. (Golder). 1996a Field Investigation – Proposed Underground Mine Area. Draft Technical Memorandum to Royal Oak Mines. December 5, 1996.)

- The conductivity testing was performed using nitrogen inflated pneumatic packers size N (75.7mm) and B (60.0 mm). A wireline single-packer system (2 packers) was used to seal the selected intervals within each borehole. Prior each test, the drill rods were pulled off the bottom of the hole and the packers were installed with one inside the drill pipe and one below the bit. The test interval included the section of the open borehole between the lower packer and the bottom of the borehole. Length of the test intervals varied based on the groundwater conditions encountered in each borehole.
- After drilling to the desired interval depth, drill water was circulated for 5 minutes to clean the hole.
- The bit was pulled to the desired packer setting depth and if the borehole was not flowing, the core barrel was pulled rapidly 3 times to remove excess water from the hole.
- The packer was then lowered into the well and set, with water level readings taken just before setting and during setting. If the borehole was flowing, the packers were flushed down the rods using a drill rig pump.
- After the packer was set, if the water level was rising in the drill pipe, small amounts · of water (approximately 112 liter) were added and water level monitored to determine the static water level. If the water level was falling after the packer was set, the water level was pumped down using a waterra tubing. If the water level then began to rise, water was added to determine static water level. If the water level was still falling, the water level was monitored over a period of 112 hour and a static water level was estimated.
- Single well response tests (Falling head) were performed by filling the drill rods with water and recording the water level recovery with time. At the end of each falling head test, if possible, water was added to the hole annulus and water level in the pipe monitored to check the packer seals and drill pipe integrity.
- If recovery to the static water level was too rapid or if the borehole was flowing, a constant head test was performed. Constant head test consisted of pumping water through the rods into the formation at different pressure and different pumping rates. If the borehole was flowing, the test was conducted by changing the flow rate from the borehole and monitoring the corresponding pressure.

Appendix B – Piezometer installations Procedure (Golder)

Procedure for piezometer installations:

(Golder Associates Ltd. (Golder). 1996a Field Investigation – Proposed Underground Mine Area. Draft Technical Memorandum to Royal Oak Mines. December 5, 1996.)

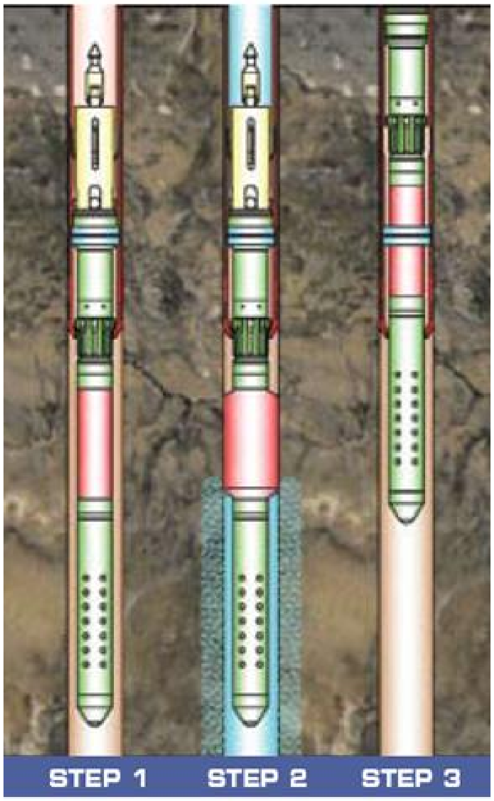
- Piezometer installations consisted of 1.25" O.D. schedule 60 PVC pipe, slotted sections cut with a hacksaw approximately 1 mm in width and 4 mm apart on alternating sides. Filter around the slotted interval consisted of fine to coarse grain sand (approximately 0.5 mm to 3 mm diameter) borrow material with some pebbles (up to 10 mm diameter) taken from Bitter Creek and sealed with hand mixed Pure Gold™ one step bentonite grout. Some slotted sections were sand packed with #20 silica sand. Sand packs were also sealed with Pure Gold™ bentonite. Installations completed with a sand pack were installed through open ended drill pipe.
- When necessary, sand back fill was deposited with the bottom of the pipe no more than 10m above the sand level.
- Sand volumes for sand pack installation were calculated and measured to fill the hole to the desired depth and the top of sand was sounded with the drill pipe to confirm the depth.
- 1.5 m of bentonite grout was placed on top of the sand back fill to create a seal.
- As the bentonite was not given time to set up, 2m of silica sand was added and assumed mixed with the bentonite down hole creating a 3m seal of mixed sand and bentonite.
- The PVC was connected and placed by hand.
- The sand pack was installed to at least 2m above the slotted section to the top of the desired interval.
- 2m of bentonite grout was placed on top of the sand pack to seal the interval.

Appendix C – Packer Test Procedure (SRK)

General procedure for packer test:

(SRK Consulting – Geotechnical and Hydrogeological Field Investigation – Packer testing conducted between September and October 2016)

- The conductivity testing was performed using an IPI Standard Wireline Packer System (SWiPS) size HQ (96 mm). A wireline single-packer system (1 packers) was used to seal the selected intervals within each borehole.
- The SWiPS was checked and tested at surface to verify the correct packer operation at the beginning of each borehole. The packer testing process steps were as follows:
  - The drill rods are pulled back to the appropriate location and test zone flushed for a minimum of 30 min to remove cuttings and debris until water is clear.
  - Packer equipment is installed down the drill rods (Step 1). If water level was below collar elevation, water level was recorded first, then single packer is lower down hole by gravity. The packer assembly was lowered down as though it were a wireline inner barrel. If water was above collar elevation (artesian), it was installed downhole using pump if necessary. The tool landed on the landing ring in core barrel equipped with a special seal, thus hydraulically connecting the inside of the packer tool to the surface via the drill rods.
  - Packers are inflated to proper pressure (Step 2). Water is pumped into the drill rods (through swivel and hoses from water pump as in during drilling). The packer tool channels the pumped water flow through a central pipe (the mandrel), which is blocked at one end by blow-out plug, retained by a shear pin. As long as the shear pin is in place (below its pressure rating), the flow is directed through a one-way TAM valve and into the packer element, inflating it. When inflation pressure exceeds the shear pin rating, the blow out plug is ejected and the flow is directed into the test zone (rock formation).
  - If water level was below collar elevation, test was conducted with injection of water at a constant pressure and until flow rate stabilized. If water was above collar elevation (flowing artesian), test was conducted by shutting of the discharge at the collar (Shut in test): 1 - Close flow valve at top of drill rods and monitor pressure. 2 - After pressure has equilibrated (steady reading for at least 3 minutes), 3 - record shut-in pressure.
  - After completing the pressure steps, the packers are deflated and removed from the rods (Step 3).
- At the completion of testing, a standard Longyear overshot is run into the rods to latch on the spear point on top of the SWiPS tool. Pulling on the tool opens the sliding deflation valve, and the packer deflates within about 10 min or less. The tool features a secondary emergency deflation valve, held by large shear pins which can be broken by pulling on the rods with rig hydraulic head.



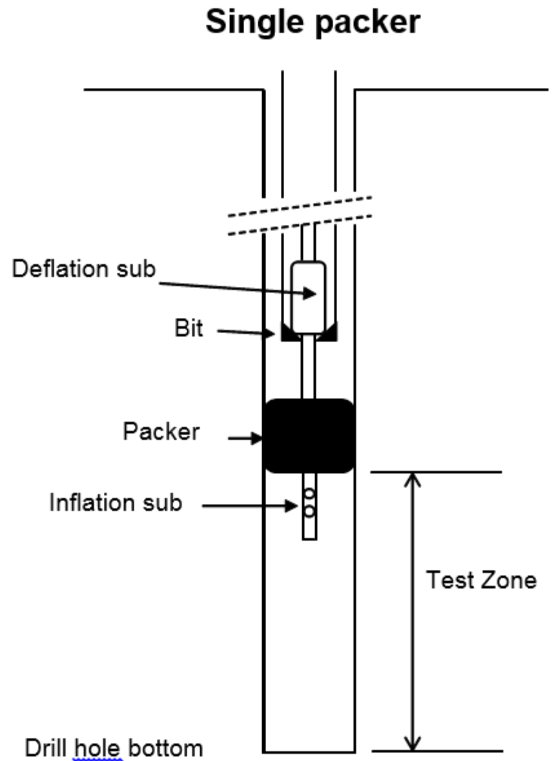


Figure 1 (Left): Drawing from IPI manual (2007) showing simplified packer test process.

Figure 2 (Right): Test zone in single packer test.

RED MOUNTAIN Hydro Designs

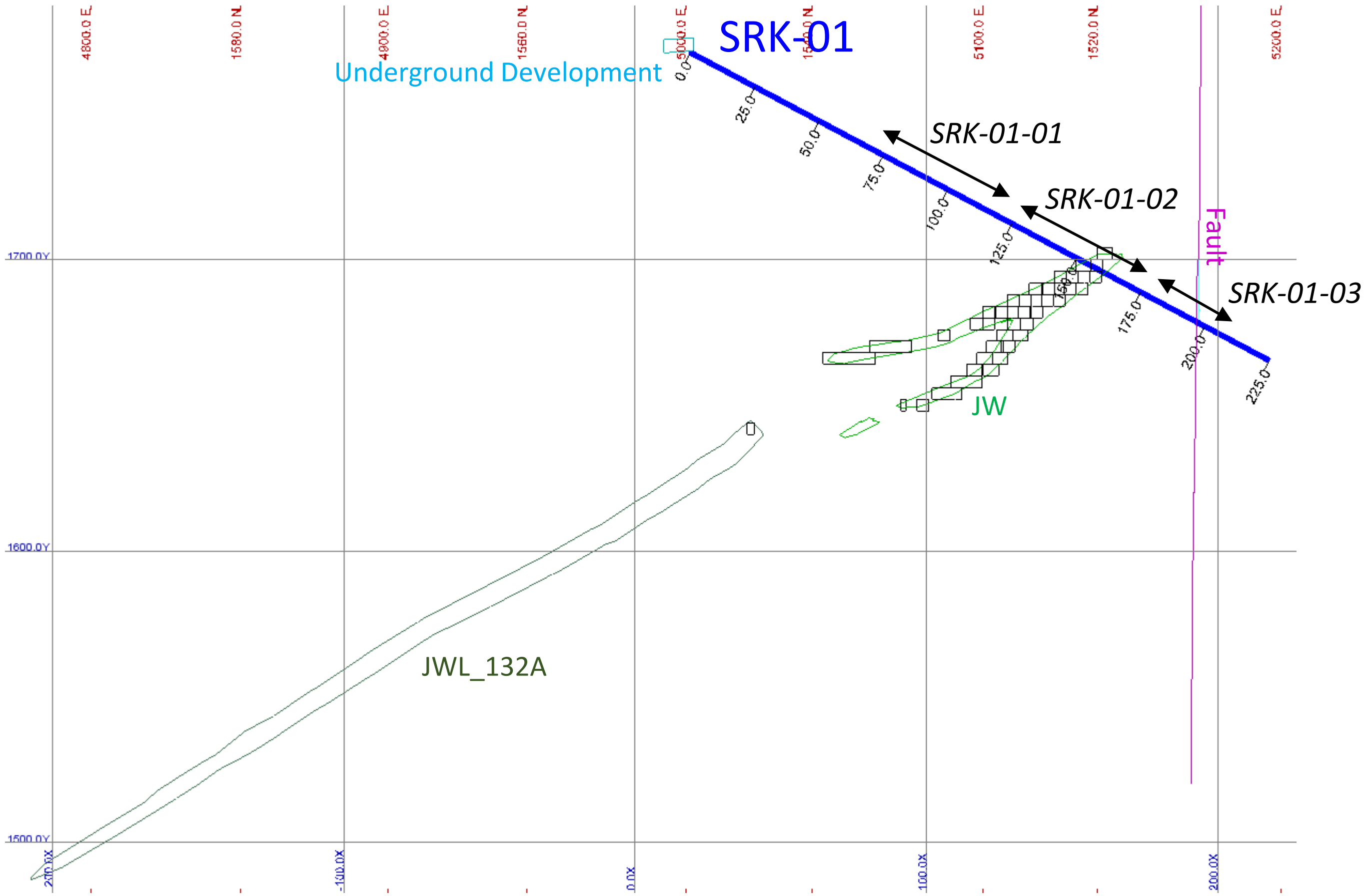
Packer Testing - Preliminary Plan

REV4: Oct. 6, 2016

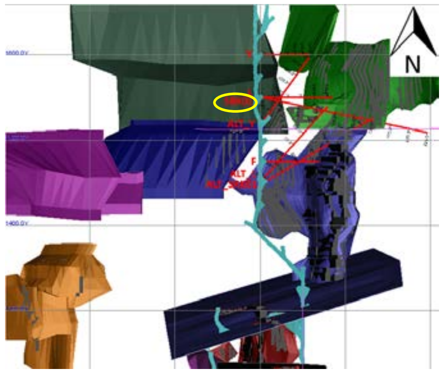
SRK-01 – Hydro Design

Status	Sign-off	Date
Draft	GF	June 29

Easting	Northing	Elevation	Length	Azimuth	Dip	Diameter
5002.00	1550.00	1771.00	225.00	102	28	HQ



Test	Test Target
SRK-01-01 (73.5 to 121.5m)	Bulk K of fractured rock along a 30 to 50m interval, unless core indicates the interception of large fractures or fault systems. In this case, SRK logging senior will provide recommendations on the specific interval that needs to be tested.
SRK-01-02 (~120 to ~170m)	
SRK-01-03 (~170 to 225m) (unsuccessful seating)	Testing identified fault (pink line shown in cross-section)

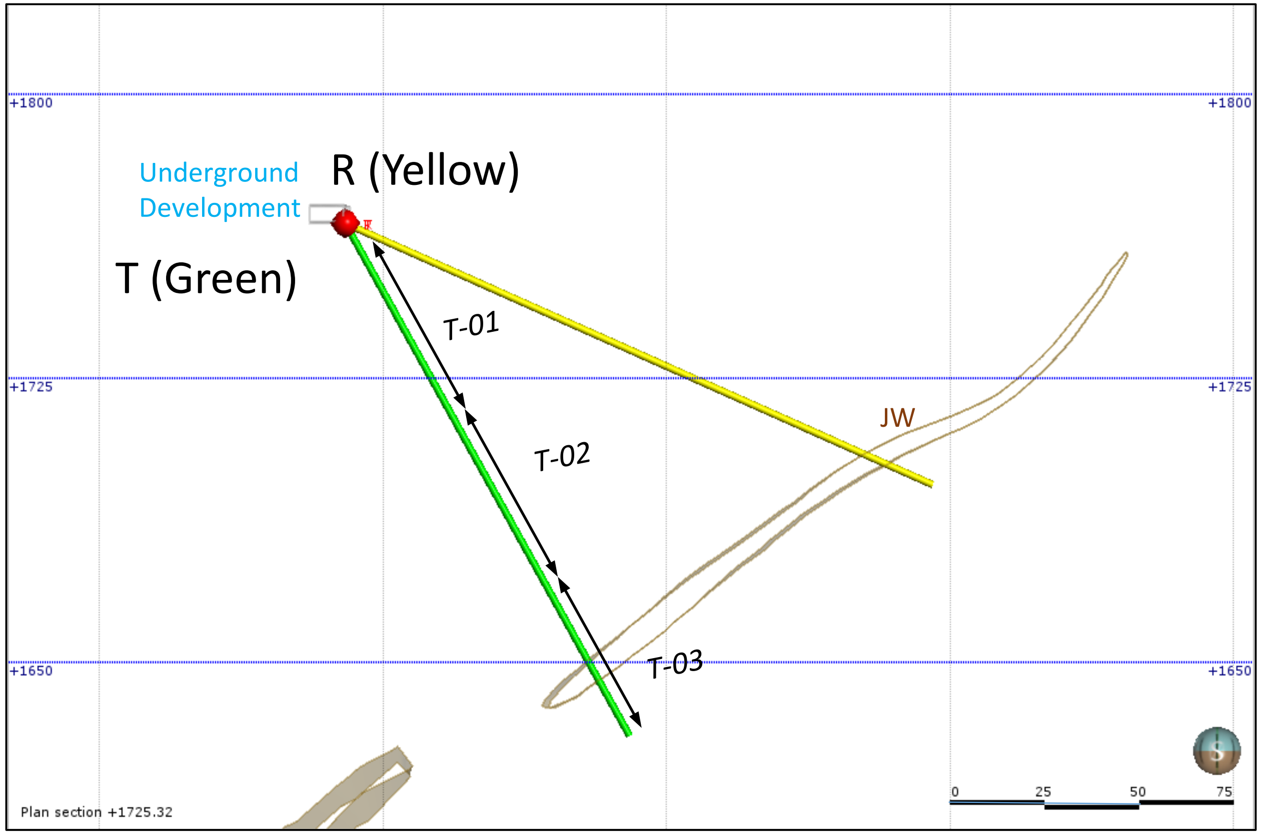


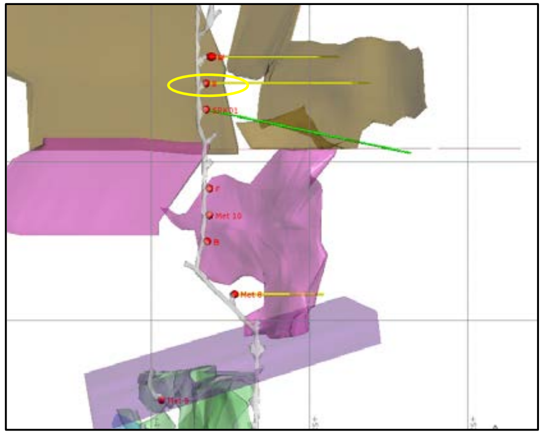
T – Hydro Design

Status	Sign-off	Date
Draft	GF	Sep 27

Easting	Northing	Elevation	Length	Azimuth	Dip	Diameter
5002	1575	1766	155	90	-61	HQ

