NORTHCLIFF RESOURCES LTD.
SISSON PROJECT



2011 HYDROMETEOROLOGY REPORT

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EXECUTIVE SUMMARY

This report presents a hydrometeorological characterization for the Sisson Project, a proposed tungsten/molybdenum mining development in west-central New Brunswick. The climate analysis considered data collected at the project site climate station between December 2007 and December 2011, along with data from regional climate stations operated by the Meteorological Service of Canada (MSC) branch of Environment Canada. The hydrological analysis used data collected at five project continuous streamflow stations, as well as data from regional long-term streamflow stations operated by the Water Survey of Canada (WSC) branch of Environment Canada. Hydrology and climate data collection continues at the project site and a 2012 Hydrometeorology Report will be produced at the end of the current monitoring season to further refine the conclusions presented in this report.

Climate

Climate summaries presented herein are for the Sisson climate station, located in the deposit area at elevation 305 masl. The Sisson climate station collects data for wind speed, wind direction, relative humidity, temperature, incoming solar radiation, barometric pressure, snow depth, and precipitation. These data were combined with historical data from the MSC stations to develop long-term meteorological estimates for the project. There are 38 MSC stations within a 70 km radius of the project site, but only seven are currently operating. The Juniper station (Station ID: 8102275) is the closest station to the site that has a long-term climate record (1969-2012) and is considered to best represent the long-term climate conditions in the project area.

- A long-term temperature series was developed for the project site by correlating short-term site and concurrent monthly Juniper temperature data, and then applying the relationship to the long-term Juniper monthly temperature data. The resulting synthetic series has a mean annual temperature of 3.3 °C, with minimum and maximum monthly mean temperatures of -16.6 °C and 20.0 °C occurring in January and July, respectively.
- The mean annual relative humidity is estimated to be approximately 78%, based on four years of site data.
- Evaporation data were not monitored at the site station, or at any of the regional Environment Canada stations, and therefore annual lake evaporation for the site was estimated to be approximately 500 mm using the empirical Thornthwaite equation. This result is consistent with the range of 500 – 600 mm indicated by the National Atlas of Canada (NAC, 1995).
- Sublimation was estimated to be 15 mm per month for December through April, on average, for an annual total of 75 mm.
- The mean annual precipitation (MAP) for the site is estimated to be 1350 mm based on a comparison of limited site data with regional data from the Juniper MSC station. On average, it is estimated that 75% of precipitation falls as rain and 25% falls as snow. Precipitation is very evenly distributed throughout the year, with July being the wettest month averaging 127 mm, and February being the driest month averaging 83 mm.

- Snow usually starts accumulating on the ground in November (but sometimes as early as October), and generally reaches a peak in late February or early March. The snowmelt period typically commences in late March and continues throughout April until almost all accumulated snow has been depleted by sometime in May.
- The 24-hour extreme precipitation values for return periods of 10, 50, and 200 years are estimated to be 95 mm, 117 mm, and 136 mm, respectively. The predicted 24-hour Probable Maximum Precipitation (PMP) value is 352 mm.

Hydrology

Hydrometric monitoring was initiated in April and May of 2008 at seven gauging stations within and around the Project area. One of these stations was discontinued in the same year, and the remaining six stations were operated through to the end of 2010. A network and data quality review in early 2011 concluded that this historical dataset was of insufficient quality for use in the hydrologic analyses to support the feasibility study and Environmental Impact Assessment, and was subsequently dismissed. A new stream gauging network was established in 2011 that included monitoring at five continuous and two intermittent hydrometric stations within the Project area. Data from these stations are of high quality and the five continuous datasets have been incorporated into the analyses presented in this report.

- The hydrographs for the project stations have very similar shapes, although there are some differences commensurate with differences in basin parameters. Low flows generally occur during the winter months when precipitation falls predominantly as snow, high flows occur during the spring and early summer months due to snowmelt, low flows again occur during the warm summer months when evaporation is high, and mid-level flows occur during the fall months when evaporation decreases.
- The average unit runoff values for the concurrent period of record for stations B-2, CL-1A, MBB-2, NB-2B, and SB-1 are 26, 22, 22, 27, and 23 l/s/km^2, respectively.
- The site stations all demonstrate similar hydrologic patterns to the closest regional station, which is operated by Water Survey on Narrows Mountain Brook (Station ID: 01AL004).
- Data from the site stations were correlated with data from Narrows Mountain Brook to generate a 38 year synthetic flow series for each station. The long-term mean annual unit runoff values for the five stations are estimated to range from 20.9 l/s/km^2 to 26.9 l/s/km^2.
- Regional scaling relations were developed for estimating return period 7-day low flows for both summer and winter periods. Generally, the lowest annual flows occur during the summer months. For example, the 10-year 7-day (7Q10) summer and winter low flows for station SB-1 are 3 l/s and 10 l/s, respectively.
- Long-term regional flow data suggest that the predominant peak flows occur during the spring snowmelt and may result from either snowmelt, or from rainfall events combined with snowmelt (rain-on-snow events). Regional scaling relations were developed for estimating return period peak instantaneous flows for both summer and winter periods. For example, the 10 and 50 year peak instantaneous flows for station SB-1 are 4.7 m^3/s and 8.3 m^3/s, respectively.

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SECTION 1.0 - INTRODUCTION

1.1 PROJECT DESCRIPTION

The Sisson Project (the project) is a proposed tungsten/molybdenum mine development located in York County, west-central New Brunswick, approximately 60 km northwest of Fredericton. Evaluation is underway for a proposed 30,000 tonnes-per-day mine with an approximately 30 year project life. Feasibility level engineering studies are being conducted concurrently with the environmental assessment work required to obtain the necessary provincial and federal approvals.

The project is located in the Napadogan Brook and McBean Brook sub-basins of the Nashwaak River watershed, which is a tributary to the Saint John River. Elevations in the project area range from 410 m in the uplands to 240 m at the McBean outlet, and 165 m at the Napadogan outlet. Forest cover is mainly deciduous at higher elevations and coniferous at lower elevations. The area has a history of extensive logging and forest management continues throughout the region.

1.2 PREVIOUS STUDIES

The meteorology data collection program for the project was initiated on November 13, 2007 with the installation of a metrological station at the site. The station is currently active; however, the data record contains several gaps that are discussed in Section 2.1.

Hydrometric monitoring was initiated in April and May of 2008 at seven gauging stations. KP reviewed the installations and the data records in 2011 and found the hydrologic data collection program to be insufficient to support further data analysis. It was therefore recommended that all seven of the historical stations (pre-2011) either be discontinued or relocated due to the poor stage-discharge relationships, discontinuous stage data, unreliable stage measurement techniques, site redundancy, or difficult gauging conditions; this is summarized in VA11-00446 “Review of Existing Sisson Project Hydrology, Climatology, and Environmental Data”. Seven new stations were installed in May 2011, of which five are continuous and two are non-continuous. Complete details of the installations and a preliminary analysis of the measured data are outlined in VA11-01512 “Preliminary Assessment of Sisson Project Hydrometric Monitoring Program” (December 22, 2011), which is included as Appendix A.

1.3 SCOPE OF REPORT

Knight Piésold Ltd. (KP) has been retained by Northcliff Resources Ltd. (Northcliff) to assist with hydrometeorological studies to support an Environmental Impact Assessment and a Feasibility Study for the Sisson Project. The scope of this report is to provide a hydrometeorological characterization for the Sisson Project, in terms of expected long-term climatic and hydrologic conditions at the site. The report summarizes data collected on site as well as regional data from Environment Canada.

SECTION 2.0 - CLIMATE

2.1 PROJECT SITE STATION

An automated meteorological station was installed at the Sisson Project site (Sisson station) in December 2007 at the south of the deposit area, at an elevation of 305 masl. The meteorological station monitors the following parameters at hourly intervals:

- Air temperature (ºC)
- Relative humidity (%)
- Atmospheric pressure (mbar)
- Precipitation (tipping bucket rain gauge with winter adapter kit) (mm)
- Snow depth (ultrasonic) (m above ground surface)
- Incoming solar radiation (W/m^2)
- Wind speed (m/s), and
- Wind direction (degrees from true north).

The station details are summarized in Table 2.1, and the station location is shown on Figure 2.1. Several discrete interruptions in the data collection occurred during the following periods:

- January 7, 2008 – April 28, 2008
- November 18, 2008 – January 13, 2009
- March 11 2010 – April 23, 2010
- May 28, 2010 – June 22, 2010, and
- August 25, 2010 – April 15, 2011.

Snow course surveys were conducted in the winters of 2010-2011 and 2011-2012 at the locations shown on Figure 2.7.

2.2 REGIONAL STATIONS

Data from regional climate stations operated by the Meteorological Services of Canada (MSC) branch of Environment Canada were incorporated in the climate analyses to predict long-term regional climate patterns at the project site. The seven active MSC climate stations shown on Figure 2.1 are within a 70 km radius of the project site. Station details for both active and inactive MSC stations are summarized in Table 2.2. The closest active MSC station is Juniper (8102275), which is located approximately 23 km northwest of the Sisson climate station at an elevation of 259 masl. There are 36 complete years of record at this station. The following sections summarize the findings of the climate data analyses, with an assessment of temperature, relative humidity, evapotranspiration, sublimation, precipitation, and extreme precipitation.

2.3 TEMPERATURE

Site specific temperature data from the Sisson climate station do not cover a sufficient duration for the developing temperature normals, which are commonly based on 30 year average values. Data are incomplete for most years due to technical difficulties and site access constraints resulting in discrete periods of data loss, as shown on Figure 2.2.

Available Sisson data for 2007-2011 were correlated with concurrent regional data from the Juniper MSC station to provide long-term monthly and annual estimates for the project. The regression equation, with an R^2 of 0.99, was applied to the long-term (1969 - 2011) Juniper data in Table 2.3 to generate a synthetic long-term monthly temperature series for the project site. These data were used to estimate the mean monthly and annual temperature values shown in Table 2.4 and on Figure 2.3. The mean annual temperature is estimated to be 3.3 °C, with minimum and maximum monthly mean temperatures of -16.6 °C and 20.0 °C occurring in January and July, respectively.

2.4 RELATIVE HUMIDITY

Mean monthly relative humidity data are summarized in Table 2.5. The four year period of record indicates a mean annual relative humidity of 78%. The minimum mean monthly relative humidity for months with complete datasets was 65% in May 2010 and the maximum mean monthly relative humidity was 86% in December 2009.

Relative humidity is monitored at the Fredericton Aquatic Centre (FAC) MSC climate station. The most complete year of data at the Sisson station was 2009, and comparison of these data with concurrent FAC data reveals similar monthly trends but largely dissimilar daily trends. The correlation between the two datasets wasn't sufficiently strong at this time to merit a regression analysis to generate long-term synthetic values for the project site.

2.5 EVAPORATION / EVAPOTRANSPIRATION

Evaporation data are not collected at the Sisson climate station, nor at any of the regional MSC stations. However, the Hydrological Atlas of Canada indicates a mean annual lake evaporation for the region of between 500 and 600 mm (NAC 1995), as shown on Figure 2.4.

Potential evapotranspiration (PET) is defined as the amount of evapotranspiration that would occur given an infinite supply of water (Ponce, 1989), and accordingly is commonly used to estimate evaporation. The PET for the project site was estimated using the Thornthwaite equation, which is an empirical equation requiring only temperature as a site-specific data input. The calculated long-term PET values are expected to reasonably represent lake evaporation conditions at site. PET was calculated on a monthly time-step using both the site temperature records and the long-term monthly temperatures series developed for the site. The resulting monthly and annual values are summarized in Table 2.6. Long-term mean monthly values range from 0 mm in most winter months to 119 mm in July. The mean annual lake evaporation is estimated at 500 mm based on the long term average PET and is consistent with the 500 mm to 600 mm range suggested on Figure 2.4.

2.6 SUBLIMATION

Sublimation is the process by which moisture is returned to the atmosphere directly from snow and ice without passing through the liquid phase (Liston and Sturm, 2004). Sublimation can play a significant role in the annual hydrologic water balance in areas where winter precipitation comprises a large proportion of annual precipitation. However, the processes causing and influencing sublimation are not well understood, and many estimates and methods of estimation found in the literature are site-specific, subject to significant uncertainty, and not easily extrapolated. It is known that sublimation values can vary substantially according to a number of factors, most notably wind speed and humidity. A reasonable estimate for the project site is likely to be in the order of 10 mm to 20 mm per month, with appreciable snow on the ground (Fassnacht, 2004). Given the average wind speed of 2.5 m/s (Stantec Air Quality Baseline Report), and relative humidity in the order of 80%, sublimation was estimated to be 15 mm per month for December through April, for an annual total of 75 mm.

2.7 PRECIPITATION

2.7.1 Site & Regional Data

Hourly total precipitation data have been collected at the Sisson climate station since December, 2007 and long-term precipitation data are available from the nearby regional MSC climate stations.

The short-term period of record at the Sisson climate station contains numerous data gaps. Monthly and annual precipitation data from this station are summarized in Table 2.7. Details of all active MSC stations within a 70 km radius of the project area are summarized in Table 2.2 and shown on Figure 2.1. The regional data indicates that annual precipitation is reasonably uniform throughout the region.

2.7.2 Monthly & Total Annual Precipitation

Precipitation at the most relevant long-term stations in the region appears to be quite consistent, as is evident in Table 2.8, with all stations demonstrating similar monthly patterns and annual precipitation values. A plot of annual precipitation versus elevation, for all regional stations listed in Table 2.2 with more than 15 years of record, shows no clear correlation. This is demonstrated on Figure 2.5, and suggests that there are no notable orographic effects in the region.

An analysis of the site and long-term regional data was undertaken to estimate the long-term precipitation values for the project site. Precipitation data from the Juniper MSC station, which are presented in Table 2.9, were compared with the site data using a double mass curve analysis of concurrent data, as shown on Figure 2.6. Data from Juniper were selected for the analysis because of the station's close proximity and similar elevation to the project site, and because of its concurrent and long-term period of record. This analysis indicates that the site is substantially wetter than Juniper, with the short-term concurrent records suggesting approximately 27% more precipitation at the Project site. Application of this factor to Juniper's MAP of 1136 mm results in a MAP estimate for the site of 1443 mm. This is greater than the highest long-term MAP value recorded in the region, which is 1297 mm at Hamtown Corner (34 km from the site and at a similar elevation). It is possible that the Sisson project site receives more precipitation that the other areas in the region where precipitation is recorded, and the high unit runoff values presented in Section 3.0 of this report support this possibility (728 mm for Narrows Mountain Brook). However, the site record is still relatively short and incomplete, which introduces uncertainty into the analysis.

Results from the watershed modelling being undertaken by KP suggest that mean annual precipitation at the site should be approximately 1350 mm. Accordingly, the MAP for the site has been estimated at 1350 mm, which is distributed monthly according to the long-term pattern for Juniper. The estimated mean monthly precipitation values for the site are provided in Table 2.10. Precipitation is evenly distributed throughout the year, with July being the wettest month averaging 127 mm, and February being the driest month averaging 83 mm.

2.7.3 Wet and Dry Year Precipitation

The annual wet and dry year precipitation values for a return period of 10 years were calculated to be 1634 mm and 1066 mm, respectively. These values provide a measure of the year-to-year variability of precipitation. Corresponding monthly values were also estimated based on the monthly coefficients of variation of the precipitation records at Juniper. It was assumed, as is common practice, that the data are normally distributed about the mean. The results are summarised in Table 2.11.

2.7.4 Precipitation Distribution

Precipitation records from the Sisson climate station do not differentiate between rainfall and snowfall. However, mean monthly and mean annual rainfall and snowfall distribution data for a number of the regional MSC stations are available, and are summarised in Table 2.8. These data indicate that precipitation in the region falls predominantly as snow from January through March, and exclusively as rain from May through September. During April, October, November and December, precipitation is often mixed rain and snow. Precipitation is the lowest during February at all regional stations, though it is evenly distributed throughout the year, with each month experiencing 6% to 10% of the annual precipitation, on average.

The mean ratio of rain to snow at the two closest stations to the site, Juniper and Hamtown Corner, is approximately 75% to 25%. Therefore, it is expected that the precipitation ratio at the Sisson station can be similarly estimated as 75% rain and 25% snow. The long-term precipitation distribution for Juniper was selected as representative of expected conditions at the site, as shown in Table 2.10.

2.7.5 Snowpack

Snowpack is the accumulation of snow on the ground, and the amount of water in the snowpack is a function of both snow depth and snow density. The characteristics of the snowpack can greatly impact the magnitude and timing of spring runoff. A sensor is installed at the Sisson station to monitor snow depth, but does not measure snow density, which is crucial in estimating the snow water equivalent (SWE) of the snowpack. Snow depth and density measurements were taken at five locations around the site using manual snow surveying techniques in the winters of 2010-2011 and 2011-2012 to collect SWE data to complement the automatic snow depth record. The snow survey locations are shown on Figure 2.7 and the results are given in Table 2.12. These data indicate that maximum snow depths and SWE generally occur in March, with the timing varying marginally from year to year. This finding is generally consistent with historical monthly snow depth information for Juniper shown in Table 2.13, which indicates that snow usually starts accumulating on the ground in November (sometimes as early as October), and generally reaches a peak in late February or early March. The snowmelt period commences in late March and continues throughout April with very little snowmelt occurring in May. However, these data are for the Juniper climate station, which is at an elevation of 259 masl. Snow may persist at higher elevations at the Sisson project and contribute to runoff in May.

2.8 EXTREME PRECIPITATION

Extreme 24-hour rainfall values for the Project were estimated using annual maximum daily precipitation data from Juniper (1969 to 2004) that were adjusted to equivalent 24-hour values using a scaling factor of 1.13 (Herschfield, 1961). The values were then further adjusted by the ratio of the estimated MAP of the site to the MAP of Juniper (1350 mm/1136 mm = 1.19), to reflect that 24-hour extreme precipitation is strongly correlated to MAP (Cathcart, 2001). The mean and standard deviation of the adjusted 24-hour precipitation record are 72 mm and 17 mm, respectively. These values were used with extreme value frequency factors to estimate 24-hour precipitation values for various return periods according to the procedure outlined in the Rainfall Frequency Atlas of Canada (Hogg and Carr, 1985). The estimated values are summarized in Table 2.14. The 24-hour extreme precipitation values for return periods of 10, 50, and 200 years are estimated to be 95 mm, 117 mm, and 136 mm, respectively.

The 24-hour Probable Maximum Precipitation (PMP) value was estimated to be 352 mm using the Herschfield (1961) equation.

SECTION 3.0 - HYDROLOGY

3.1 PROJECT STATIONS

Hydrometric monitoring was initiated in April and May of 2008 at seven gauging stations within and around the project area. One of these stations was discontinued in the same year, and the remaining six stations were operated through to the end of 2010. A network and data quality review in early 2011 concluded that this historical dataset was not of sufficient quality for use in the hydrologic analyses to support the Feasibility Study and the Environmental Impact Assessment, and was subsequently dismissed. A new monitoring network was established in May 2011 that included continuous monitoring at five hydrometric stations within the Project area. Data from these stations are of high quality and have been incorporated into the analyses presented in this report. Two additional stations (SB-3A and FR-1A) were equipped for intermittent monitoring (discrete discharge measurements).

Monitoring station locations and catchment areas are shown on Figure 3.1, and a summary of each site is given in Table 3.1. Continuous water level (stage) data were collected from mid-May to the end of November 2011. The stations were then decommissioned for winter at the end of November to prevent damage due to ice. Complete details of the station installations and a preliminary analysis of the measured data are provided in Appendix A.

3.2 REGIONAL STATIONS

There are five active regional streamflow stations operated by the Water Survey of Canada (WSC) in close proximity to the project, as shown on Figure 3.2 and summarized in Table 3.1. The station most relevant to the project is the Narrows Mountain Brook station (01AL004), which is located approximately 10 km south the project and has watershed characteristics that are generally similar to those in the project area. However, the Narrows Mountain Brook basin is relatively small (3.9 km^2) compared to the drainages of stations MBB-2 and NB-2B, which have areas of 31 km^2 and 52.6km^2, respectively. Therefore, data from several WSC stations were considered for comparison with data from the MBB-2 and NB-2B gauges.

Annual flow patterns are very similar at all the WSC stations in the area, as shown on Figure 3.3. Low flows generally occur during the winter months when precipitation falls predominantly as snow, high flows occur during the spring and early summer months due to snowmelt, low flows again occur during the warm summer months when evaporation is high, and mid-level flows occur during the fall months when evaporation decreases.

The Narrows Mountain Brook station has the highest unit runoff in the region during the spring freshet period, likely due its basin's relatively small size, narrow elevation range, and wet conditions.

3.3 PROJECT STATION RUNOFF

3.3.1 Measured Streamflow Records

Stream discharge and stage (water level) gauging was initiated at the project site in May 2011. Instrumentation was installed and benchmark surveys were conducted once the streams were completely ice-free. Water levels were measured with pressure transducers and recorded on 15 minute intervals with automated data loggers at the five continuous hydrometric streamflow sites and with manual benchmark surveys at the other two sites. Stage and discharge measurements were collected manually at all seven sites during each of the 10 to 12 site visits. Preliminary rating curves and hydrographs were developed for the five continuous hydrometric streamflow gauging stations using the data collected to the end of August 2011; these are discussed in Appendix A. The preliminary rating curves were subsequently updated using data collected to the end of November 2011, and are shown on Figures 3.4 to 3.8. All of the site stations show reasonably strong relationships between stage and discharge over the range of measured discharge. The curves include considerable extrapolation to both high and low stages and flows, and it is therefore recommended that ongoing manual measurements be collected to extend the range of the measured data and strengthen the validity of the curves.

3.3.2 Streamflow Records

Streamflow records for each gauging station were developed by applying the stage-discharge rating curves to the corresponding water level records. Hydrographs were developed from the average daily discharge values, and are presented in two groups according to basin size to facilitate comparison. Figure 3.9 shows the measured hydrographs for basins ranging in size from 4.3 km^2 to 7.7 km^2, while Figure 3.10 shows the same for basins ranging in size from 30.8 km^2 to 52.6km^2. Figure 3.11 compares all five hydrographs, which are plotted in terms of unit runoff (flow per unit area). Table 3.2 provides a summary of the monthly average flows and unit flows for the period of record.

The hydrographs for all the project stations have very similar shapes. Rising flows occur at similar times and the peak flows in response to rainfall events are well correlated. Some minor differences are notable, which is not surprising given the potential for localized climatic conditions and differences in basin parameters, such as shape, area, stream network, slope, land cover, and in-catchment storage. For example, the CL-1A basin appears to generally have lower flows and a slower hydrologic response to storm events than the other basins, even those with a similar basin size, because of suspected lower precipitation and the attenuating and evaporating effects of the many lakes contained within it.

For the May to November 2011 period of record, the highest flows occur in August and September, due to heavy rains. However, these were not likely the highest flows of the year, since the gauges were not operating during the typical high flow freshet period of April and early May.

3.3.3 Unit Runoff

The average unit runoff values for the concurrent period of record for stations B-2, CL-1A, MBB-2, NB-2B, and SB-1 are 26, 22, 22, 27, and 23 l/s/km^2, respectively. The differences are attributed to the differences in basin characteristics, as discussed previously. For example, the CL-1A and MBB-2 gauges have the lowest average unit runoff values; this is consistent with them having higher evaporation losses because of the substantial lake content in their basins, and possibly lower precipitation due to their location in a different watershed.

3.3.4 Long-term Flow Patterns

The 2011 discharge data from the Narrows Mountain Brook station suggest that the flows in March through September, and in December, were higher than average. The monthly mean flows in both August and September of 2011 were over three times greater than the long-term average values. The abnormally high runoff conditions in 2011 may have influenced the results of the regression modelling discussed in Section 3.4; it is therefore recommended that the estimated long-term flows be treated with appropriate caution, and that the analyses be updated when more site data become available.

3.4 SYNTHETIC FLOW DATA

Five WSC stations are currently being operated within 45 km of the project area. Flow data from these stations were considered for comparison with flow data from the project stations. A preliminary regression analysis of concurrent flow data was used to quantify the relationships between the regional and site data. The results of these preliminary analyses indicated that the Narrows Mountain Brook (01AL004) data were generally the most strongly correlated with the site data.

Concurrent WSC and project station flow data were correlated using a seasonal ranked linear regression technique to generate a long-term flow series for each project station. This technique is similar to ordinary linear regression, but the data are separated into distinct hydrological seasons and ranked from lowest to highest values prior to analysis. The seasonal regression equations account for differences in drainage area and other physical characteristics that affect runoff; it is assumed that these parameters are generally constant within seasons over a period of several years. When comparing sets of ranked daily flows for two or more gauging records, each flow value of equal rank has an equal probability of exceedance in the data set (since the data sets are of equal length). Therefore, a comparison of ranked daily flows amounts to a comparison of flow frequency distributions. The comparison of flow distributions rather than simultaneous daily flows overcomes differences in the timing of rainstorm or snowmelt events between watersheds, and ultimately provides a better model for synthetically generating a likely scenario of future flow patterns. It must be recognized that the ultimate objective of this exercise is not to reproduce the exact historical flow patterns of the project area streams so that one can predict what the flows were on any particular day, but rather to generate datasets that provide a good representation of the expected future long-term mean annual discharge in each creek and the associated year-to-year, month-to-month and day-to-day variability of flows.

Three regression equations were developed for each gauging site: one for flows in May that are driven by the melting of the winter snowpack, and one each for the low and high flow periods during the rainfall-runoff months of June to November. The quality of each synthetic flow series was assessed by comparing the concurrent measured and synthesized flows, both in terms of streamflow, shown on Figures 3.12, 3.14, 3.16, 3.18, and 3.20, and in terms of flow duration curves, shown on Figure 3.13, 3.15, 3.17, 3.19, and 3.21.

The match between measured and synthetic flow hydrographs is generally strong at all stations, as indicated by R^2 and Nash-Sutcliffe coefficients generally in the order of 0.70 and 75, respectively. There are some notable differences during some peak flow events, but this is not unexpected given the ranking process used for the synthetic flow development.

The low and high flow ranked regression relations were applied to December, January, February, March and April data despite the lack of concurrent winter flow records. This is considered reasonable given that that the winter flows are not outside the range of flows used in developing the ranked regression equations.

The synthetic flow series generated for each station demonstrate similar mean monthly patterns to the regional flow data, as is evident on Figure 3.22: this is expected given the proximity of the WSC stations to the project site. A summary of the mean monthly and annual flows based on the synthesized 38 year daily datasets for all five project stations is provided in Table 3.3 and corresponding unit runoff values are provided in Table 3.4. Summaries of the monthly and annual totals for the five synthesized flow series are provided in Table 3.5 to 3.9. These tables provide good examples of the range and variability of flows that can be expected from year to year and month to month. The synthesized long-term mean annual unit runoff for the five stations ranges from 20.9 l/s/km^2 to 26.9 l/s/km^2 (660 mm to 849 mm). This range is consistent with differences in the hydrologic characteristics of the basins. For instance, the two lowest annual unit flows are for the two gauges in the McBean Brook watershed. The catchments for these gauges are known to have extensive marshlands and lakes leading to increased losses due to evaporation and evapotranspiration. Furthermore, these sites drain to the south and southwest, as opposed to the other three sites that are in the Napodogan Brook watershed and drain to the east and southeast. It is possible that the Napodogan Brook watershed is slightly wetter and/or that basin orientation is affecting evaporation, such that the southwest facing McBean Brook watershed basins experience more direct sunshine and greater evaporation.

3.5 7-DAY LOW FLOWS

Long-term regional flow data suggest that low flows predominantly occur during the late summer or mid-winter. Low-flow periods may also occur during the fall as shown in the measured project streamflow records on Figures 3.9 and 3.10.

Due to the uncertainty in the measured project low flows, and the very short period of site record, regional historical data collected by the Water Survey of Canada at gauging stations on five small streams considered representative of conditions in the project area were used to estimate low flows for the project. Analyses were run on annual data as well as seasonal data, with winter and summer periods defined as December to April and May to November, respectively. Table 3.10 presents return period 7-day low flow statistics for each of the Water Survey of Canada stations, on an annual, summer, and winter basis, and Table 3.11 shows minimum measured 7-day low flows at gauging stations in the project area. It should be noted that the summer values are lower than the annual values in some instances, which may at first appear to be counterintuitive. However, this is the result of the annual datasets being largely comprised of summer values, but also containing the occasional winter value, and the effect this has on the data statistics (stdev and skew) and the associated distributional parameters. For practical purposes, the annual values and the summer values are the same.

The conclusions from the frequency analyses appear to be watershed specific, and thus the results are plotted separately for the Napadogan Brook and McBean Brook watersheds. Figures 3.23 to 3.26 present scaling curves for estimating return period low flows for basins in the Napagodan Brook and McBean Brook watersheds, respectively. The figures generally indicate that low flows are proportionally greater and less variable in large watersheds; this is expected because low flows are generated by groundwater discharge (baseflow) which is typically higher in larger watersheds with a larger groundwater storage component.

3.6 PEAK FLOWS

Long-term regional flow data suggest that peak flows predominantly occur during the spring snowmelt period and may result from either snowmelt or from rainfall events combined with snowmelt (rain-on-snow events). Short-term peak flows may also occur during late summer and fall due to high rainfall, low evapotranspiration, and reduced infiltration capacity due to increasing antecedent (soil) moisture content.

An assessment of regional historical peak flow statistics, using data collected by Water Survey of Canada at gauging stations on five small streams considered representative of conditions in the project area, indicates that peak flows generally vary linearly with watershed size. At first glance, the statistics summarized in Table 3.12 suggest that the scaling relation is nonlinear, with unit runoff generally decreasing with decreasing scale. However, the period of concurrent record for all stations is only two years, so the sample size is very small and the statistics are therefore not particularly valid. Furthermore, such a relation is inconsistent with hydrologic theory and typical observed peak flow scaling patterns (Cathcart, 2001), such that it is much more likely an artifact of the small sample size and the characteristics of the particular watersheds considered, than representative of the true regional peak flow scaling pattern. However, it does indicate that the assumption of a linear scaling pattern is reasonable and appropriately conservative, and that the available long-term records should provide a strong basis for estimating peak flows for all small basins (≤ 10 km^2) in the project area.

Distributional peak flow statistics for the two regional stations with reasonably long periods of record, Hayden Brook (01AL003) and Narrows Mountain Brook (01AL003), were summarized in Table 3.13, and general consistency is evident in the values, although there is some notable variation in the skewness (L-Cs: Note that the L prefix simply indicates that the statistic was computed using linear moments, as opposed to conventional moments). In particular, the daily values for Narrows Mountain Brook, which are based on the longest available record of 35 years, have the highest L-Cs, which reflects the effect of the very high flow event in 1973 that is missing from all the other records. A high L-Cs corresponds to a long upper tail in the flood frequency distribution, and therefore it was considered prudent to adopt this value for estimating return period flows for the project area.

A flood frequency analysis was completed assuming a Generalized Extreme Value distribution and using the long-term statistical values summarized at the bottom of Table 3.13. The resulting return period flow values for the Narrows Mountain Brook station are provided in Table 3.14, and corresponding equations applicable to all small basins (≤ 10 km^2) within the project area were simply generated by dividing the values by the drainage area. Peak flow values for any basin can be determined by inputting the respective drainage area into the equations. For example, a 10-year peak instantaneous flow for a 2 km^2 basin would be computed at $Q_{10} = 0.93 \times 2 = 1.86\ m^3/s$.

Return period flood estimates for basins larger than 10 km^2 should be separately assessed on the basis of available regional data.

SECTION 4.0 - WATER BALANCE MODELLING INPUTS

This section discusses the hydrometeorological parameters required for water balance modelling, such as unit runoff for undisturbed areas and lake evaporation. It should be noted that runoff is recommended as the primary method to calculate water inflow to facilities or water management structures, rather than precipitation, since runoff inherently accounts for precipitation, as well as snow accumulation and melt patterns, sublimation, and evapotranspiration. Rainfall-runoff models such as HydroCAD can be used in instances where using a runoff value is not appropriate.

The monthly variability of precipitation and runoff must be quantified for stochastic water balance modelling. This is often done using the coefficient of variation (Cv), which is a dimensionless statistic that represents the standard deviation normalized by the mean, and is used to quantify the scale parameter of common frequency distributions.

Unit runoff values for the various project site drainages presented in Table 3.4 can be used with the corresponding Cv values presented in Table 3.3 to model runoff from natural areas in the vicinity of the mine.

To model runoff from mine affected areas, the runoff values used for natural areas should be adjusted to reflect changes to the runoff characteristics of the drainages that are caused by the various mine development activities. This can be done by multiplying the natural unit runoff values by the ratios of the mine development and natural runoff coefficients. The mine development runoff coefficients should be selected by the design engineer on the basis of design guides and experience. For example, a coefficient of 0.80 is commonly used for tailings beaches. The natural runoff coefficients can be determined by dividing the mean annual runoff for a basin by estimates of the respective mean annual precipitation.

To model evaporation losses from open bodies of water such as ponds, the lake evaporation values listed in Table 2.6 can be used.

SECTION 5.0 - CLIMATE CHANGE

There is a general consensus in the scientific community that the global atmosphere is warming and that climate patterns are correspondingly changing throughout the world. The Intergovernmental Panel on Climate Change (IPCC) provides general predictions for northern regions, including eastern Canada, which include increased temperatures, and increased precipitation magnitude and intensity (Field et. al., 2007).