Test	Test Target
T-01 (~10 to 60m)	Bulk K of fractured rock along a 30 to 50m interval, unless core indicates the interception of large fractures or fault systems. In this case, SRK logging senior will provide recommendations on the specific interval that needs to be tested.
T-02 (~60 to 110m)	
T-03 (~110 to 155m)	

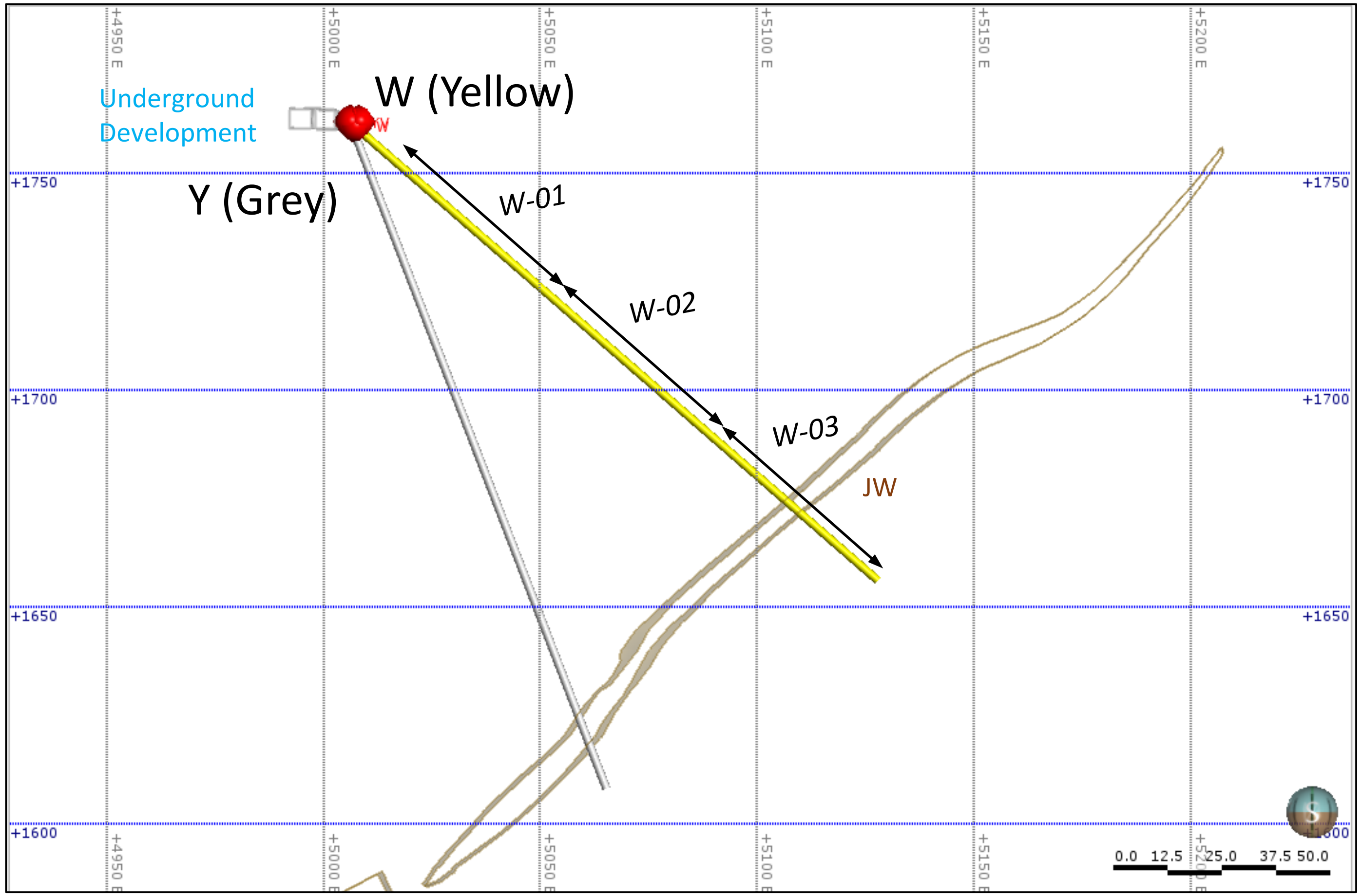




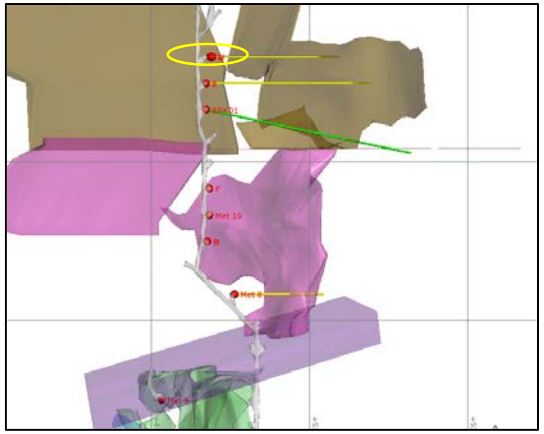
W – Hydro Design

Status	Sign-off	Date
Draft	GF	Sep 27

Easting	Northing	Elevation	Length	Azimuth	Dip	Diameter
5007	1600	1761	160	90	-41	HQ



Test	Test Target
W-01 (~10 to 60m)	Bulk K of fractured rock along a 30 to 50m interval, unless core indicates the interception of large fractures or fault systems. In this case, SRK logging senior will provide recommendations on the specific interval that needs to be tested.
W-02 (~60 to 110m)	
W-03 (~110 to 160m)	

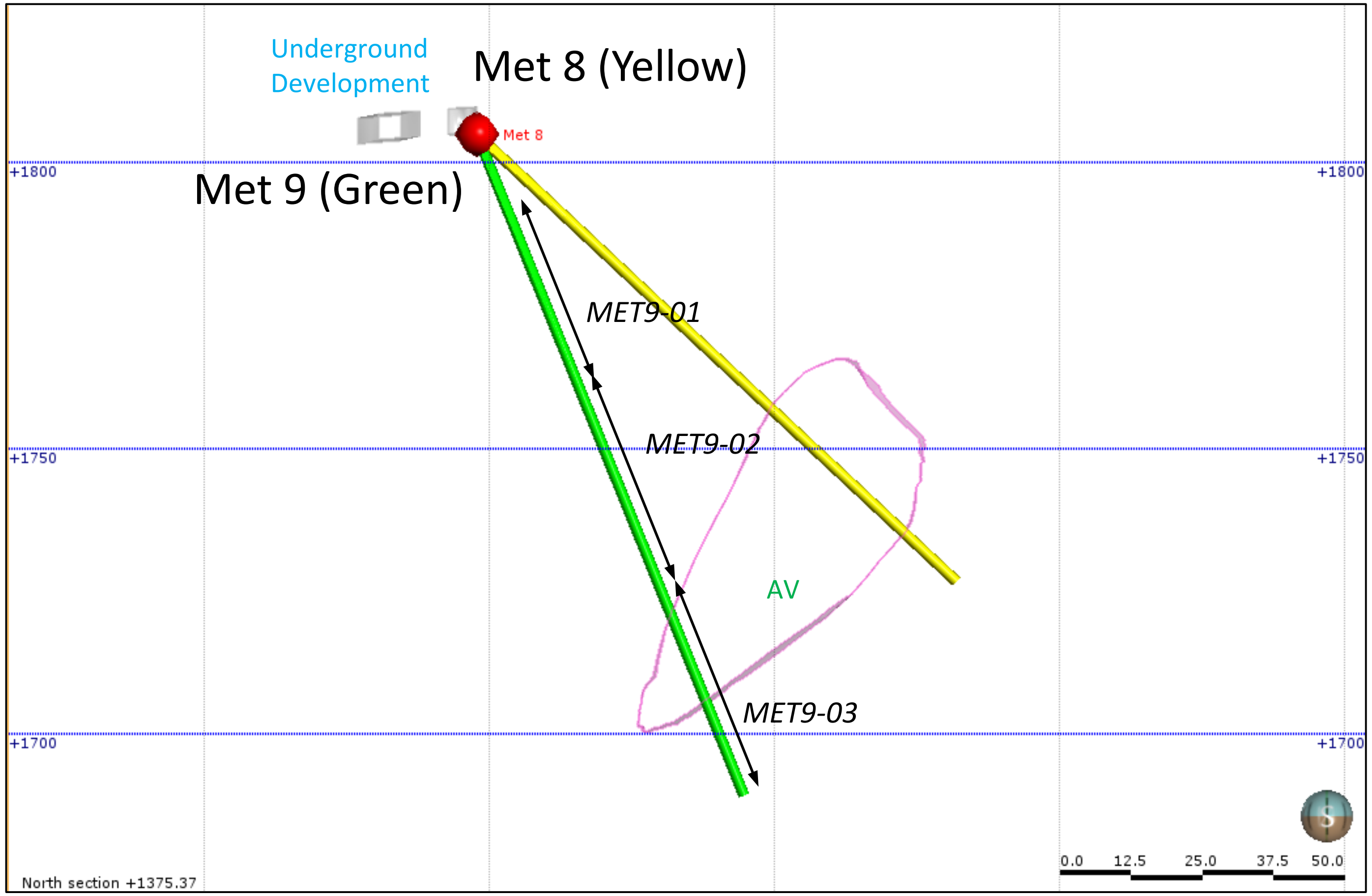


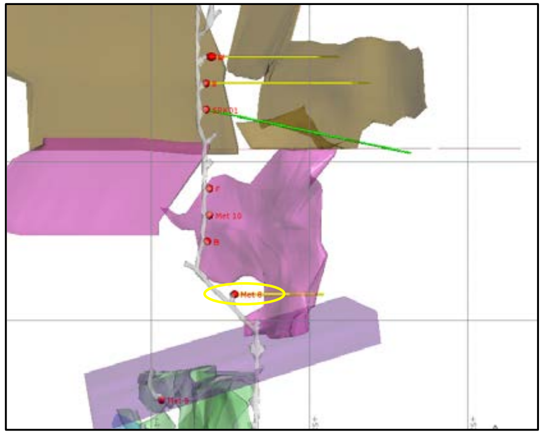
Met9 – Hydro Design

Status	Sign-off	Date
Draft	GF	Sep 27

Easting	Northing	Elevation	Length	Azimuth	Dip	Diameter
5029	1375	1805	125	90	-68	HQ

Test	Test Target
Met 9-01 (~10 to 45m)	Bulk K of fractured rock along a 30 to 50m interval, unless core indicates the interception of large fractures or fault systems.
Met 9-02 (45 to 85m)	
Met 9-03 (85 to 125 m)	





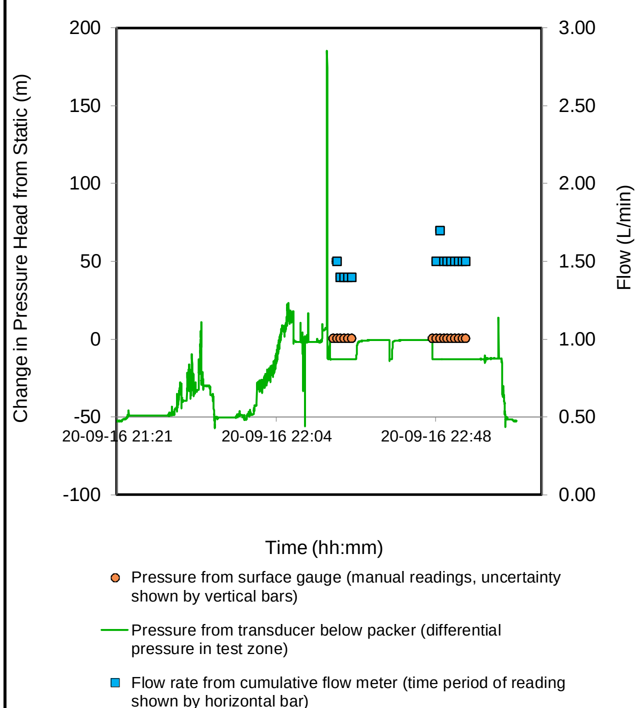
SHUT IN TEST

Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1202**	Test Number:	**1**	Start:	**20-Sep-16 21:20**
Drillhole ID 2:	**SRK01**	From depth (m):	**73.5**	End:	**20-Sep-16 23:00**
Location:	Red Mountain	To depth (m):	**121.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**121.5**	Water Table (m):	**-13.40**

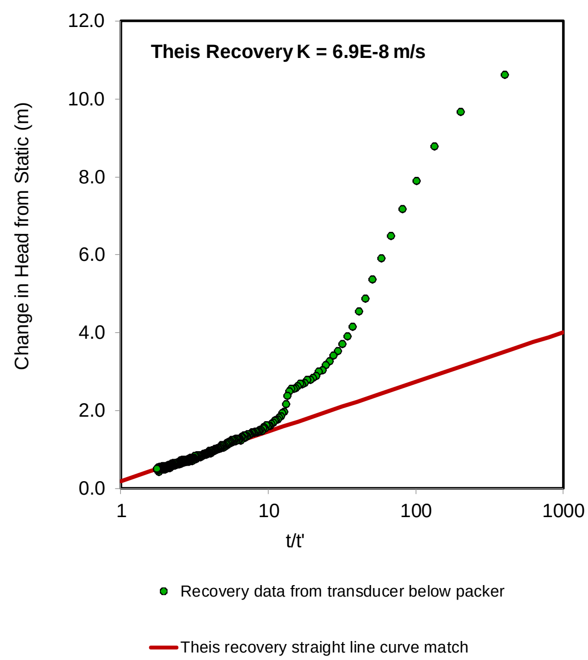
Test zone comments & results

Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock, 2 fault zones logged at 83.63-83.91 and 84.3-84.47 mabh
Test quality:	Good

Pressure and Flow Rate vs. Time Graph



Recovery Plot



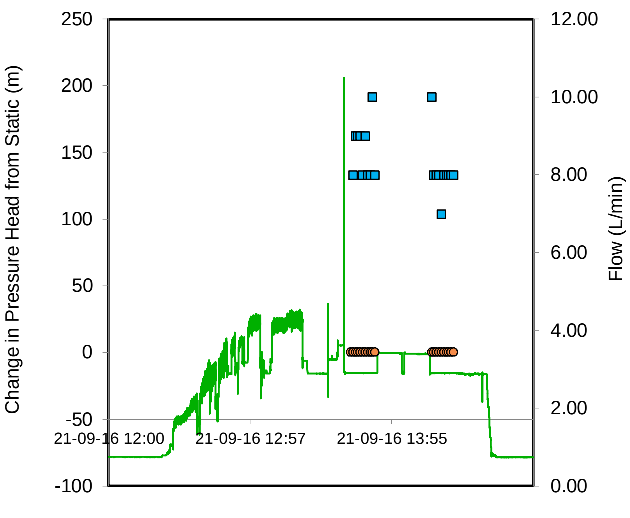
SHUT IN TEST

Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1202**	Test Number:	**2**	Start:	**21-Sep-16 12:15**
Drillhole ID 2:	**SRK01**	From depth (m):	**118.5**	End:	**21-Sep-16 14:40**
Location:	Red Mountain	To depth (m):	**181.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**181.5**	Water Table (m):	**-13.40**

Test zone comments & results

Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock, Ore Zone (JW)
Test quality:	Good

Pressure and Flow Rate vs. Time Graph

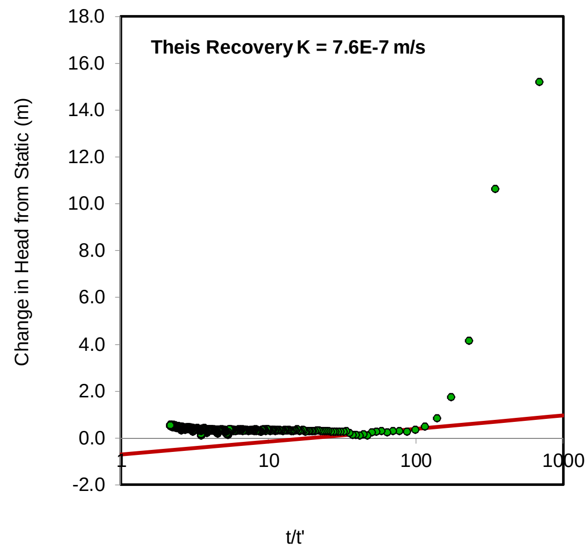


Pressure from surface gauge (manual readings, uncertainty shown by vertical bars)

Pressure from transducer below packer (differential pressure in test zone)

Flow rate from cumulative flow meter (time period of reading shown by horizontal bar)

Recovery Plot



Recovery data from transducer below packer

Theis recovery straight line curve match

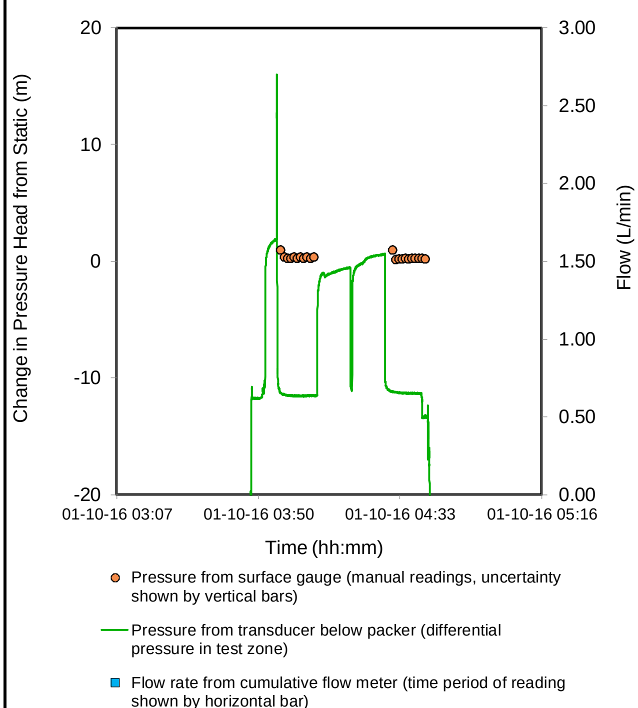
SHUT IN TEST

Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1207**	Test Number:	**1**	Start:	**1-Oct-16 4:00**
Drillhole ID 2:	**T**	From depth (m):	**22.5**	End:	**1-Oct-16 5:00**
Location:	Red Mountain	To depth (m):	**61.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**61.5**	Water Table (m):	**-14.06**

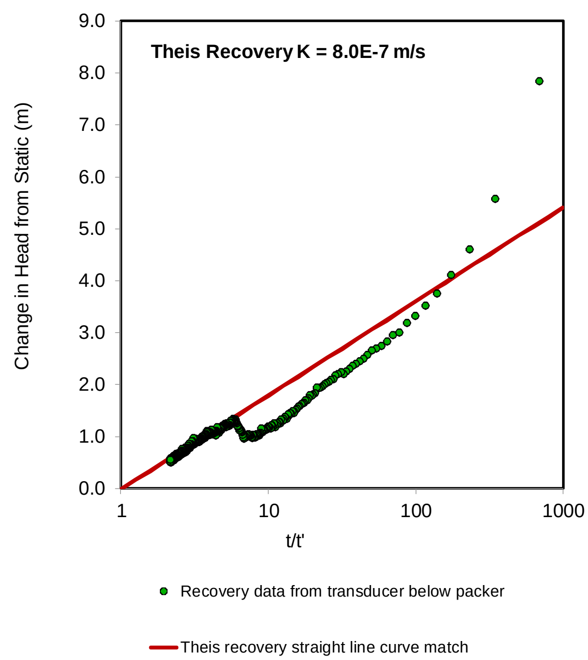
Test zone comments & results

Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock, two small fault with trace of gouge logged at 43.74-43.8 and 45.09-45.1 mabh
Test quality:	Good. Pressure measured only from transducer because 0-300psi gauge broken, and unable to get reading on 0-1000 gauge.

Pressure and Flow Rate vs. Time Graph



Recovery Plot

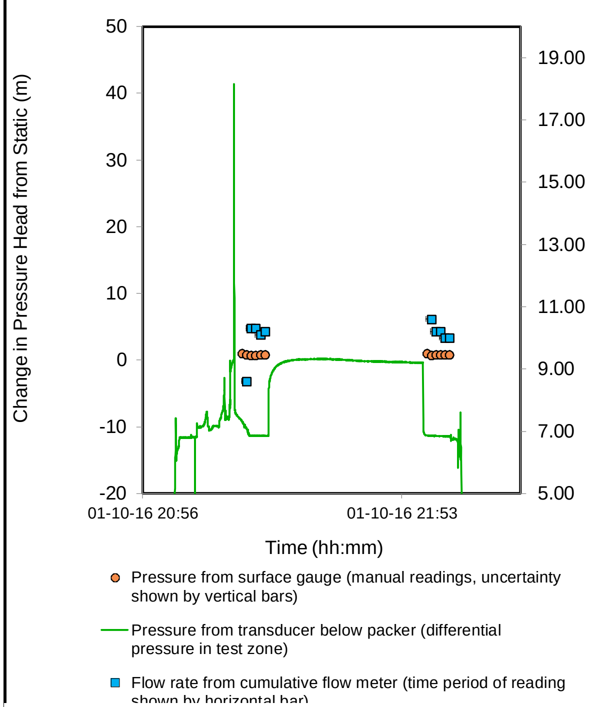


SHUT IN TEST

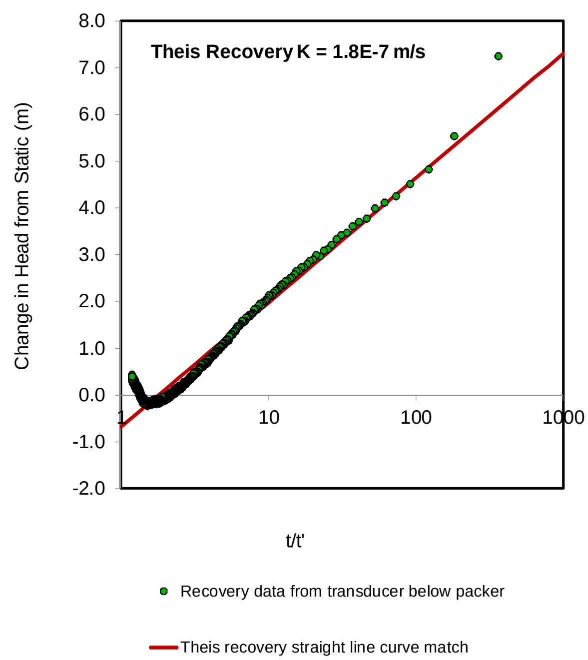
	Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)
Drillhole ID:	**U16-1207**	Test Number:	**2**	Start:	**1-Oct-16 21:00**
Drillhole ID 2:	**T**	From depth (m):	**55.5**	End:	**1-Oct-16 22:00**
Location:	Red Mountain	To depth (m):	**118.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**118.5**	Water Table (m):	**-14.06**

	Test zone comments & results
Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock. Fault logged 59.84-59.87, 64.33 - 64.34, 76.36-76.5, 104.77-104.79, and 108.18-108.65 mabh. Two shallowest with trace or small amount of gouge, others with gray gouge
Test quality:	Good. Pressure measured only from transducer because 0-300psi gauge broken, and unable to get reading on 0-1000 gauge.

Pressure and Flow Rate vs. Time Graph



Recovery Plot



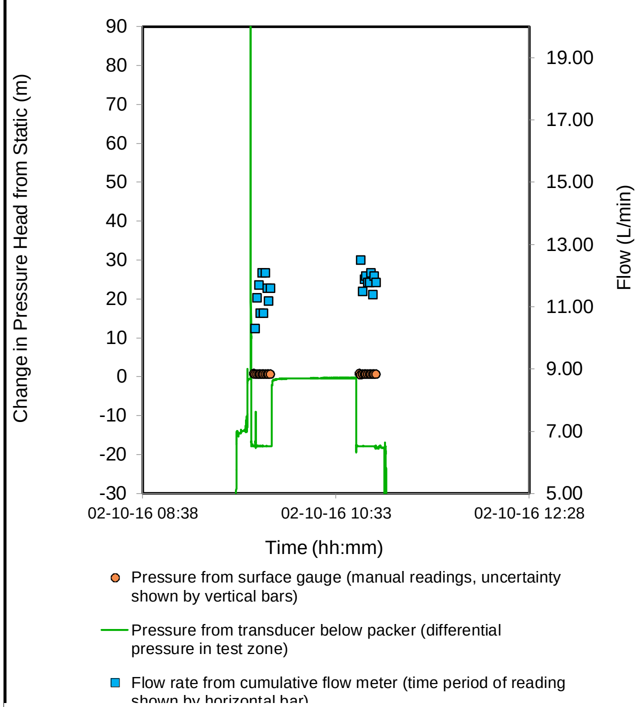
SHUT IN TEST

Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1207**	Test Number:	**3**	Start:	**2-Oct-16 9:20**
Drillhole ID 2:	**T**	From depth (m):	**118.5**	End:	**2-Oct-16 11:20**
Location:	Red Mountain	To depth (m):	**154.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**154.5**	Water Table (m):	**-14.06**

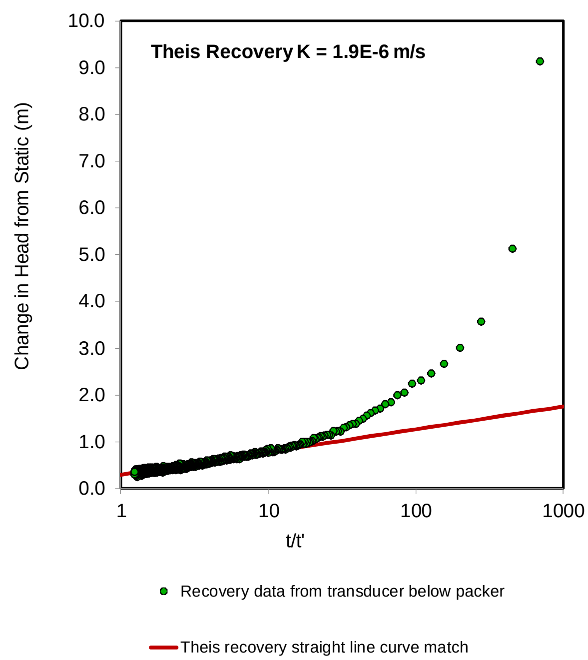
Test zone comments & results

Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock, Ore Zone (JW)
Test quality:	Good. Pressure measured only from transducer because 0-300psi gauge broken, and unable to get reading on 0-1000 gauge.

Pressure and Flow Rate vs. Time Graph



Recovery Plot



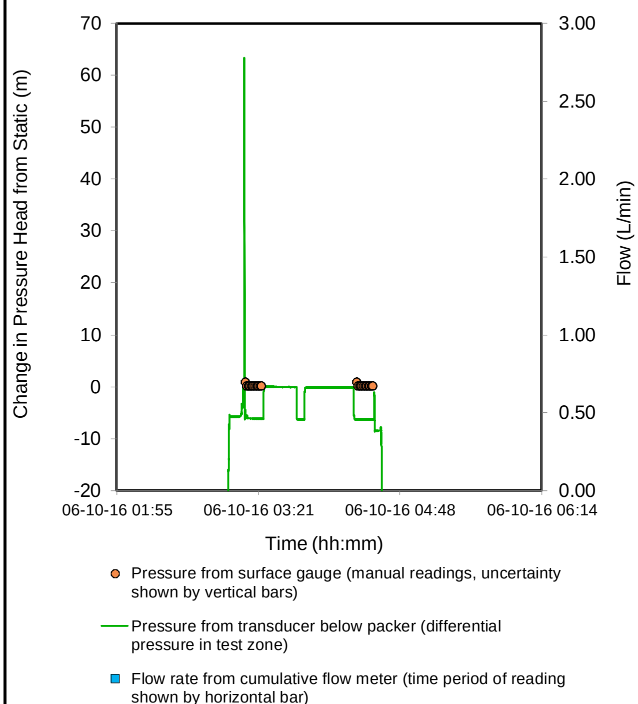
SHUT IN TEST

Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1209**	Test Number:	**1**	Start:	**6-Oct-16 2:50**
Drillhole ID 2:	**W**	From depth (m):	**49.5**	End:	**6-Oct-16 4:50**
Location:	Red Mountain	To depth (m):	**82.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**82.5**	Water Table (m):	**-14.06**

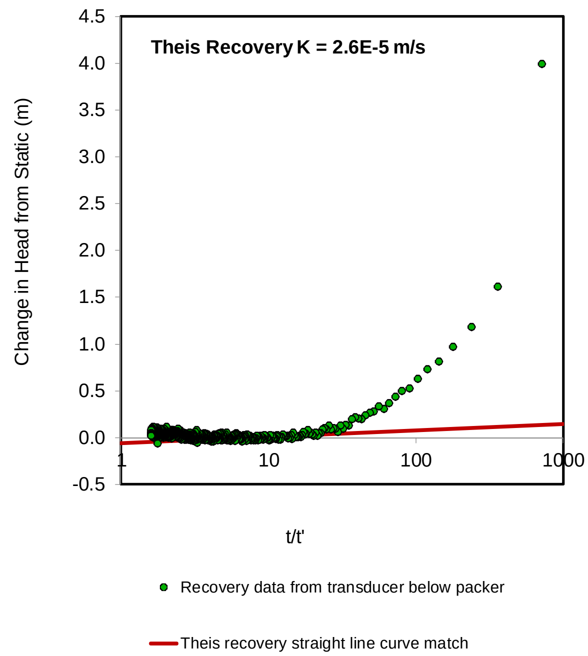
Test zone comments & results

Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock, Fault (i.e. highly broken zone) logged at 66.26-67.32 mabh
Test quality:	Good. Pressure measured only from transducer because 0-300psi gauge broken, and unable to get reading on 0-1000 gauge.

Pressure and Flow Rate vs. Time Graph



Recovery Plot



SHUT IN TEST

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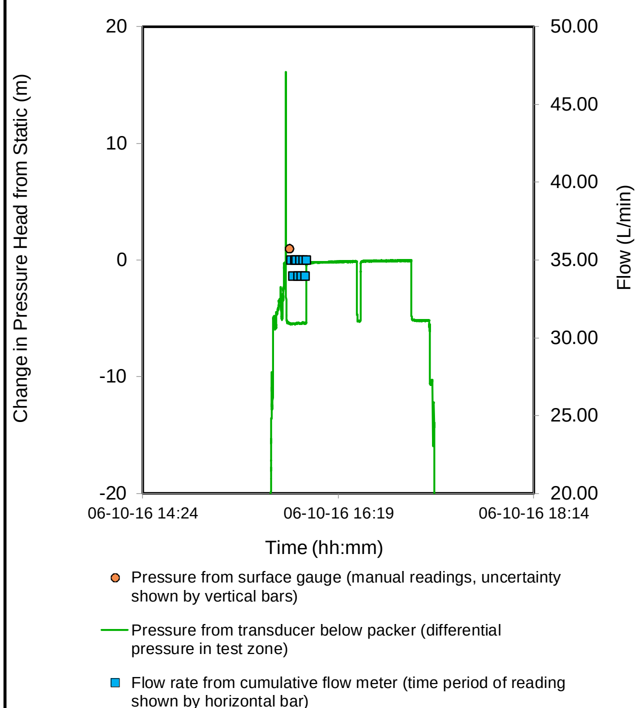
Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1209**	Test Number:	**2**	Start:	**6-Oct-16 15:30**
Drillhole ID 2:	**W**	From depth (m):	**82.5**	End:	**6-Oct-16 17:30**
Location:	Red Mountain	To depth (m):	**118.5**	Supervisor:	**ST**
Project Number:	2CI017.000	Drilled depth (m):	**118.5**	Water Table (m):	**-14.06**

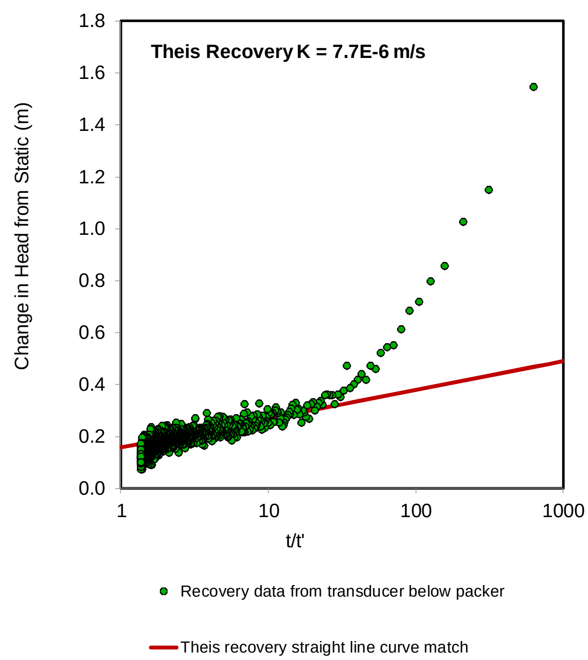
Test zone comments & results

Test purpose & type:	Shut in Test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock. Fault/broken zones logged at 95.04-97.4, 101.98-102.01 and 107.08-107.32 mabh
Test quality:	Good. Pressure measured only from transducer because 0-300psi gauge broken, and unable to get reading on 0-1000 gauge.