The effects of the predicted increases in temperature and precipitation on the hydrology and climate of the Sisson Project area are not easy to determine. For instance, increases in precipitation may not necessarily lead to increases in runoff as they may be offset by higher evaporation rates driven by warmer temperatures. Along similar lines, a shorter winter season resulting from warmer temperatures may not lead to smaller spring freshet flows because higher winter precipitation may offset the shorter snow-accumulation period. Even if the future volumes of freshet flows are similar to current conditions, the timing of the runoff may be earlier. Increased rainfall intensity can be expected to result in increased flooding and landslides or debris flows in areas susceptible to such events.

Given these possible changes, there is understandably some concern about whether or not the historical streamflow and climate records that were used to assess hydrometeorological conditions at the Sisson Project reasonably represent conditions that might be expected over the next 20 to 40 years and beyond.

Predictions presented by IPCC are based on outputs from Global Circulation Models (GCMs) and a wide range of results were determined from the different models and different CO_2 emission scenarios considered. The predicted changes are considered the most likely outcome; however, confidence in the magnitude of the predicted changes remains low. Consequently, we have not modified quantitative predictions presented in this report to account for climate change. However, extreme event estimates (peak flows, low flows, extreme rainfall) are often modified by 10% to 20% to account for potential climate change affects, and similar factors may be required for daily, monthly, and annual hydrometeorological estimates. It is recommended that appropriate conservatism or factors of safety be applied to any decisions based on data presented in this report to account for potential climate change scenarios.

SECTION 6.0 - CONCLUSIONS & RECOMMENDATIONS

The key findings of this report are summarized below. All meteorological results are presented for the location of the Sisson climate station and adjustments may be required to apply them to other locations within the project area.

- The mean annual temperature is estimated to be 3.3 °C, with minimum and maximum monthly mean temperatures of -16.6 °C and 20.0 °C occurring in January and July, respectively.
- The mean annual relative humidity is estimated to be approximately 78%, based on four years of site data.
- The annual lake evaporation for the site was estimated to be approximately 500 mm.
- Sublimation was estimated to be 15 mm per month for December through April, on average, for an annual total of 75 mm.
- The mean annual precipitation (MAP) for the site is estimated to be 1350 mm, with 1013 mm falling as rain and 337 mm falling as snow. Precipitation is evenly distributed throughout the year, with July being the wettest month averaging 127 mm, and February being the driest month averaging 83 mm.
- Snow usually starts accumulating on the ground in December and generally reaches a peak in late February or early March. The snowmelt period commences in late March and continues throughout April until almost all accumulated snow has been depleted by sometime in May.
- The 24-hour extreme precipitation values for return periods of 10, 50, and 200 years are estimated to be 95 mm, 117 mm, and 136 mm, respectively. The predicted 24-hour Probable Maximum Precipitation (PMP) value is 352 mm.
- The hydrographs for the project stations have very similar shapes, although there are some differences commensurate with differences in basin parameters. Low flows generally occur during the winter months when precipitation falls predominantly as snow, high flows occur during the spring and early summer months due to snowmelt, low flows again occur during the warm summer months when evaporation is high, and mid-level flows occur during the fall months when evaporation decreases.
- The long-term mean annual unit runoff values for the five site streamflow gauging stations are estimated to range from 20.9 $l/s/km^2$ to 26.9 $l/s/km^2$.
- Regional scaling relations were developed for estimating return period 7-day low flows for both summer and winter periods. Generally, the lowest annual flows occur during the summer months. For example, the 10-year 7-day (7Q10) summer and winter low flows for station SB-1 are 3 l/s and 10 l/s, respectively.
- Long-term regional flow data suggest that the predominant peak flows occur during the spring snowmelt and may result from either snowmelt or from rainfall events combined with snowmelt (rain-on-snow events). Regional scaling relations were developed for estimating return period peak instantaneous flows for both summer and winter periods. For example, the 10 and 50 year peak instantaneous flows for station SB-1 are 4.7 m^3/s and 8.3 m^3/s, respectively.
- Potential climate change effects have not been considered explicitly in any hydrometeorological estimates in this report, and appropriate allowances should be made where necessary.

A reasonable amount of hydrological and meteorological data has been collected at the project site. However, periods of limited or missing data exist within the records. The most notable of these is the lack of winter precipitation data at the Sisson climate station, as well as limited May freshet runoff data and winter discharge data. It is therefore suggested that ongoing data collection be continued and that the estimated values in this report be reviewed and updated once additional data become available.

SECTION 7.0 - REFERENCES

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SECTION 8.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

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TABLE 2.1

NORTHCLIFF RESOURCES LTD.
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SISSON CLIMATE STATION DETAILS

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Station Name	Total Years of Record	Complete Years of Record	Start Year	End Year	Latitude	Longitude	Elevation (m)
Sisson Brook	4	0	2007	2011	46° 21' 33"	67° 03' 01"	305

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REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.2

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SUMMARY OF REGIONAL CLIMATE STATIONS

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	Station Name	Station ID	Total Years of Record	Complete Years of Record	Start Year	End Year	Latitude	Longitude	Elevation (m)	Distance from Project (km)	Mean Annual Precipitation (mm)
Active	Aroostook	8100300	83	75	1929	2012	46°42 '36 "	67°43 '11 "	80	67	1067
	Fredericton	8101500	61	59	1951	2012	45°52 '11 "	66°31 '48 "	21	68	1093
	Fredericton Aquatic Centre	8101507	17	17	1995	2012	45°57 '36 "	66°39 '0 "	8	54	n/a
	Gagetown Avos	8101794	7	6	2005	2012	45°50 '24 "	66°27 '0 "	51	77	1057
	Juniper	8102275	43	36	1969	2012	46°32 '59 "	67°10 '12 "	259	23	1136
	Mactaquac Provincial Park	8102536	39	35	1973	2012	45°57 '0 "	66°54 '0 "	110	47	1060
	Woodstock	8105600	126	91	1886	2012	46°10 '12 "	67°32 '59 "	153	46	981
Inactive	Mapleton	8102566	39	38	1972	2011	46°11'00"	67°14'00"	167.6	25	1144
	Williamsburg	8105580	14	11	1912	1926	46°20'00	66°43'00	321.6	27	1034
	Hamtown Corner	8102110	16	15	1973	1989	46°07'00	66°47'00	243.8	34	1297
	McGivney	8102800	23	22	1953	1976	46°22'00	66°34'00	176.8	39	1175
	Royal Road West	8104482	15	15	1966	1981	46°05'00	66°44'00	160	40	1240
	Kingsley Ihd	8102316	8	8	1973	1981	46°04'00	66°44'00	164.6	41	1234
	Keswick Ridge	8102308	4	< 1	1964	1968	46°00'00	66°53'00	121.9	42	n/a
	Royal Road	8102308	28	25	1965	1993	46°03'00"	66°43'00"	115.8	44	1233
	Parker Ridge	8103825	10	8	1886	1896	46°29'00"	66°31'00"	209	45	1192
	Nackawic	8103425	6	4	1966	1972	45°58'00	67°14'00	45.7	46	993
	Keswick Ridge Mactaquac	8102312	13	11	1965	1978	45°58'00	66°52'00	7.6	46	1027
	Woodstock Grafton	8105605	2	1	1964	1965	46°09'00	67°34'00	32	48	n/a
	Lower Holmesville	8102522	2	1	1971	1972	46°34'00	67°35'00	144.8	49	1135
	Holmesville	8102226	4	2	1971	1974	46°35'00	67°36'00	189	51	1303
	Centreville	8100850	28	27	1965	1993	46°23'00	67°42'00	143	53	1069
	Beechwood	8100512	31	27	1966	1997	46°32'00	67°40'00	91.4	53	1092
	Upper Holmesville	8105546	2	1	1971	1972	46°37'00	67°37'00	182.9	54	n/a
	Bon Accord	8100566	45	41	1966	2011	46°39'03"	67°35'04	450.3	54	1299
	Arthucette Birch Ridge	8100350	17	15	1967	1983	46°45'00	67°28'00	214.9	54	1150
	Kings Landing	8102314	3	3	1975	1978	45°51'00	66°57'00	67.4	55	1117
	Fredericton Unb	8101700	81	79	1871	1952	45°57'00	66°36'00	50	57	1102
	Fredericton CDA	8101600	87	86	1913	2000	45°55'00	66°37'00	39.6	58	1124
	Dungarvon River	8101272	2	< 1	1986	1987	46°49'00	66°39'00	317	60	n/a
	Canterbury	8100775	21	20	1970	1990	45°53'00	67°28'00	173.8	63	1197
	Plaster Rock NBEPC	8104001	12	9	1955	1967	46°54'00	67°23'00	140.2	66	942
	Plaster Rock	8104000	46	23	1947	1993	46°54'00	67°24'00	160	66	897
	Acadia Forest Exp	8100100	55	51	1955	2010	45°59'25	66°21'48	54.00	69	1203
	Harvey Station	8102200	56	55	1920	1976	45°44'00	67°00'00	152.4	70	1066
	Tobique Narrows	8105400	4	4	1953	1957	46°47'00	67°41'00	91.4	70	1005
	Magaguadavic Lake	8102550	10	9	1958	1967	45°44'00	67°12'00	106.7	70	1089
	Oromocto	8103800	37	36	1957	1994	45°50'00	66°28'00	45.7	71	1104

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NOTES:
1. DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA

0	07JUN'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.3

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

JUNIPER MONTHLY TEMPERATURE (˚C)

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YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
1969							16.4	16.3					
1970	-15.8	-11.1	-5.8										
1971													
1972						15.3	17.0						
1973		-11.6							11.4				
1974						15.2	16.6	16.7					
1975					10.5	15.3	19.9	16.3	11.0			-10.5	
1976	-14.7	-11.0	-6.0	1.7		15.8	17.1	15.8				-13.2	
1977		-11.5	-1.3	-0.4		13.6	16.9	16.5			0.3	-8.5	
1978	-14.0	-12.9	-7.6	0.0	11.8	15.2	17.5	16.1			-2.7	-8.8	
1979	-9.6		-1.0	2.6	10.7	15.1	18.3	14.9	11.0	5.8	0.8	-8.4	
1980	-11.1	-12.6	-5.3	3.6		12.8	16.0	16.2	9.1	3.5	-2.0		
1981			-3.1	3.2	10.9	15.0	18.0	16.4	11.0	4.1	-0.4	-5.1	
1982	-16.3	-11.8		0.5	10.3	13.9	17.7	14.1	11.9	6.1	0.5	-5.6	
1983	-9.7	-9.7		4.1	8.4	15.5	17.6	17.1	13.3	6.3	0.2		
1984	-13.2	-5.5	-7.1	3.0	9.0	14.6	18.2	18.1	10.8	6.0	1.0	-7.4	3.9
1985	-14.8	-9.2	-5.5	1.1	9.0	14.2	18.2	16.0	12.7	5.5	-2.6	-12.8	2.6
1986	-11.3		-5.9	4.2	9.3	12.3	15.8	15.0	9.1	4.7	-3.6	-9.3	
1987	-12.6	-11.1	-3.5	5.6	9.9	14.6	17.7	15.3	11.5	6.1	-1.5	-8.2	3.6
1988	-11.8	-10.9	-4.4	3.4	12.0	13.7	19.4	17.4	10.8	4.2	1.0	-10.5	3.7
1989	-11.5	-12.3	-6.9	1.6	12.4	15.2	16.6	16.3	12.3	6.0	-2.3	-16.9	2.6
1990	-8.7	-12.7	-5.1	3.1	8.6	16.2	17.8	18.0	11.4	6.8	-0.6	-7.2	4.0
1991	-14.3	-10.6	-3.2	2.7	10.5	15.4	17.4	17.8	10.8	7.3	0.3	-10.7	3.6
1992	-12.6	-11.5	-7.5	1.9	10.6	14.9	15.0	17.1	12.9	5.2	-2.1	-6.9	3.1
1993	-12.4	-15.8	-5.4	3.8	9.8	14.5	17.3	18.1	12.5	3.9	-1.0	-6.9	3.2
1994	-17.4	-13.7	-3.6	2.8	8.4	16.6	19.7	16.4	11.4	6.9	1.0	-7.1	3.4
1995	-9.5	-13.1	-3.6	0.5	9.0	16.1	19.6	17.3	10.6	8.7	-1.8	-10.5	3.6
1996	-11.7	-9.6	-5.2	3.1	8.6	15.6	17.3	17.2	12.4	5.7	-2.0	-3.8	4.0
1997	-12.0	-11.3	-7.4	1.2	7.9	15.1	17.8	16.3	12.3	4.7	-1.6	-8.5	2.9
1998	-9.6	-7.1	-3.2	3.9	12.6	15.1	18.8	16.6	12.9	6.1	-1.2	-5.9	4.9
1999	-11.8	-7.1	-1.3	3.2	13.2	17.7	18.7	17.1	16.1	5.4	1.9	-5.7	5.6
2000	-11.9	-9.7	-1.5	2.9	9.0	14.6	17.1	16.7	12.0	5.6	1.7	-9.6	3.9
2001	-11.8	-10.1	-5.4	1.9	11.9	16.5	17.7	18.7	13.5	7.3	1.9	-3.4	4.9
2002	-8.9	-8.3	-4.4	2.8		13.8	17.8	17.6	13.6	4.7	-1.8	-8.1	
2003	-14.6	-13.1	-5.6	0.3	9.6	15.8	17.7	18.3	13.8	6.4	0.9	-5.4	3.7
2004	-16.2	-8.8	-3.3										
2005													
2006													
2007													
2008									12.9	5.7	5.9		
2009							21.5	18.4	12.2	5.8	2.9	-7.5	
2010	-9.8	-7.5	-1.2	6.0	11.4	15.2	19.6	17.0	14.5	8.1	1.6	-2.2	6.1
2011	-10.8	-10.0	-3.3	2.5	10.1	15.7	19.1	18.4	14.8	8.3	2.8	-6.4	5.1
Mean	-12.3	-10.7	-4.5	2.6	10.2	15.0	17.9	16.8	12.1	5.9	-0.1	-8.0	3.7
Maximum	-8.7	-5.5	-1.0	6.0	13.2	17.7	21.5	18.7	16.1	8.7	5.9	-2.2	7.5
Minimum	-17.4	-15.8	-7.6	-0.4	7.9	12.3	15.0	14.1	9.1	3.5	-3.6	-16.9	0.0

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Climate\[Table 2.3 & 2.4 & Figure 2.2 & 2.3 - Temperature Regression from Juniper MSC.xlsx]Table 2.3

NOTES:

1. BLANK MONTHS HAVE MISSING OR INCOMPLETE DATA (INCOMPLETE HAS BEEN DEFINED AS MONTHS WITH MORE THAN TWO DAYS OF MISSING DATA
2. MONTHLY AVERAGES HAVE BEEN CALCULATED BASED ON AVERAGE DAILY DATA PROVIDED BY E.C.

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
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TABLE 2.4

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

ESTIMATED LONG-TERM TEMPERATURE (˚C)

Print Jul/31/12 9:32:05

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
Mean	-11.8	-10.3	-4.4	2.2	9.4	13.9	16.6	15.6	11.2	5.3	-0.3	-7.8	3.3
Maximum	-8.4	-5.4	-1.2	5.4	12.1	16.4	20.0	17.3	14.9	7.9	5.3	-2.3	6.8
Minimum	-16.6	-15.1	-7.3	-0.6	7.2	11.3	13.9	13.0	8.3	3.0	-3.6	-16.1	-0.2

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Climate\[Table 2.3 & 2.4 & Figure 2.2 & 2.3 - Temperature Regression from Juniper MSC.xlsx]Table 2.4

NOTES:

1. TEMPERATURE VALUES ESTIMATED THROUGH CORRELATION OF SITE DATA WITH CONCURRENT AND LONG-TERM DATA FROM THE ENVIRONMENT CANADA MSC STATION AT JUNIPER

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
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TABLE 2.5

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SISSON CLIMATE STATION
RELATIVE HUMIDITY (%)

Print Jul/31/12 9:33:37

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
2007												87	87
2008	86					80	78	83	80	80	86		82
2009	79	81	67	71	67	78	83	78	79	82	78	86	78
2010	82	83	65	80	65	79	78	76					76
2011				71	80	76	76	83	82	80	79	89	80
Average	82	82	67	71	71	78	79	81	80	81	78	86	78

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NOTES:
1. GREY SHADED VALUES BASED ON INCOMPLETE MONTHS OF DATA.
2. BLANK MONTHS INDICATE PERIODS OF MISSING DATA

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.6

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

POTENTIAL EVAPOTRANSPIRATION AT SITE METEOROLOGICAL STATION (mm)

Print Jul/31/12 9:34:32

	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total
2007												87	– [1]
2008	6			34	60	101	132	104	69	30	18		– [1]
2009	0	0	0	25	72	101	116	115	66	19	12	0	526
2010	0	0	0	37	81	107	135	112					– [1]
2011				22	66	99	125	110	76	38	11	0	– [1]
Site Average	2	0	0	30	70	102	127	110	71	29	14	29	583
Long Term Maximum[3]	0	0	0	29	78	108	134	107	78	37	20	0	591
Long Term Average[3]	0	0	0	15	68	100	119	104	65	29	0	0	500
Long Term Minimum[3]	0	0	0	0	56	87	111	98	60	10	0	0	421

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NOTES:
1. ANNUAL SUM NOT CALCULATED DUE TO MISSING MONTHLY VALUES
2. BLANK MONTHS HAVE MISSING OR INCOMPLETE DATA
3. ALL VALUES CALCULATED USING THE THORNTHWAITE EQUATION
4. LONG-TERM VALUES CALCULATED ON THE BASIS OF ESTIMATED LONG-TERM MONTHLY TEMPERATURE VALUES

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.7

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SISSON CLIMATE STATION
MONTHLY TOTAL PRECIPITATION (mm)

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	January	February	March	April	May	June	July	August	September	October	November	December	Annual Total (mm)
2007												5.9	6
2008	27.9			36.6	53.3	160.3	82.3	130.6	145.5	104.1	121.7		862
2009	6.4	77.2	62.5	110.2	110.0	137.9	144.3	82.3	60.5	182.6	115.3	111.8	1201
2010	85.1	67.3	3.6	17.8	65.3	31.5	94.5	30.7					396
2011				43.9	140.7	155.4	152.4	240.6	88.9	115.6	72.6	12.7	1023
Average	85.1	72.3	62.5	110.2	92.3	151.2	118.4	151.1	98.3	134.1	94.0	111.8	1281

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NOTES:

1. SHADED VALUES ARE BASED ON INCOMPLETE MONTHS OF DATA
2. BLANK MONTHS ARE PERIODS OF MISSING DATA
3. AVERAGE VALUES USE ONLY COMPLETE MONTHS OF RECORD

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
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TABLE 2.8

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

REGIONAL MONTHLY AND ANNUAL PRECIPITATION AND PRECIPITATION DISTRIBUTION

Print 7/31/12 9:35

MSC Station	Period of Record	Distance from Site (km)	Elevation (m)	Type	Mean Total Precipitation												
					Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Aroostook	1929 - 2012	67	80	Rain (mm)	23	15	29	54	82	97	107	96	93	86	68	35	785
				% monthly precip.	26%	21%	37%	75%	98%	100%	100%	100%	100%	94%	72%	36%	74%
				Snow (mm)	65	58	49	18	1	0	0	0	0	5	26	61	283
				% monthly precip.	74%	79%	63%	25%	2%	0%	0%	0%	0%	6%	28%	64%	26%
				Precip. (mm)	87	72	77	73	83	97	107	96	93	92	94	95	1067
				% annual precip.	8%	7%	7%	7%	8%	9%	10%	9%	9%	9%	9%	9%	100%
Fredericton	1951 - 2012	69	21	Rain (mm)	40.0	33.2	43.1	62.7	87.4	86	88	86	87	94	90	56.8	855
				% monthly precip.	42%	41%	49%	77%	99%	100%	100%	100%	100%	98%	85%	53%	78%
				Snow (mm)	55	49	45	19	1	0	0	0	0	2	16	50	236
				% monthly precip.	58%	59%	51%	23%	1%	0%	0%	0%	0%	2%	15%	47%	22%
				Precip. (mm)	95.3	81.7	88.3	81.5	88.6	86	88	86	87	96	106	106.5	1091
				% annual precip.	9%	7%	8%	7%	8%	8%	8%	8%	8%	9%	10%	10%	100%
Juniper	1969 - 2012	23	259	Rain (mm)	29	18	38	59	93	95	107	103	100	95	71	43	852
				% monthly precip.	30%	26%	42%	73%	99%	100%	100%	100%	100%	97%	73%	42%	75%
				Snow (mm)	68	52	52	22	1	0	0	0	0	3	26	61	284
				% monthly precip.	70%	74%	58%	27%	1%	0%	0%	0%	0%	3%	27%	58%	25%
				Precip. (mm)	97	70	90	81	93	95	107	103	100	98	97	104	1136
				% annual precip.	8%	6%	8%	7%	8%	8%	9%	9%	9%	9%	9%	9%	100%
Hamtown Corner	1973 - 1989	34	244	Rain (mm)	37	29	50	69	100	116	116	100	105	102	96	54	974
				% monthly precip.	29%	34%	49%	67%	98%	100%	100%	100%	100%	97%	81%	48%	75%
				Snow (mm)	94	54	57	36	2	0	0	0	0	2	24	61	330
				% monthly precip.	73%	64%	55%	35%	2%	0%	0%	0%	0%	2%	20%	53%	25%
				Precip. (mm)	129	85	104	104	102	116	116	100	105	104	118	114	1297
				% annual precip.	10%	7%	8%	8%	8%	9%	9%	8%	8%	8%	9%	9%	100%
Woodstock	1886 - 2012	46	153	Rain (mm)	24	16	31	53	75	92	87	82	83	88	71	38	738
				% monthly precip.	28%	23%	41%	76%	99%	100%	100%	100%	100%	97%	81%	43%	75%
				Snow (mm)	60	52	44	17	1	0	0	0	0	2	17	51	243
				% monthly precip.	72%	77%	59%	24%	1%	0%	0%	0%	0%	3%	19%	57%	25%
				Precip. (mm)	84	67	75	69	76	92	87	82	83	91	87	89	981
				% annual precip.	9%	7%	8%	7%	8%	9%	9%	8%	8%	9%	9%	9%	100%

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NOTES:
1. PRECIPITATION DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA. ALL ARE ACTIVE STATIONS, EXCEPT HAMTOWN CORNER.

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TABLE 2.9

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

JUNIPER MONTHLY PRECIPITATION

Print Jul/31/12 9:35:56

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	ANNUAL
1969							95	95	155	31	116	102	
1970	12	140	67	64	110	75	138	102	104	92	49		
1971				36	94	65	85		43	95	98	96	
1972	78	98	133	31	95	142	85			109	96	162	
1973	115	103	87	141	124	83	142	174	134	37	97		
1974	66	51	111	154	91	88	132	85	116	65	88		
1975					114	62	68	43	160	50	134	175	
1976	110	129	87	72		72	135	175	80	187	69	173	
1977	56	80	94	59	71	214	75	123	104	184	62	135	1256
1978	142	7	120	77	78	118	66	43	51	102	66	125	995
1979	155	49	144	99	138	98	99	176	120	88	135	100	1399
1980	48	22	126	76	61	84	218	71	139	119	110	113	1185
1981	91	66	119	83	91	104	68	106	132	175	68	139	1242
1982	139	79	80	107	26	129	71	137	134	47	180	95	1223
1983	93	67	107	154	153	29	139	109	68	63	217	149	1347
1984	132	75	86	63	181	153	113	67	58	47	83	121	1178
1985	24	97	69	45	84	109	119	30	72	60	107	58	873
1986	140	35	86	101	62	75	107	104	135	44	107	74	1069
1987	89	17	73	41	62	125	71	58	160	86	107	65	954
1988	87	79	38	43	53	68	82	190	60	119	130	46	993
1989	73	71	79	103	116	58	116	149	109	67	140	82	1163
1990	117	40	35	94	124	96	154	199	104	193	97	142	1396
1991	96	31	97	63	105	98	41	162	146	108	49	59	1056
1992	105	103	66	60	31	107	144	55	68	168	74	107	1086
1993	98	80	70	121	95	177	106	110	112	157	104	156	1385
1994	174	60	133	141	133	119	85	60	72	44	126	79	1224
1995	159	98	65	102	79	55	70	83	67	144	142	98	1162
1996	153	98	103	113	99	64	191	41	88	110	111	226	1397
1997	154	76	109	31	149	78	67	107	86	32	88	132	1110
1998	135	55	110	86	122	82	121	131	123	97	79	97	1237
1999	160	58	155	44	61	69	57	92	206	113	133	112	1259
2000	118	95	83	149	102	78	121	142	89	79	68	97	1222
2001	49	89	66	59	77	68	91	118	90	71	76	27	882
2002	109	128	112	114		57	188	71	116	63	100	67	
2003	61	70	102	44	89	76	152	103	63	249	111	125	1245
2004	60	38	61										
2005													
2006													
2007													
2008									42	49	76		
2009							25	28	43	97	2	59	
2010	12	5	14	15	20	79	90	33	84	112	97	12	573
2011	37	101	71	43	89	181	147	134	75	82	13	25	998
2012	29	29											
Average	97	70	90	81	93	95	107	103	100	98	97	104	1147
StDev	46	34	31	39	36	39	42	48	39	52	40	47	188
CV	0.47	0.49	0.34	0.48	0.39	0.41	0.39	0.47	0.38	0.53	0.41	0.45	0.16

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NOTES:

1. BLANK MONTHS CONTAIN INCOMPLETE DATA
1. SHADED MONTHS CONTAIN LESS THAN TWO DAYS OF MISSING DATA. THESE MONTHS ARE STILL CONSIDERED IN THE CALCULATION OF AVERAGES.

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TABLE 2.10

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

ESTIMATED LONG-TERM SITE PRECIPITATION

Print 7/31/12 9:37

Type	Mean Total Precipitation												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rain (mm)	34	21	45	70	110	113	127	122	119	113	85	51	1012
% monthly precip.	30%	26%	42%	73%	99%	100%	100%	100%	100%	97%	73%	42%	75%
Snow (mm)	81	62	62	26	1	0	0	0	0	3	31	72	338
% monthly precip.	70%	74%	58%	27%	1%	0%	0%	0%	0%	3%	27%	58%	25%
Total Precip. (mm)	115	83	107	96	111	113	127	122	119	117	116	123	1350
% annual precip.	8%	6%	8%	7%	8%	8%	9%	9%	9%	9%	9%	9%	100%

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NOTES:

1. PRECIPITATION DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA.

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
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TABLE 2.11

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

HYDROMETEOROLOGY REPORT
ESTIMATED MEAN, 10-YEAR WET AND 10-YEAR DRY PRECIPITATION DEPTHS

Print Jul/31/12 9:36

Location	Return Period	Precipitation (mm)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Coefficient of Variation		0.47	0.49	0.34	0.48	0.39	0.41	0.39	0.47	0.38	0.53	0.41	0.45	**0.16**
Sisson	10 yr wet	184	135	154	155	166	173	192	195	178	195	176	194	**1634**
	Mean	115	83	107	96	111	113	127	122	119	117	116	123	**1350**
	10 yr dry	45	31	0	0	56	53	63	49	60	38	55	52	**1066**

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NOTES:

1. COEFFICIENT OF VARIATION (CV) WAS BASED ON DATA MEASURED AT JUNIPER.
2. COEFFICIENT OF VARIATION (CV) = STANDARD DEVIATION / MEAN.
3. 10 YEAR WET AND 10 YEAR DRY PRECIPITATION WERE CALCULATED ASSUMING A NORMAL DISTRIBUTION.

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.12

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SUMMARY OF SITE SNOW SURVEYS IN 2011 AND 2012

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Station	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)
SNOW-SISBR-EXP	14-Feb-11	80	0.14	11.8	01-Mar-11	90	0.20	17.9	16-Mar-11	67	0.32	20.6
SNOW-SISBR-CANOPY	14-Feb-11	44	0.20	8.8	01-Mar-11	57	0.20	11.5	16-Mar-11	51	0.23	11.5
SNOW-BIRD-HIGH	14-Feb-11	77	0.16	12.2	02-Mar-11	76	0.20	16.5	16-Mar-11	69	0.25	17.6
SNOW-BIRD-MID1	14-Feb-11	80	0.10	8.6	03-Mar-11	93	0.20	19.0	15-Mar-11	78	0.14	10.9
SNOW-BIRD-MID2	14-Feb-11	83	0.20	14.1	02-Mar-11	100	0.16	15.8	15-Mar-11	77	0.19	14.9
Average		**73**	**0.16**	**11.1**		**83**	**0.19**	**16.1**		**68**	**0.23**	**15.1**

	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)
SNOW-SISBR-EXP	01-Apr-11	57	0.39	21.5	28-Apr-11	n/a [1]	n/a [1]	n/a [1]
SNOW-SISB-CANOPY	01-Apr-11	43	0.30	12.7	28-Apr-11	16	0.31	6.1
SNOW-BIRD-HIGH	30-Mar-11	63	0.30	19.3	28-Apr-11	3	0.10	1.3
SNOW-BIRD-MID1	31-Mar-11	68	0.30	20.2	28-Apr-11	31	0.40	11.6
SNOW-BIRD-MID2	30-Mar-11	72	0.27	19.5	27-Apr-11	11	0.24	4.1
Average		**61**	**0.31**	**18.7**		**15**	**0.26**	**5.8**

Station	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)	Date	Snow Depth (cm)	Density (g/cm^3)	Snow Water Equivalent (cm)
SNOW-SISBR-EXP	10-Feb-12	51	0.17	8.8		n/a [1]	n/a [1]	n/a [1]	19-Mar-12	53	0.22	11.6
SNOW-SISB-CANOPY	10-Feb-12	23	0.22	5.0		n/a [1]	n/a [1]	n/a [1]	19-Mar-12	24	0.33	7.9
SNOW-BIRD-HIGH	09-Feb-12	57	0.21	11.6	08-Mar-12	73	0.23	16.3	21-Mar-12	25	0.40	9.7
SNOW-BIRD-MID1	10-Feb-12	52	0.22	11.1	07-Mar-12	85	0.15	12.4	20-Mar-12	58	0.26	14.7
SNOW-BIRD-MID2	10-Feb-12	55	0.18	10.0	07-Mar-12	95	0.11	13.4	20-Mar-12	53	0.28	14.7
Average		**48**	**0.20**	**9.3**		**84**	**0.17**	**14.0**		**42**	**0.30**	**11.7**

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Climate\[Table 2.12 - Snow Course Data.xlsx]Table 2.12

NOTES:

1. SNOW SURVEY NOT CONDUCTED DURING THIS PERIOD

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 2.13

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

JUNIPER CLIMATE STATION
MAXIMUM MONTHLY SNOW DEPTH (cm)

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Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	93	64	70	25	0	0	0	0	0	0	5	35
1982	53	74	0	0	0	0	0	0	0	0	20	10
1983	19	31	26	0	0	0	0	0	0	0	32	23
1984	54	65	86	34	0	0	0	0	0	6	1	28
1985	38	38	0	0	0	0	0	0	0	0	21	24
1986	75	25	0	0	0	0	0	0	0	0	38	0
1987	0	0	0	0	0	0	0	0	0	0	0	42
1988	67	105	60	0	0	0	0	0	0	1	20	45
1989	69	70	70	32	0	0	0	0	0	0	27	62
1990	94	93	86	44	0	0	0	0	0	0	12	32
1991	72	70	84	49	0	0	0	0	0	0	8	28
1992	28	63	58	22	0	0	0	0	0	0	5	32
1993	40	80	83	52	0	0	0	0	0	0	9	18
1994	107	73	90	73	0	0	0	0	0	0	20	45
1995	78	79	91	77	5	0	0	0	0	0	7	56
1996	55	35	70	20	0	0	0	0	0	0	16	14
1997	41	78	99	77	5	0	0	0	0	10	36	75
1998	99	97	80	45	0	0	0	0	0	0	16	31
1999	76	72	104	50	0	0	0	0	0	0	0	25
2000	50	96	25	17	0	0	0	0	0	12	8	22
2001	50	85	82	67	0	0	0	0	0	0	11	4
2002	61	86	44	23	0	0	0	0	0	6	10	40
2003	65	107	115	52	0	0	0	0	0	9	12	64
2004	57	59	41	0	0	0	0	0	0	0	0	0
Mean	60	69	61	32	0	0	0	0	0	2	14	31

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Climate\[Table 2.10, Figure 2.6, Table 2.13 - Long Term Precipitation.xlsx]Table 2.13

NOTES:

1. PRECIPITATION DATA OBTAINED FROM THE METEOROLOGICAL SERVICES OF CANADA BRANCH (MSC) OF ENVIRONMENT CANADA.

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TABLE 2.14

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

ESTIMATED PROJECT SITE 24-HOUR EXTREME RAINFALL RETURN PERIOD VALUES

Mean (mm) = **72.2**
Standard Deviation (mm) = **17.3**

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Return Period (years)	Frequency Factor	24 hr Extreme Rainfall (mm)
2	-0.164	69
5	0.719	85
10	1.305	95
15	1.635	100
20	1.866	104
25	2.044	108
50	2.592	117
100	3.137	126
200	3.679	136
500	4.395	148
1000	4.936	158
PMP	**-**	**352**

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NOTES:

1. MEAN ANNUAL 24 HOUR EXTREME RAINFALL AND STANDARD DEVIATION WERE ESTIMATED USING THE MAXIMUM DAILY RAINFALL RECORD FROM JUNIPER ADJUSTED FOR EQUIVALENT 24-HOUR VALUES AND FOR HIGHER PRECIPITATION AT THE SITE.