Pressure and Flow Rate vs. Time Graph



Recovery Plot



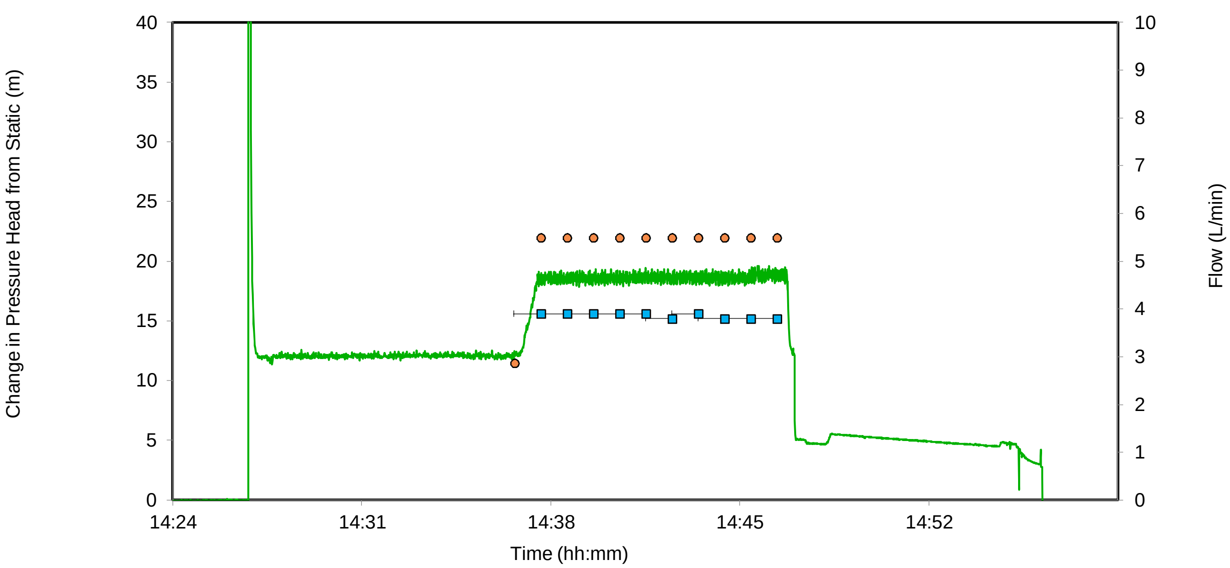
PACKER INJECTION TEST

	Location Description		Test Interval		
Drillhole ID:	**U16-1216**	Test Number:	**1**	Start:	**21-Oct-16 14:00**
Drillhole ID 2:	**MET9**	From depth (m):	**19.3**	End:	**21-Oct-16 15:20**
Location:	Red Mountain	To depth (m):	**51.0**	Supervisor:	**GF**
Project Number:	2CI017.000	Drilled depth (m):	**51.0**	Water Table (m):	**14.10**

Test zone comments & results

Test purpose & type:	Injection test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock
Test quality:	good

Pressure and Flow Rate vs. Time Graph



Summary of Calculation Results

						H_f (friction loss)		0.03	m
P_{max} (hydrojacking)	21.5	psi	Q (flow rate)	3.86	l/min	H_{nit} (net inj.head)		27.0	m
P1 (surface)	20.0	psi	System leak	2.14	l/min	**K1 (Surface)**	=	**2.8E-08**	m/s
$P2_{nit}$ (downhole; graph)	19.1	m	Q (adj.flow rate)	1.72	l/min	**K2 (Downhole)**	=	**4.0E-08**	m/s

Variables and Constants

D_w	14.1	m	$P_{aquifer}$	5	psi
D_{br}	0.0	m	P_{diff}	17	psi
D_p	19.3	m	P_g	20	psi
D_t	35.1	m	H_g	1.0	m
ß	48.0	deg.	L_p	2.50	m
Dw'	10.5	m	r_p	0.0075	m
$H_{stickup}$	1.5	m	R	10	m
Dp'	14.3	m	r_b	0.048	m
Dt'	26.1	m	L	31.8	m
P_{rods}	22	psi			

Drilling and testing

Rod size	**HQ**
Water	Fresh (with sediment)
Additive	None
Drill type	diamond
Packer Tool	SWiPS

Pressure monitoring

Below Packer (transducer)	✓
Above packer (transducer)	
Surface (flow meter)	
Surface (manual)	✓
Other	

Logical messages about test data:

System pressurized

Packer tool is in water

Sensor wet - zone pressurized

Flow monitoring

Electronic	
Cumulative	✓
Other	

PACKER INJECTION TEST

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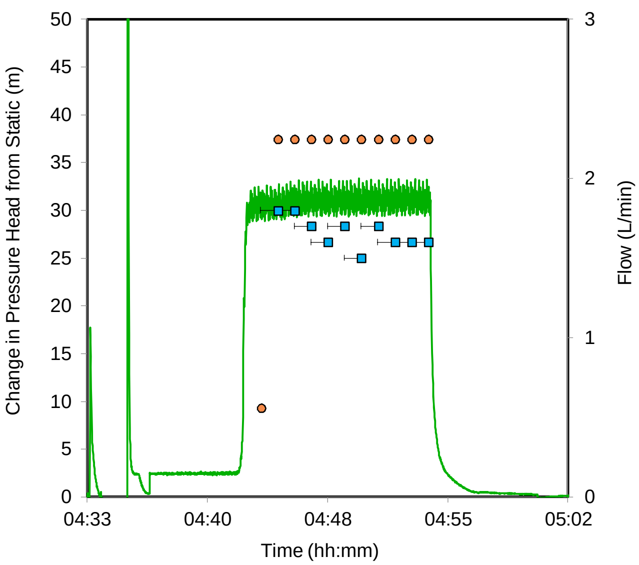
Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	U16-1216	Test Number:	2	Start:	22-Oct-16 4:00
Drillhole ID 2:	MET9	From depth (m):	52.3	End:	22-Oct-16 17:30
Location:	Red Mountain	To depth (m):	84.0	Supervisor:	GF
Project Number:	2CI017.000	Drilled depth (m):	84.0	Water Table (m):	11.20

Test zone comments & results

Test purpose & type:	Injection test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock. Rubble zone logged at 56.01-56.44, 60.94-61, 61.19-61.26, and 65.48-65.62 mabh
Test quality:	good

Pressure and Flow Rate vs. Time Graph

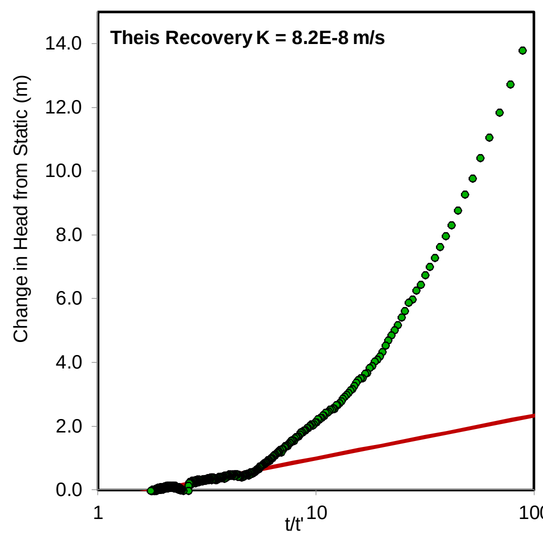


Pressure from surface gauge (manual readings, uncertainty shown by vertical bars)

Pressure from transducer below packer (differential pressure in test zone)

Flow rate from cumulative flow meter (time period of reading shown by horizontal bar)

Recovery Plot



Recovery data from transducer below packer

Theis recovery straight line curve match

Summary of Calculation Results

						H_f (friction loss)		0.01	m
P_{max} (hydrojacking)	58.2	psi	Q (flow rate)	1.66	l/min	H_{nit} (net inj.head)		46.0	m
P1 (surface)	50.0	psi	System leak	0.50	l/min	K1 (Surface)	=	1.1E-08	m/s
$P2_{nit}$ (downhole; graph)	32.4	m	Q (adj.flow rate)	1.16	l/min	K2 (Downhole)	=	1.6E-08	m/s

Variables and Constants

Dw	11.2	m	$P_{aquifer}$	43	psi
D_{br}	0.0	m	P_{diff}	14	psi
D_p	52.3	m	P_g	50	psi
D_t	68.1	m	H_g	1.0	m
ß	48.0	deg.	L_p	2.50	m
Dw'	8.3	m	r_p	0.0075	m
$H_{stickup}$	1.5	m	R	10	m
Dp'	38.8	m	r_b	0.048	m
Dt'	50.6	m	L	31.8	m
P_{rods}	57	psi			

Drilling and testing

Rod size	HQ
Water	Fresh (with sediment)
Additive	None
Drill type	diamond
Packer Tool	SWiPS

Pressure monitoring

Below Packer (transducer)	✓
Above packer (transducer)	
Surface (flow meter)	
Surface (manual)	✓
Other	

Logical messages about test data:

System pressurized

Packer tool is in water

Sensor wet - zone pressurized

Flow monitoring

Electronic	
Cumulative	✓
Other	

PACKER INJECTION TEST

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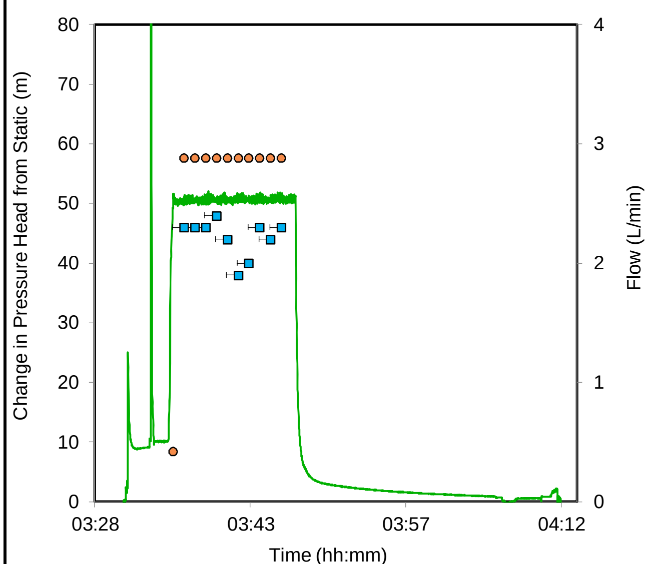
Location Description		Test Interval		Date & Time (d-mmm-yy hh:mm)	
Drillhole ID:	**U16-1216**	Test Number:	**3**	Start:	**23-Oct-16 3:35**
Drillhole ID 2:	**MET9**	From depth (m):	**91.3**	End:	**23-Oct-16 3:50**
Location:	Red Mountain	To depth (m):	**138.0**	Supervisor:	**GF**
Project Number:	2CI017.000	Drilled depth (m):	**138.0**	Water Table (m):	**10.05**

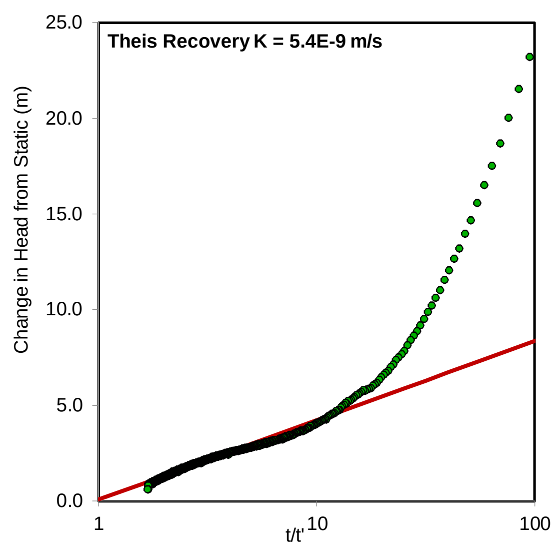
Test zone comments & results

Test purpose & type:	Injection test
Drilling comments:	-
Geology, hydrogeology & rock mass:	Igneous rock, Ore Zone (AV)
Test quality:	good

Pressure and Flow Rate vs. Time Graph



Recovery Plot



Summary of Calculation Results

						H_f (friction loss)		**0.01**	m
P_{max} (hydrojacking)	101.7	psi	Q (flow rate)	**2.22**	l/min	H_{nit} (net inj.head)		**73.3**	m
P1 (surface)	**90.0**	**psi**	System leak	**1.88**	l/min	**K1 (Surface)**	**=**	**1.4E-09**	m/s
$P2_{nit}$ (downhole; graph)	**51.7**	**m**	Q (adj.flow rate)	**0.35**	l/min	**K2 (Downhole)**	**=**	**2.0E-09**	m/s

Variables and Constants

Dw	10.1	m	$P_{aquifer}$	86	psi
D_{br}	0.0	m	P_{diff}	13	psi
D_p	91.3	m	P_g	90	psi
D_t	114.6	m	H_g	1.0	m
ß	48.0	deg.	L_p	2.50	m
Dw'	7.5	m	r_p	0.0075	m
$H_{stickup}$	1.5	m	R	10	m
Dp'	67.8	m	r_b	0.048	m
Dt'	85.2	m	L	46.8	m
P_{rods}	99	psi			

Drilling and testing

Rod size	**HQ**
Water	Fresh (with sediment)
Additive	None
Drill type	diamond
Packer Tool	SWiPS

Pressure monitoring

Below Packer (transducer)	✓
Above packer (transducer)	
Surface (flow meter)	
Surface (manual)	✓
Other	

Logical messages about test data:

System pressurized

Packer tool is in water

Sensor wet - zone pressurized

Flow monitoring

Electronic	
Cumulative	✓
Other	

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BOREHOLE LOG: U16-1202

PROJECT: Red Mountain Geotechnical Data Collection

LOCATION: IDM Mining Red Mountain

SITE & PROJECT No: 2CI017.000

BORING DATE: **TO:**

DIP: -28 **AZIMUTH:** 104

COORDINATES: 5002 N 1548 E 1772 Z

DRAFT

TOTAL DEPTH: 229.5m

PAGE: 1 **OF** 4

DRILL TYPE:

CORE DIA.: HQ

DEFINTIONS

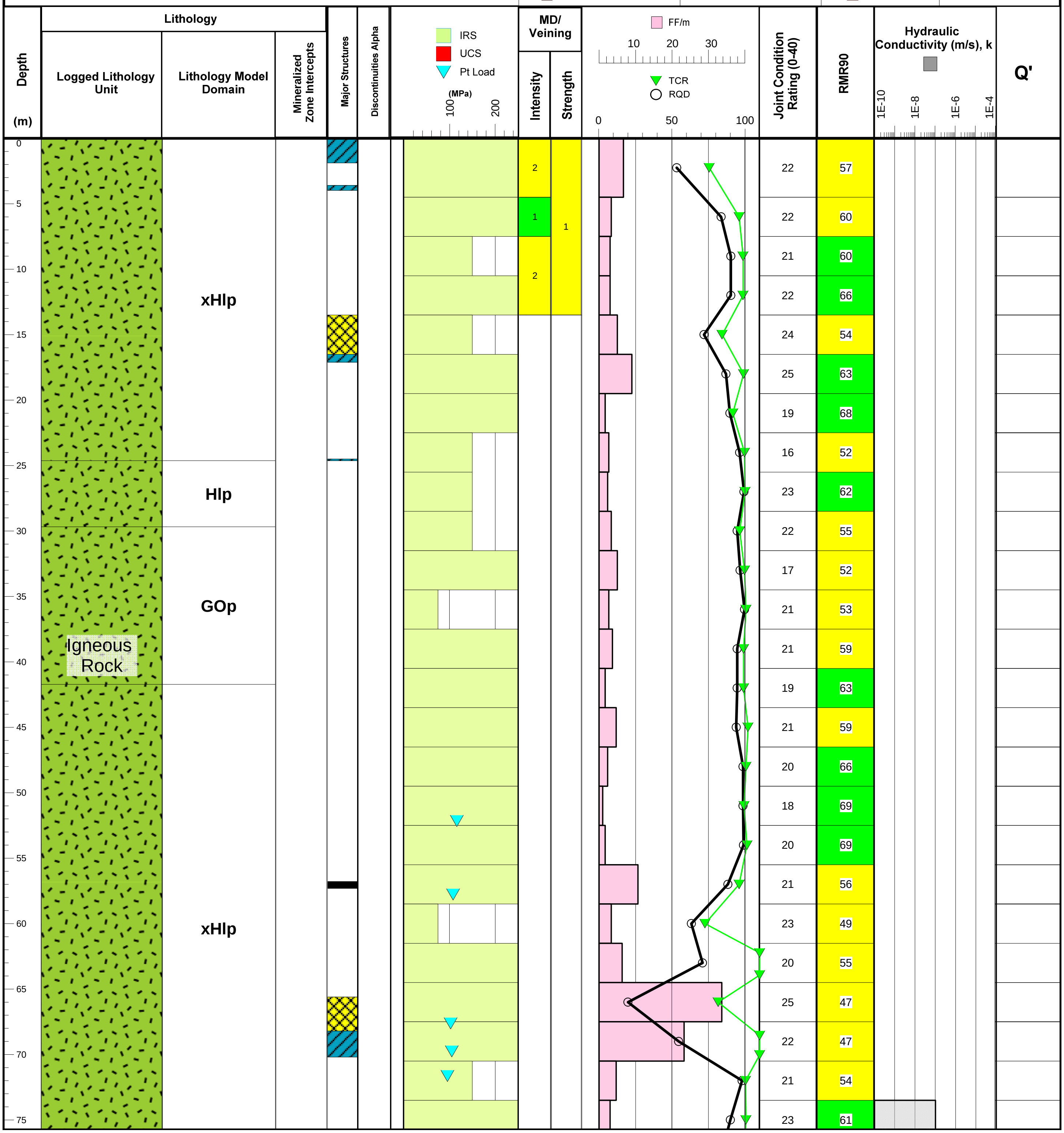
IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES
GOUGE
SHEARED
BROKEN
JOINTED
CRYSTALIZED CALCITE

LEGEND OF RMR89
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100

LEGEND OF MD/VEINING INTENSITY
0 - None
1 - Minor
2 - Moderate
3 - Intense

LEGEND OF MD/VEINING STRENGTH
0 - Never Breaks
1 - Sometimes Breaks
2 - Always Breaks



Joint Condition Rating (0-40)	RMR90
22	57
22	60
21	60
22	66
24	54
25	63
19	68
16	52
23	62
22	55
17	52
21	53
21	59
19	63
21	59
20	66
18	69
20	69
21	56
23	49
20	55
25	47
22	47
21	54
23	61

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BOREHOLE LOG: U16-1202

PROJECT: Red Mountain Geotechnical Data Collection
LOCATION: IDM Mining Red Mountain
SITE & PROJECT No: 2CI017.000
BORING DATE: **TO:**
DIP: -28 **AZIMUTH:** 104
COORDINATES: 5002 N 1548 E 1772 Z

DRAFT

TOTAL DEPTH: 229.5m
PAGE: 2 **OF** 4
DRILL TYPE:
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DEFINTIONS

IRS: Intact Rock Strength (field est.)
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TCR: Total Core Recovery
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UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
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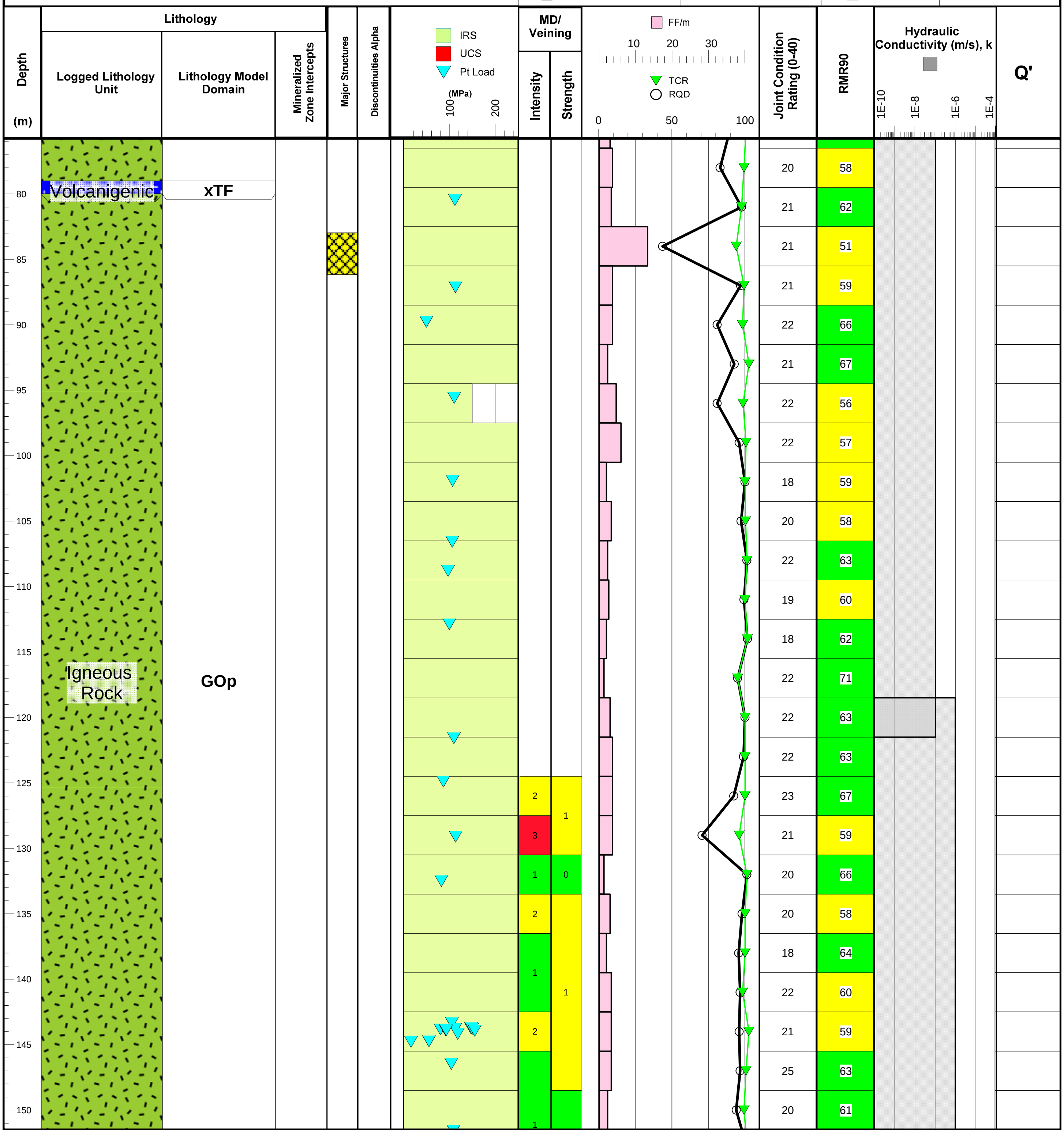
LEGEND OF MAJOR STRUCTURES
GOUGE
SHEARED
BROKEN
JOINTED
CRYSTALIZED CALCITE

LEGEND OF RMR89
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100

LEGEND OF MD/VEINING INTENSITY
0 - None
1 - Minor
2 - Moderate
3 - Intense

LEGEND OF MD/VEINING STRENGTH
0 - Never Breaks
1 - Sometimes Breaks
2 - Always Breaks



Joint Condition Rating (0-40)	RMR90
20	58
21	62
21	51
21	59
22	66
21	67
22	56
22	57
18	59
20	58
22	63
19	60
18	62
22	71
22	63
22	63
23	67
21	59
20	66
20	58
18	64
22	60
21	59
25	63
20	61

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BOREHOLE LOG: U16-1202

PROJECT: Red Mountain Geotechnical Data Collection
LOCATION: IDM Mining Red Mountain
SITE & PROJECT No: 2CI017.000
BORING DATE: **TO:**
DIP: -28 **AZIMUTH:** 104
COORDINATES: 5002 N 1548 E 1772 Z

DRAFT

TOTAL DEPTH: 229.5m
PAGE: 3 **OF** 4
DRILL TYPE:
CORE DIA.: HQ

DEFINTIONS

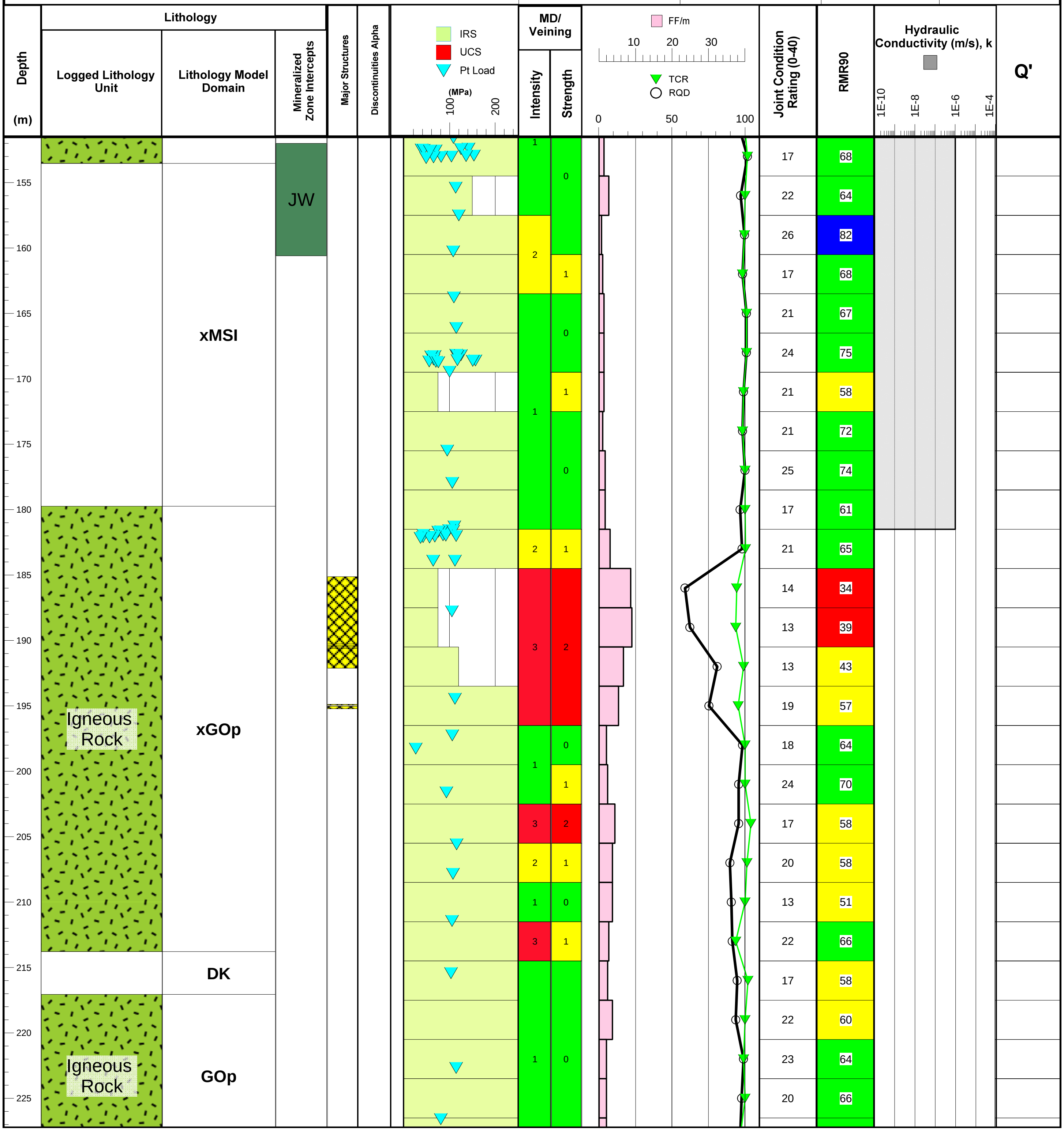
IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES
- GOUGE
- SHEARED
- BROKEN
- JOINTED
- CRYSTALIZED CALCITE

LEGEND OF RMR89
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

LEGEND OF MD/VEINING INTENSITY
- 0 - None
- 1 - Minor
- 2 - Moderate
- 3 - Intense

LEGEND OF MD/VEINING STRENGTH
- 0 - Never Breaks
- 1 - Sometimes Breaks
- 2 - Always Breaks



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BOREHOLE LOG: U16-1202

PROJECT: Red Mountain Geotechnical Data Collection
LOCATION: IDM Mining Red Mountain
SITE & PROJECT No: 2CI017.000
BORING DATE: **TO:**
DIP: -28 **AZIMUTH:** 104
COORDINATES: 5002 N 1548 E 1772 Z

DRAFT

TOTAL DEPTH: 229.5m
PAGE: 4 **OF** 4
DRILL TYPE:
CORE DIA.: HQ

DEFINTIONS

IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES
- GOUGE
- SHEARED
- BROKEN
- JOINTED
- CRYSTALIZED CALCITE

LEGEND OF RMR89
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

LEGEND OF MD/VEINING INTENSITY
- 0 - None
- 1 - Minor
- 2 - Moderate
- 3 - Intense

LEGEND OF MD/VEINING STRENGTH
- 0 - Never Breaks
- 1 - Sometimes Breaks
- 2 - Always Breaks

Depth (m)	Lithology: Logged Lithology Unit	Lithology: Lithology Model Domain	Mineralized Zone Intercepts	Major Structures	Discontinuities Alpha	IRS / UCS / Pt Load (MPa) 100 200	MD/Veining: Intensity	MD/Veining: Strength	FF/m 10 20 30; TCR / RQD 0 50 100	Joint Condition Rating (0-40)	RMR90	Hydraulic Conductivity (m/s), k 1E-10 1E-8 1E-6 1E-4	Q'
										20	66		

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BOREHOLE LOG: U16-1209

PROJECT: Red Mountain Geotechnical Data Collection
LOCATION: IDM Mining Red Mountain
SITE & PROJECT No: 2CI017.000
BORING DATE: **TO:**
DIP: -41 **AZIMUTH:** 90.5
COORDINATES: 1599 N 1762 E 1762 Z