3. RETURN PERIOD RAINFALL AMOUNTS COMPUTED ASSUMING AN EXTREME VALUE DISTRIBUTION.

4. THE PMP WAS ESTIMATED FROM THE HERSCHFIELD EQUATION

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
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TABLE 3.1

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

HYDROMETRIC STATION DETAILS

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PROJECT STATIONS							
Station Name	Location		Start of Record	Open Water Site Visits	Data Logger	Area	Description
	East	North				km^2	
B-2	2459130	7487724	11-May-11	12	Yes	7.7	Bird Brook at Napadogan
CL-1A	2454600	7481659	27-May-11	10	Yes	4.3	Stream from Chainey Lakes Basin
FR-1A	2456514	7487200	11-May-11	11	No	1.1	Stream draining potential dry-stack site
MBB-2	2453974	7481513	18-May-11	11	Yes	30.8	McBean Brook
NB-2B	2460952	7484144	11-May-11	12	Yes	52.6	Napadogan Brook
SB-1	2459358	7486130	10-May-11	12	Yes	5.0	Sisson Brook
SB-3A	2458551	7485979	11-May-11	12	No	2.6	Sisson Brook - upstream

REGIONAL WSC STATIONS										
Station Name	Location		ID	Start of Record	Period of Record	Distance to Project	Drainage Area km^2	MAD m^3/s	MAUR	
	Latitude	Longitude							$L/s/km^2$	mm
Narrows Mtn Brook	46° 16' 37" N	67° 01' 17" W	01AL004	1972	39	10 km S	3.9	0.09	23.1	728
Becaguimec Stream	46° 20' 27" N	67° 27' 54" W	01AJ010	1973	38	33 km W	350	7.6	21.7	684
Middle Branch Nashwaaksis	46° 04' 58" N	66° 43' 58" W	01AK006	1966	45	41 km SE	5.7	.0.9	15.8	498
Nackawic Stream	46° 02' 55" N	67° 14' 22" W	01AK007	1967	44	32 km SW	240	5	20.8	657
Nashwaak River	46° 07' 33" N	66° 36' 40" W	01AL002	1961	50	42 km SE	1450	36.6	25.2	796

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Hydrology\[Table 3.1 - Hydrometric Station Details.xlsx]Table 3.1 -Hydrometric Stations

NOTES:

1. PROJECT HYDROMETRIC STATION COORDINATE GRID IN METRES. COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC
2. WSC STATION COORDINATE SYSTEM: WGS 1984

0	31MAY'12	ISSUED WITH REPORT VA101-447/3-1	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.2

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SUMMARY OF 2011 MEASURED FLOWS

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STATION	TYPE	Jan-11	Feb-11	Mar-11	Apr-11	May-11	Jun-11	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11
B-2	Average Discharge (m^3/s)	-	-	-	-	0.35	0.29	0.15	0.27	0.19	0.15	0.13	-
	Average Unit Runoff ($L/s/km^2$)	-	-	-	-	44.8	38.2	18.9	35.3	24.7	19.0	16.9	-
CL-1A	Average Discharge (m^3/s)	-	-	-	-	-	0.11	0.07	0.15	0.10	0.06	0.09	-
	Average Unit Runoff ($L/s/km^2$)	-	-	-	-	-	24.7	15.8	34.1	22.9	14.8	20.5	-
MBB-2	Average Discharge (m^3/s)	-	-	-	-	-	0.90	0.59	0.98	0.74	0.51	0.46	-
	Average Unit Runoff ($L/s/km^2$)	-	-	-	-	-	28.4	18.6	30.9	23.4	16.0	14.6	-
NB-2B	Average Discharge (m^3/s)	-	-	-	-	2.18	1.88	1.17	1.94	1.60	1.09	1.22	-
	Average Unit Runoff ($L/s/km^2$)	-	-	-	-	39.2	33.7	21.0	34.8	28.6	19.6	21.8	-
SB-1	Average Discharge (m^3/s)	-	-	-	-	0.22	0.16	0.07	0.16	0.13	0.08	0.09	-
	Average Unit Runoff ($L/s/km^2$)	-	-	-	-	43.2	31.3	14.2	31.5	26.0	16.6	17.2	-

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Hydrology\[Table 3.2 and Figure 3.9 3.10 3.11 - Hydrographs.xlsx]Table 3.2

NOTES:

1. B-1, NB-2B, AND SB-1 COMMENCED DATA COLLECTION ON MAY 10 AND 11, 2011.
2. CL-1A AND MBB-2 COMMENCED DATA COLLECTION ON MAY 27, 2011 (THEREFORE MAY AVERAGE HAS NOT BEEN PRESENTED).
3. DATA COLLECTION CEASED AT ALL SITES BETWEEN NOVEMBER 28 AND 30, 2011.

0	06JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.3

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SYNTHESIZED LONG-TERM FLOW FOR PROJECT STATIONS

Print Jul/31/12 9:58:39

STATION	PARAMETER	UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
B-2	Mean Discharge	m^3/s	0.118	0.090	0.188	0.631	0.398	0.146	0.095	0.074	0.074	0.155	0.242	0.211	0.202
	St.Dev.	m^3/s	0.083	0.092	0.150	0.185	0.139	0.103	0.076	0.062	0.065	0.127	0.140	0.144	0.05
	C.V.	-	0.71	1.02	0.80	0.29	0.35	0.70	0.80	0.84	0.87	0.82	0.58	0.68	0.26
CL-1A	Mean Discharge	m^3/s	0.052	0.037	0.081	0.299	0.174	0.067	0.040	0.029	0.029	0.068	0.110	0.093	0.090
	St.Dev.	m^3/s	0.037	0.043	0.058	0.099	0.077	0.046	0.037	0.032	0.032	0.057	0.058	0.061	0.03
	C.V.	-	0.72	1.15	0.72	0.33	0.44	0.68	0.92	1.10	1.12	0.84	0.53	0.65	0.28
MBB-2	Mean Discharge	m^3/s	0.523	0.389	0.787	2.506	1.328	0.607	0.456	0.417	0.399	0.732	1.007	0.802	0.829
	St.Dev.	m^3/s	0.340	0.281	0.517	0.654	0.513	0.370	0.262	0.295	0.230	0.497	0.453	0.439	0.18
	C.V.	-	0.65	0.72	0.66	0.26	0.39	0.61	0.58	0.71	0.58	0.68	0.45	0.55	0.21
NB-2B	Mean Discharge	m^3/s	0.860	0.664	1.258	4.246	2.514	1.067	0.701	0.534	0.530	1.069	1.642	1.422	1.375
	St.Dev.	m^3/s	0.499	0.571	0.791	1.365	1.057	0.619	0.502	0.449	0.445	0.776	0.794	0.821	0.35
	C.V.	-	0.58	0.86	0.63	0.32	0.42	0.58	0.72	0.84	0.84	0.73	0.48	0.58	0.25
SB-1	Mean Discharge	m^3/s	0.058	0.106	0.415	0.256	0.087	0.060	0.049	0.049	0.090	0.134	0.117	0.000	0.118
	St.Dev.	m^3/s	0.045	0.070	0.126	0.094	0.050	0.038	0.032	0.033	0.062	0.067	0.069	0.000	0.03
	C.V.	-	0.78	0.66	0.30	0.37	0.58	0.63	0.65	0.66	0.69	0.50	0.59	0.00	0.23

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0	07JUN'12	ISSUED WITH REPORT VA101-447/3-1	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.4

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

ESTIMATED LONG-TERM MEAN UNIT RUNOFF FOR PROJECT STATIONS

Print Jul/31/12 9:58:39

STATION	UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
B-2	mm	41	28	65	212	138	49	33	26	25	54	81	73	827
	L/s/km^2	15.3	11.7	24.4	82.0	51.6	19.0	12.3	9.6	9.7	20.1	31.4	27.4	26.2
CL-1A	mm	32	21	51	180	108	41	25	18	17	42	66	58	660
	L/s/km^2	12.1	8.6	18.9	69.5	40.4	15.7	9.4	6.8	6.7	15.8	25.6	21.7	20.9
MBB-2	mm	45	31	68	211	115	51	40	36	34	64	85	70	849
	L/s/km^2	17.0	12.6	25.5	81.4	43.1	19.7	14.8	13.5	12.9	23.8	32.7	26.0	26.9
NB-2B	mm	44	30	64	209	128	53	36	27	26	54	81	72	824
	L/s/km^2	16.3	12.6	23.9	80.7	47.8	20.3	13.3	10.1	10.1	20.3	31.2	27.0	26.1
SB-1	mm	38	28	57	215	137	45	32	26	26	48	69	63	785
	L/s/km^2	14.4	11.5	21.1	83.0	51.2	17.3	12.1	9.9	9.9	18.0	26.7	23.5	24.9

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0	07JUN'12	ISSUED WITH REPORT VA101-447/3-1	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.5

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

B-2 SYNTHETIC FLOWS (m^3/s)

Print: 7/24/12 6:26

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1972	0.10	0.09	0.16	0.30	0.78	0.23	0.10	0.06	0.07	0.17	0.25	0.27	0.22
1973	0.13	0.19	0.18	1.04	0.62	0.20	0.37	0.22	0.06	0.05	0.07	0.54	0.31
1974	0.11	0.10	0.23	0.61	0.62	0.18	0.26	0.06	0.06	0.10	0.09	0.28	0.22
1975	0.08	0.04	0.04	0.33	0.69	0.24	0.05	0.02	0.04	0.06	0.22	0.14	0.16
1976	0.17	0.30	0.15	0.72	0.49	0.07	0.07	0.21	0.06	0.39	0.20	0.21	0.25
1977	0.09	0.05	0.12	0.60	0.39	0.46	0.08	0.04	0.05	0.28	0.19	0.17	0.21
1978	0.33	0.09	0.08	0.40	0.52	0.10	0.07	0.03	0.02	0.09	0.09	0.04	0.15
1979	0.27	0.10	0.83	0.57	0.43	0.17	0.08	0.20	0.27	0.13	0.29	0.17	0.29
1980	0.14	0.03	0.11	0.50	0.26	0.11	0.18	0.11	0.15	0.26	0.24	0.20	0.19
1981	0.07	0.51	0.20	0.68	0.32	0.19	0.13	0.14	0.20	0.44	0.29	0.36	0.30
1982	0.10	0.05	0.09	0.91	0.29	0.11	0.07	0.09	0.19	0.10	0.32	0.24	0.21
1983	0.16	0.15	0.33	0.60	0.42	0.21	0.09	0.04	0.06	0.09	0.50	0.45	0.26
1984	0.08	0.17	0.20	0.80	0.49	0.53	0.22	0.04	0.03	0.03	0.09	0.07	0.23
1985	0.05	0.06	0.25	0.44	0.31	0.11	0.12	0.08	0.04	0.06	0.15	0.07	0.14
1986	0.14	0.10	0.16	0.58	0.25	0.09	0.08	0.19	0.23	0.14	0.14	0.15	0.19
1987	0.04	0.03	0.15	0.51	0.22	0.10	0.03	0.02	0.08	0.16	0.13	0.24	0.14
1988	0.05	0.06	0.27	0.54	0.22	0.04	0.02	0.02	0.02	0.08	0.25	0.07	0.14
1989	0.03	0.03	0.15	0.70	0.48	0.05	0.02	0.08	0.06	0.10	0.30	0.06	0.17
1990	0.09	0.07	0.14	0.68	0.38	0.12	0.08	0.11	0.07	0.37	0.32	0.43	0.24
1991	0.14	0.05	0.22	0.76	0.33	0.08	0.02	0.07	0.16	0.35	0.16	0.10	0.20
1992	0.15	0.05	0.14	0.51	0.26	0.11	0.11	0.13	0.03	0.14	0.19	0.09	0.16
1993	0.11	0.04	0.07	0.75	0.34	0.23	0.08	0.03	0.04	0.20	0.28	0.43	0.22
1994	0.14	0.09	0.10	0.90	0.48	0.18	0.09	0.03	0.03	0.03	0.16	0.08	0.19
1995	0.11	0.06	0.13	0.67	0.40	0.12	0.03	0.01	0.02	0.06	0.42	0.07	0.17
1996	0.18	0.16	0.17	0.58	0.39	0.10	0.27	0.04	0.05	0.07	0.25	0.49	0.23
1997	0.13	0.06	0.06	0.42	0.61	0.11	0.06	0.02	0.05	0.02	0.05	0.03	0.14
1998	0.06	0.10	0.59	0.84	0.25	0.09	0.06	0.05	0.03	0.09	0.15	0.12	0.20
1999	0.14	0.18	0.32	0.61	0.23	0.04	0.05	0.03	0.13	0.20	0.29	0.30	0.21
2000	0.09	0.05	0.30	0.61	0.30	0.08	0.04	0.02	0.03	0.04	0.08	0.14	0.15
2001	0.04	0.04	0.04	0.44	0.29	0.05	0.02	0.00	0.01	0.02	0.03	0.05	0.09
2002	0.01	0.01	0.19	0.82	0.29	0.07	0.08	0.01	0.03	0.04	0.13	0.10	0.15
2003	0.04	0.02	0.12	0.67	0.51	0.10	0.07	0.17	0.03	0.36	0.40	0.28	0.23
2004	0.07	0.02	0.07	0.51	0.23	0.05	0.04	0.07	0.10	0.03	0.14	0.24	0.13
2005	0.08	0.03	0.30	0.76	0.43	0.15	0.07	0.03	0.14	0.42	0.53	0.39	0.28
2006	0.45	0.09	0.09	0.35	0.34	0.27	0.14	0.03	0.02	0.09	0.45	0.14	0.21
2007	0.13	0.02	0.22	0.44	0.36	0.09	0.03	0.03	0.02	0.06	0.52	0.13	0.17
2008	0.10	0.07	0.08	0.79	0.43	0.13	0.10	0.16	0.11	0.28	0.51	0.47	0.27
2009	0.08	0.04	0.10	1.04	0.42	0.20	0.14	0.08	0.03	0.28	0.31	0.21	0.24
2010	0.12	0.09	0.24	0.59	0.22	0.09	0.04	0.01	0.04	0.11	0.34	0.73	0.22
2011	0.09	0.04	0.29	0.63	0.45	0.25	0.14	0.29	0.28	0.12	0.14	0.25	0.25
Average	**0.12**	**0.09**	**0.19**	**0.63**	**0.39**	**0.15**	**0.09**	**0.08**	**0.08**	**0.15**	**0.24**	**0.22**	**0.20**
% Annual	**4.8%**	**3.6%**	**7.9%**	**25.8%**	**16.2%**	**6.0%**	**3.9%**	**3.2%**	**3.2%**	**6.3%**	**9.9%**	**9.2%**	**100%**
CV	**0.69**	**1.02**	**0.77**	**0.29**	**0.35**	**0.69**	**0.79**	**0.90**	**0.91**	**0.81**	**0.57**	**0.72**	**0.25**
Maximum	**0.45**	**0.51**	**0.83**	**1.04**	**0.78**	**0.53**	**0.37**	**0.29**	**0.28**	**0.44**	**0.53**	**0.73**	**4.68**
Minimum	**0.01**	**0.01**	**0.04**	**0.30**	**0.22**	**0.04**	**0.02**	**0.00**	**0.01**	**0.02**	**0.03**	**0.03**	**2.95**

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Hydrology\[Figure 3.12 and 3.13 and Table 3.5 - Synthetic B-2.xlsx]TABLE 3.5

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.6

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

CL-1A SYNTHETIC FLOWS (m^3/s)

Print: 7/24/12 6:26

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1972	0.05	0.04	0.08	0.12	0.38	0.12	0.05	0.02	0.03	0.09	0.13	0.12	0.10
1973	0.07	0.10	0.09	0.52	0.30	0.10	0.16	0.11	0.02	0.02	0.03	0.22	0.14
1974	0.06	0.05	0.12	0.29	0.30	0.09	0.12	0.02	0.02	0.05	0.04	0.12	0.11
1975	0.03	0.01	0.01	0.12	0.33	0.11	0.02	0.00	0.01	0.02	0.10	0.07	0.07
1976	0.06	0.13	0.07	0.35	0.22	0.03	0.03	0.09	0.03	0.16	0.10	0.09	0.11
1977	0.04	0.01	0.06	0.29	0.17	0.20	0.03	0.01	0.02	0.13	0.10	0.08	0.09
1978	0.15	0.04	0.03	0.17	0.24	0.05	0.03	0.00	0.00	0.04	0.04	0.01	0.07
1979	0.12	0.05	0.31	0.27	0.20	0.09	0.04	0.10	0.13	0.07	0.14	0.09	0.13
1980	0.06	0.00	0.05	0.23	0.10	0.05	0.09	0.06	0.08	0.13	0.12	0.09	0.09
1981	0.03	0.21	0.10	0.33	0.14	0.10	0.07	0.07	0.09	0.19	0.15	0.16	0.14
1982	0.05	0.02	0.04	0.45	0.11	0.05	0.02	0.04	0.09	0.05	0.14	0.12	0.10
1983	0.07	0.07	0.14	0.29	0.19	0.10	0.04	0.01	0.02	0.04	0.20	0.19	0.11
1984	0.04	0.09	0.10	0.39	0.23	0.22	0.11	0.01	0.00	0.00	0.04	0.03	0.10
1985	0.02	0.02	0.10	0.20	0.13	0.05	0.06	0.03	0.01	0.02	0.07	0.03	0.06
1986	0.05	0.05	0.06	0.27	0.09	0.04	0.03	0.09	0.11	0.07	0.07	0.08	0.08
1987	0.01	0.00	0.05	0.23	0.07	0.04	0.01	0.00	0.03	0.08	0.07	0.10	0.06
1988	0.02	0.02	0.09	0.25	0.07	0.01	0.00	0.00	0.00	0.03	0.12	0.03	0.05
1989	0.00	0.00	0.05	0.34	0.22	0.02	0.00	0.03	0.02	0.05	0.14	0.02	0.08
1990	0.04	0.03	0.07	0.33	0.17	0.06	0.03	0.04	0.03	0.16	0.15	0.19	0.11
1991	0.07	0.02	0.10	0.37	0.14	0.03	0.00	0.03	0.06	0.16	0.09	0.05	0.09
1992	0.07	0.01	0.05	0.24	0.10	0.05	0.05	0.05	0.00	0.06	0.10	0.05	0.07
1993	0.05	0.01	0.03	0.36	0.14	0.11	0.03	0.00	0.01	0.09	0.14	0.18	0.10
1994	0.07	0.05	0.05	0.44	0.22	0.09	0.04	0.00	0.01	0.00	0.08	0.04	0.09
1995	0.05	0.02	0.07	0.32	0.18	0.06	0.00	0.00	0.00	0.02	0.17	0.03	0.08
1996	0.07	0.08	0.09	0.27	0.17	0.05	0.12	0.01	0.02	0.03	0.11	0.20	0.10
1997	0.07	0.02	0.02	0.18	0.29	0.06	0.02	0.00	0.02	0.00	0.02	0.00	0.06
1998	0.02	0.05	0.23	0.41	0.09	0.04	0.02	0.01	0.01	0.04	0.08	0.06	0.09
1999	0.07	0.09	0.15	0.29	0.08	0.01	0.02	0.01	0.05	0.10	0.14	0.13	0.10
2000	0.04	0.01	0.13	0.29	0.13	0.04	0.01	0.00	0.01	0.01	0.03	0.06	0.06
2001	0.01	0.01	0.01	0.19	0.11	0.02	0.00	0.00	0.00	0.00	0.01	0.02	0.03
2002	0.00	0.00	0.10	0.40	0.12	0.03	0.03	0.00	0.01	0.01	0.06	0.05	0.07
2003	0.01	0.00	0.05	0.32	0.23	0.05	0.03	0.07	0.00	0.14	0.18	0.13	0.10
2004	0.03	0.00	0.02	0.24	0.08	0.02	0.01	0.03	0.04	0.01	0.05	0.11	0.05
2005	0.03	0.00	0.11	0.37	0.20	0.08	0.03	0.01	0.06	0.18	0.22	0.15	0.12
2006	0.19	0.04	0.04	0.15	0.14	0.12	0.06	0.00	0.00	0.04	0.18	0.08	0.09
2007	0.06	0.00	0.09	0.19	0.16	0.03	0.01	0.01	0.00	0.03	0.21	0.07	0.07
2008	0.05	0.03	0.04	0.38	0.19	0.06	0.04	0.07	0.04	0.12	0.21	0.20	0.12
2009	0.04	0.01	0.05	0.52	0.19	0.09	0.08	0.04	0.00	0.13	0.15	0.11	0.12
2010	0.07	0.05	0.10	0.28	0.07	0.04	0.01	0.00	0.01	0.05	0.15	0.28	0.09
2011	0.05	0.01	0.13	0.30	0.21	0.12	0.07	0.12	0.13	0.07	0.07	0.12	0.12
Average	**0.05**	**0.04**	**0.08**	**0.30**	**0.17**	**0.07**	**0.04**	**0.03**	**0.03**	**0.07**	**0.11**	**0.10**	**0.09**
% Annual	**4.8%**	**3.3%**	**7.6%**	**27.4%**	**15.8%**	**6.3%**	**3.7%**	**2.8%**	**2.8%**	**6.2%**	**10.1%**	**9.1%**	**100%**
CV	**0.70**	**1.15**	**0.69**	**0.32**	**0.45**	**0.67**	**0.91**	**1.13**	**1.15**	**0.82**	**0.52**	**0.67**	**0.28**
Maximum	**0.19**	**0.21**	**0.31**	**0.52**	**0.38**	**0.22**	**0.16**	**0.12**	**0.13**	**0.19**	**0.22**	**0.28**	**4.68**
Minimum	**0.00**	**0.00**	**0.01**	**0.12**	**0.07**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**	**2.95**

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Hydrology\[Figure 3.14 and 3.15 and Table 3.6 - Synthetic CL-1A.xlsx]TABLE 3.6

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.7

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

MBB-2 SYNTHETIC FLOWS (m^3/s)

Print: 7/24/12 6:26

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1972	0.40	0.34	0.65	0.95	2.88	0.86	0.38	0.24	0.27	0.69	0.97	0.92	0.80
1973	0.53	0.74	0.69	3.81	2.34	0.78	1.20	0.84	0.24	0.20	0.29	1.74	1.12
1974	0.43	0.41	0.92	2.23	2.32	0.69	0.92	0.22	0.22	0.39	0.36	0.92	0.84
1975	0.30	0.16	0.17	1.02	2.57	0.87	0.20	0.09	0.18	0.24	0.76	0.55	0.59
1976	0.54	0.99	0.60	2.71	1.82	0.29	0.26	0.72	0.26	1.26	0.77	0.72	0.91
1977	0.35	0.18	0.45	2.21	1.32	1.59	0.30	0.17	0.18	1.03	0.72	0.60	0.76
1978	1.13	0.35	0.30	1.33	1.84	0.39	0.28	0.10	0.09	0.33	0.35	0.16	0.55
1979	0.92	0.38	2.36	2.17	1.54	0.65	0.33	0.73	0.94	0.52	1.09	0.66	1.03
1980	0.52	0.12	0.43	1.86	0.74	0.41	0.70	0.42	0.60	0.97	0.90	0.74	0.70
1981	0.27	1.65	0.76	2.51	1.04	0.74	0.51	0.56	0.73	1.50	1.14	1.21	1.05
1982	0.38	0.21	0.36	3.37	0.86	0.44	0.25	0.35	0.71	0.39	1.12	0.90	0.78
1983	0.60	0.54	1.08	2.26	1.52	0.78	0.35	0.17	0.25	0.36	1.59	1.52	0.92
1984	0.30	0.67	0.76	2.98	1.80	1.70	0.83	0.17	0.11	0.12	0.36	0.28	0.84
1985	0.20	0.22	0.85	1.56	1.01	0.43	0.45	0.28	0.18	0.24	0.54	0.29	0.52
1986	0.46	0.40	0.54	2.19	0.66	0.35	0.31	0.72	0.83	0.55	0.52	0.60	0.68
1987	0.18	0.11	0.50	1.77	0.55	0.39	0.14	0.07	0.30	0.62	0.50	0.77	0.49
1988	0.20	0.22	0.78	2.02	0.53	0.14	0.08	0.09	0.07	0.30	0.93	0.27	0.47
1989	0.12	0.11	0.44	2.63	1.70	0.22	0.10	0.31	0.25	0.40	1.09	0.24	0.63
1990	0.34	0.27	0.56	2.54	1.40	0.48	0.28	0.40	0.27	1.26	1.17	1.48	0.87
1991	0.54	0.22	0.79	2.85	1.04	0.31	0.07	0.29	0.52	1.26	0.62	0.41	0.74
1992	0.57	0.19	0.48	1.89	0.75	0.43	0.43	0.48	0.11	0.49	0.73	0.36	0.58
1993	0.43	0.16	0.29	2.78	1.08	0.85	0.31	0.11	0.15	0.72	1.06	1.35	0.77
1994	0.54	0.36	0.39	3.35	1.74	0.66	0.36	0.12	0.12	0.11	0.62	0.32	0.72
1995	0.42	0.24	0.51	2.41	1.39	0.46	0.11	0.05	0.08	0.25	1.36	0.27	0.63
1996	0.61	0.64	0.67	2.05	1.38	0.40	0.91	0.18	0.19	0.28	0.85	1.58	0.81
1997	0.53	0.25	0.24	1.40	2.28	0.44	0.24	0.09	0.19	0.09	0.19	0.10	0.50
1998	0.23	0.40	1.80	3.18	0.71	0.36	0.24	0.18	0.13	0.36	0.59	0.46	0.72
1999	0.56	0.70	1.15	2.33	0.58	0.17	0.21	0.13	0.45	0.74	1.06	1.03	0.76
2000	0.34	0.19	0.99	2.28	0.95	0.32	0.18	0.09	0.11	0.15	0.30	0.50	0.53
2001	0.17	0.14	0.16	1.45	0.87	0.20	0.07	0.01	0.05	0.07	0.12	0.21	0.29
2002	0.04	0.05	0.74	3.11	0.93	0.27	0.30	0.05	0.12	0.15	0.49	0.40	0.55
2003	0.17	0.10	0.40	2.47	1.78	0.38	0.27	0.62	0.11	1.05	1.41	1.02	0.81
2004	0.27	0.09	0.27	1.92	0.57	0.20	0.16	0.26	0.38	0.13	0.50	0.81	0.46
2005	0.32	0.13	0.88	2.88	1.57	0.61	0.27	0.13	0.53	1.44	1.70	1.19	0.97
2006	1.41	0.37	0.36	1.22	1.08	0.91	0.52	0.11	0.09	0.33	1.41	0.57	0.70
2007	0.51	0.09	0.71	1.46	1.25	0.33	0.11	0.13	0.08	0.25	1.61	0.51	0.59
2008	0.38	0.29	0.32	2.90	1.48	0.47	0.38	0.61	0.36	0.95	1.66	1.54	0.95
2009	0.33	0.18	0.38	3.89	1.45	0.73	0.56	0.33	0.11	0.97	1.09	0.80	0.90
2010	0.49	0.37	0.76	2.11	0.51	0.36	0.18	0.06	0.15	0.43	1.19	2.08	0.72
2011	0.36	0.14	1.04	2.31	1.62	0.92	0.56	0.93	0.97	0.49	0.55	0.91	0.90
Average	**0.43**	**0.33**	**0.66**	**2.31**	**1.34**	**0.55**	**0.36**	**0.29**	**0.29**	**0.55**	**0.86**	**0.78**	**0.73**
% Annual	**5.0%**	**3.8%**	**7.6%**	**26.4%**	**15.3%**	**6.3%**	**4.1%**	**3.3%**	**3.3%**	**6.3%**	**9.8%**	**8.9%**	**100%**
CV	**0.59**	**0.89**	**0.64**	**0.31**	**0.45**	**0.62**	**0.71**	**0.85**	**0.85**	**0.74**	**0.50**	**0.63**	**0.25**
Maximum	**1.41**	**1.65**	**2.36**	**3.89**	**2.88**	**1.70**	**1.20**	**0.93**	**0.97**	**1.50**	**1.70**	**2.08**	**4.68**
Minimum	**0.04**	**0.05**	**0.16**	**0.95**	**0.51**	**0.14**	**0.07**	**0.01**	**0.05**	**0.07**	**0.12**	**0.10**	**2.95**

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev B\Tables and Figures\Hydrology\[Figure 3.16 and 3.17 - Synthetic MBB-2-REVISED.xlsx]TABLE 3.7

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold
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TABLE 3.8

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

NB-2B SYNTHETIC FLOWS (m^3/s)

Print: 7/24/12 6:26

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1972	26.27	20.80	38.90	54.20	165.83	51.21	24.07	14.87	16.62	41.48	55.47	55.72	47.12
1973	33.90	40.09	43.69	217.19	130.45	45.50	70.55	51.10	14.23	12.63	17.66	98.79	64.65
1974	28.12	24.03	55.96	122.99	131.10	42.11	55.32	13.78	13.36	25.14	22.50	55.26	49.14
1975	19.07	8.47	10.07	55.96	146.67	50.22	12.56	4.89	10.40	14.88	43.91	34.71	34.32
1976	31.33	54.84	35.34	147.04	100.06	18.02	16.15	43.25	15.71	73.38	44.71	43.10	51.91
1977	23.03	9.96	28.17	122.63	75.26	85.35	19.24	10.19	9.99	59.39	43.87	36.58	43.64
1978	66.12	20.81	19.46	74.11	106.21	24.54	17.57	5.44	4.94	20.81	21.03	9.46	32.54
1979	54.34	21.63	135.14	115.57	87.82	39.02	21.13	44.73	55.57	33.89	62.24	41.61	59.39
1980	31.31	6.62	25.11	99.22	46.08	25.19	42.62	27.66	36.46	58.51	52.01	44.32	41.26
1981	17.56	83.73	47.49	139.56	62.74	43.97	32.15	33.52	40.22	85.91	63.43	70.39	60.06
1982	24.72	11.90	23.23	188.49	50.16	25.13	14.76	21.58	41.90	24.66	62.67	54.09	45.27
1983	35.91	29.81	62.93	121.84	85.75	44.27	21.62	10.64	15.13	22.52	88.43	86.33	52.10
1984	19.64	38.45	46.41	163.95	101.47	93.82	50.36	10.14	5.96	6.52	21.05	17.67	47.95
1985	12.11	12.38	48.91	85.80	59.85	26.17	28.72	16.38	10.36	14.89	32.46	17.31	30.45
1986	25.43	23.00	31.39	117.41	41.21	21.24	18.35	43.74	47.72	35.20	31.37	37.46	39.46
1987	10.68	5.73	28.14	98.94	34.51	22.75	7.97	3.45	17.23	38.05	31.08	46.41	28.74
1988	12.58	12.89	45.08	108.91	33.41	7.95	4.19	4.58	3.38	18.29	54.10	17.02	26.87
1989	6.73	5.71	25.51	142.81	97.12	13.06	5.32	18.15	14.14	25.10	62.60	15.09	35.95
1990	21.20	15.66	33.66	139.31	77.19	29.13	16.01	23.80	15.58	72.89	65.93	84.59	49.58
1991	34.50	12.19	47.71	156.67	61.35	18.24	3.36	16.90	28.24	72.18	39.74	27.12	43.18
1992	34.22	10.77	28.25	101.04	44.74	23.87	26.18	27.68	6.12	28.59	43.44	23.57	33.21
1993	25.92	8.53	16.87	153.49	64.63	49.30	19.31	6.41	8.41	43.42	61.53	80.02	44.82
1994	33.69	21.24	25.52	185.30	97.37	40.32	22.93	6.88	6.41	5.84	36.29	20.16	41.83
1995	25.95	13.73	33.55	135.18	79.56	28.55	6.34	2.01	4.11	15.25	75.90	17.22	36.45
1996	35.52	36.54	43.32	115.77	78.21	25.32	54.17	10.66	11.02	17.91	50.37	89.94	47.40
1997	33.46	14.03	15.11	78.31	127.48	27.83	15.10	4.67	10.99	5.01	11.60	5.71	29.11
1998	14.37	22.44	104.04	173.89	42.72	22.13	13.84	9.09	7.25	22.46	35.89	30.09	41.52
1999	34.61	38.45	67.01	124.14	36.53	10.22	13.35	7.39	24.79	45.11	60.72	60.57	43.57
2000	21.61	10.97	60.20	124.78	57.66	20.34	10.66	4.60	5.92	8.63	18.61	29.88	31.16
2001	10.52	7.56	9.94	81.17	51.50	12.16	3.36	0.14	2.48	3.28	6.44	12.81	16.78
2002	1.63	1.97	45.03	170.11	54.59	16.82	18.75	2.16	6.53	9.12	29.43	24.46	31.72
2003	10.03	4.80	23.19	137.16	102.75	23.45	16.26	35.48	5.62	62.89	77.66	60.23	46.63
2004	17.41	4.52	14.47	102.16	36.16	11.77	9.73	14.67	22.53	7.54	27.45	49.03	26.45
2005	19.15	6.79	52.34	156.55	88.67	35.93	16.17	7.07	29.47	80.86	94.71	70.16	54.82
2006	82.96	20.91	22.54	66.88	64.09	52.42	31.37	5.87	4.83	19.67	79.86	36.64	40.67
2007	31.32	4.26	43.21	83.50	71.85	19.30	6.43	7.51	3.70	14.72	90.01	31.88	33.97
2008	24.79	17.39	20.66	160.97	85.83	27.44	23.49	36.29	20.40	55.58	92.33	89.13	54.52
2009	21.24	9.78	24.59	217.22	82.80	42.56	36.11	21.14	5.92	57.66	63.29	49.98	52.69
2010	31.97	21.78	47.28	119.76	32.78	21.72	10.77	2.41	8.41	25.98	66.98	121.96	42.65
2011	23.78	7.54	60.39	128.32	92.22	53.07	34.36	56.03	56.29	31.55	33.56	54.21	52.61
Average	**26.72**	**18.57**	**39.75**	**127.21**	**77.16**	**32.29**	**21.77**	**17.17**	**16.71**	**32.93**	**49.31**	**46.27**	**42.15**
% Annual	**5.3%**	**3.7%**	**7.9%**	**25.1%**	**15.3%**	**6.4%**	**4.3%**	**3.4%**	**3.3%**	**6.5%**	**9.7%**	**9.1%**	**100%**
CV	**0.57**	**0.85**	**0.61**	**0.31**	**0.43**	**0.57**	**0.71**	**0.88**	**0.87**	**0.71**	**0.48**	**0.60**	**0.25**
Maximum	**82.96**	**83.73**	**135.14**	**217.22**	**165.83**	**93.82**	**70.55**	**56.03**	**56.29**	**85.91**	**94.71**	**121.96**	**4.68**
Minimum	**1.63**	**1.97**	**9.94**	**54.20**	**32.78**	**7.95**	**3.36**	**0.14**	**2.48**	**3.28**	**6.44**	**5.71**	**2.95**