DRAFT

TOTAL DEPTH: 160.5 m
PAGE: 1 **OF** 3
DRILL TYPE:
CORE DIA.: HQ

DEFINTIONS

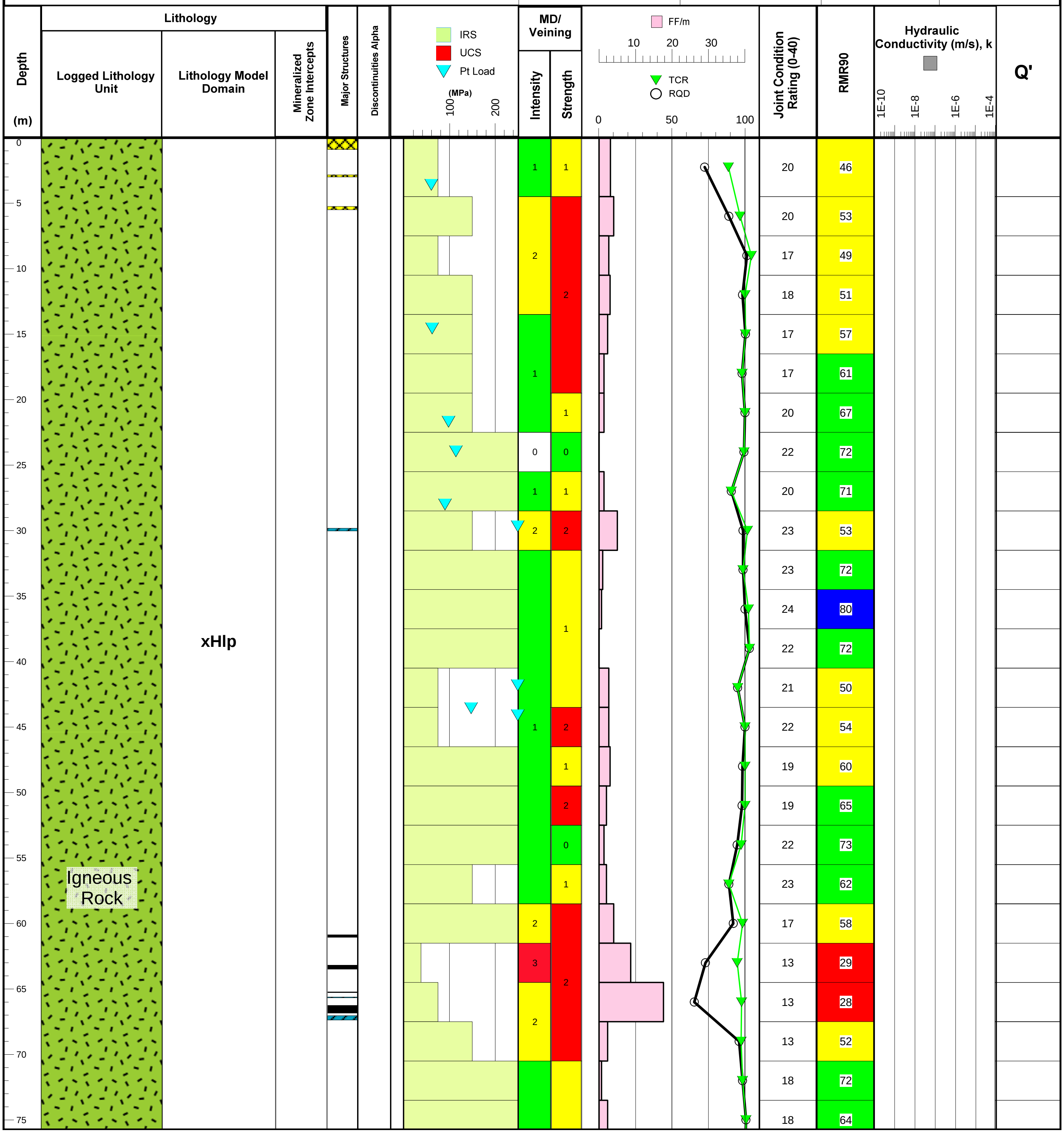
IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES
GOUGE
SHEARED
BROKEN
JOINTED
CRYSTALIZED CALCITE

LEGEND OF RMR89
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100

LEGEND OF MD/VEINING INTENSITY
0 - None
1 - Minor
2 - Moderate
3 - Intense

LEGEND OF MD/VEINING STRENGTH
0 - Never Breaks
1 - Sometimes Breaks
2 - Always Breaks



BOREHOLE LOG: U16-1209

PROJECT: Red Mountain Geotechnical Data Collection
LOCATION: IDM Mining Red Mountain
SITE & PROJECT No: 2CI017.000
BORING DATE: **TO:**
DIP: -41 **AZIMUTH:** 90.5
COORDINATES: 1599 N 1762 E 1762 Z

DRAFT

TOTAL DEPTH: 160.5 m
DRILL TYPE:
CORE DIA.: HQ

DEFINTIONS

IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
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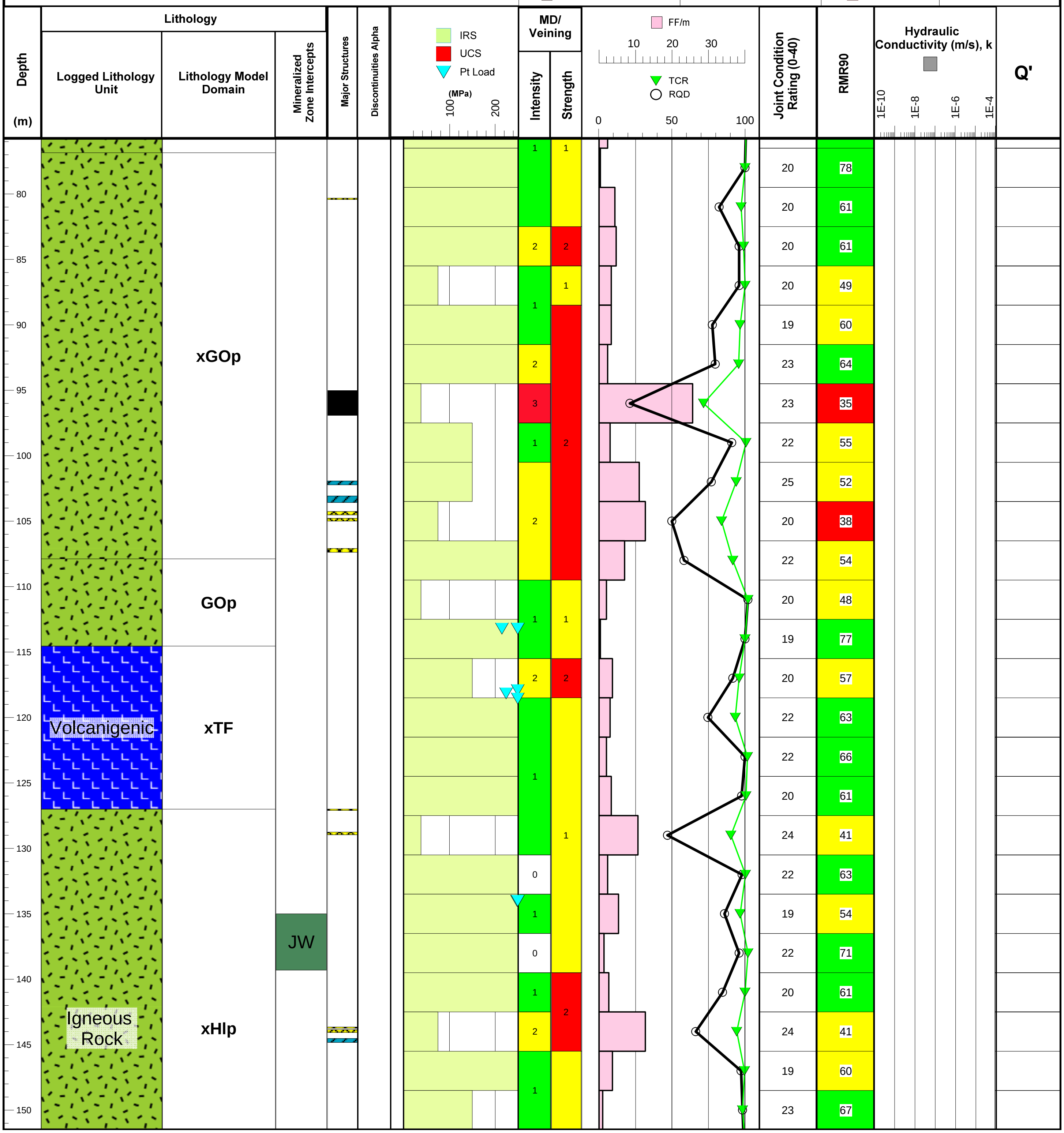
LEGEND OF MAJOR STRUCTURES
GOUGE
SHEARED
BROKEN
JOINTED
CRYSTALIZED CALCITE

LEGEND OF RMR89
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100

LEGEND OF MD/VEINING INTENSITY
0 - None
1 - Minor
2 - Moderate
3 - Intense

LEGEND OF MD/VEINING STRENGTH
0 - Never Breaks
1 - Sometimes Breaks
2 - Always Breaks



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BOREHOLE LOG: U16-1209

PROJECT: Red Mountain Geotechnical Data Collection
LOCATION: IDM Mining Red Mountain
SITE & PROJECT No: 2CI017.000
BORING DATE: **TO:**
DIP: -41 **AZIMUTH:** 90.5
COORDINATES: 1599 N 1762 E 1762 Z

DRAFT

TOTAL DEPTH: 160.5m
PAGE: 3 **OF** 3
DRILL TYPE:
CORE DIA.: HQ

DEFINTIONS

IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES: GOUGE, SHEARED, BROKEN, JOINTED, CRYSTALIZED CALCITE

LEGEND OF RMR89: 0 - 20, 21 - 40, 41 - 60, 61 - 80, 81 - 100

LEGEND OF MD/VEINING INTENSITY: 0 - None, 1 - Minor, 2 - Moderate, 3 - Intense

LEGEND OF MD/VEINING STRENGTH: 0 - Never Breaks, 1 - Sometimes Breaks, 2 - Always Breaks

Depth (m)	Logged Lithology Unit	Lithology Model Domain	Mineralized Zone Intercepts	Major Structures	Discontinuities Alpha	IRS / UCS / Pt Load (MPa) 100 200	MD/Veining Intensity	MD/Veining Strength	FF/m (10 20 30); TCR / RQD (0 50 100)	Joint Condition Rating (0-40)	RMR90	Hydraulic Conductivity (m/s), k (1E-10 1E-8 1E-6 1E-4)	Q'
155							0	1		23	69		
										19	60		
160							1			22	66		

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BOREHOLE LOG: U16-1216

PROJECT: Red Mountain Geotechnical Data Collection

LOCATION: IDM Mining Red Mountain

SITE & PROJECT No: 2CI017.000

BORING DATE: **TO:**

DIP: -45 **AZIMUTH:** 130

COORDINATES: 5004 N 1422 E 1794 Z

DRAFT

TOTAL DEPTH: 138 m

PAGE: 1 **OF** 2

DRILL TYPE:

CORE DIA.: HQ

DEFINTIONS

IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES

- GOUGE
- SHEARED
- BROKEN
- JOINTED
- CRYSTALIZED CALCITE

LEGEND OF RMR89

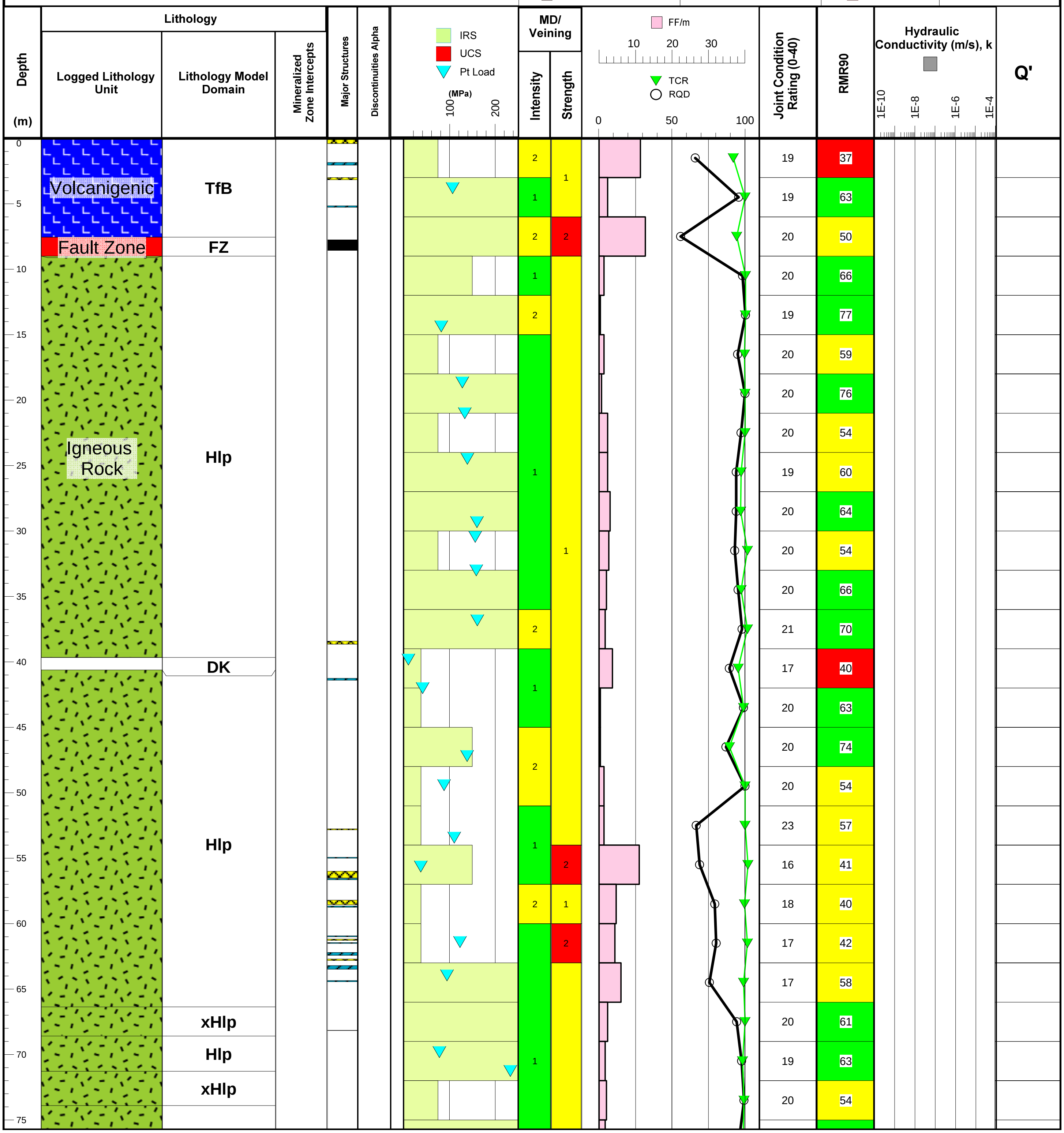
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100

LEGEND OF MD/VEINING INTENSITY

- 0 - None
- 1 - Minor
- 2 - Moderate
- 3 - Intense

LEGEND OF MD/VEINING STRENGTH

- 0 - Never Breaks
- 1 - Sometimes Breaks
- 2 - Always Breaks



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BOREHOLE LOG: U16-1216

PROJECT: Red Mountain Geotechnical Data Collection

LOCATION: IDM Mining Red Mountain

SITE & PROJECT No: 2CI017.000

BORING DATE: **TO:**

DIP: -45 **AZIMUTH:** 130

COORDINATES: 5004 N 1422 E 1794 Z

DRAFT

TOTAL DEPTH: 138 m

PAGE: 2 **OF** 2

DRILL TYPE:

CORE DIA.: HQ

DEFINTIONS

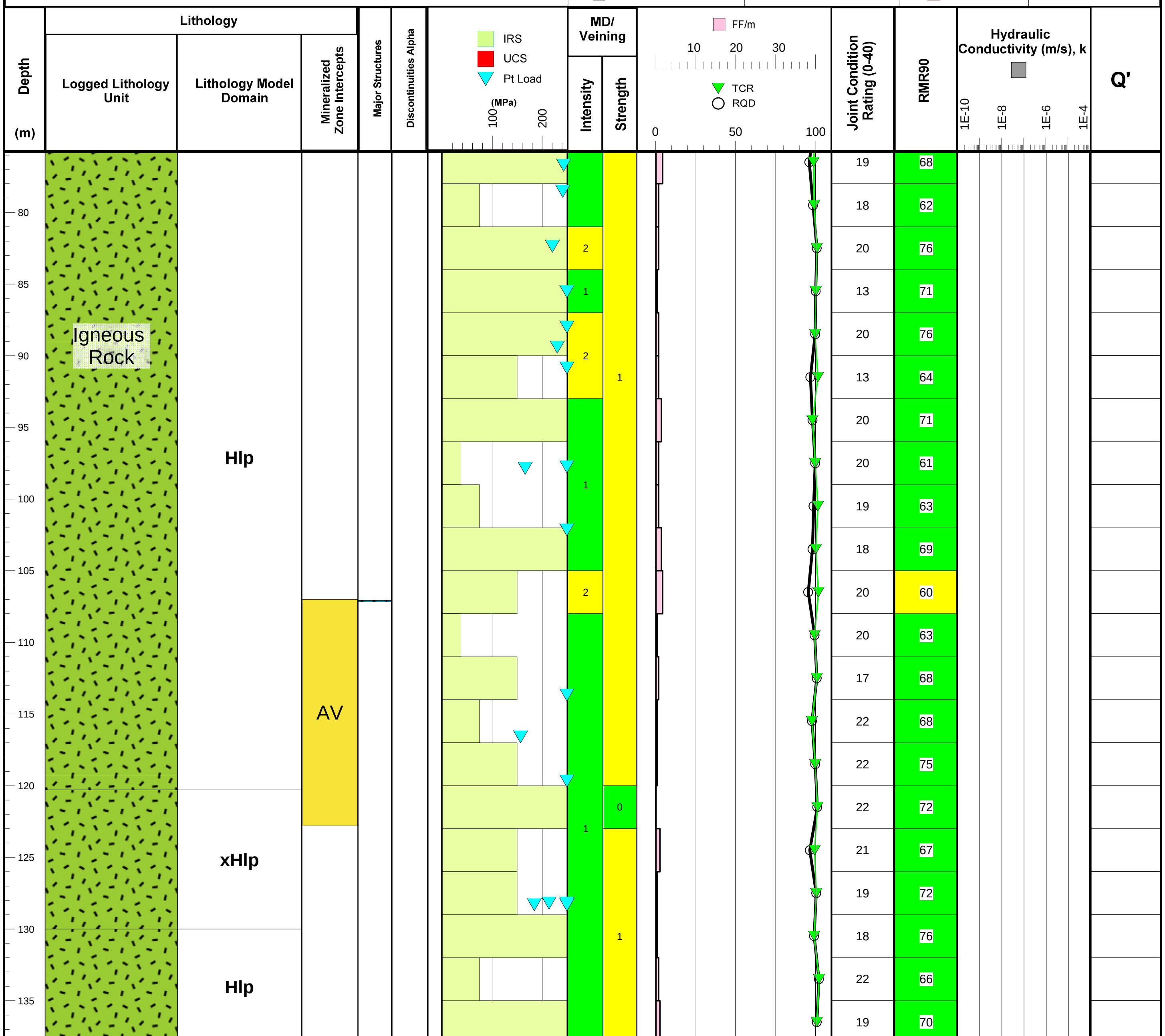
IRS: Intact Rock Strength (field est.)
Pt Load: Point Load Test (MPa)
TCR: Total Core Recovery
RMR: Rock Mass Rating
UCS: Uniaxial Compressive Strength (MPa)
FF/m: Fracture Frequency per metre
RQD: Rock Quality Designation

LEGEND OF MAJOR STRUCTURES
GOUGE
SHEARED
BROKEN
JOINTED
CRYSTALIZED CALCITE

LEGEND OF RMR89
0 - 20
21 - 40
41 - 60
61 - 80
81 - 100

LEGEND OF MD/VEINING INTENSITY
0 - None
1 - Minor
2 - Moderate
3 - Intense

LEGEND OF MD/VEINING STRENGTH
0 - Never Breaks
1 - Sometimes Breaks
2 - Always Breaks



Appendix D – Groundwater Head Records

Hole ID	Collar			Hole Length	Az.	Dip	Date	GW Depth	GW Level	Source
	Easting (utm NAD83)	Northing (utm NAD83)	Elevation (masl)	m	deg	deg		mabh	masl	
T93158	455582	6201443	1444	28.5	45.5	90	2-Oct-93	10.3	1434.1	Klohn Report June 94 - Table 4.1
T93159	455418	6201369	1427	45.7	45.5	90	9-Nov-93	12.0	1415.4	Klohn Report June 94 - Table 4.1
T93160	455617	6201225	1425	11.6	45.5	90	9-Nov-93	2.3	1422.6	Klohn Report June 94 - Table 4.1
M93124	456646	6202577	1974	198.4	90.5	84	27-Jul-93	40.0	1934.3	Klohn 1993
8902	456448	6202011	1659	209.4	175.8	46	7-Sep-96	Flowing	na	Golder Memo 5-dec-1996, Table 3
8905	456481	6202112	1701	153.0	178.3	45	7-Sep-96	yes>10	na	Golder Memo 5-dec-1996, Table 3
9004	456894	6201769	1850	53.6	45.5	90	1-Oct-96	19.2	1831.3	Golder Memo 5-dec-1996, Table 3
9005	456894	6201769	1850	51.2	48.0	46	1-Oct-96	19.9	1836.0	Golder Memo 5-dec-1996, Table 3
M8901	456749	6202505	1901	139.3	327.2	45	3-Sep-96	41.8	1871.3	Golder Memo 5-dec-1996, Table 3
M8902	456749	6202504	1900	55.8	298.4	46	3-Sep-96	40.3	1871.3	Golder Memo 5-dec-1996, Table 3
M8903	456749	6202504	1900	62.8	298.0	63	3-Sep-96	15.8	1886.6	Golder Memo 5-dec-1996, Table 3
M8905	456681	6202474	1883	103.0	120.1	47	3-Sep-96	40.1	1853.9	Golder Memo 5-dec-1996, Table 3
M8914	456664	6202463	1871	133.5	149.9	47	3-Sep-96	40.0	1842.2	Golder Memo 5-dec-1996, Table 3
M8915	456664	6202463	1871	242.9	149.7	65	3-Sep-96	34.4	1840.0	Golder Memo 5-dec-1996, Table 3
M8916	456663	6202463	1871	228.6	150.2	80	3-Sep-96	32.5	1839.0	Golder Memo 5-dec-1996, Table 3
M9024	456588	6202557	1967	265.8	117.0	87	28-Aug-96	>62	na	Golder Memo 5-dec-1996, Table 3
M9033	456588	6202557	1967	250.9	136.9	81	28-Aug-96	>62	na	Golder Memo 5-dec-1996, Table 3
M9035	456609	6202611	2006	253.9	115.5	86	28-Aug-96	16.0	1990.2	Golder Memo 5-dec-1996, Table 3
M9041	456604	6202612	2006	389.5	199.3	88	27-Aug-96	50.2	1955.3	Golder Memo 5-dec-1996, Table 3
M9042	456580	6202634	2023	269.8	132.8	72	27-Aug-96	28.3	1996.0	Golder Memo 5-dec-1996, Table 3
M9047	456687	6202467	1877	136.3	135.0	47	3-Sep-96	48.4	1842.8	Golder Memo 5-dec-1996, Table 3
M9169	456730	6202463	1874	93.0	125.5	45	26-Jul-96	37.9	1847.0	Golder Memo 5-dec-1996, Table 3
M93123	456577	6202516	1928	445.7	91.4	68	28-Aug-96	>26	na	Golder Memo 5-dec-1996, Table 3
M9384	456779	6202456	1861	75.6	90.5	45	26-Jul-96	36.0	1835.3	Golder Memo 5-dec-1996, Table 3
M9385	456779	6202456	1861	71.3	91.5	64	26-Jul-96	36.0	1828.5	Golder Memo 5-dec-1996, Table 3
M9386	456779	6202456	1860	43.3	90.5	80	26-Jul-96	36.0	1824.9	Golder Memo 5-dec-1996, Table 3
M9391	456734	6202485	1888	274.3	93.5	69	3-Sep-96	35.7	1854.2	Golder Memo 5-dec-1996, Table 3
M9392	456734	6202485	1887	223.1	90.8	79	3-Sep-96	33.7	1854.2	Golder Memo 5-dec-1996, Table 3
M94167	456756	6202480	1880	196.9	91.8	63	3-Sep-96	30.5	1853.2	Golder Memo 5-dec-1996, Table 3
M94168	456756	6202480	1881	99.4	90.0	44	3-Sep-96	35.8	1855.8	Golder Memo 5-dec-1996, Table 3
M94169	456756	6202480	1881	117.7	91.0	81	3-Sep-96	36.0	1845.0	Golder Memo 5-dec-1996, Table 3
M94172	456506	6201719	1674	441.1	91.8	44	1-Oct-96	Flowing	na	Golder Memo 5-dec-1996, Table 3
M94173	456506	6201719	1674	587.3	76.4	85	1-Oct-96	Flowing	na	Golder Memo 5-dec-1996, Table 3
M94178	456637	6201838	1734	402.6	93.6	59	1-Oct-96	51.3	1690.1	Golder Memo 5-dec-1996, Table 3
M94195	456355	6202373	1856	214.0	91.0	58	7-Sep-96	36.7	1825.2	Golder Memo 5-dec-1996, Table 3
M94205	456588	6201729	1725	147.8	226.0	61	1-Oct-96	35.3	1693.8	Golder Memo 5-dec-1996, Table 3
M94215	456406	6202332	1813	283.5	93.4	44	7-Sep-96	26.5	1794.2	Golder Memo 5-dec-1996, Table 3
M94217	456244	6202203	1765	255.7	92.6	47	7-Sep-96	Flowing	na	Golder Memo 5-dec-1996, Table 3
T93159	455418	6201369	1427	45.7	45.5	90	5-Sep-96	10.9	1416.5	Golder Memo 5-dec-1996, Table 3
T93160	455617	6201225	1425	11.6	45.5	90	5-Sep-96	3.7	1421.2	Golder Memo 5-dec-1996, Table 3
T93162	456076	6201635	1535	152.4	183.0	44	7-Sep-96	Flowing	na	Golder Memo 5-dec-1996, Table 3
T93163	456076	6201635	1535	142.6	212.8	89	7-Sep-96	Flowing	na	Golder Memo 5-dec-1996, Table 3
M94172	456506	6201719	1674	441.1	91.8	44	29-May-16	7 psi	1676.8	Avison 2015-16
M94173	456506	6201719	1674	587.3	76.4	85	29-May-16	16 psi	1683.1	Avison 2015-16
8902	456448	6202011	1659	209.4	175.8	46	16-Oct-15	15 psi	1670.5	Avison 2015-16
M94217	456244	6202203	1765	255.7	92.6	47	20-Jun-16	10 psi	1774.7	Avison 2015-16
T93159	455418	6201369	1427	45.7	45.5	90	16-Oct-15	8.7	1420.2	Avison 2015-16
T93159	455418	6201369	1427	45.7	45.5	90	29-May-16	8.5	1420.4	Avison 2015-16
T93160	455617	6201225	1425	11.6	45.5	90	16-Oct-15	1.1	1427.1	Avison 2015-16
T93160	455617	6201225	1425	11.6	45.5	90	19-Jul-16	1.2	1427.0	Avison 2015-16

Appendix E – Groundwater Pressure Records

Hole ID	Collar			Hole Length	Az.	Dip	Date	Pressure	GW Level	GW Level	Source
	Easting (utm NAD83)	Northing (utm NAD83)	Elevation (masl)	m	deg	deg		psi	mH2O	masl	
941123	456397	6202856	1761	248.4	89.4	-31	27-Aug-94	80 psi	56.2	1817.7	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941123	456397	6202856	1761	248.4	89.4	-31	17-Sep-94	70 psi	49.2	1810.6	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941125	456397	6202856	1764	286.8	89.7	20	27-Aug-94	75 psi	52.7	1816.3	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941125	456397	6202856	1764	286.8	89.7	20	17-Sep-94	65 psi	45.7	1809.3	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941126	456397	6202856	1762	282.6	90.5	-4	27-Aug-94	80 psi	56.2	1818.6	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941126	456397	6202856	1762	282.6	90.5	-4	17-Sep-94	70 psi	49.2	1811.6	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941151	456349	6202894	1756	462.7	74.0	-36	27-Aug-94	+/- 160 psi	112.5	1868.2	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1400N	na	na	1802	na	na	na	27-Aug-94	15-20 psi	14.1	1816.1	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1400N	na	na	1802	na	na	na	19-Sep-94	10, 18, 20 psi	14.1	1816.1	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1450N	na	na	1793	na	na	na	27-Aug-94	15,25,30 psi	21.1	1814.1	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1450N	na	na	1793	na	na	na	19-Sep-94	30, 33 psi	23.2	1816.2	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1525N	na	na	2119	na	na	na	27-Aug-94	40 psi	28.1	2147.3	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1550N	na	na	1775	na	na	na	27-Aug-94	55 psi	38.7	1813.7	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
1550N	na	na	1775	na	na	na	19-Sep-94	55, 55, 60, 60 psi	42.2	1817.2	11.8.7 Hydrology U_G Hydrogeologic Data.pdf
941122	456397	6202856	1762	248.7	88.5	-23	27-Sep-96	23.0	16.2	1777.7	Golder memo 5-dec-1996, Table 4
941123	456397	6202856	1761	248.4	89.4	-31	25-Sep-96	22.0	15.5	1776.9	Golder memo 5-dec-1996, Table 4
941124	456397	6202856	1762	305.3	88.7	-15	27-Sep-96	20.0	14.1	1776.1	Golder memo 5-dec-1996, Table 4
941125	456397	6202856	1764	286.8	89.7	20	27-Sep-96	16.0	11.2	1774.8	Golder memo 5-dec-1996, Table 4
941126	456397	6202856	1762	282.6	90.5	-4	27-Sep-96	22.0	15.5	1777.9	Golder memo 5-dec-1996, Table 4
941127	456396	6202855	1761	303.3	88.7	-47	27-Sep-96	22.0	15.5	1776.9	Golder memo 5-dec-1996, Table 4
941128	456433	6202820	1773	343.5	90.2	18	27-Sep-96	14.5	10.2	1783.5	Golder memo 5-dec-1996, Table 4
941129	456433	6202821	1772	259.4	89.5	-3	27-Sep-96	11.5	8.1	1780.2	Golder memo 5-dec-1996, Table 4
941131	456433	6202820	1771	209.1	88.0	-25	27-Sep-96	16.0	11.2	1782.6	Golder memo 5-dec-1996, Table 4
941132	456432	6202819	1771	249.9	89.1	-43	27-Sep-96	16.0	11.2	1782.6	Golder memo 5-dec-1996, Table 4
941133	456433	6202820	1772	231.7	89.6	-17	27-Sep-96	60.0	42.2	1814.0	Golder memo 5-dec-1996, Table 4
941134	456433	6202821	1772	281.9	89.6	-12	27-Sep-96	15.5	10.9	1783.0	Golder memo 5-dec-1996, Table 4
961162	456349	6202892	1756	240.8	0.0	-9	25-Sep-96	22.5	15.8	1771.7	Golder memo 5-dec-1996, Table 4
961164	456342	6203042	1762	417.0	88.0	-70	23-Sep-96	19.5	13.7	1775.6	Golder memo 5-dec-1996, Table 4
961166	456342	6203042	1762	415.4	82.3	-85	23-Sep-96	18.0	12.7	1774.6	Golder memo 5-dec-1996, Table 4
961168	456332	6203129	1763	560.8	93.0	-74	20-Sep-96	25.0	17.6	1780.2	Golder memo 5-dec-1996, Table 4