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 0\Tables and Figures\Hydrology\[Figure 3.18 and 3.19 and Table 3.8 - Synthetic NB-2B.xlsx]TABLE 3.8

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.9

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

SB-1 SYNTHETIC FLOWS (m^3/s)

Print: 7/24/12 6:26

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1972	0.07	0.06	0.10	0.19	0.52	0.13	0.06	0.04	0.05	0.10	0.14	0.15	0.13
1973	0.08	0.11	0.10	0.70	0.41	0.11	0.19	0.13	0.04	0.04	0.05	0.27	0.19
1974	0.07	0.07	0.13	0.40	0.41	0.11	0.14	0.04	0.04	0.06	0.06	0.15	0.14
1975	0.05	0.03	0.03	0.21	0.46	0.13	0.04	0.02	0.03	0.04	0.12	0.09	0.11
1976	0.09	0.16	0.09	0.47	0.32	0.05	0.05	0.12	0.05	0.20	0.12	0.12	0.15
1977	0.06	0.04	0.07	0.40	0.25	0.24	0.05	0.03	0.04	0.15	0.11	0.10	0.13
1978	0.17	0.06	0.05	0.26	0.34	0.06	0.05	0.02	0.02	0.06	0.06	0.03	0.10
1979	0.15	0.06	0.40	0.38	0.28	0.10	0.06	0.11	0.15	0.08	0.16	0.10	0.17
1980	0.08	0.03	0.07	0.32	0.16	0.07	0.11	0.07	0.09	0.14	0.14	0.11	0.12
1981	0.05	0.26	0.12	0.45	0.20	0.11	0.08	0.09	0.11	0.23	0.17	0.19	0.17
1982	0.06	0.04	0.06	0.60	0.18	0.07	0.05	0.06	0.11	0.06	0.17	0.14	0.13
1983	0.09	0.09	0.17	0.39	0.27	0.12	0.06	0.03	0.04	0.06	0.25	0.23	0.15
1984	0.05	0.10	0.11	0.53	0.32	0.27	0.13	0.03	0.03	0.03	0.06	0.05	0.14
1985	0.04	0.04	0.13	0.28	0.20	0.07	0.07	0.05	0.03	0.04	0.09	0.05	0.09
1986	0.08	0.06	0.09	0.38	0.15	0.06	0.05	0.11	0.13	0.09	0.08	0.09	0.11
1987	0.03	0.03	0.08	0.33	0.14	0.06	0.03	0.02	0.05	0.09	0.08	0.13	0.09
1988	0.04	0.04	0.14	0.35	0.14	0.03	0.02	0.02	0.02	0.05	0.14	0.05	0.09
1989	0.03	0.03	0.08	0.46	0.31	0.04	0.02	0.05	0.04	0.07	0.17	0.04	0.11
1990	0.06	0.05	0.09	0.45	0.25	0.08	0.05	0.07	0.05	0.19	0.17	0.23	0.14
1991	0.09	0.04	0.12	0.50	0.21	0.05	0.02	0.05	0.09	0.19	0.10	0.07	0.13
1992	0.09	0.04	0.08	0.33	0.17	0.07	0.07	0.08	0.03	0.08	0.11	0.06	0.10
1993	0.07	0.03	0.05	0.50	0.21	0.13	0.05	0.03	0.03	0.11	0.16	0.22	0.13
1994	0.09	0.06	0.06	0.60	0.31	0.10	0.06	0.03	0.03	0.03	0.10	0.05	0.13
1995	0.07	0.04	0.08	0.44	0.26	0.07	0.03	0.02	0.02	0.04	0.22	0.05	0.11
1996	0.10	0.10	0.10	0.38	0.25	0.06	0.14	0.03	0.04	0.05	0.14	0.25	0.14
1997	0.08	0.04	0.04	0.27	0.40	0.07	0.04	0.02	0.04	0.02	0.04	0.02	0.09
1998	0.04	0.06	0.29	0.56	0.16	0.06	0.04	0.03	0.03	0.06	0.09	0.07	0.13
1999	0.09	0.11	0.17	0.40	0.14	0.03	0.04	0.03	0.08	0.12	0.16	0.16	0.13
2000	0.06	0.04	0.16	0.40	0.19	0.05	0.03	0.02	0.03	0.03	0.05	0.08	0.10
2001	0.03	0.03	0.03	0.28	0.18	0.04	0.02	0.01	0.02	0.02	0.03	0.04	0.06
2002	0.02	0.02	0.11	0.55	0.18	0.05	0.05	0.02	0.03	0.03	0.08	0.06	0.10
2003	0.03	0.02	0.07	0.44	0.33	0.06	0.05	0.10	0.03	0.18	0.21	0.16	0.14
2004	0.05	0.02	0.05	0.33	0.14	0.04	0.03	0.05	0.06	0.03	0.08	0.13	0.08
2005	0.05	0.03	0.15	0.50	0.28	0.09	0.05	0.03	0.08	0.22	0.27	0.20	0.16
2006	0.23	0.06	0.06	0.22	0.22	0.15	0.08	0.03	0.02	0.06	0.23	0.09	0.12
2007	0.08	0.02	0.12	0.29	0.23	0.06	0.03	0.03	0.02	0.04	0.26	0.08	0.11
2008	0.06	0.05	0.05	0.52	0.28	0.08	0.06	0.10	0.06	0.15	0.26	0.24	0.16
2009	0.06	0.03	0.06	0.69	0.27	0.11	0.09	0.06	0.03	0.15	0.17	0.12	0.15
2010	0.08	0.06	0.13	0.39	0.13	0.06	0.03	0.02	0.03	0.07	0.18	0.35	0.13
2011	0.06	0.03	0.16	0.42	0.29	0.14	0.09	0.15	0.15	0.08	0.08	0.14	0.15
Average	**0.07**	**0.06**	**0.11**	**0.41**	**0.25**	**0.09**	**0.06**	**0.05**	**0.05**	**0.09**	**0.13**	**0.12**	**0.13**
% Annual	**4.8%**	**3.8%**	**7.1%**	**27.6%**	**16.9%**	**5.8%**	**4.0%**	**3.4%**	**3.4%**	**5.9%**	**8.9%**	**8.2%**	**100%**
CV	**0.55**	**0.78**	**0.64**	**0.30**	**0.37**	**0.57**	**0.62**	**0.69**	**0.70**	**0.68**	**0.50**	**0.62**	**0.22**
Maximum	**0.23**	**0.26**	**0.40**	**0.70**	**0.52**	**0.27**	**0.19**	**0.15**	**0.15**	**0.23**	**0.27**	**0.35**	**4.68**
Minimum	**0.02**	**0.02**	**0.03**	**0.19**	**0.13**	**0.03**	**0.02**	**0.01**	**0.02**	**0.02**	**0.03**	**0.02**	**2.95**

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev B\Tables and Figures\Hydrology\[Figure 3.20 and 3.21- Synthetic SB-1.xlsx]TABLE 3.9

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	CMB	JGC	JPH
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.10

NORTHCLIFF RESOURCES LTD.
SCISSON PROJECT

REGIONAL RETURN PERIOD 7-DAY LOW FLOWS

Print Aug/23/12 13:49:08

Station Name	Drainage Area (km^2)	Period	Regional Return Period Annual and Seasonal Flows (L/s)						
			2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	Mean
Narrows Mountain Brook (01AL004)	3.9	Annual	**7.3**	**4.0**	**2.6**	**1.7**	**0.79**	**0.33**	**7.6**
		Winter	17	10	7.7	5.8	4.2	3.3	17
		Summer	7.5	3.6	2.1	1.3	0.57	0.060	8.5
Becaguimec Stream (01AJ010)	350	Annual	**554**	**388**	**319**	**274**	**234**	**214**	**579**
		Winter	853	587	494	439	398	381	932
		Summer	584	388	315	270	235	219	630
Middle Branch Nashwaaksis (01AK006)	5.7	Annual	**2.1**	**0.67**	**0.28**	**0.10**	**0.0**	**0.0**	**2.9**
		Winter	12.9	8.3	6.4	5.2	4.1	3.6	13.6
		Summer	3.2	0.61	0.24	0.08	0.0	0.0	3.5
Nackawic Stream (01AK007)	240	Annual	**88**	**45**	**31**	**24**	**20**	**18**	**106**
		Winter	376	203	152	126	108	101	456
		Summer	90	43	30	23	20	18	116
Nashwaak River (01AL002)	1450	Annual	**4271**	**3188**	**2807**	**2581**	**2409**	**2334**	**4573**
		Winter	6542	4753	3990	3469	3007	2769	6759
		Summer	4497	3212	2796	2564	2399	2333	4951

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 1\Tables and Figures\Hydrology\[Table 3.10 & Table 3.11 - Day Low Flow Sisson Working File_BW Edits.xlsx]Table 3.10

NOTES:

1. THE REGIONAL RETURN PERIOD VALUES WERE CALCULATED USING ENVIRONMENT CANADA'S LFA SOFTWARE.

1	23JUL'12	ISSUED WITH REPORT VA101-447/3-1	JM	NS	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.11

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

MEASURED PROJECT 7-DAY LOW FLOWS (SPRING TO FALL 2011)

Print Aug/23/12 13:49:08

Station	Drainage Area (km^2)	Period	7-Day Low Flows (L/s)
B-2	7.7	Oct 8-14	70
CL-1A	4.3	Oct 8-14	15
MBB-2	30.8	Nov 4-10	254
NB-2B	52.6	Aug 15-21	649
SB-1	5.0	Aug 15-21	44

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev 1\Tables and Figures\Hydrology\[Table 3.10 & Table 3.11 - Day Low Flow Sisson Working File_BW Edits.xlsx]Table 3.11

1	23JUL'12	ISSUED WITH REPORT VA101-447/3-1	ALR	JM	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

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TABLE 3.12

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

REGIONAL ANNUAL PEAK FLOW STATISTICS - 1

Print Jul/27/12 7:43:42

WSC Station Name	Station No.	Drainage Area (km^2)	Period of Record	Period of Record					1977-1978				
				Inst. Mean (m^3/s)	Daily Mean (m^3/s)	Inst/Daily Ratio	Unit Inst. Mean $m^3/s/km^2$	Unit Daily Mean $m^3/s/km^2$	Inst. Mean (m^3/s)	Daily Mean (m^3/s)	Inst/Daily Ratio	Unit Inst. Mean $m^3/s/km^2$	Unit Daily Mean $m^3/s/km^2$
Hayden Brook	01AL003	6.48	1971-1993	3.82	2.26	1.81	0.59	0.40	2.58	1.72	1.47	0.40	0.26
Narrows Mountain Brook	01AL004	3.89	1972-2010	2.19	1.38	1.66	0.56	0.34	1.34	0.91	1.51	0.34	0.23
Narrows Mountain Brook	01AL005	0.8	1975-1980	0.19	0.22	1.30	0.23	0.24	0.19	0.17	1.16	0.24	0.21
Narrows Mountain Brook	01AL006	0.91	1975-1980	0.35	0.27	1.27	0.38	0.33	0.30	0.24	1.28	0.33	0.26
Narrows Mountain Brook	01AL007	0.41	1977-1980	0.14	0.12	1.22	0.35	0.26	0.11	0.09	1.22	0.26	0.21

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev B\Tables and Figures\Hydrology\[Table 3.12, 3.13 and 3.14 - Peak flow analysis jgc.xlsx]Table 3.12

NOTES:

1. THE REGIONAL RETURN PERIOD VALUES WERE CALCULATED USING ENVIRONMENT CANADA'S CFA SOFTWARE.
2. 1977-78 IS THE ONLY PERIOD OF CONCURRENT RECORD FOR ALL STATIONS.

0	06JUL'12	ISSUED WITH REPORT VA101-447/3-1	JGC	JGC	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.13

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

REGIONAL ANNUAL PEAK FLOW STATISTICS - 2

Print Jul/27/12 7:43:42

Station	Drainage Area (km^2)	Parameter	Record Length (years)	Mean (m^3/s)	L-Cv	L-Cs
Hayden Brook (01AL003)	6.48	Instantaneous	20	3.82	0.31	0.14
		Daily	23	2.26	0.31	0.30
Narrows Mountain Brook (01AL004)	3.89	Instantaneous	30	2.19	0.29	0.32
		Daily	35	1.38	0.26	0.40
		Instantaneous	long-term	2.19	0.29	0.40

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev B\Tables and Figures\Hydrology\[Table 3.12, 3.13 and 3.14 - Peak flow analysis jgc.xlsx]Table 3.13

NOTES:

1. THE NARROWS MOUNTAIN BROOK VALUES ARE BASED ON A GEV DISTRIBUTION AND THE WSC HISTORICAL PEAK INSTANTANEOUS FLOW RECORD, WHICH INDICATES: MEAN = 2.19 m^3/s, L-Cv = 0.29, L-Cs = 0.32. HOWEVER, THE L-Cs WAS INCREASED TO 0.40 TO MATCH THE L-Cs OF THE DAILY RECORD AND ACCOUNT FOR THE VERY HIGH FLOOD IN 1973 THAT IS MISSING FROM THE INSTANTANEOUS RECORD.
2. REGIONAL DATA INDICATE THAT FLOODS APPEAR TO CHANGE WITH SCALE IN A NEAR LINEAR MANNER. THEREFORE, PEAK FLOWS CAN BE ESTIMATED FOR ANY LOCATION IN THE PROJECT AREA USING THE SAME UNIT FLOWS AS NARROWS MOUNTAIN BROOK.
3. L-Cv = LINEAR MOMENT COEFFICIENT OF VARIATION
4. L-CS = LINEAR MOMENT COEFFICIENT OF SKEW

0	06JUL'12	ISSUED WITH REPORT VA101-447/3-1	JGC	JGC	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

Knight Piésold CONSULTING

TABLE 3.14

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

RETURN PERIOD PEAK FLOWS

Print Jul/27/12 7:43:42

Station	Drainage Area (km^2)	Instantaneous Peak Flow (m^3/s)						
		2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr
Narrows Mountain Brook (01AL004)	3.9	1.8	2.7	3.6	4.6	6.4	8.1	10.6
Project Area	$A \leq 10\ km^2$	$Q_2 = 0.46 \times A$	$Q_5 = 0.69 \times A$	$Q_{10} = 0.93 \times A$	$Q_{20} = 1.18 \times A$	$Q_{50} = 1.65 \times A$	$Q_{100} = 2.08 \times A$	$Q_{200} = 2.62 \times A$

M:\1\01\00447\03\A\Report\1 - Hydrometeorology Report\Rev B\Tables and Figures\Hydrology\[Table 3.12, 3.13 and 3.14 - Peak flow analysis jgc.xlsx]Table 3.14

NOTES:

1. THE NARROWS MOUNTAIN BROOK VALUES ARE BASED ON A GEV DISTRIBUTION AND THE WSC HISTORICAL PEAK INSTANTANEOUS FLOW RECORD, WHICH INDICATES: MEAN = 2.19 m^3/s, L-Cv = 0.29, L-Cs = 0.32. HOWEVER, THE L-Cs WAS INCREASED TO 0.40 TO MATCH THE L-Cs OF THE DAILY RECORD AND ACCOUNT FOR THE VERY HIGH FLOOD IN 1973 THAT IS MISSING FROM THE INSTANTANEOUS RECORD.
2. REGIONAL DATA INDICATE THAT FLOODS APPEAR TO CHANGE WITH SCALE IN A NEAR LINEAR MANNER. THEREFORE, PEAK FLOWS CAN BE ESTIMATED FOR ANY LOCATION IN THE PROJECT AREA USING THE SAME UNIT FLOWS AS NARROWS MOUNTAIN BROOK.
3. A = AREA IN km^2.

0	06JUL'12	ISSUED WITH REPORT VA101-447/3-1	JGC	JGC	KJB
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

LEGEND:

SISSON ORE BODY

METEROLOGICAL SERVICES OF CANADA (MSC) CLIMATE STATION

NOTES:

1. BASE MAP: ESRI ARCGIS TOPOGRAPHIC MAPS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:500,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26JUL'12	ISSUED WITH REPORT	AMD	AMD	CMB	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

REGIONAL CLIMATE STATIONS

Knight Piésold CONSULTING

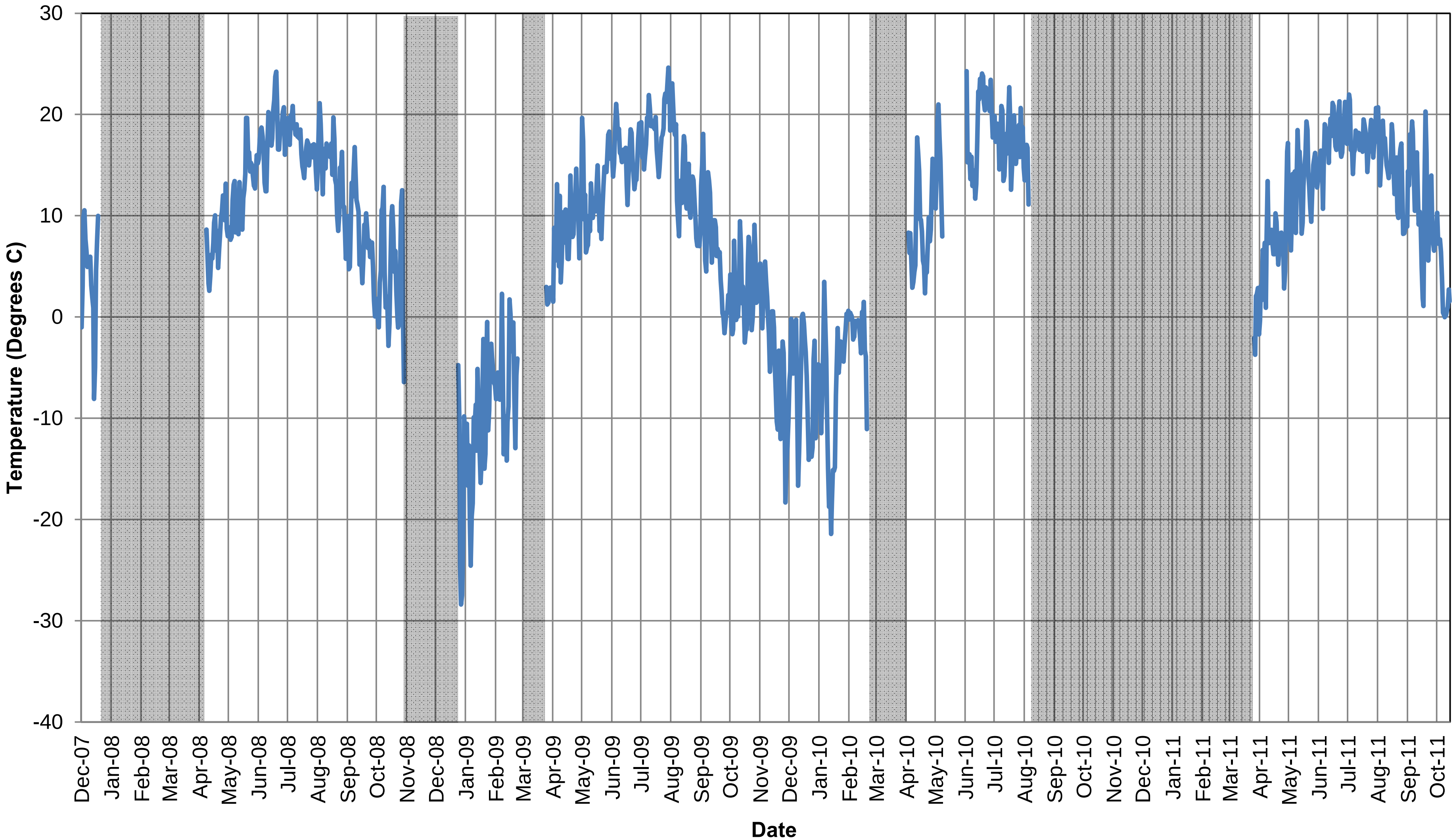
P/A NO. VA101-447/3

REF NO. 1

FIGURE 2.1

REV 0

KP FIGURE SAVED: M:\1\01\00447\03\A\GIS\Figs\B08_RegionalMSC_Stations.mxd; Jul 26, 2012 11:34:50 AM; kkraszova



NOTES:
1. SHADED AREAS INDICATE PERIODS OF MISSING DATA.

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SISSON CLIMATE STATION
AVERAGE DAILY TEMPERATURE

Knight Piésold CONSULTING

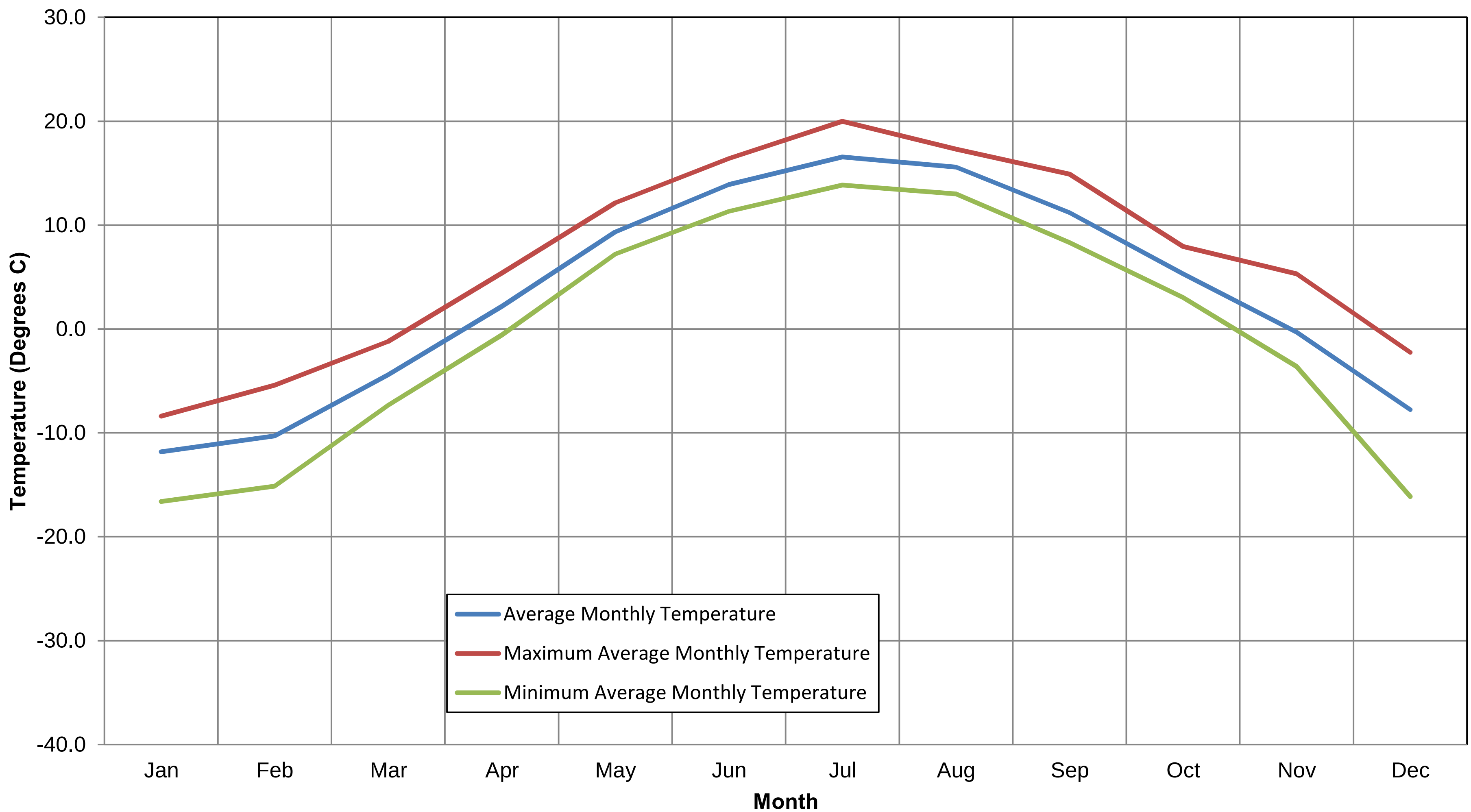
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 2.2

REV 0

0	20JUL'12	ISSUED WITH REPORT	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SISSON MONTHLY TEMPERATURE

Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 2.3

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
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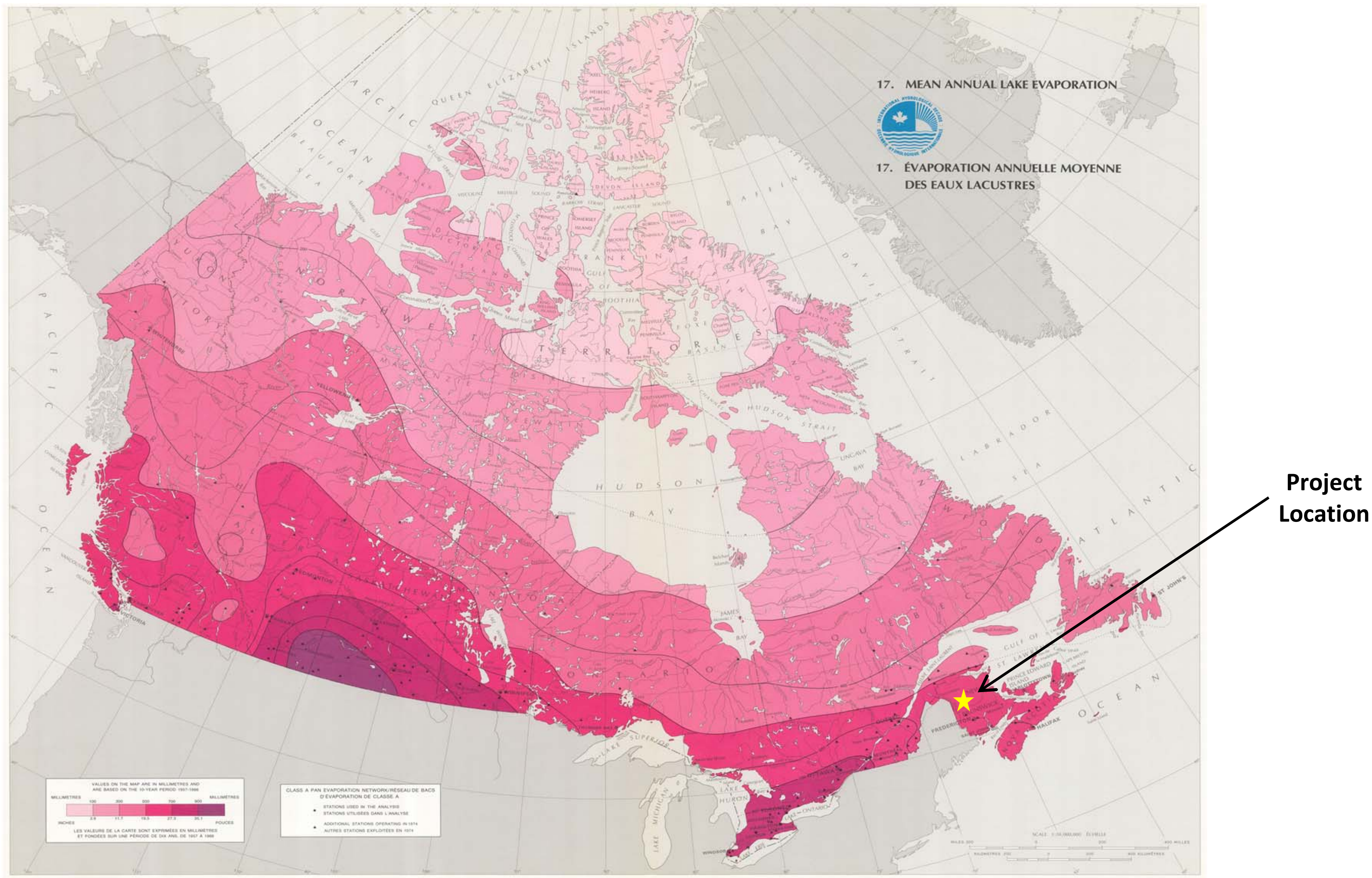


NOTES:

1. REFERENCE: NATIONAL ATLAS OF CANADA, 1995, THE HYDROLOGICAL ATLAS OF CANADA - MEAN ANNUAL LAKE EVAPORATION, NATURAL RESOURCES CANADA.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	20JUL'12	ISSUED WITH REPORT	TO	CMB	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

HYDROLOGICAL ATLAS OF CANADA EVAPORATION

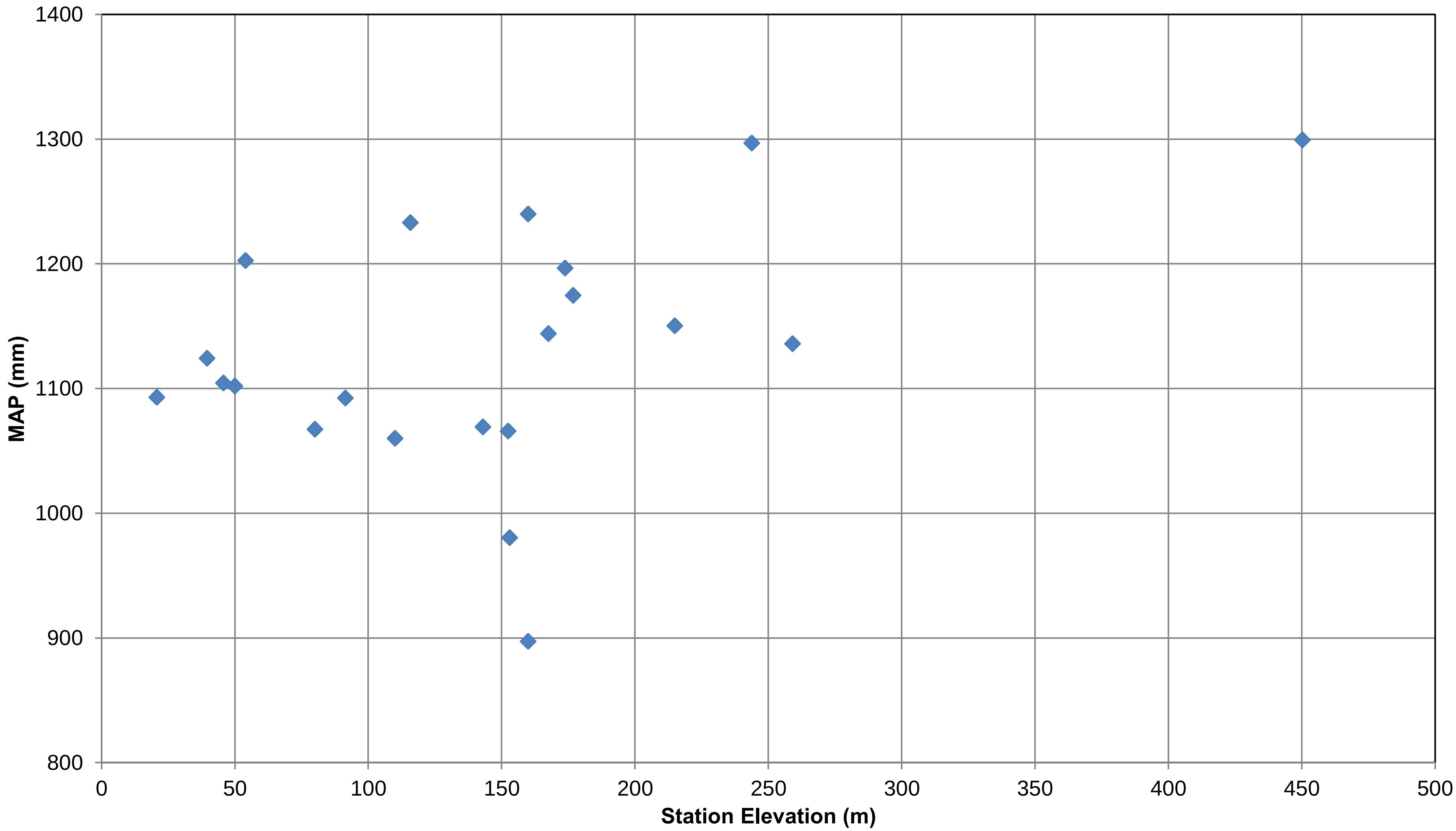
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 2.4

REV 0



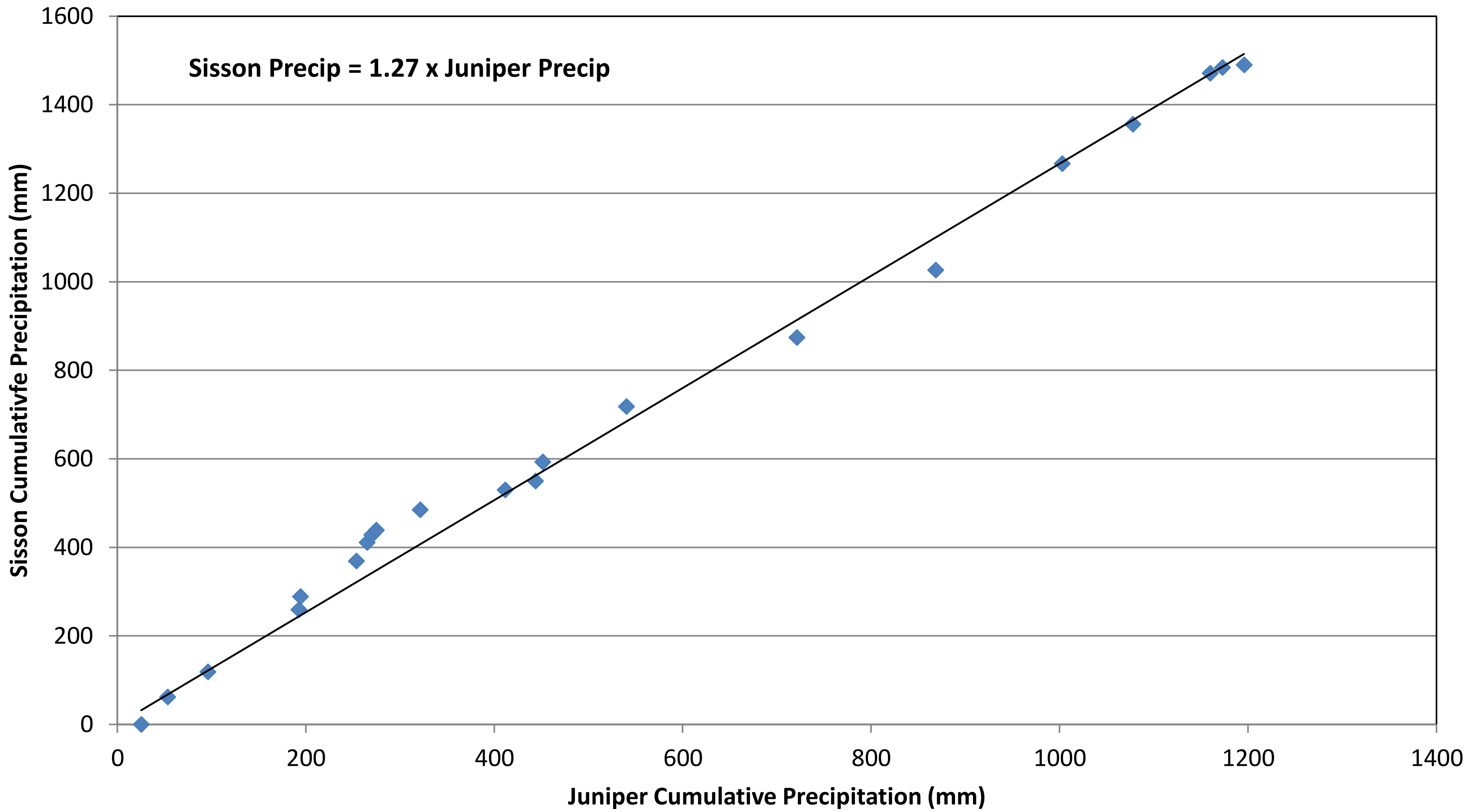
NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

REGIONAL CLIMATE STATION MEAN ANNUAL PRECIPITATION VERSUS ELEVATION

Knight Piésold CONSULTING	P/A NO. VA101-447/3	REF. NO. 1			
	FIGURE 2.5	REV 0			

0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



0	20JUL'12	ISSUED WITH REPORT VA101-447/3-1	TO	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SISSON AND JUNIPER CLIMATE STATIONS DOUBLE MASS CURVE

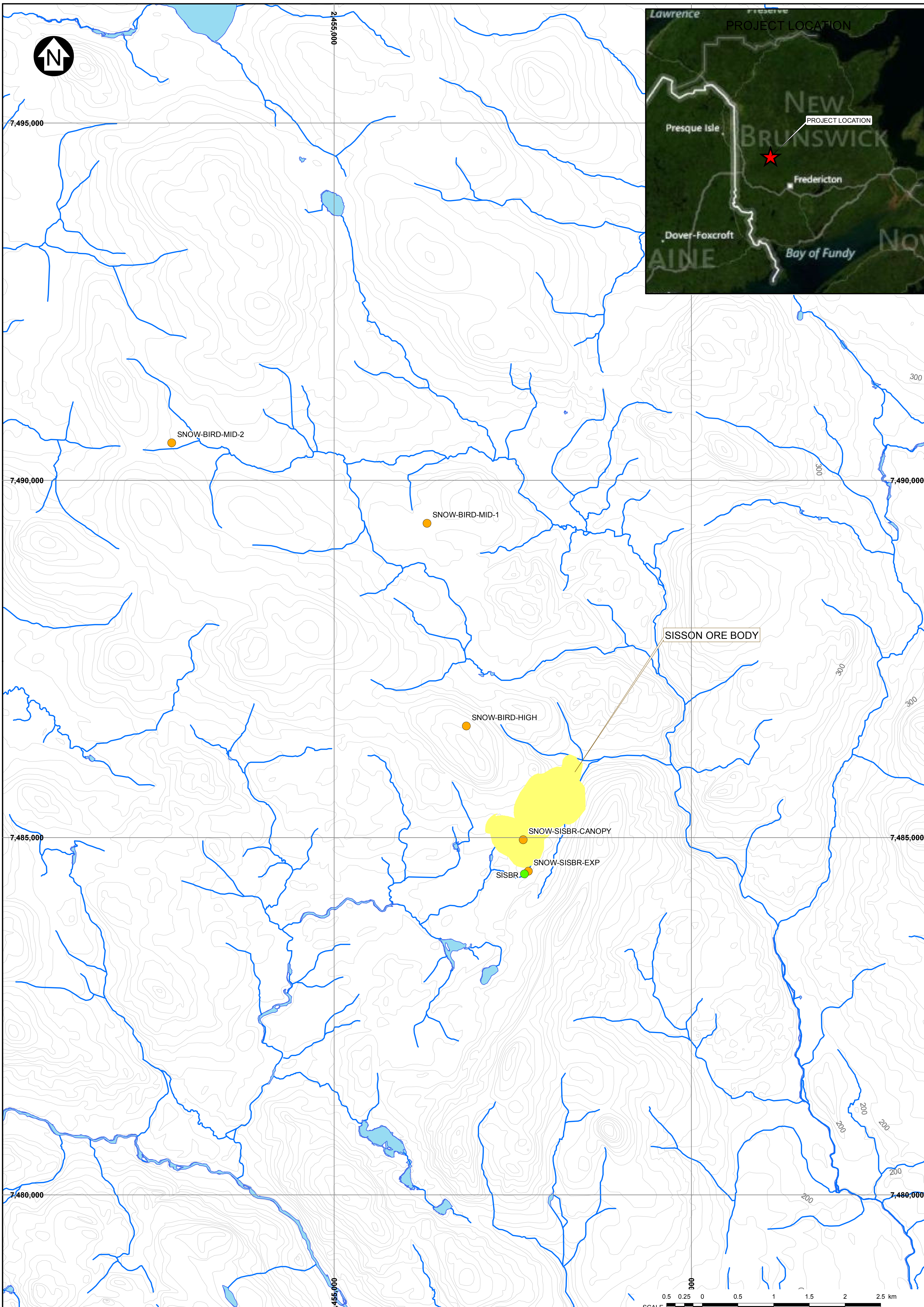
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 2.6

REV 0



LEGEND:

- PROJECT LOCATION
- CLIMATOLOGY STATION
- SNOW SURVEY LOCATION
- CONTOUR (10 M)
- RIVER
- LAKE

NOTES:

1. BASE MAP: CANADA NTS MAPS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:50,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 10 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26JUL'12	ISSUED WITH REPORT	AMD	AMD	CMB	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

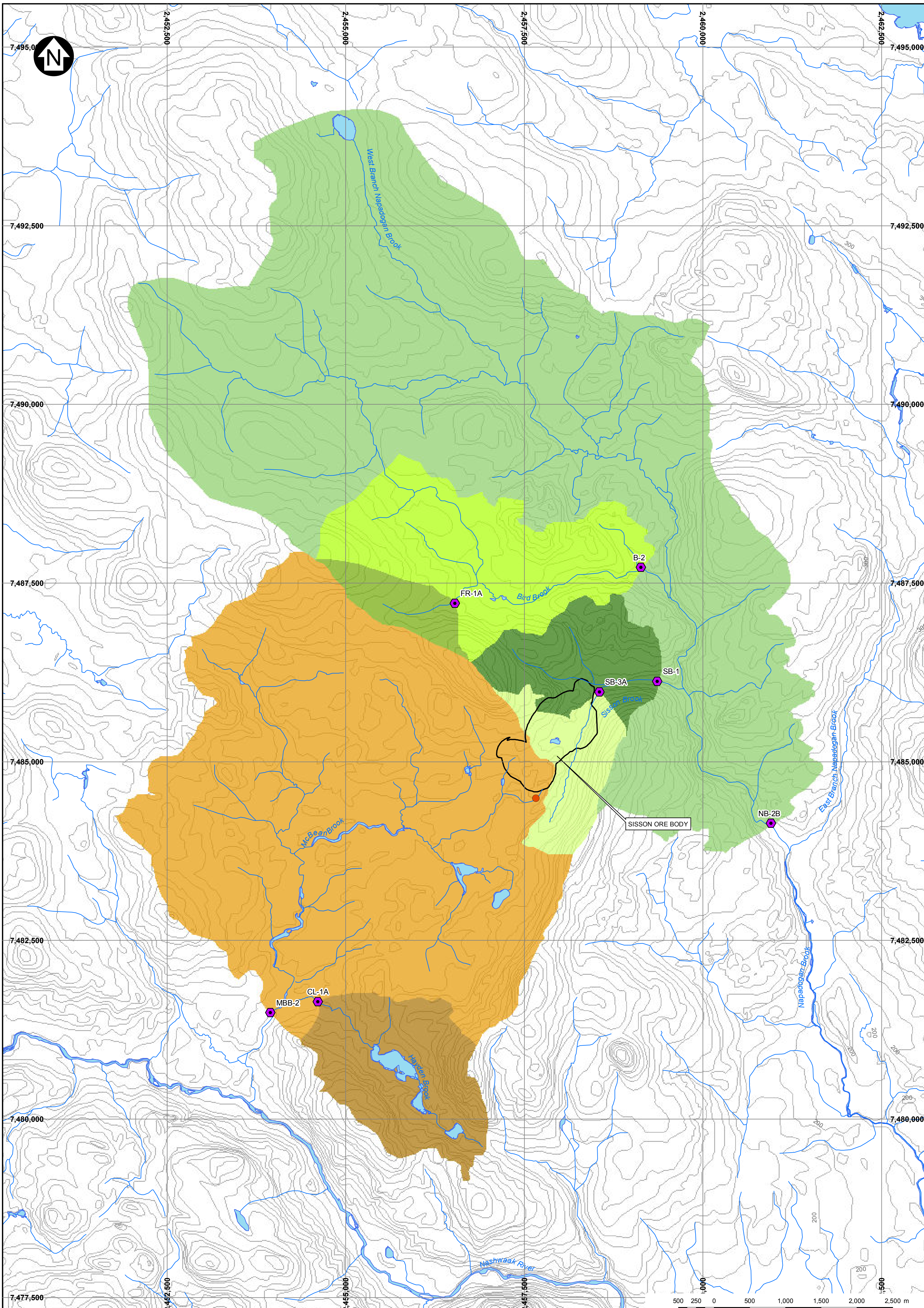
REGIONAL SNOW SURVEY LOCATIONS

Knight Piésold CONSULTING

P/A NO. VA101-447/3 | REF NO. 1

FIGURE 2.7 | REV 0

KP FIGURE SAVED: M:\1\01\00447\03\A\GIS\Figs\B02_RegionalSnowSurveyLocations.mxd; Jul 26, 2012 11:46:26 AM kkrauszova



LEGEND:

- CLIMATOLOGY STATION
- HYDROLOGY STATION
- CONTOUR (10 M)
- RIVER
- LAKE
- PROPOSED PIT

NOTES:

1. BASE MAP: CANADA NTS MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:50,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 10 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26JUL'12	ISSUED WITH REPORT	ALR	AMD	CMB	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

PROJECT HYDROMETRIC STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-447/3	1

FIGURE 3.1 REV 0

KP FIGURE SAVED: M:\1\01\00447\03\A\GIS\Figs\B03_ProjectHydrometricStations.mxd; Jul 26, 2012 11:42:53 AM lkrauszova

LEGEND:

- SISSON ORE BODY
- COMMUNITY
- WSC STATION

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE TOPOGRAPHIC MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	26JUL'12	ISSUED WITH REPORT	ALR	ASM	CMB	JGC

NORTHCLIFF RESOURCES LTD.

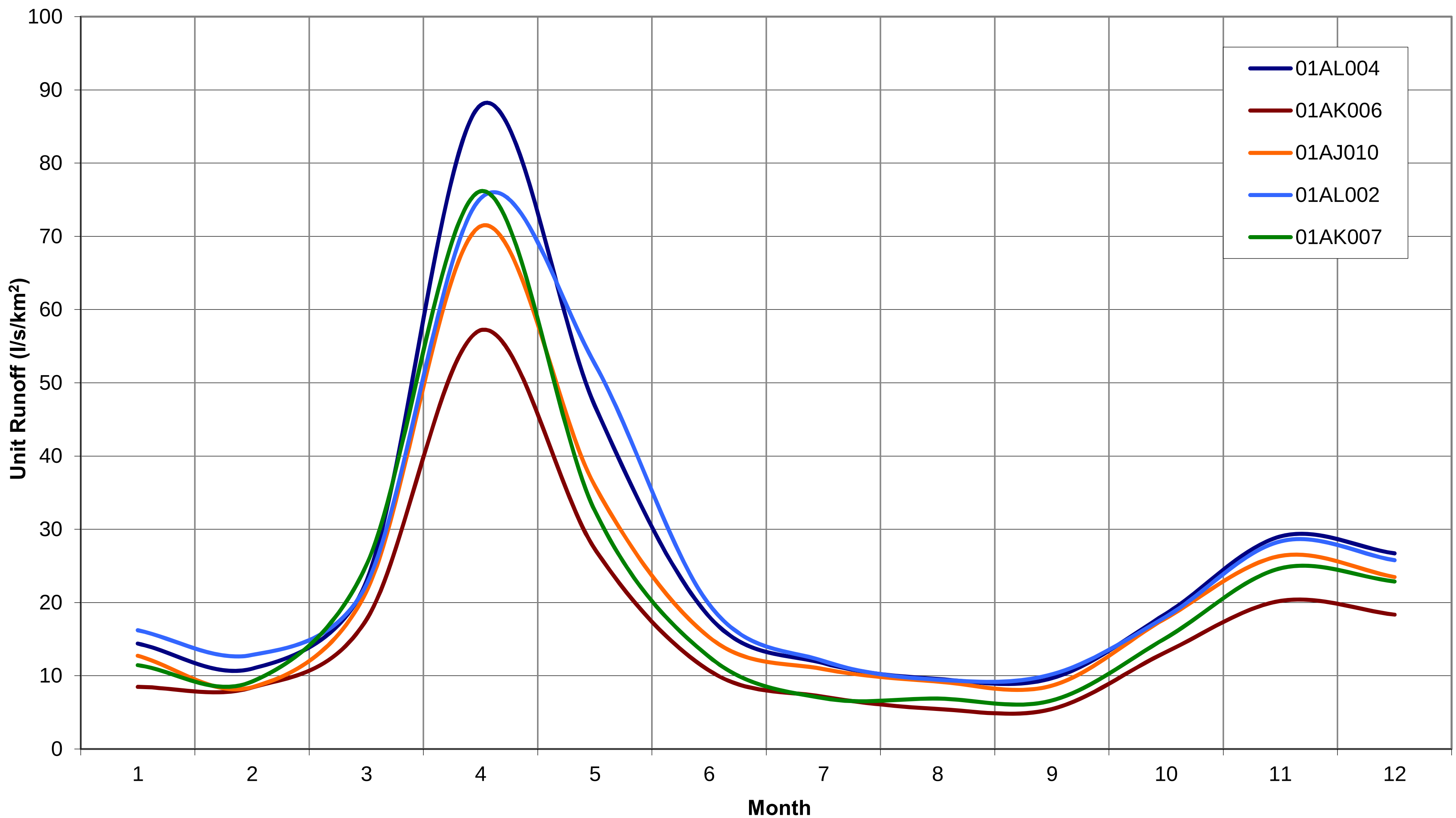
SISSON PROJECT

WATER SURVEY OF CANADA STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-447/3	1

FIGURE 3.2 REV 0



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

WATER SURVEY OF CANADA MEAN MONTHLY HYDROGRAPHS

Knight Piésold CONSULTING

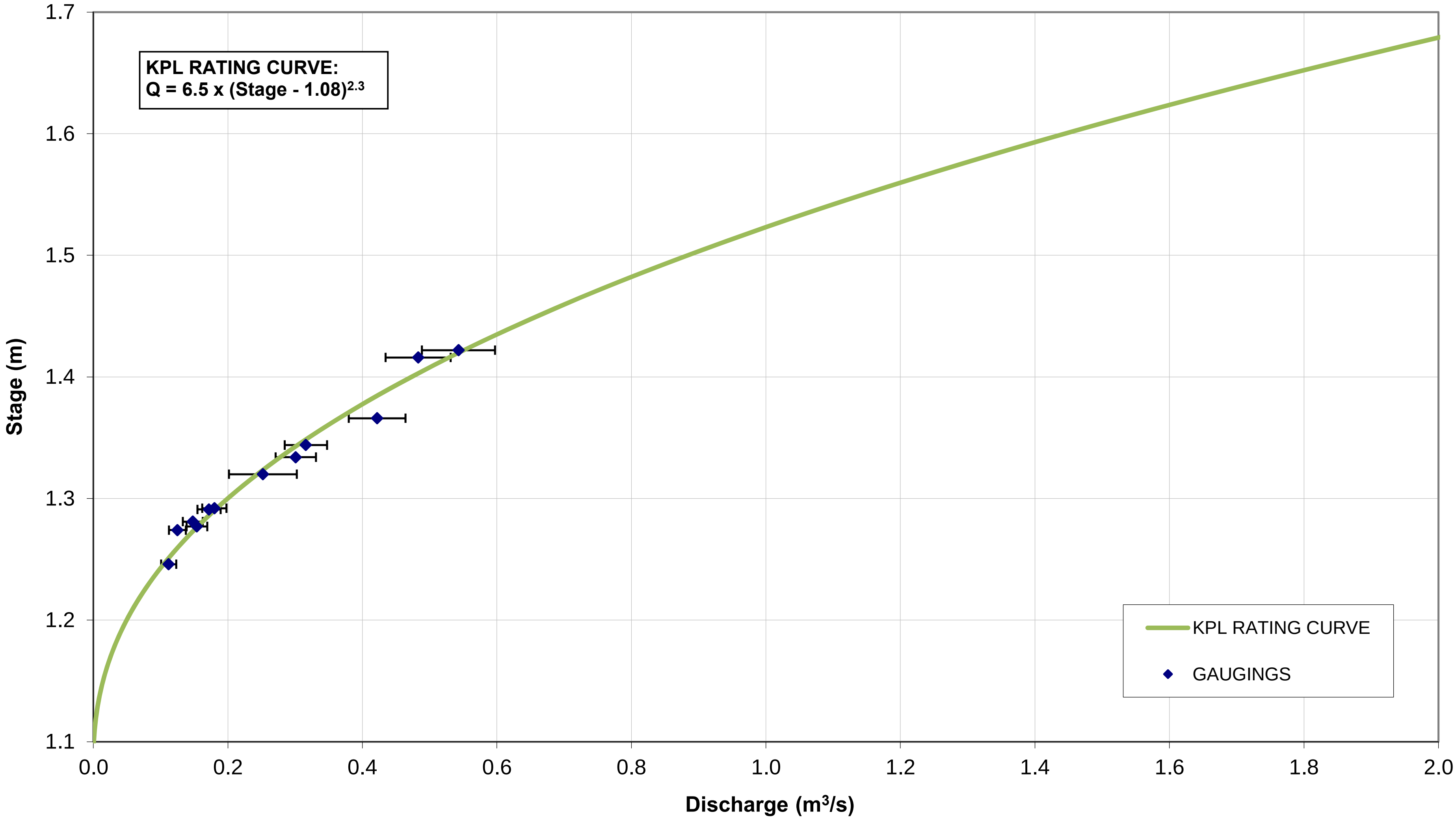
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.3

REV 0

0	28JUN'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	MAY'12	ISSUED WITH REPORT	ALR	KT	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

B-2
RATING CURVE

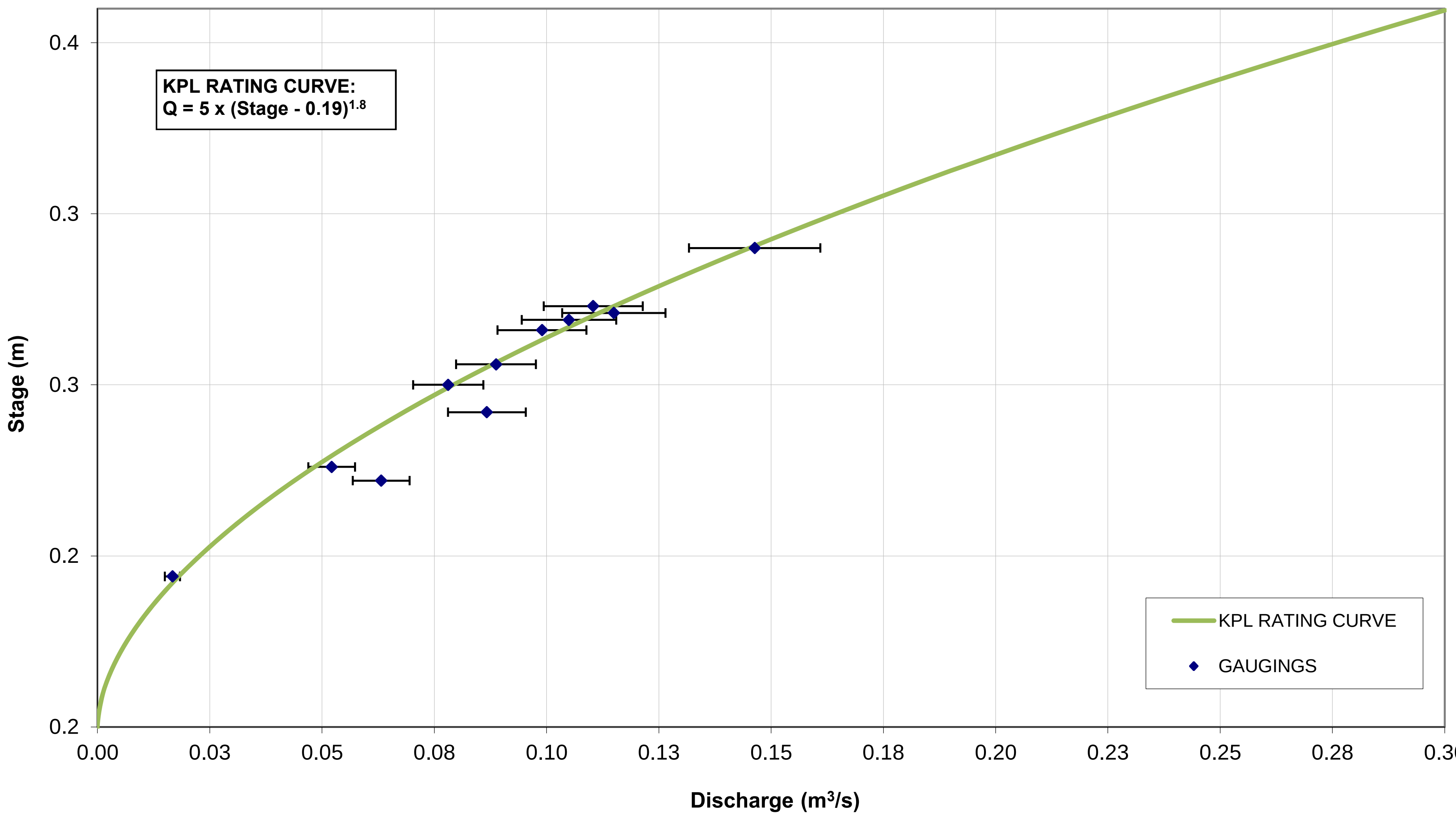
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.4

REV 0



NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

0	MAY'12	ISSUED WITH REPORT	ALR	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

CL-1A
RATING CURVE

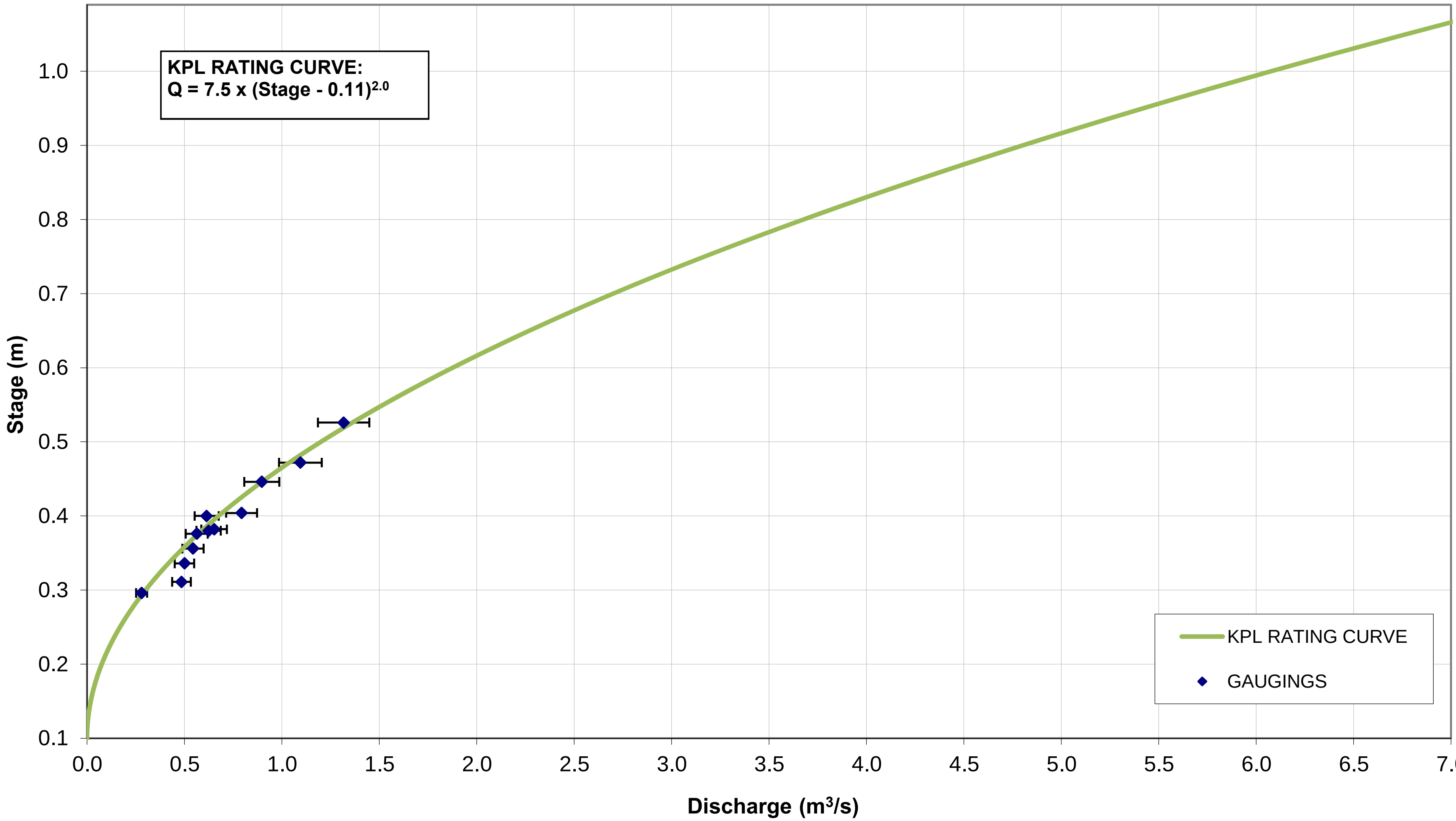
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.5

REV 0



NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

0	MAY'12	ISSUED WITH REPORT	ALR	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

MBB-2
RATING CURVE

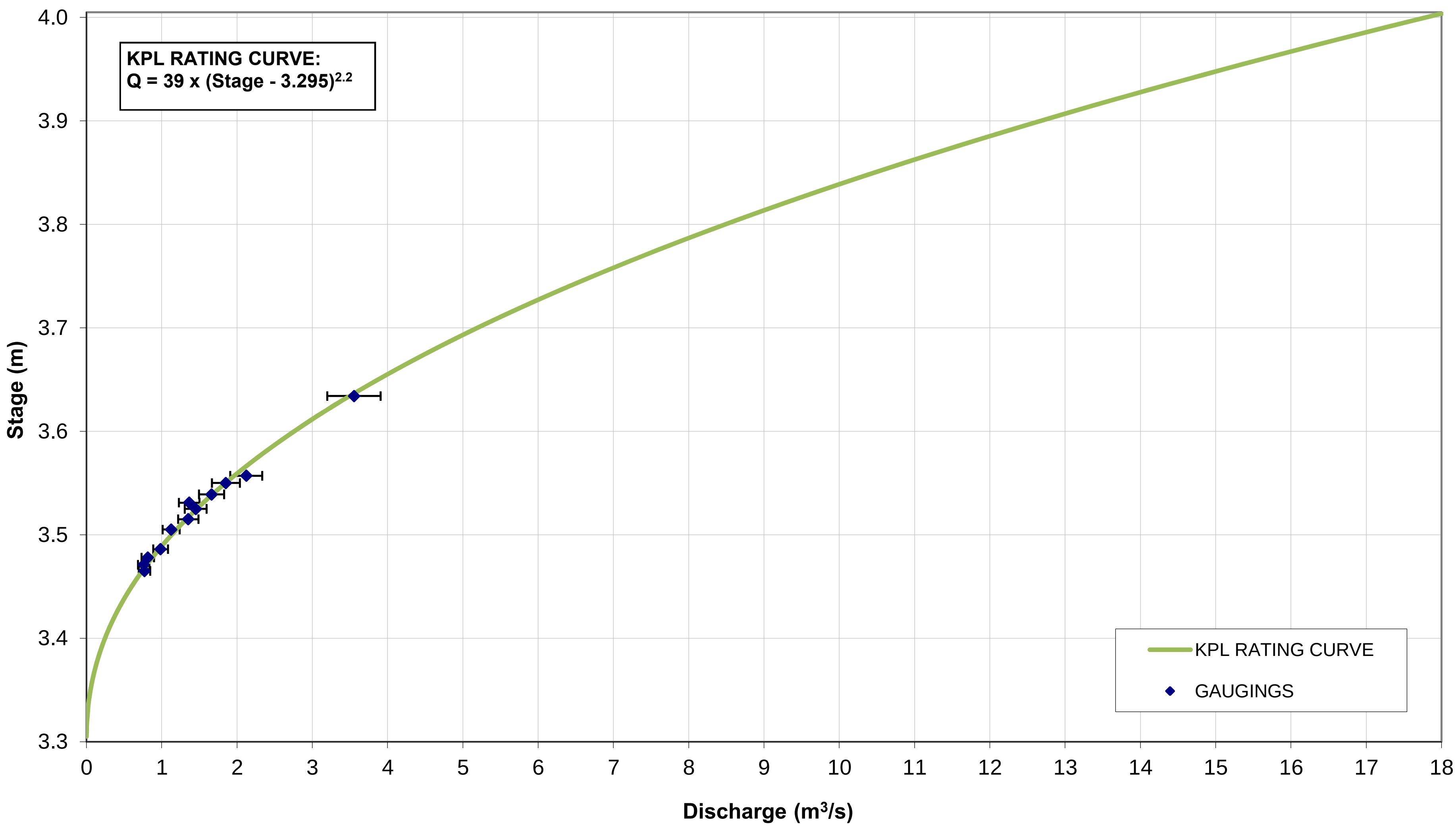
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.6