Appendix F – Groundwater Inflow Records

Hole ID	Collar			Hole Length	Az.	Dip	Date	Infow rate	Source
	Easting (utm NAD83)	Northing (utm NAD83)	Elevation (masl)	m	deg	deg		liter/min	
M9276	456594	6202411	1842	237.7	90.5	-65	27-Jul-93	76.0	Golder memo 4-sep-1996, text
M93124	456646	6202577	1974	198.4	90.5	-84	27-Jul-93	170.0	Golder memo 4-sep-1996, text
941097	456608	6202712	1811	162.5	262.3	-76	26-May-94	24.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941098	456610	6202714	1812	149.4	86.7	-3	26-May-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941105	456507	6202754	1789	169.5	92.6	-7	12-May-94	200.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941105	456507	6202754	1789	169.5	92.6	-7	26-May-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941105	456507	6202754	1789	169.5	92.6	-7	3-Jun-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941105	456507	6202754	1789	169.5	92.6	-7	9-Jun-94	52.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941105	456507	6202754	1789	169.5	92.6	-7	16-Jun-94	48.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941105	456507	6202754	1789	169.5	92.6	-7	23-Jun-94	75.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941106	456505	6202752	1789	179.8	92.4	-39	26-May-94	150.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941106	456505	6202752	1789	179.8	92.4	-39	9-Jun-94	133.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941106	456505	6202752	1789	179.8	92.4	-39	16-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941106	456505	6202752	1789	179.8	92.4	-39	23-Jun-94	90.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941107	456505	6202752	1789	197.8	91.0	-50	26-May-94	170.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941107	456505	6202752	1789	197.8	91.0	-50	3-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941107	456505	6202752	1789	197.8	91.0	-50	9-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941107	456505	6202752	1789	197.8	91.0	-50	16-Jun-94	52.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941107	456505	6202752	1789	197.8	91.0	-50	23-Jun-94	100.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941108	456505	6202751	1789	237.6	95.8	-73	3-Jun-94	168.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941108	456505	6202751	1789	237.6	95.8	-73	9-Jun-94	174.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941108	456505	6202751	1789	237.6	95.8	-73	16-Jun-94	90.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941108	456505	6202751	1789	237.6	95.8	-73	23-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941109	456504	6202751	1788	224.0	117.8	-85	3-Jun-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941109	456504	6202751	1788	224.0	117.8	-85	9-Jun-94	52.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941109	456504	6202751	1788	224.0	117.8	-85	16-Jun-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941109	456504	6202751	1788	224.0	117.8	-85	23-Jun-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941110	456504	6202751	1788	227.1	248.8	-79	3-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941110	456504	6202751	1788	227.1	248.8	-79	9-Jun-94	102.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941110	456504	6202751	1788	227.1	248.8	-79	16-Jun-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941110	456504	6202751	1788	227.1	248.8	-79	23-Jun-94	110.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941111	456525	6202701	1798	295.7	277.8	-17	11-May-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941111	456525	6202701	1798	295.7	277.8	-17	26-May-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941111	456525	6202701	1798	295.7	277.8	-17	3-Jun-94	168.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941111	456525	6202701	1798	295.7	277.8	-17	9-Jun-94	150.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941111	456525	6202701	1798	295.7	277.8	-17	16-Jun-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941111	456525	6202701	1798	295.7	277.8	-17	23-Jun-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	16-May-94	300.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	18-May-94	200.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	26-May-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	3-Jun-94	48.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	9-Jun-94	150.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	16-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941112	456525	6202701	1797	304.8	278.0	-21	23-Jun-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941113	456525	6202701	1798	341.7	275.6	-4	26-May-94	170.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941113	456525	6202701	1798	341.7	275.6	-4	3-Jun-94	198.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941113	456525	6202701	1798	341.7	275.6	-4	9-Jun-94	120.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941113	456525	6202701	1798	341.7	275.6	-4	16-Jun-94	174.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941114	456527	6202703	1797	204.5	293.2	-88	3-Jun-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941114	456527	6202703	1797	204.5	293.2	-88	16-Jun-94	42.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941114	456527	6202703	1797	204.5	293.2	-88	23-Jun-94	90.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941115	456527	6202703	1797	201.8	88.1	-68	3-Jun-94	95.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941115	456527	6202703	1797	201.8	88.1	-68	16-Jun-94	48.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941115	456527	6202703	1797	201.8	88.1	-68	23-Jun-94	35.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941116	456528	6202704	1797	160.0	88.0	-47	23-Jun-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941118	456507	6202754	1790	197.8	92.1	1	23-Jun-94	170.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941119	456469	6202785	1779	368.8	270.3	-37	23-Jun-94	170.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941120	456472	6202789	1779	210.0	87.6	-21	23-Jun-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941121	456471	6202788	1779	199.3	89.4	-37	23-Jun-94	80.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941130	456526	6202702	1797	396.2	277.1	-38	9-Jun-94	150.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941130	456526	6202702	1797	396.2	277.1	-38	16-Jun-94	102.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
941130	456526	6202702	1797	396.2	277.1	-38	23-Jun-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1295N	na	na	1825	na	na	na	9-Jun-94	2.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1340N	na	na	1818	na	na	na	9-Jun-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1350N	na	na	1815	na	na	na	7-May-94	12.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1350N	na	na	1815	na	na	na	12-May-94	6.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1350N	na	na	1815	na	na	na	19-May-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1350N	na	na	1815	na	na	na	26-May-94	5.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1350N	na	na	1815	na	na	na	2-Jun-94	6.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1390N	na	na	1805	na	na	na	9-Jun-94	1.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	7-May-94	7.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	12-May-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	19-May-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	26-May-94	2.5	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	2-Jun-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	23-Jun-94	5.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	30-Jun-94	24.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	8-Jul-94	10.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	13-Jul-94	23.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	21-Jul-94	19.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	28-Jul-94	12.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	8-Aug-94	1.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	7-Sep-94	0.1	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	9-Jun-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	16-Aug-94	1.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1410N	na	na	1800	na	na	na	25-Aug-94	0.3	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	7-May-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	12-May-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	19-May-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	19-May-94	5.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	26-May-94	2.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84

Hole ID	Collar			Hole Length	Az.	Dip	Date	Infow rate	Source
	Easting (utm NAD83)	Northing (utm NAD83)	Elevation (masl)	m	deg	deg		liter/min	
1500N	na	na	1784	na	na	na	26-May-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	2-Jun-94	5.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	2-Jun-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	23-Jun-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	30-Jun-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1500N	na	na	1784	na	na	na	30-Jun-94	3.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	7-May-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	19-May-94	30.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	26-May-94	45.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	2-Jun-94	24.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	23-Jun-94	34.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	30-Jun-94	11.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	8-Jul-94	15.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	13-Jul-94	21.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	21-Jul-94	30.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	28-Jul-94	25.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	8-Aug-94	6.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	16-Aug-94	20.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	25-Aug-94	20.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	7-Sep-94	30.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	17-Sep-94	18.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1525N	na	na	1779	na	na	na	9-Jun-94	12.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1570N	na	na	1771	na	na	na	20-May-94	35.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1570N	na	na	1771	na	na	na	26-May-94	13.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1570N	na	na	1771	na	na	na	2-Jun-94	13.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	29-May-94	15.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	2-Jun-94	15.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	23-Jun-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	30-Jun-94	17.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	8-Jul-94	48.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	13-Jul-94	45.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	21-Jul-94	48.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	28-Jul-94	25.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	8-Aug-94	15.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	16-Aug-94	40.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	25-Aug-94	30.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	7-Sep-94	60.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1600N	na	na	1765	na	na	na	17-Sep-94	30.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1625N	na	na	1762	na	na	na	2-Jun-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1625N	na	na	1762	na	na	na	8-Aug-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1625N	na	na	1762	na	na	na	9-Jun-94	30.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	23-Jun-94	5.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	30-Jun-94	4.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	8-Jul-94	8.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	13-Jul-94	7.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	21-Jul-94	6.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	28-Jul-94	5.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	16-Aug-94	12.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	25-Aug-94	12.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1637N	na	na	1762	na	na	na	7-Sep-94	2.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1640N	na	na	1762	na	na	na	9-Jun-94	230.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	23-Jun-94	180.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	30-Jun-94	325.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	8-Jul-94	360.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	13-Jul-94	240.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	21-Jul-94	300.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	28-Jul-94	300.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	8-Aug-94	227.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	16-Aug-94	515.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	25-Aug-94	450.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	7-Sep-94	171.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84
1643N	na	na	1762	na	na	na	17-Sep-94	103.0	11.8.7 Hydrology U_G Hydrogeologic Data.pdf - pages 72 to 84

Appendix G – Comparison of Climate Data for the period of 1981 to 2016

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Memo

To:	-	**Client:**	IDM Mining
From:	Victor Munoz Saavedra	**Project No:**	1CI019.002
Cc:	-	**Date:**	April 6, 2017
Subject:	Comparison of temperatures for the period 1981-2016 - Red Mountain Project.		

SRK completed a comparison of the temperatures for the period 1981-2016 in the area of the Red Mountain Project.

Daily temperature data were obtained from the NASA Prediction of Worldwide Energy Resource (POWER) model, publically available at https://power.larc.nasa.gov/. The POWER model uses the parameters from a reanalysis climate model called MERRA, Modern-Era Retrospective analysis for Research and Applications. Reanalysis combines satellite information, land records and numerical models that simulate the earth's climatic conditions. Typically, Reanalysis extends for several decades, and covers the entire planet.

SRK relied on the daily temperature provided from the reanalysis MERRA because the baseline dataset of daily and monthly average temperatures measured at site[1] were not available for the complete year 2016.

Reanalysis MERRA daily temperature data were extracted for the following location and time period:

- Coordinates: Latitude 55.95°, Longitude -129.70°
- Dates (month/day/year): 01/01/1981 through 12/31/2016

The monthly average temperatures calculated based on the MERRA data were compiled in Table 1. The results were validated by comparing the model information to the Red Mountain Baseline temperature data[1], as shown on Figure 1. The two datasets were considered to match reasonably well with a R^2 = 0.7.

The comparison of the temperatures for the period 1981-2016 in the Red Mountain area suggests that the 2016 mean annual temperature was the highest within the period of record (1981-2016), whereas in 1996, it was the lowest.

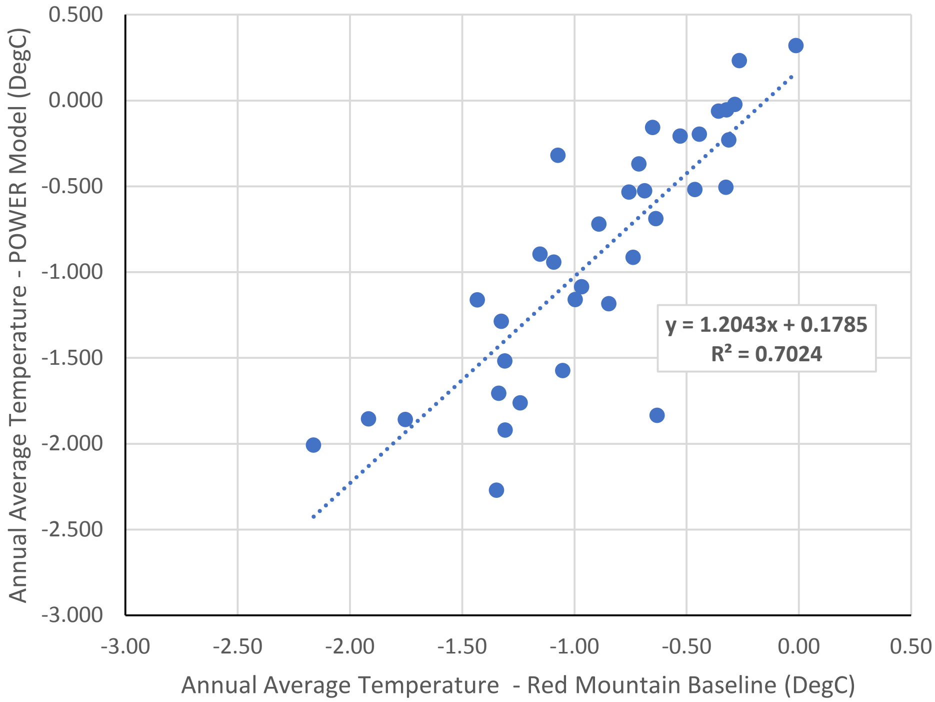
[1]SRK 2017, Red Mountain Underground Gold Project- Baseline Climate and Hydrology Report

Table 1: Reanalysis MERRA - Monthly Temperature Data between 1981 and 2016

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Avg.
1981	-3.27	-5.54	-3.27	-2.48	1.18	2.96	5.85	5.84	3.13	-0.18	-2.97	-6.93	-0.44
1982	-10.52	-8.50	-5.57	-3.96	-0.85	4.69	6.05	4.78	3.78	-0.34	-6.63	-6.35	-1.92
1983	-4.94	-4.19	-4.68	-1.86	1.55	4.53	5.22	4.83	2.10	-0.62	-4.39	-10.57	-1.07
1984	-5.26	-3.45	-2.52	-2.14	0.25	3.12	4.82	4.76	2.08	-1.89	-6.03	-9.76	-1.33
1985	-4.19	-6.58	-4.22	-3.00	-0.37	1.65	5.69	4.43	2.50	-1.15	-11.33	-4.99	-1.75
1986	-4.74	-8.11	-2.11	-2.54	0.08	3.31	5.39	5.10	2.70	1.69	-4.48	-4.54	-0.64
1987	-5.56	-3.79	-4.57	-1.57	0.43	3.47	6.05	5.31	3.20	0.22	-2.33	-4.94	-0.32
1988	-7.99	-5.80	-3.50	-2.36	0.62	3.24	4.39	5.09	2.71	0.78	-3.34	-7.22	-1.09
1989	-6.48	-9.63	-5.84	-2.10	1.43	4.36	6.31	6.15	4.06	-0.16	-3.36	-3.90	-0.71
1990	-6.56	-7.00	-3.52	-2.12	0.62	4.06	6.53	6.32	3.56	-1.46	-5.90	-8.76	-1.15
1991	-9.34	-3.57	-5.97	-2.18	0.44	3.98	5.12	5.41	3.29	-1.84	-2.69	-2.85	-0.85
1992	-3.81	-5.28	-3.47	-2.13	-0.16	3.84	5.87	5.15	1.64	-0.83	-3.16	-8.62	-0.89
1993	-8.56	-6.02	-4.46	-1.13	2.79	4.78	5.87	5.72	3.46	1.29	-3.88	-4.09	-0.32
1994	-4.67	-9.02	-3.04	-1.43	0.92	3.89	6.04	6.88	3.02	-0.32	-5.11	-6.65	-0.74
1995	-6.59	-6.07	-4.63	-1.51	2.22	4.70	5.57	4.56	4.76	-0.30	-4.36	-6.87	-0.69
1996	**-11.56**	**-5.38**	**-5.45**	**-1.58**	**-0.45**	**3.30**	**5.14**	**4.79**	**2.34**	**-1.20**	**-6.47**	**-9.52**	-2.16
1997	-7.38	-3.88	-5.28	-2.49	0.84	4.32	5.51	6.19	3.86	-0.22	-2.54	-3.39	-0.36
1998	-8.16	-3.62	-4.12	-1.66	2.22	5.35	6.40	4.78	2.67	0.33	-4.23	-6.43	-0.53
1999	-6.39	-4.64	-3.91	-2.15	-0.52	3.20	5.21	5.49	2.47	-0.21	-2.75	-3.62	-0.63
2000	-8.52	-6.40	-3.58	-2.68	-0.31	2.87	5.19	4.42	2.61	-0.37	-3.51	-7.18	-1.43
2001	-3.93	-7.52	-4.49	-2.85	-0.53	2.39	4.53	5.42	2.71	-0.46	-4.39	-6.25	-1.24
2002	-5.78	-5.73	-7.42	-3.59	-0.41	3.30	4.87	4.94	2.72	0.38	-1.40	-3.74	-0.97
2003	**-4.61**	**-6.25**	**-5.49**	**-2.02**	**0.40**	**3.99**	**5.70**	**5.20**	**3.10**	**0.77**	**-5.21**	**-5.07**	-0.76
2004	**-7.49**	**-4.11**	**-3.58**	**-1.15**	**1.18**	**5.78**	**6.40**	**6.53**	**2.45**	**-0.37**	**-3.54**	**-5.49**	-0.27
2005	**-7.30**	**-5.67**	**-3.34**	**-1.08**	**2.04**	**4.73**	**5.02**	**5.98**	**2.95**	**-0.10**	**-2.81**	**-4.17**	-0.29
2006	**-4.52**	**-6.84**	**-5.61**	**-2.09**	**0.58**	**4.29**	**5.66**	**4.52**	**3.37**	**-0.25**	**-7.60**	**-3.92**	-1.00
2007	-5.32	-5.53	-4.08	-2.74	-0.10	2.76	5.51	5.29	2.96	-0.19	-4.36	-7.12	-1.05
2008	-6.90	-5.13	-4.34	-3.54	0.27	2.31	4.59	5.20	3.23	-0.49	-2.48	-9.06	-1.35
2009	-6.65	-7.77	-6.14	-2.68	-0.06	3.94	7.07	5.55	3.35	-0.49	-2.89	-9.29	-1.31
2010	-4.80	-3.71	-2.72	-1.91	1.12	3.42	5.16	5.70	3.05	0.13	-4.86	-6.36	-0.46
2011	-6.95	-7.55	-4.92	-2.57	0.52	3.57	4.60	4.27	3.18	0.05	-5.03	-5.64	-1.34
2012	-6.62	-4.82	-4.32	-2.02	-0.58	2.29	5.36	5.48	3.14	-2.42	-4.12	-7.26	-1.31
2013	-4.82	-3.93	-5.42	-2.95	0.81	4.85	5.90	6.43	4.18	0.73	-3.85	-5.88	-0.31
2014	-4.10	-9.06	-5.67	-2.07	1.16	3.57	5.97	6.03	4.08	0.99	-4.73	-4.63	-0.65
2015	-3.87	-4.73	-2.81	-1.52	2.83	5.23	6.05	5.07	2.57	1.06	-4.14	-6.24	-0.01
2016	**-4.78**	**-2.75**	**-1.07**	**-0.15**	**3.37**	**5.86**	**7.75**	**7.87**	**4.03**	**0.30**	**-3.32**	**-9.58**	0.64

Source: Prediction of Worldwide Energy Resource - POWER (NASA, 2017); MERRA Adjusted to Site

Figure 1: Annual Average Temperature Data - Red Mountain Baseline versus Reanalysis MERRA (POWER Model).



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Senior Consultant

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