REV 0



NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	MAY'12	ISSUED WITH REPORT	ALR	KT	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

NB-2B
RATING CURVE

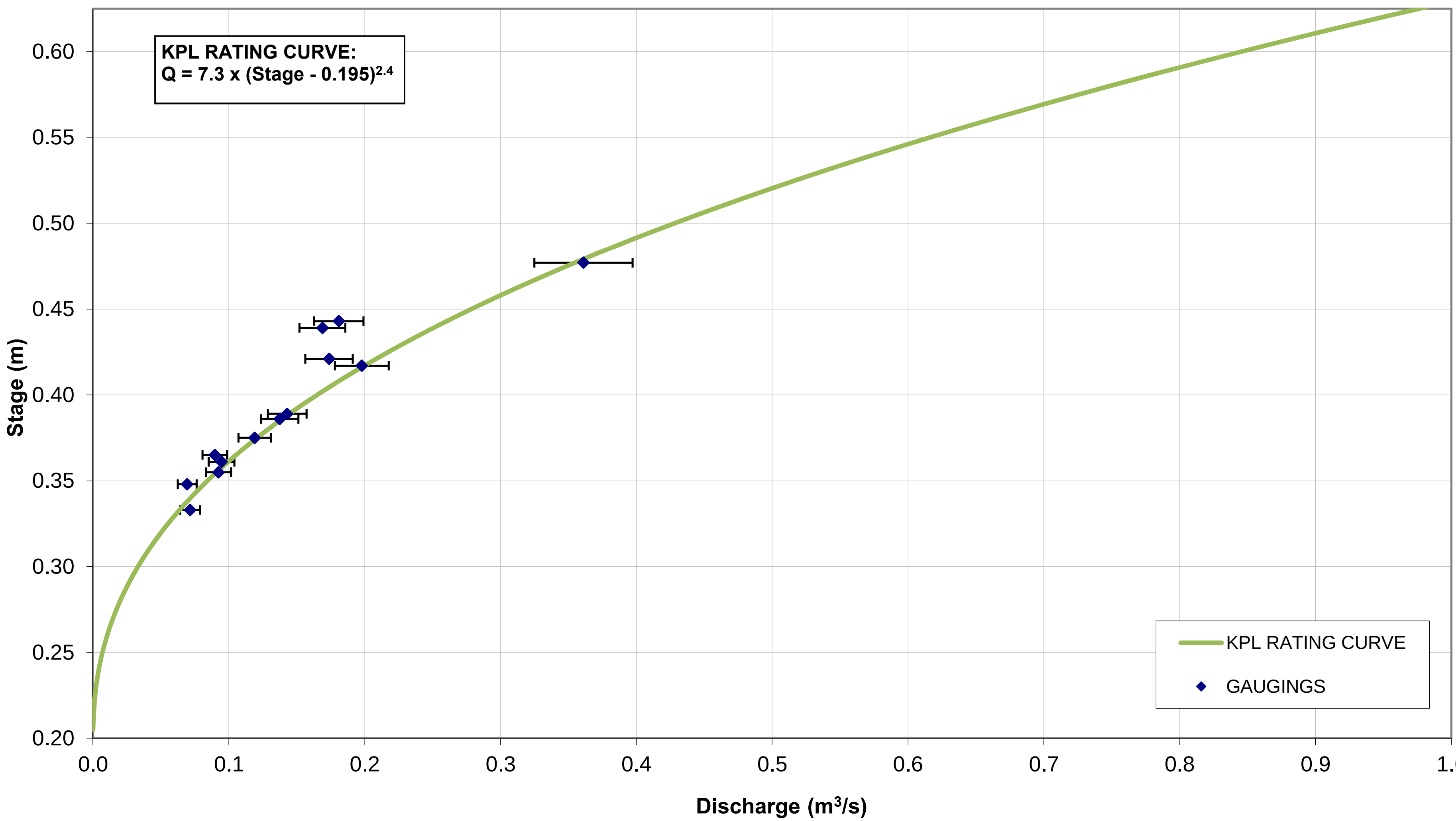
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.7

REV 0



NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

0	MAY'12	ISSUED WITH REPORT	ALR	KT	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SB-1
RATING CURVE

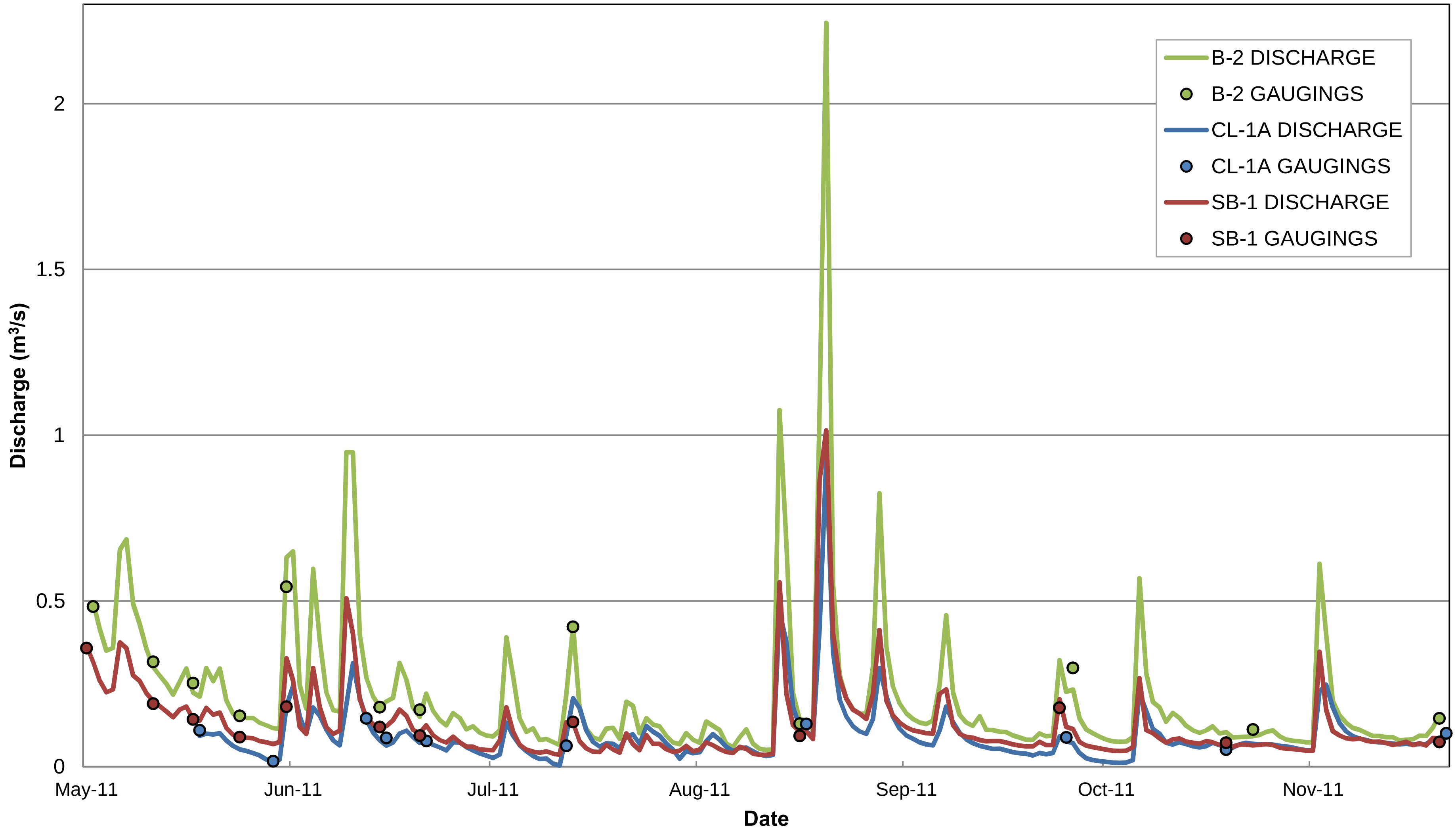
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.8

REV 0



0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

DISCHARGE HYDROGRAPHS B-2, CL-1A AND SB-1

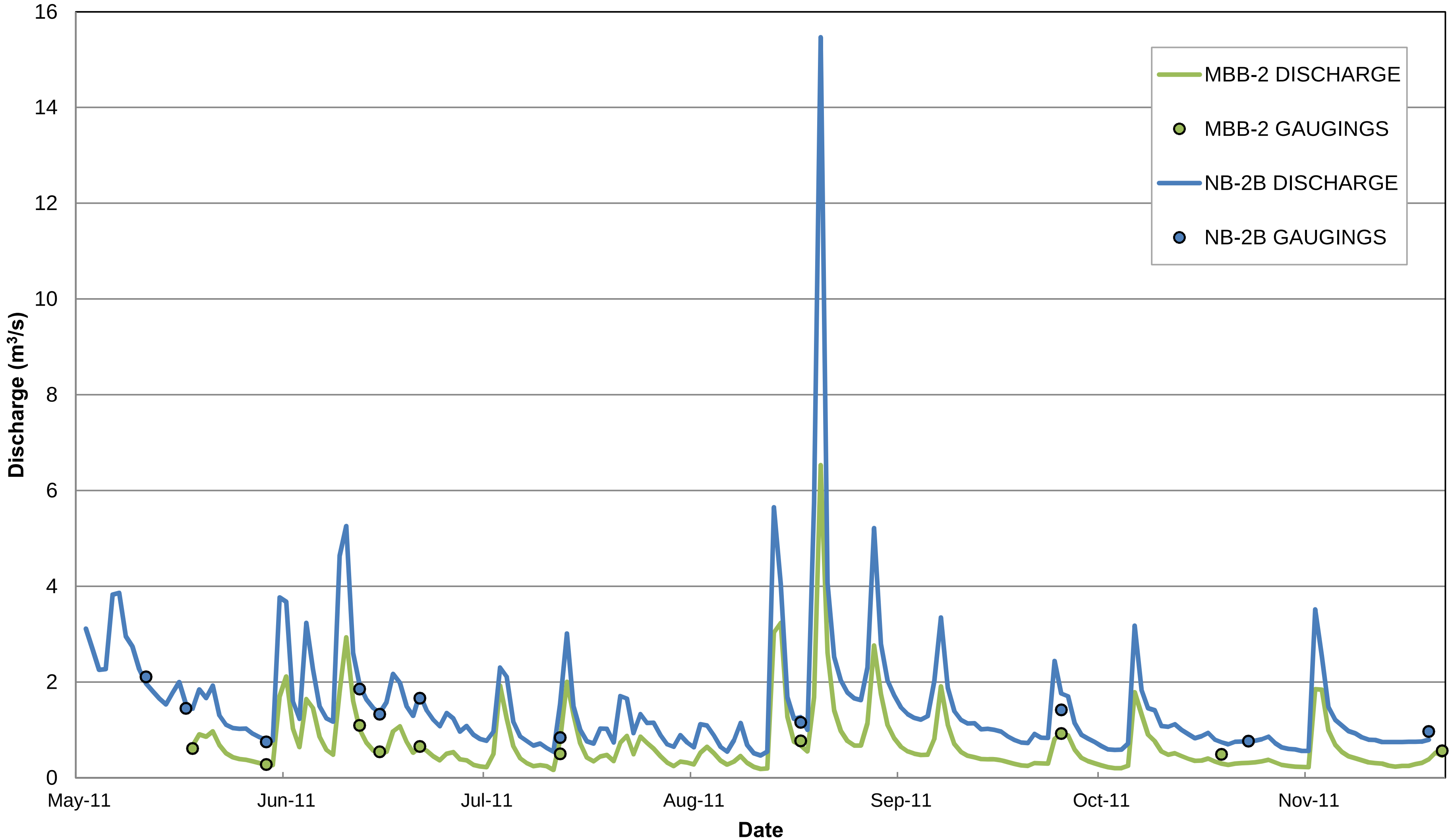
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

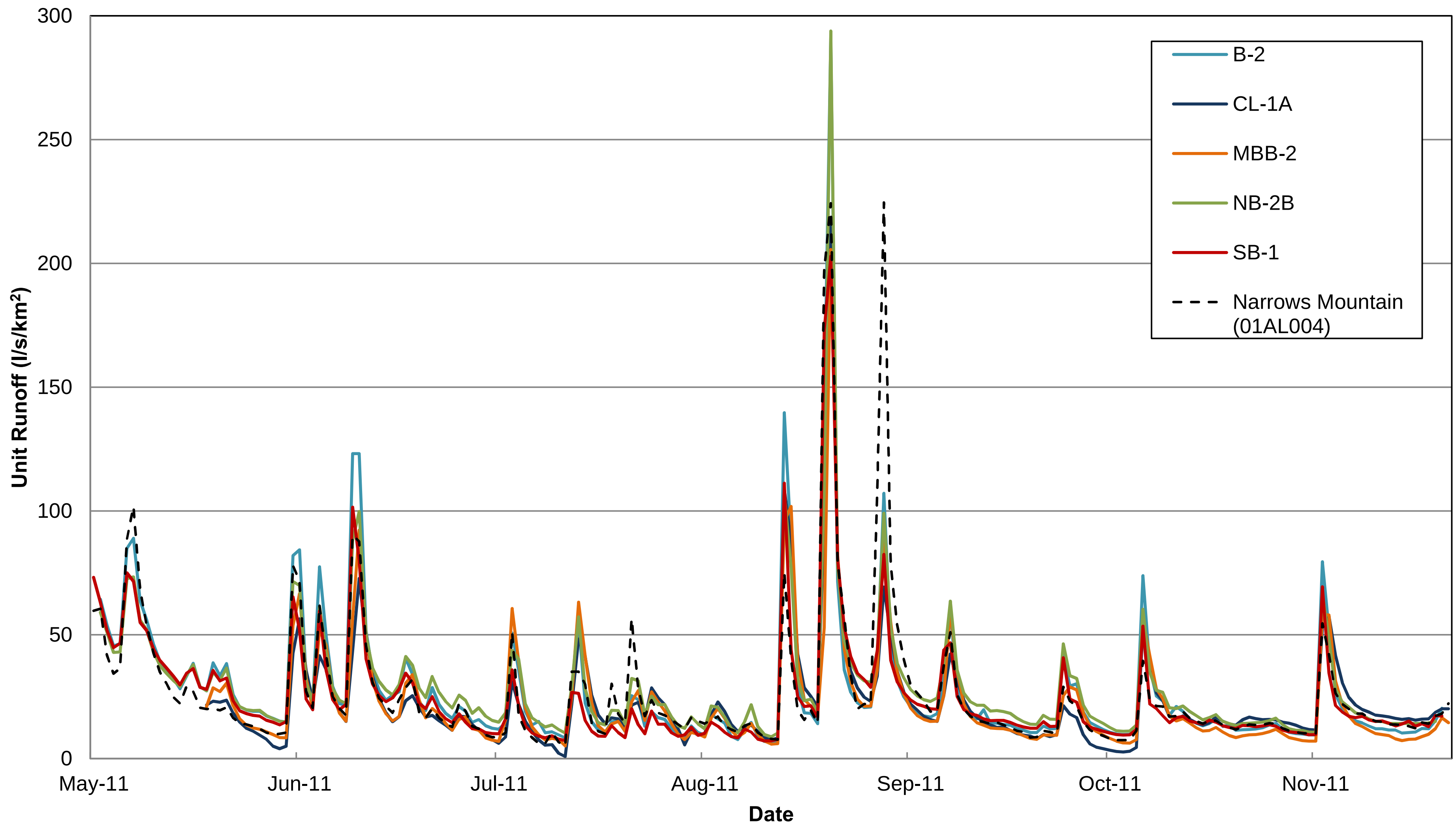
FIGURE 3.9

REV 0



0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D

NORTHCLIFF RESOURCES LTD.		
SISSON PROJECT		
DISCHARGE HYDROGRAPHS NB-2B AND MBB-2		
Knight Piésold CONSULTING	P/A NO. VA101-447/3	REF. NO. 1
	FIGURE 3.10	REV 0



0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

UNIT RUNOFF HYDROGRAPHS

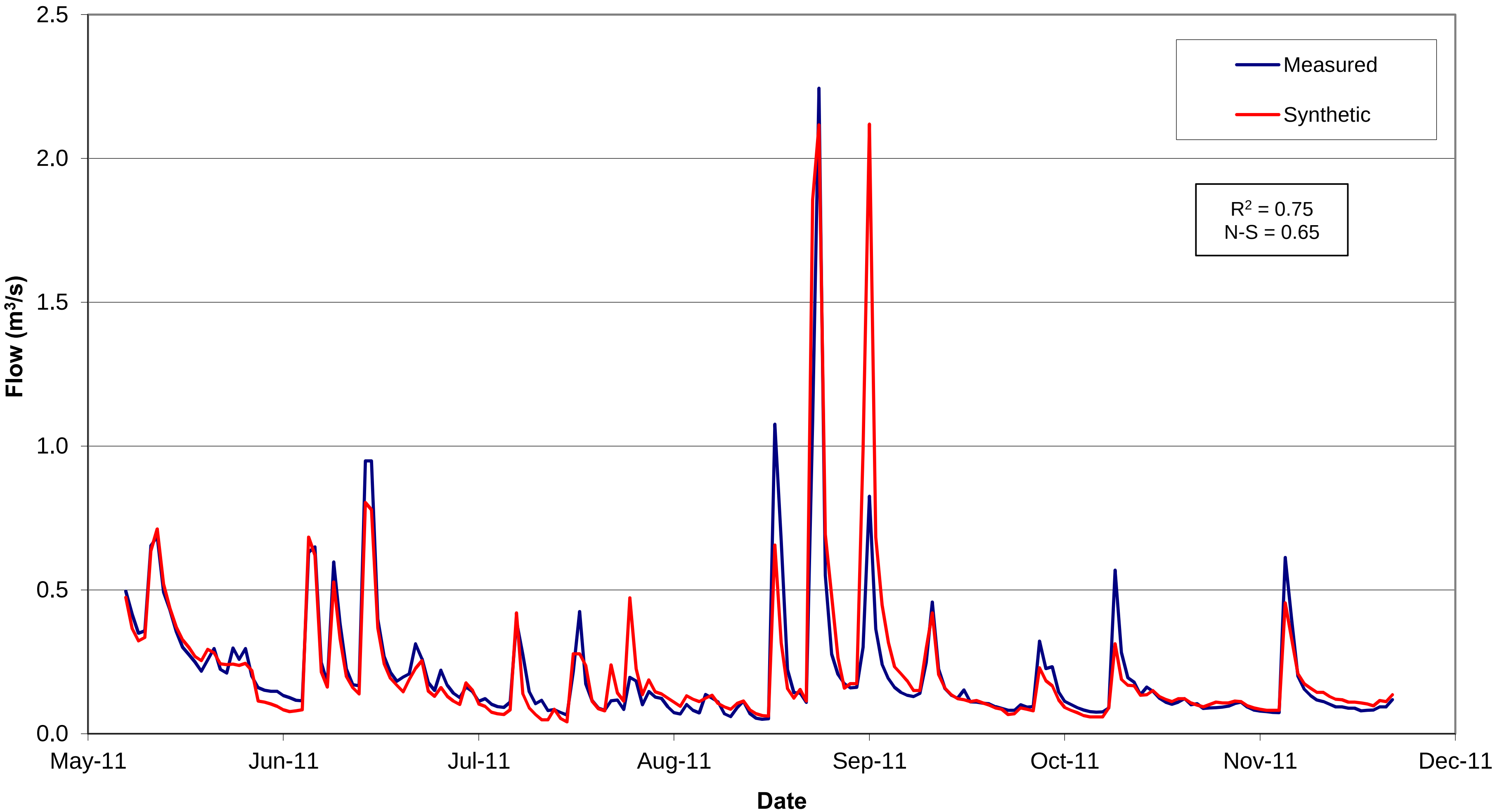
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.11

REV 0



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

B-2 MEASURED AND SYNTHETIC STREAM FLOW SERIES

Knight Piésold CONSULTING

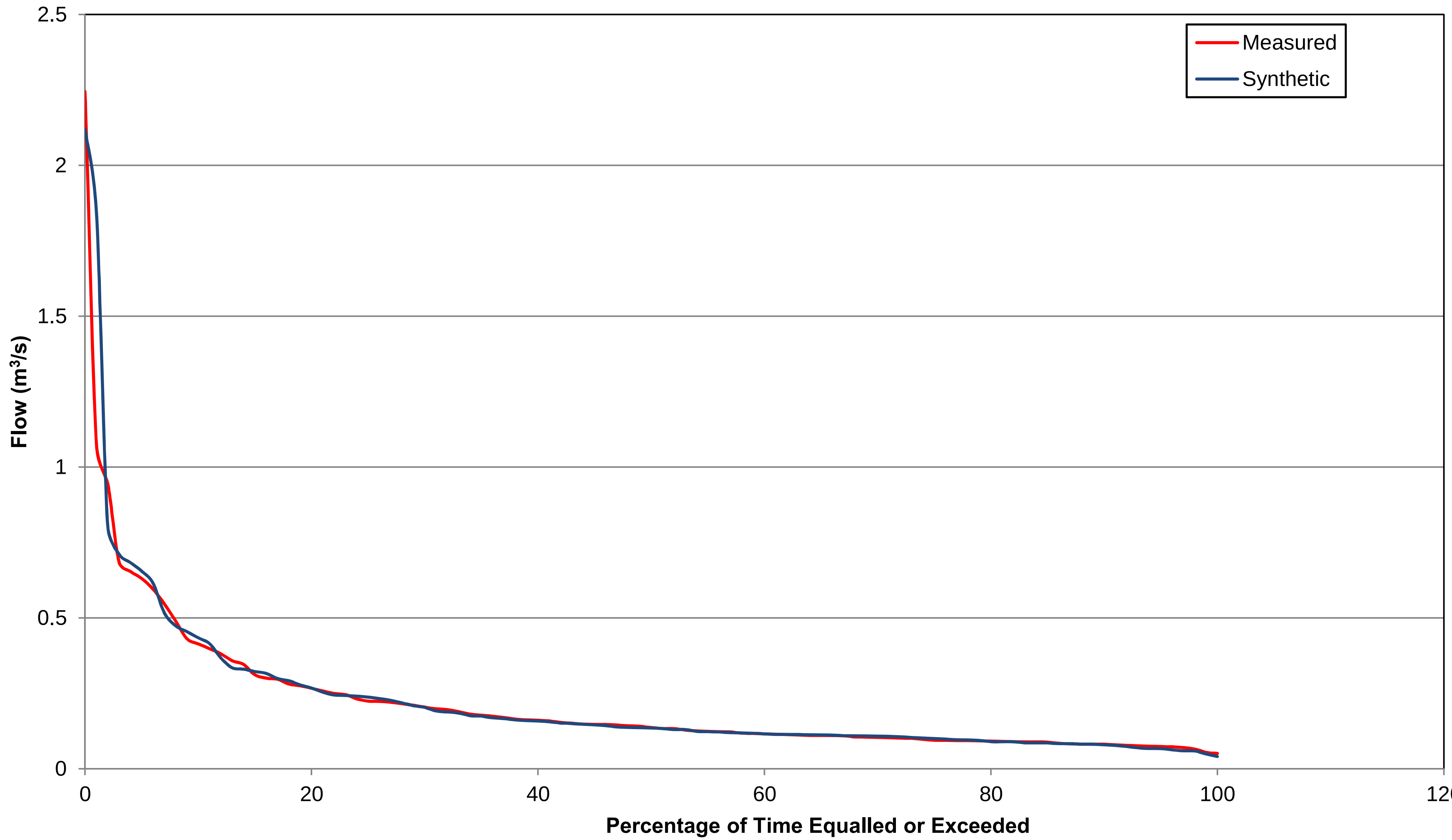
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.12

REV 0

0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

B-2 FLOW DURATION CURVE

Knight Piésold CONSULTING

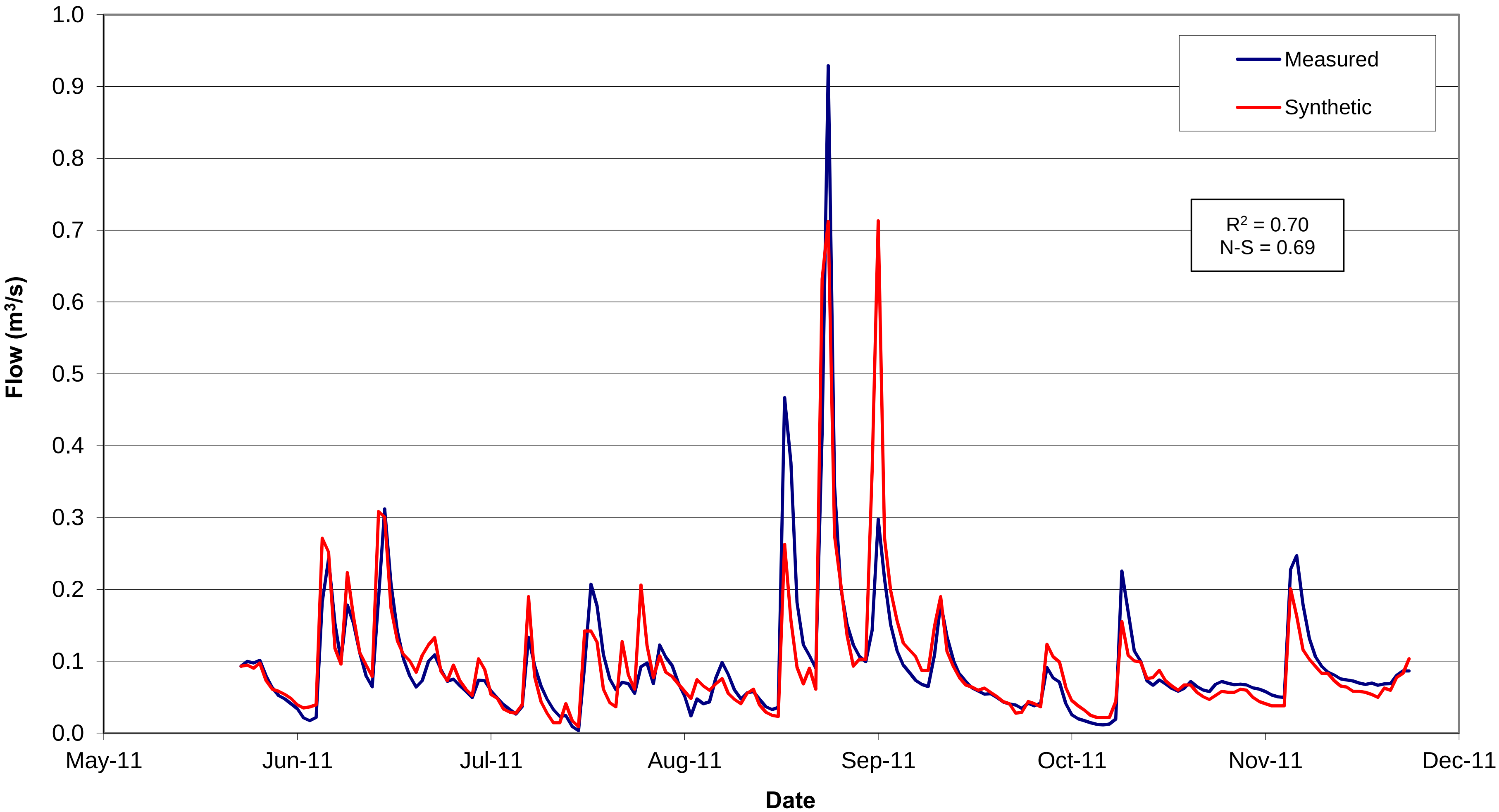
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.13

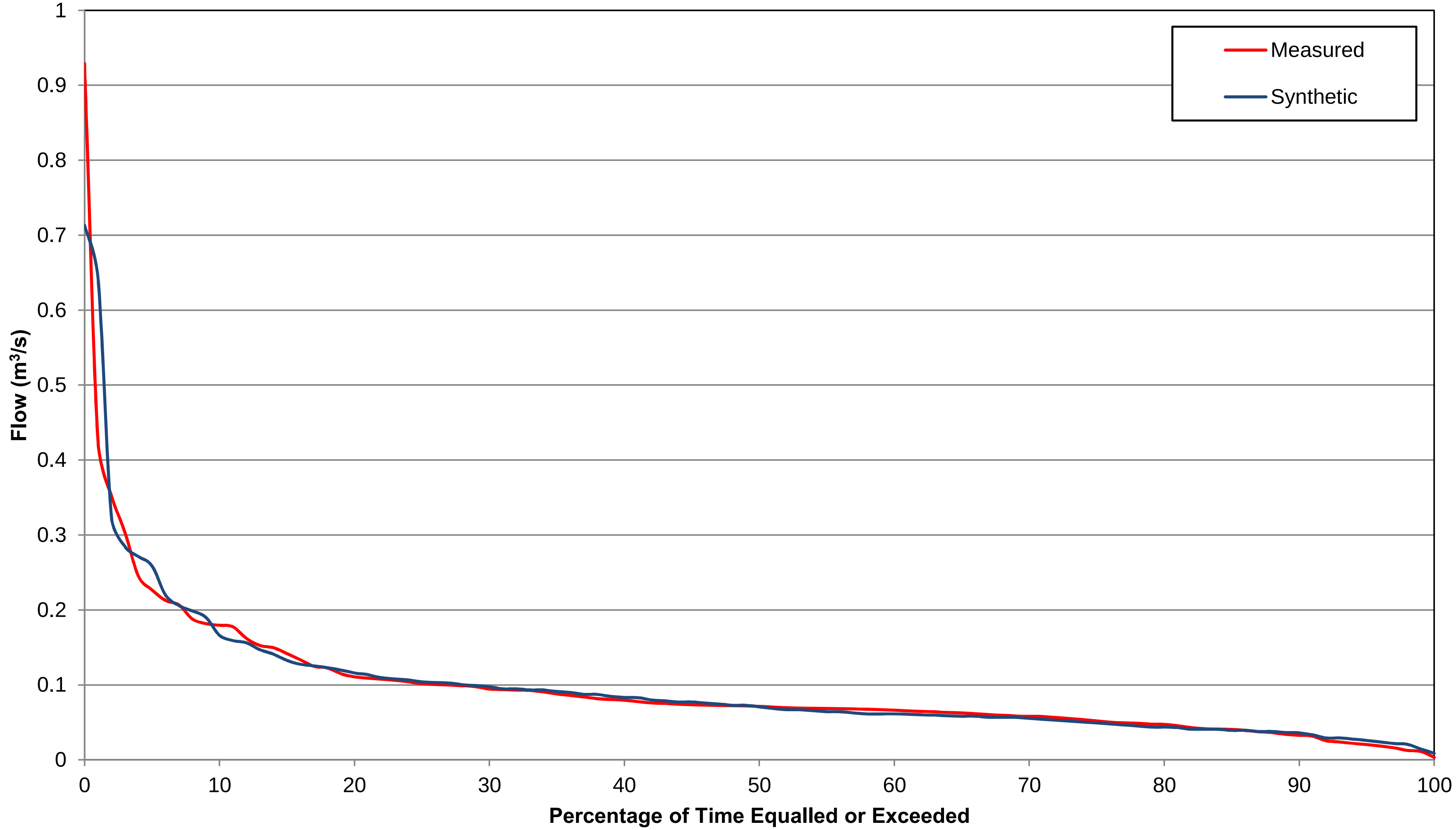
REV 0

0	MAY'12	ISSUED WITH REPORT	ALR	ALR	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD.	
SISSON PROJECT	
CL-1A MEASURED AND SYNTHETIC STREAM FLOW SERIES	
Knight Piésold CONSULTING	P/A NO. VA101-447/3 · REF. NO. 1
	FIGURE 3.14 · REV 0

0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

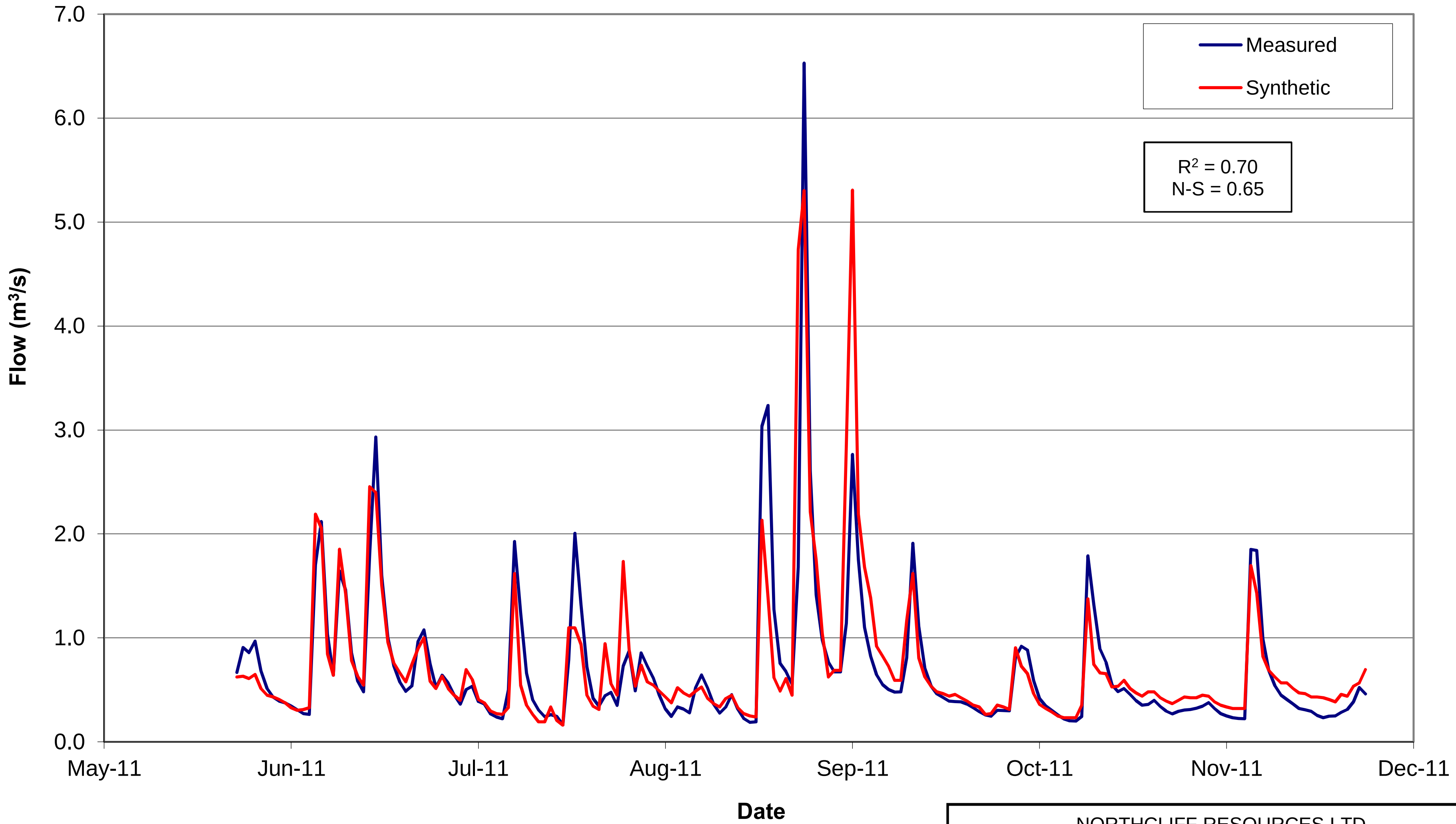
CL-1A FLOW DURATION CURVE

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-447/3	1

FIGURE 3.15 REV 0

0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

MBB-2 MEASURED AND SYNTHETIC STREAM FLOW SERIES

Knight Piésold CONSULTING

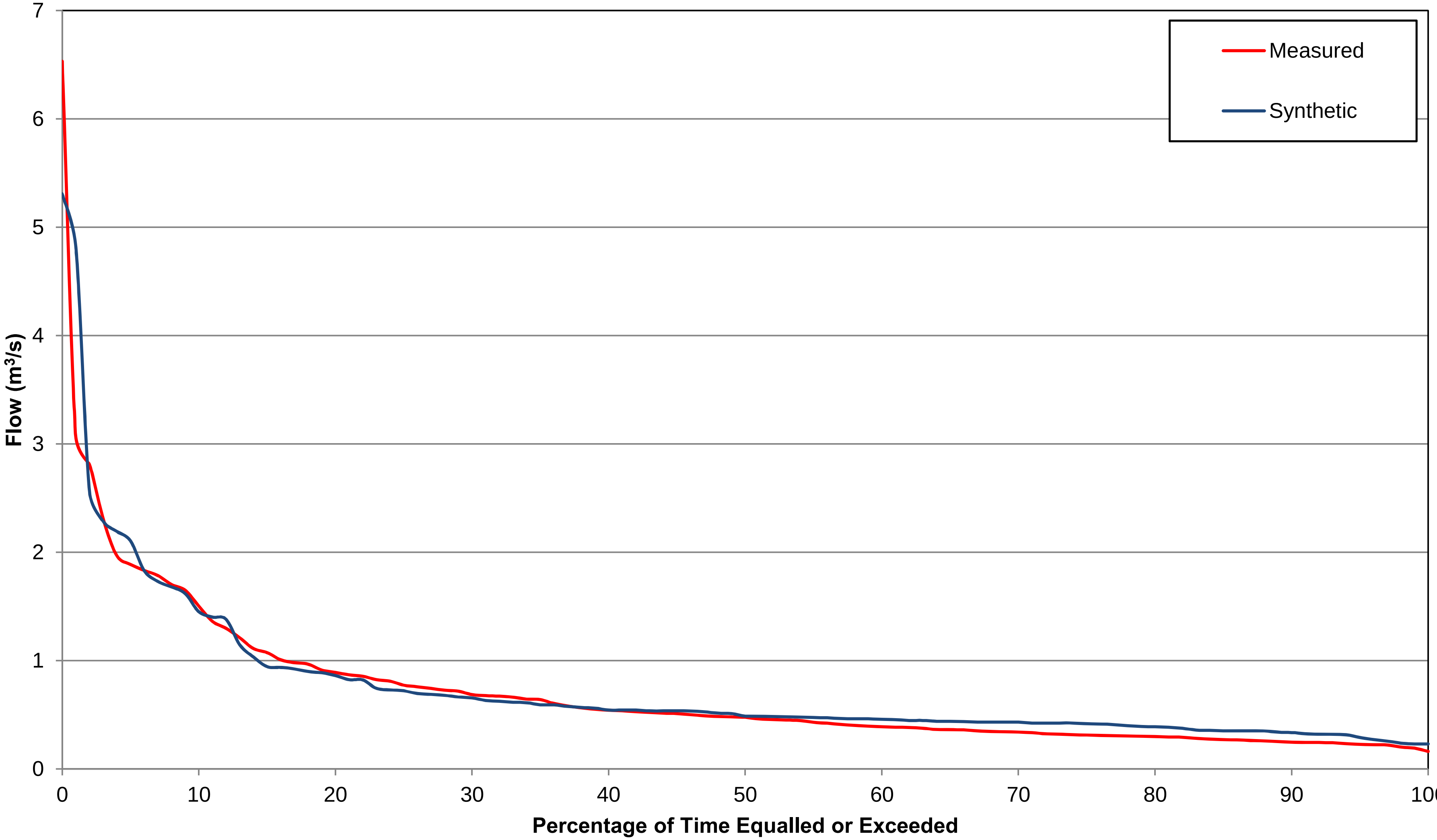
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.16

REV 0

0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

MBB-2 FLOW DURATION CURVE

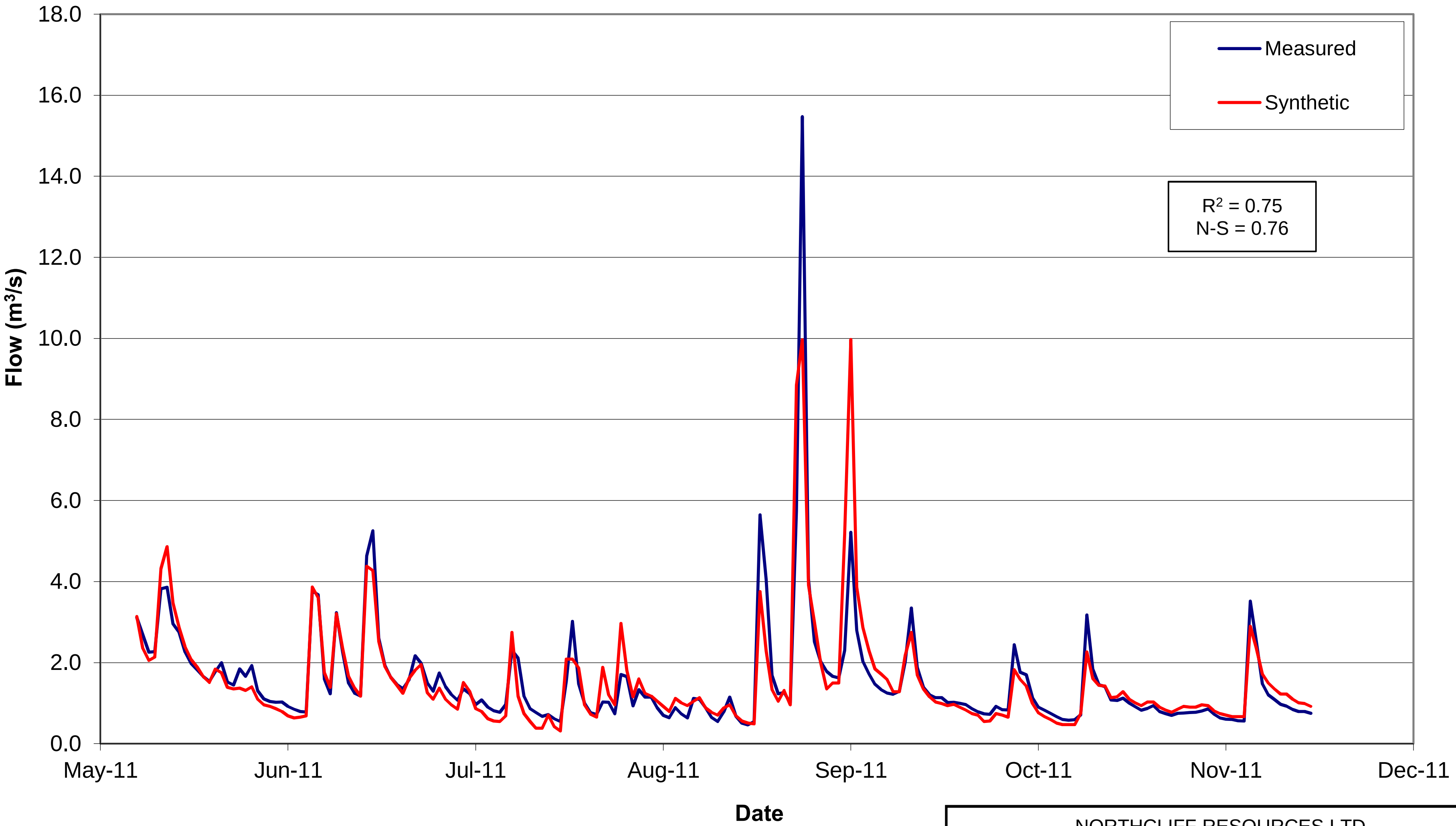
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

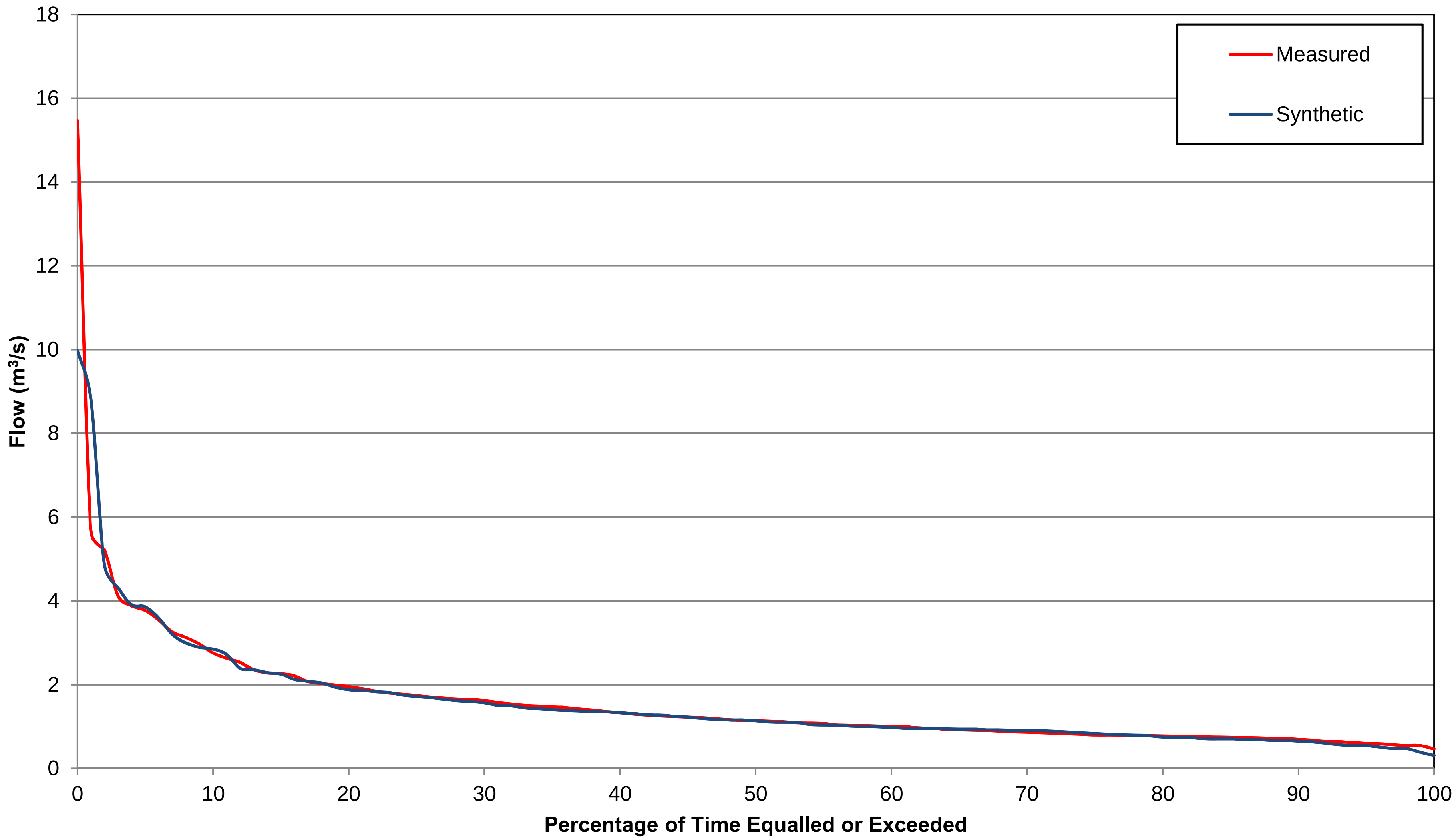
FIGURE 3.17

REV 0



NORTHCLIFF RESOURCES LTD.	
SISSON PROJECT	
NB-2B MEASURED AND SYNTHETIC STREAM FLOW SERIES	
Knight Piésold CONSULTING	P/A NO. VA101-447/3 — REF. NO. 1
	FIGURE 3.18 — REV 0

0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

NB-2B FLOW DURATION CURVE

Knight Piésold CONSULTING

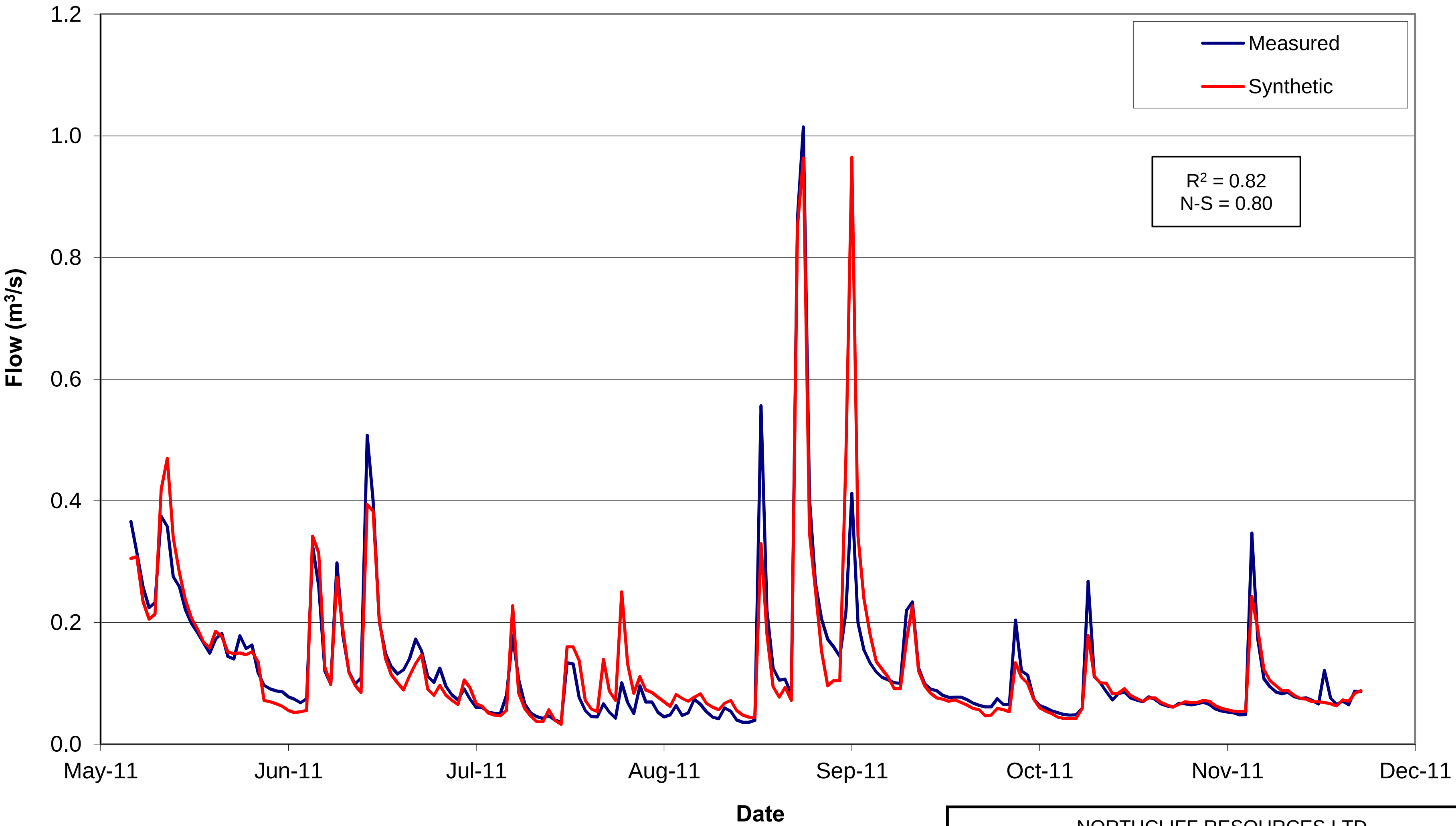
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.19

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC



0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SB-1 MEASURED AND SYNTHETIC STREAM FLOW SERIES

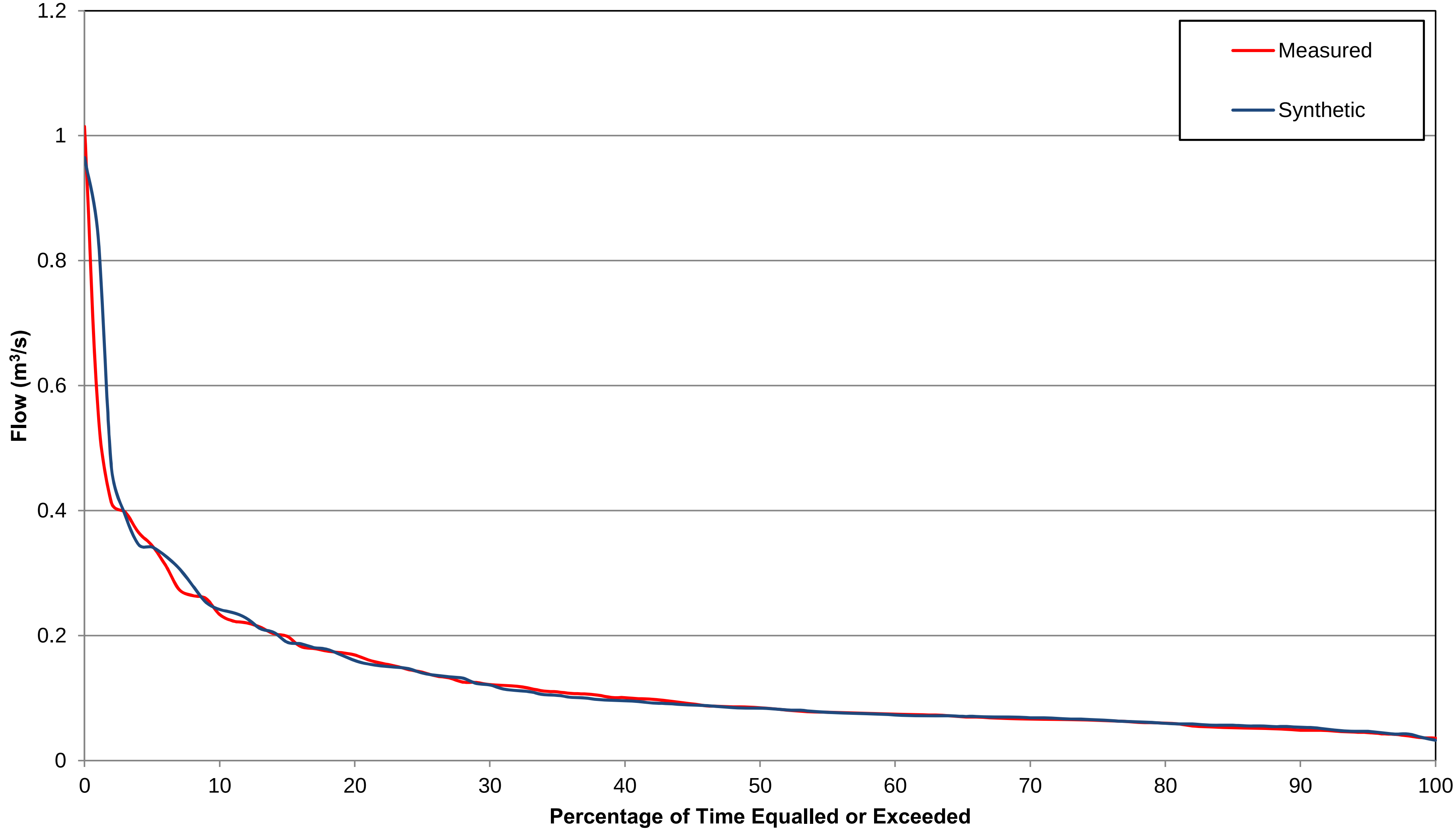
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.20

REV 0



0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SB-1 FLOW DURATION CURVE

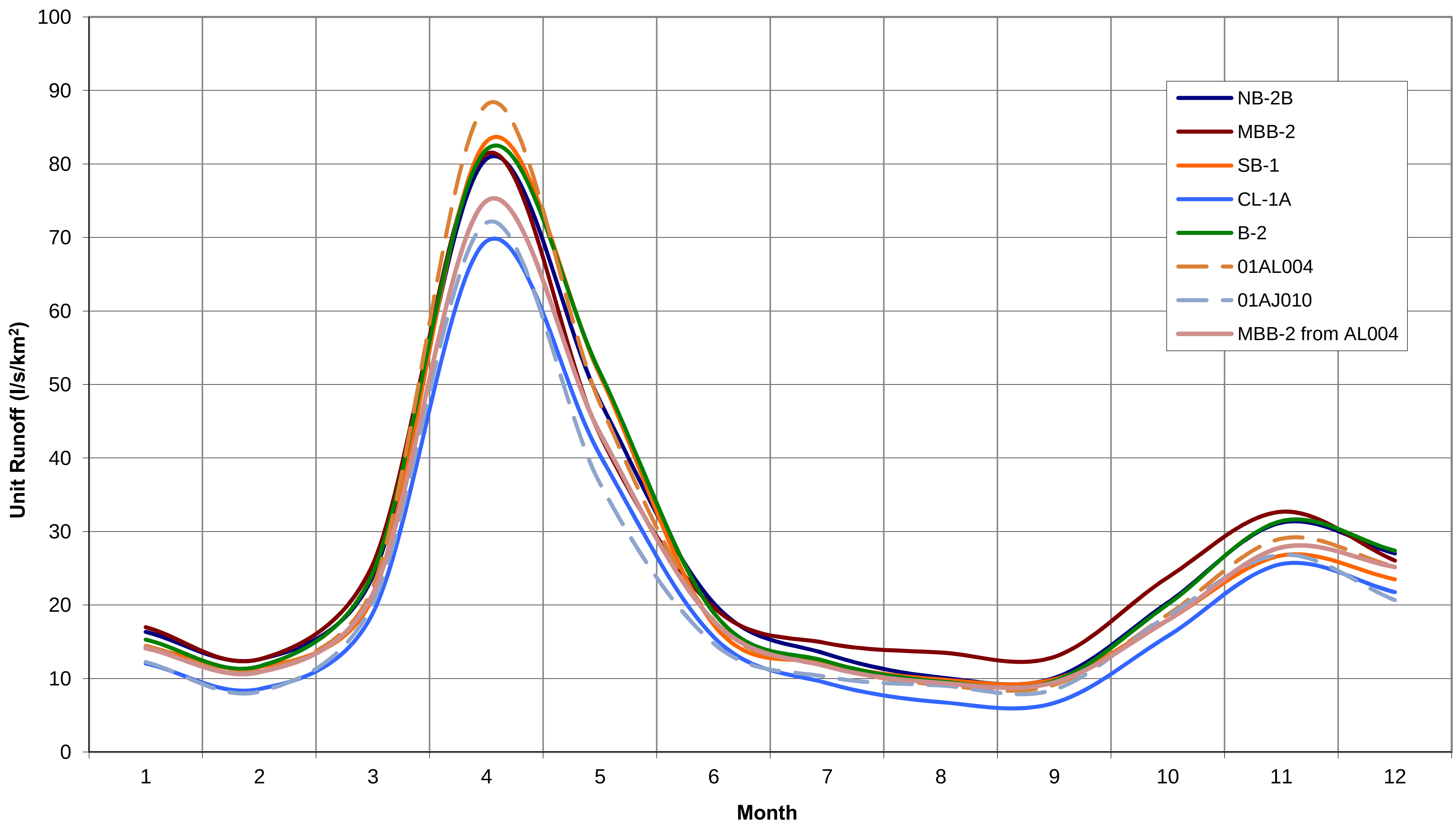
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.21

REV 0



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

SYNTHETIC TIME SERIES DATA FOR ALL STATIONS

Knight Piésold CONSULTING

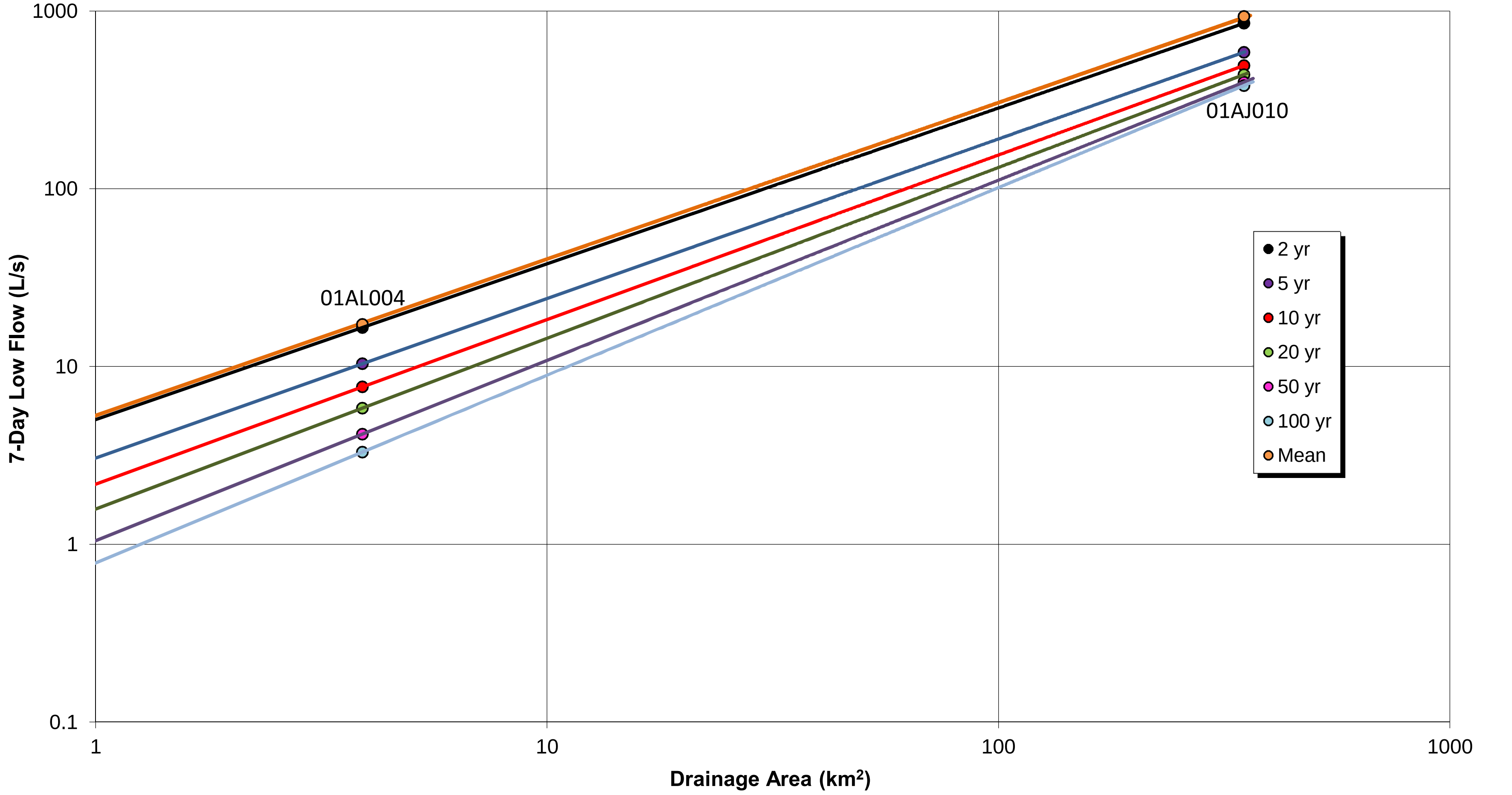
P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.22

REV 0

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	MAY'12	ISSUED WITH REPORT	ALR	CMB	JGC



NOTES:
1. THIS FIGURE CAN BE USED TO ESTIMATE 7-DAY WINTER LOW FLOWS FOR BASINS IN THE NAPADOGAN BROOK WATERSHED.

0	23JUL'12	ISSUED WITH REPORT	JM	NS	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

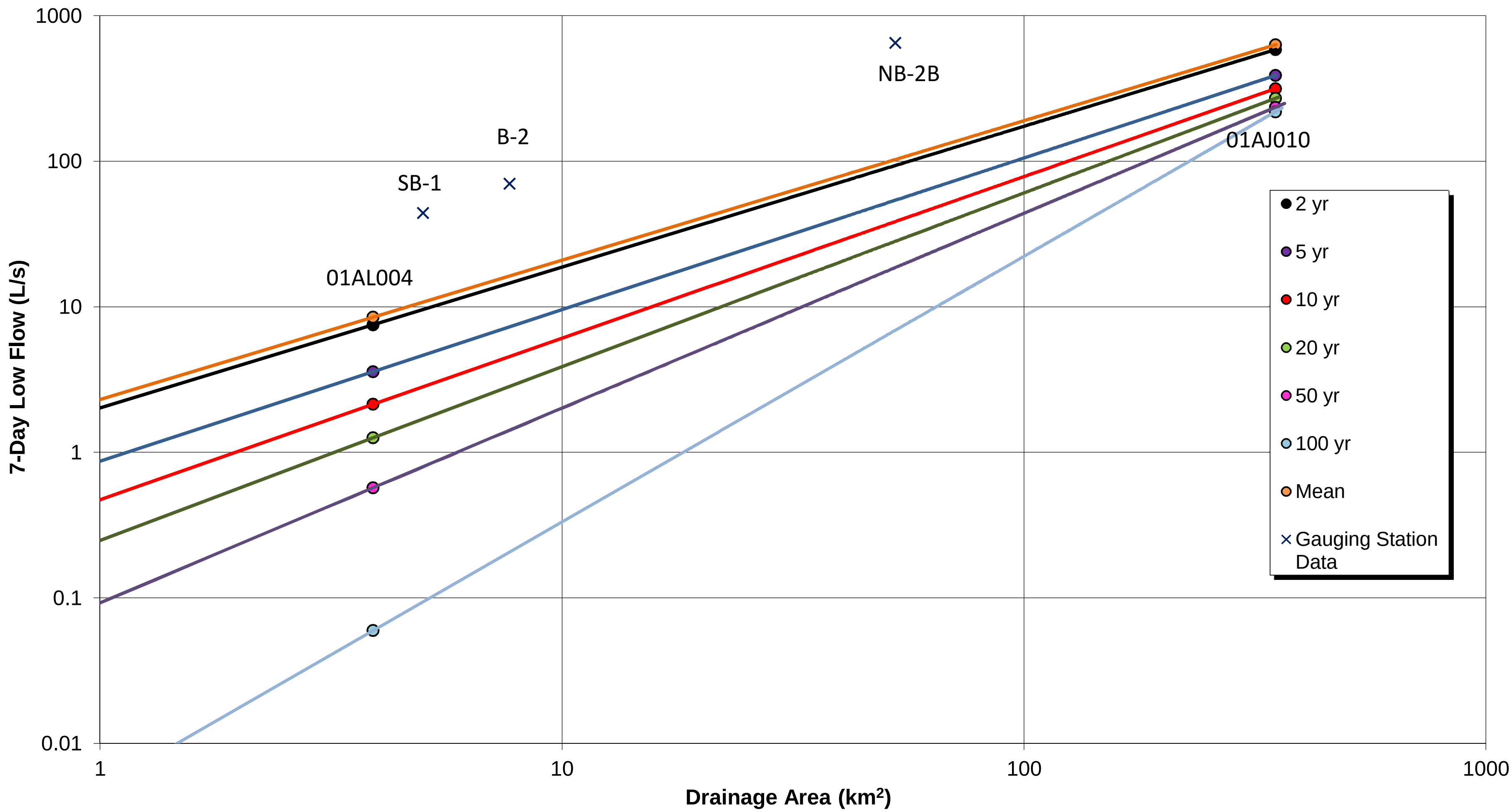
SISSON PROJECT

REGIONAL RETURN PERIOD
7-DAY WINTER LOW FLOWS
NAPADOGAN BROOK WATERSHED

Knight Piésold CONSULTING

P/A NO. VA101-447/3 | REF. NO. 1

FIGURE 3.23 | REV 0



NOTES:
1. THIS FIGURE CAN BE USED TO ESTIMATE 7-DAY SUMMER LOW FLOWS FOR BASINS IN THE NAPADOGAN BROOK WATERSHED.
2. MINUMUM MEASURED 7-DAY LOW FLOWS FOR PROJECT GAUGING STATIONS INCLUDED FOR COMPARISON.

1	23JUL'12	ISSUED WITH REPORT	JM	NS	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

REGIONAL RETURN PERIOD
7-DAY SUMMER LOW FLOWS
NAPADOGAN BROOK WATERSHED

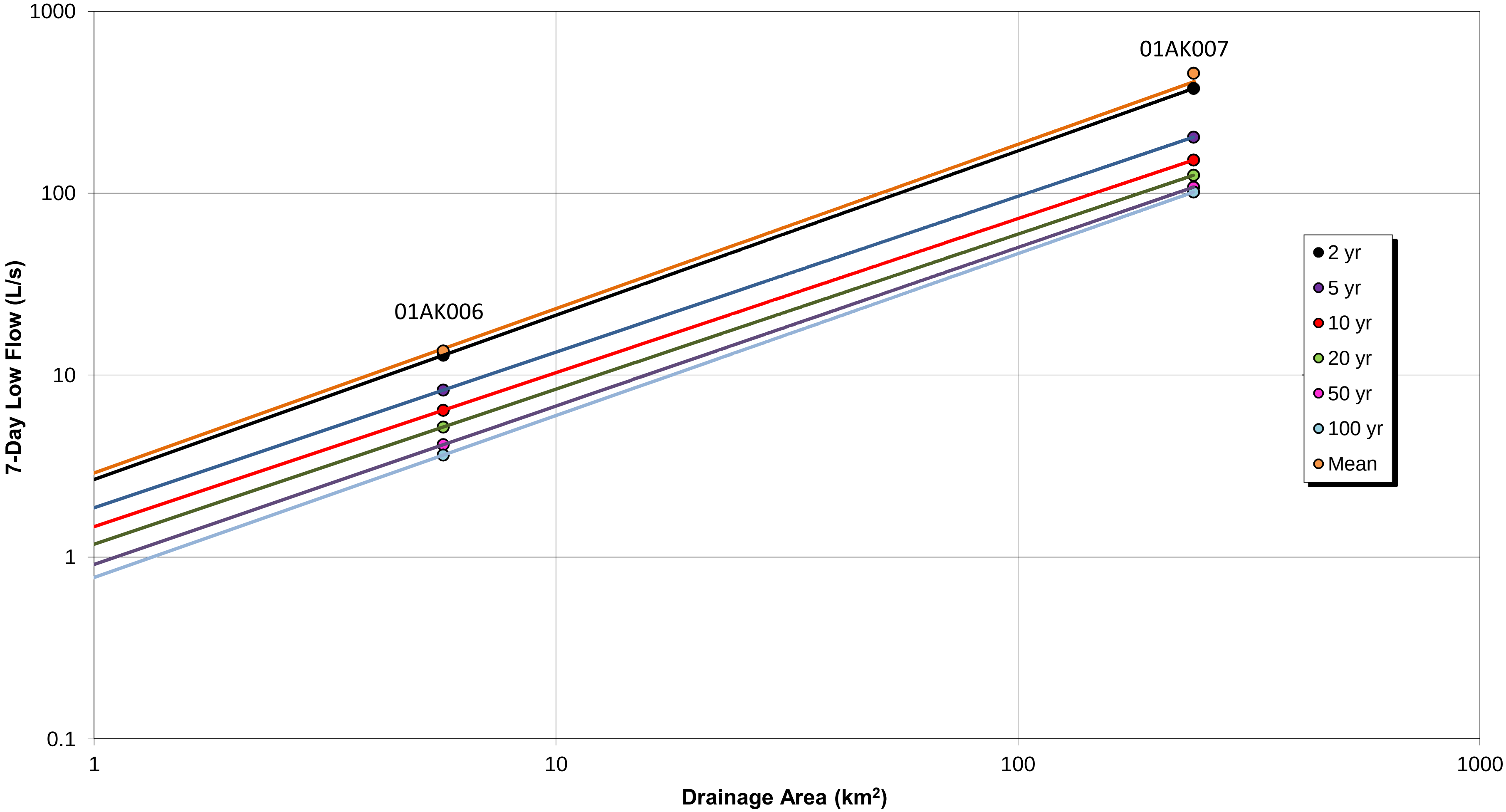
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.24

REV 0



NOTES:
1. THIS FIGURE CAN BE USED TO ESTIMATE 7-DAY WINTER LOW FLOWS FOR BASINS IN THE MCBEAN BROOK WATERSHED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D
0	23JUL'12	ISSUED WITH REPORT	JM	NS	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

REGIONAL RETURN PERIOD 7-DAY WINTER LOW FLOWS MCBEAN BROOK WATERSHED

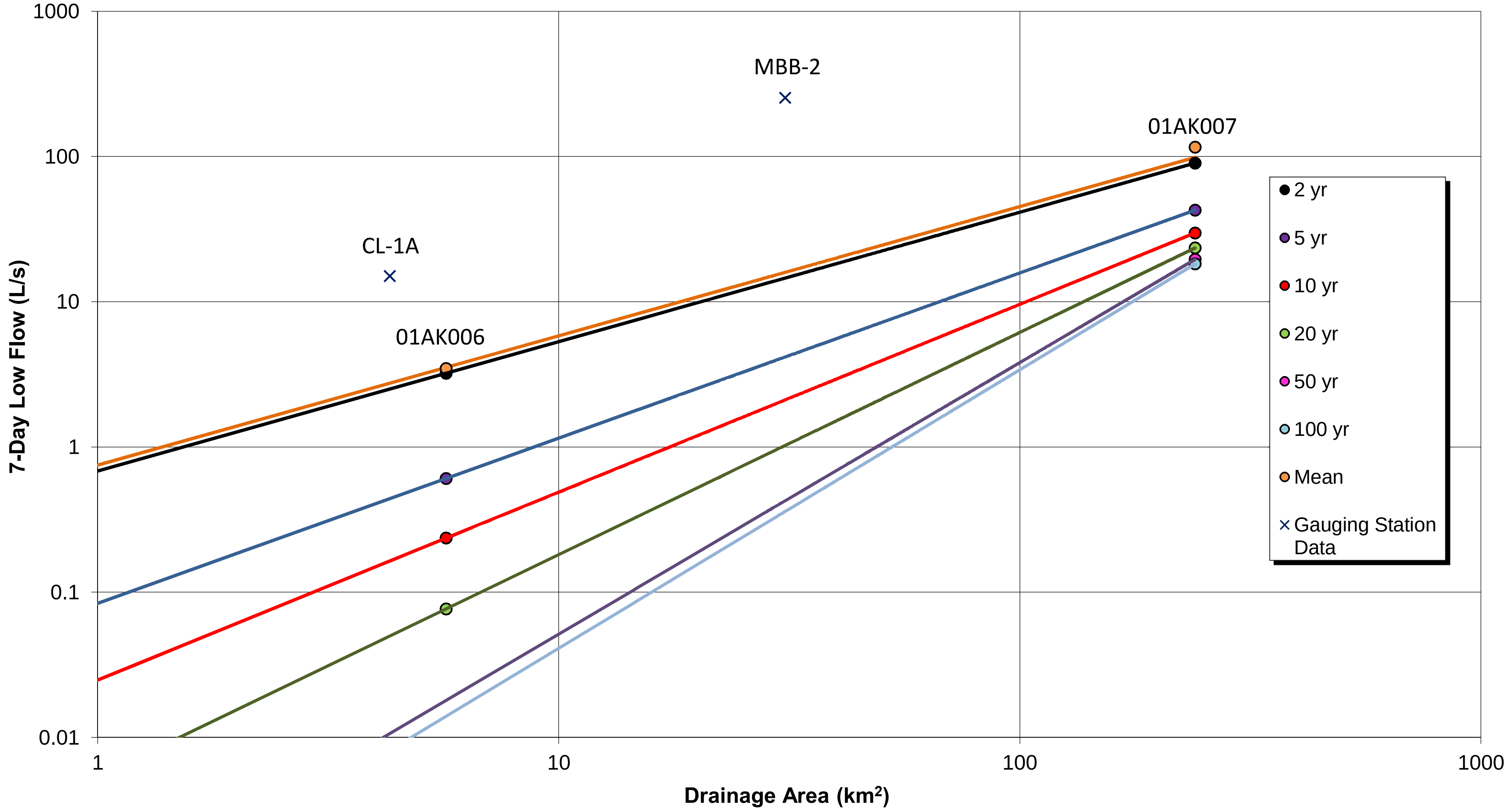
Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.25

REV 0



NOTES:

1. THIS FIGURE CAN BE USED TO ESTIMATE 7-DAY SUMMER LOW FLOWS FOR BASINS IN THE MCBEAN BROOK WATERSHED.
2. MINUMUM MEASURED 7-DAY LOW FLOWS FOR PROJECT GAUGING STATIONS INCLUDED FOR COMPARISON.
3. THE 50 YEAR AND 100 YEAR RETURN PERIOD 7-DAY SUMMER LOW FLOWS AT 01AK006 WERE CALCULATED TO BE 0 L/s. AS SUCH, THE 50 YEAR AND 100 YEAR TREND LINES WERE ESTIMATED BASED ON THE SHAPE OF THE OTHER RETURN PERIOD TREND LINES.

0	23JUL'12	ISSUED WITH REPORT	JM	NS	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

REGIONAL RETURN PERIOD
7-DAY SUMMER LOW FLOWS
MCBEAN BROOK WATERSHED

Knight Piésold CONSULTING

P/A NO. VA101-447/3

REF. NO. 1

FIGURE 3.26

REV 0

Knight Piésold CONSULTING

APPENDIX A

PRELIMINARY ASSESSMENT OF SISSON PROJECT HYDROMETRIC MONITORING PROGRAM

(Pages A-1 to A-35)

Knight Piésold
CONSULTING

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North Bay, ON CanadaP1B 8G5

Tel: 705-476-2165
Fax: 705-474-8095
www.knightpiesold.com

File No.:VA101-447/1-A.01
Cont. No.:VA11-01512

December 22, 2011

Mr. John Boyle
Northcliff Resources Ltd.
15th Floor, 1040 West Georgia Street
Vancouver, BC V6E 4H8

Dear John,

Re: Preliminary assessment of Sisson Project hydrometric monitoring program

Northcliff Resources Ltd. has retained Knight Piésold Ltd. (KPL) and Stantec Consulting (Stantec) to assist with the baseline monitoring studies for the Sisson Project. Stantec has been retained to collect hydrometric, meteorological, and water quality data and KPL has been retained to assist with the site monitoring program, quality assurance of data, and data management.

KPL previously summarized historic hydrometric data collection, and made several recommendations to improve data quality. In accordance with these recommendations, several hydrometric monitoring stations were relocated or discontinued, several new stations were established, and new field data collection and archiving protocols were implemented.

KPL is currently monitoring 7 stations while 7 sites have been discontinued. The active sites show good relationships between stage and discharge. This is largely due to stable hydraulic control sections, the use of bench mark surveys to obtain water level, and reliable discharge measuring techniques. Between 8 and 15 site visits have been completed since installation of the active sites. The 7 discontinued sites were removed at the recommendation of KPL because of poor stage-discharge relationships, discontinuous stage data, unreliable stage measurement techniques, site redundancy, or difficult gauging conditions.

The objective of this letter is to provide a preliminary assessment of the ongoing hydrometric monitoring program and a summary of the data collected up to the beginning of September 2011.

Study Area

The Sisson Project is located in west central New Brunswick, approximately 55 km northwest of Fredericton. The Project area is located in the Napadogan River and McBean Brook sub-basins of the Nashwaak River watershed. Elevations in the Project area range from 410 m in the uplands to 240 m at the McBean outlet, and 165 m at the Napadogan outlet. Forest cover is mainly deciduous at higher elevations and coniferous at lower elevations. Mixed wood stands are also found in the area. Dominant species in the region are Beech, Sugar Maple, Red Spruce and Balsam Fir. Mean Annual Precipitation (MAP) in Fredericton, from the 1971-2000 Environment Canada climate normals, is 1143 mm, of which 25% is snowfall. The average maximum end-of-month snow depth is 28 cm and occurs in February, and the mean annual air temperature is 5.3 ˚C. The Project location is expected to have slightly cooler temperatures and greater snowfall than Fredericton due to its higher elevation. Dickison and Daugharty, 1980, report slightly higher mean annual precipitation (1250 mm), and much greater average maximum snow depth (93 cm), in the Nashwaak Experimental Watershed, which is located approximately 8 km to the south of the Project site.

Hydrometric Data Collection

There are 14 hydrometric monitoring stations associated with the Project. Seven are currently being monitored and seven have been discontinued. Station details are provided in Table 1. Of the seven currently monitored stations, five are outfitted with pressure transducers and continuous loggers, while two have only benchmarks. Continuous flow records are not required at these two stations because the interest in these sites is to support groundwater, low flow, and fisheries related studies where only point measurements are required. Furthermore these flows can be correlated with concurrent flows at the other sites. The discontinued stations were all installed in April and May of 2008, and operated until May of 2011. KPL recommended that seven of the historical stations (pre-2011) be either discontinued or relocated due to poor stage-discharge relationships, discontinuous stage data, unreliable stage measurement techniques, site redundancy, or difficult gauging conditions.

For the active stations, hydrometric data collection began in mid-winter of 2011, when low flow measurements were obtained. In the spring, stream discharge was gauged along with stream stage (water level). Instrumentation and benchmark surveys were conducted once streams were completely ice-free. Pressure transducers (Instrumentation Northwest Inc., model PS98i) were installed at all sites except SB-3A and FR-1A. The PS98i instruments are calibrated prior to installation and provide a ± 0.1% accuracy. The transducers were installed in protective aluminum pipes, which are then fastened to the stream bank and wired directly into ELF2 dataloggers. These instruments provide nearly continuous water depth (as head above sensor tip) at 10 minute intervals. Short term water level fluctuations are minimized by installing the pressure transducer in a natural pool, called a gauge pool. The ideal gauge pool is located upstream of a solid bedrock control feature. Bench mark surveys are used to establish the site gauge datum, which is a semi-permanent (yet arbitrary) reference point from which all stage data are referenced. Bench marks are typically installed in stable areas, close to the site, and above the maximum expected flood levels. The use of bench marks allow recorded stream stage to be related from year to year, even when gauging instrumentation is re-installed each spring at different levels, and it provides a necessary means to perform routine checks on water level data quality. Staff gauges were also installed at most sites and surveyed to provide a reference for stream stage.

Discharge measurements were performed using the standard area-velocity technique, with a wading current meter (Marsh-McBirney Flo-mate 2000). These sensitive instruments provide a measure of instantaneous flow velocity using an electromagnetic sensor with a resolution of ± 1 cm/s. A top-setting wading rod was used to measure total stream depth and the flow velocity at a depth equal to 0.6 of the total depth (0.4 from the bottom). Where deviation from the standard velocity profile was expected, velocities at 0.2 and 0.8 total depth were also obtained.

Discharge measurements and corresponding gauge heights were entered on field sheets and then into the KPL FULCRUM database. FULCRUM provides a means for cataloging field data and facilitates the calculation and assessment of stage and discharge error. Discharge measurements using area-velocity are estimated to be in the range +/- 5% to 15%. Error estimates are based on the precision of repeat discharge measurements, the spatial distribution of discharge throughout the cross sectional area of the stream, and a qualitative observation of flow turbulence.

Gauging sites were established at stable natural control sections along the stream channels. The ideal location is one where the channel morphology does not change, through erosion, deposition or a combination of both, within or among years. Stability is important because as channel shapes are altered by natural processes, so too are the relationships between stage and discharge. Establishing a robust relationship between stage and discharge is necessary to convert continuous water level data into a record of continuous discharge.

For natural stream controls, rating curves are determined empirically from estimates of discharge and stage obtained during site visits, with consideration of the hydraulic characteristics of each channel. Measurements are made at different gauge heights in order to capture a range of discharge, and to develop a robust relationship. It is important that rating curve development be assessed throughout data collection to ensure that the relationship is stable and to make corrections if necessary.

The seven active stations were visited between eight and nine times between May 1 and September 1, 2011. Site SB-1 on Sisson Brook was visited six times throughout the winter to obtain low flow measurements. Winter data are not used in developing rating curves because it is not possible to reference stream stage under ice cover. However, these data are useful in assessing the contribution of groundwater to base flow, and for interpolating flows throughout the winter period.

At least two measurements of discharge were obtained along with gauge height and relevant site photos during each site visit. Where installed, dataloggers were downloaded and an on-site validation check was performed to ensure correct operation. At the two sites without dataloggers (FR-1A and SB-3A), a bench mark survey was completed during each site visit to measure water level. All site data are recorded in FULCRUM.

Hydrometric Data Analysis

Hydrometric Data Analysis consists of rating curve development and the development of daily discharge hydrographs.

Rating Curve Development

Directly obtaining a time-series of discharge is not logistically or technically feasible in most areas. As such, dataloggers are used to automatically record changes in stage, and a time-series of discharge can be based on these stage data, through the use of a rating curve. For natural stream controls, a rating curve can be defined by the following relation.

$$\boldsymbol{Q = C(h - a)^n}$$

Where:

- *Q* is discharge
- *C is* a coefficient
- *a* is a constant representing the point of zero flow
- *h* is the measured stage, and
- *n* is an exponent.

Although rating curves can and often do require the use of multiple rating curve equations, with each equation relevant for a specific range of stage, rating curves for the Sisson project stations were generally able to be fitted to measured data using a single equation. This was possible because flows were contained to well-developed channels with generally regular cross-sections.

Preliminary rating curves were generated visually for each of the stations. Curve parameters, given above, were adjusted to provide a better fit to measurements of higher confidence, with less emphasis on measurements that have a higher degree of uncertainty. Portions of the rating curves that were extrapolated beyond the range of measured flows should be used with caution until verification measurements can be obtained. This is especially important for higher flows where channel geometry and flow characteristics can change significantly during flood conditions.

Rating Curve Development at Active Sites

The following sections describe Rating Curve development for five of the active stations in the Project area. All rating curves are preliminary, pending a full hydrometeorology report for the project. The two stations without rating curves are simply monitored on basis of instantaneous stage and discharge measurements that provide a means for comparison with concurrent flows at other sites.

Station B-2

B-2 is located on Bird Brook at the confluence of Napadogan Brook and has a drainage area of 7.7 km^2. The site has a staff gauge and ELF2 datalogger with PS98i pressure transducer. The site is shown on Photo 1. Discharge was measured during nine separate site visits in 2011. The pressure transducer is located in a pool above a local narrowing of the channel, as shown on Photo 1, providing a section control that minimizes downstream disturbance (backwater) from affecting the stage-discharge relationship at the site. Discharge is gauged downstream of the pressure transducer in an area of reasonably steady and uniform flow.

The rating curve for B-2 shows a reasonably strong and consistent relationship between stage and discharge, although there is some scatter of the points about the curve, as shown on Figure 3, and additional high flow points are needed to validate the curve over the full range of measured stage (max ~ 1.7 m). The fit of points to the curve suggests that the channel is stable through the range of observed flows, with the scatter attributable to measurement uncertainty. The channel bed and banks at the hydraulic control section consist of boulders and large cobbles, with exposed bedrock in many places. As such, it is expected that the control should continue to provide a stable relationship between stage and discharge.

Station CL-1A

CL-1A is located on the Chainy Lakes sub-basin of the McBean Brook Watershed and has a drainage area of 4.3 km^2. The site has a staff gauge, PS98i pressure transducer and ELF2 datalogger installed. The site is shown on Photo 2. The pressure transducer is located in a pool upstream of a hydraulic jump which provides good section control, as shown on Photo 2. Discharge is gauged near the pressure transducer in an area of reasonably steady and uniform flow. The site has been visited seven times in 2011, during which stage and discharge were measured.

The rating curve shows a reasonably good relationship between stage and discharge, as shown on Figure 4, although additional high flow points are needed to validate the curve over the full range of measured stage (max ~ 0.57 m). There is reasonably consistent scatter of the points about the curve, which suggests that the variability is due to measurement error rather than changes in the hydraulic control section. The 2011 data suggest that the control is relatively stable under normal conditions, and should continue to provide reliable data.

Station MBB-2

MBB-2 is located on McBean Brook downstream of the Chainy Lakes inflow and has a drainage area of 30.8 km^2. The site has a staff gauge and ELF2 datalogger with PS98i pressure transducer installed, and was visited eight times in 2011. The pressure transducer is located in a pool created by some boulders at a break in channel slope. The site is shown on Photo 4.

This station was installed later in the freshet than other stations, and hence most of the discharge measurements were made across a relatively small range of discharge (0.5 to 0.8 m^3/s). The rating curve delineates a reasonably good relationship from low to mid measured flow, but a number of high flow measurements are required to validate the curve over the full range of measured stage values. The rating curve is shown on Figure 5. The channel banks at MBB-2 are bouldery with some exposed bedrock. It is expected that the site rating curve will be stable over time.

Station NB-2B

NB-2B station is located on Napadogan Brook, approximately 2.5 km downstream of the Sisson Brook confluence, and has a drainage area of 55.7 km^2. The site has an ELF 2 datalogger with PS98i pressure transducer installed and has been visited nine times in 2011. The pressure transducer is located in an eddy near a hydraulic jump, which provides good low-mid flow section control, and near a bridge with provides a constriction control for high flow. The site is shown on Photo 5.

The stage-discharge relationship at NB-2B is very strong, as shown on Figure 6. The control at this station is good and should be stable across a range of flows. The site should continue to provide a very reliable stage-discharge relationship.

Station SB-1

SB-1 is located in Sisson Brook approximately 0.5 km upstream of the confluence with Napadogan Brook, and has a drainage area of 5.0 km^2. The site has been visited 15 times in 2011. Six visits were made between February 15 and April 27 to gauge winter low flows. These measurements are crucial for categorizing low flow, but are not used in generating the site rating curve because measurements of stage during winter are complicated by the presence of ice. The site has a staff gauge, datalogger and pressure transducer installed. The PS98i pressure transducer is located in a pool along a section of relatively steady flow. The site is shown on Photos 6 and 7.

Nine site visits from May 10 to August 25, 2011 were used to generate a rating curve. There is a good relationship between stage and discharge at SB-1 in all but two measurements, as shown on Figure 7. These two outliers were measured on June 9 and have been thoroughly assessed for potential errors. No reason was found to discount the points other than the poor fit with other gauging data. Despite being ignored for the development of the preliminary rating curves, additional data collection will assist in verifying the accuracy of these discharge measurements.

Active Instantaneous Discharge Sites

A series of point measurements were taken at FR-1A and SB-3A in order to support groundwater, low flow, and fisheries related studies. These flows can be correlated with concurrent flows at the other sites. Maintaining these station is relatively simple, and data from them will facilitate the characterization of non-linear flow regimes in the region.

Station FR-1A

FR-1A has a catchment area of 1.1 km^2, and is located within a sub-basin of Bird Brook. No continuous instrumentation is installed at FR-1A. The site is shown on Photo 3. Instantaneous discharge and stage are measured in an area of steady flow, upstream of a submerged log, which provides an adequate section control for these relatively minor flows. Stream stage at FR-1A is determined using a benchmark survey. The site was visited and gauged eight times in 2011. A rating curve is not required to develop a continuous discharge hydrograph as there are no instruments installed at the site. For more detailed analyses, instantaneous discharge measurements made during site visits will be related to the discharge hydrographs at other sites, specifically B-2, located further downstream. Stage values were obtained in coincident with discharge measurements when both stage and discharge were necessary for assessing data and station quality.

The drainage area at FR-1A is relatively small, resulting in the lowest recorded flows in the Project area. The channel control and gauge pool is laden with unconsolidated sediments and has low banks. These factors often result in difficult gauging conditions.

Station SB-3A

The station at SB-3A is located on an upper branch of the Sisson Brook and has a drainage area of 2.6 km^2. There are no instruments installed at SB-3A, and instantaneous stage and discharge are measured in a section of steady flow. The site is shown on Photo 8. Stage is measured through a full benchmark survey, and the site was visited nine times in 2011.

Stage vs Discharge at Discontinued Sites

Hydrometric studies have been undertaken since 2008. For the current program, KPL recommended that six of the historical stations (pre-2011) be either discontinued or relocated due to poor stage-discharge relationships, discontinuous and unreliable stage measurement technique, site redundancy, or difficult gauging conditions. Preliminary stage and discharge were developed to rationalize the elimination of these stations.

Station MBB-1

MBB-1 was located in a sub-basin of the McBean Brook watershed. It was located downstream of a road crossing with culverts. Ten stage-discharge measurements were plotted to examine the rating curve relationship, as shown on Figure 8. The relationship is poor, especially among the three highest discharge measurements, and no reasonable curve could be delineated. The data show that the stream control was not stable and that the gauging conditions were challenging, due to significant backwater effects. The station was destroyed by a storm event in December 2010 when the mass deposition of silts and sands changed the hydraulic control section. It was deemed that the data were persistently of low quality and that data collection should be discontinued. The site was not relocated in the same area due to wetlands and channel braiding, which made it impossible to locate a suitable gauging site. A new station was located downstream at MBB-2 to record flow data for McBean Brook, which includes the flow contribution from MBB-1sub-basin.

Station CL-1

CL-1 was located on McBean Brook upstream of the Chainy Lakes inflow. The site was installed in 2008 and data were collected in 2008, 2009 and 2011. The relationship between stage and discharge is poor and not consistent between years, indicating an unstable hydraulic control, as indicated by the scatter of points on Figure 9. During a 2011 site visit it was determined that the stream channel at CL-1 was braided and the gauging location was on one branch of two parallel channels. An alternative site was not found in the area, and therefore a new station at MBB-2 was installed to replace CL-1. The station at CL-1A was installed in order to quantify flows from the Chainy Lakes sub-basin, such that flows upstream of the Chainy Lakes inflow confluence can be determined.

Station NB-2

NB-2 was located on the Napadogan Brook 2.5 km below the inflow of the Sisson Brook. Data were available from 2008 and 2009. The relationship between stage and discharge is possibly stable, although there are two unexplainable outlier points in only 6 measurements (Figure 10). The station at NB-2 was washed out by a storm event in December 2010 and reinstalled downstream as NB-2B at a more suitable section control. Station NB-2B is currently active and collecting good quality data.

Station FR-1

FR-1 was located in the same location as FR-1A. The relationship between stage and discharge was never well established at FR-1, as shown on Figure 11, and this has been largely attributed to an absence of precisely surveyed instantaneous stage data. The channel is mostly unconsolidated sediment and subject to potential shifts over times. When site FR-1A was activated, a rock bolt was installed on a large boulder and used as a stable benchmark, and benchmark surveys were used to obtain instantaneous stage readings. A better control section was chosen for gauging and the 2011 data at FR-1A are a significant improvement on data previously collected at FR-1.

Station SB-3

The station at SB-3 was located on a tributary stream of Sisson Brook. The stage-discharge data demonstrate considerable scatter and it is not possible to delineate a reasonable rating curve for the combined two year dataset, or even separate curves for each annual dataset (Figure 12). SB-3 was located downstream of a road crossing which was washed out in December 2010. Site SB-3A was established upstream of the road crossing at a better control section, but even for this site the stage-discharge date demonstrate considerable scatter.

Stations NR-1 and NR-1A

The stations at NR-1 and NR-1A were located on the Nashwaak River, downstream of the McBean Brook confluence, and upstream of the Napadogan Brook confluence. No discharge data has been collected for station NR-1. The stage-discharge relationship from data collected from station NR-1A in 2008 and 2009 is reasonable, as shown on Figure 13. However, the catchment area is large and flows at NR-1 and NR-1A are difficult to gauge under high flow conditions. The station was discontinued for 2011 following discussions with Stantec. It was determined that flow data were not considered relevant enough to warrant the effort and cost required to maintain the site rating curve and instrumentation.

Discharge Hydrographs

A discharge hydrograph is a plot of instantaneous discharge over time. Hydrograph shape is a function of the complex interplay of both physiographic and meteorological conditions within a watershed. All of the Project stations are in relatively close proximity to each other, and as such, the variability in meteorologic parameters (such as precipitation) should be minimal. Differences in hydrographs between basins will be primarily a function of differences in basin shape, area, stream network, slope, land cover, and in-catchment storage.

Pressure transducers and dataloggers provide a record of stage. Instantaneous surveyed gauge height data are used to correct raw Datalogger stage data, and a site's unique rating curve is used to generate continuous discharge from stage. Discharge hydrographs were developed for all active continuously gauged stations to show flow over time, as shown on Figures 14 and 15, with the hydrographs grouped according to basin size. Figure 14 is for basins ranging in size from 4.3 km^2 to 7.1 km^2, while Figure 15 is for basins ranging in size from 30.8 km^2 to 55.7 km^2. Figure 16 presents the unit runoff hydrographs for all five basins. The average unit runoff values for the concurrent period of record for B-2, CL-1A, MBB-2, NB-2B, and SB-1 are 29.9, 21.4, 25.0, 26.6, and 22.7 $l/s/km^2$, respectively.

As expected, the hydrographs for the various stations have very similar shapes. Rising limbs occur at similar times and the peaks in response to rainfall events are well correlated. In some cases, the time to peak discharge may by slightly different, as one would expect given the differences in basin parameters. For example, the CL-1A basin appears to have the slowest hydrologic response to storm events despite having the smallest drainage area, which is attributable to the attenuating effect of the Chainy Lakes. It also has the lowest average unit runoff over the period of concurrent record, which is possibly attributable to higher evaporation losses due to the lakes, lower precipitation due to its relatively low elevation, and/or greater groundwater recharge (losses) due to localized surficial conditions. In contrast, the B-2 basin, which is similar in size but has a higher elevation and no lakes, appears to have the highest unit peak flows and the highest average unit runoff.

Gap Analysis

In general, the Project data are of very good quality and there are no major gaps. This indicates that the sites have been well established, installed, and gauged, and have been relatively stable throughout the year. Nonetheless, there are areas where data collection, analysis, and quality can be optimized, or where fundamental processes and protocols should be reinforced. Recommendations are as follows:

- Rating curve development would be facilitated with a greater number of low flow gaugings and an accurate estimate of the point of zero flow, through control cross-section surveys. This may not be possible at some sites until lower flow conditions prevail in 2012.
- Rating curves are shown to maximum recorded stage in 2011, and as is apparent, the stage-discharge measurements were only recorded over a relatively low range of stage. High flow

measurements would be useful for validating the preliminary rating curves, although these may be difficult to capture in basins with a rapid runoff response. Without high flow measurements there is reduced confidence in the high end of the rating curve.

- For the development of rating curves and the correction of water level data, it is essential to have accurate measurements of stream stage. There are several project sites that rely on benchmark surveys for a measure of stage. It is essential that the high quality of these observations be maintained to minimize error accumulation through data processing and analyses. Minor errors in stream stage can increase and compound the error and uncertainty in rating curves and hydrographs.
- Site photographs have been integral in analysing and interpreting in-stream conditions, as well as validating gauge height data. These photographs should continue to be collected.
- All collected data and any analyses are wholly dependent on the accuracy of stage and discharge, and therefore all site instrumentation (dataloggers and pressure transducers) should be removed prior to the onset of winter, and returned to the manufacturer for calibration and maintenance. Current meters should also be sent to the manufacturer for calibration at least once annually.

Preliminary Regional Data Assessment

A complete Hydrometeorology Report will be prepared for this project following the collection of a sufficient period of data to facilitate detailed analyses. KPL have undertaken a preliminary regional study in order to identify any deficiencies that may be expected in the available regional dataset. Preliminary uncorrected discharge data from 2011 at four of the five active relevant WSC sites in the region were obtained for comparison with concurrent Project site data (data for Nackawic Stream (01AK007) were not available). Regional station details are given in Table 1, and station locations are shown on Figure 1.

2011 unit discharge hydrographs (l/s/km^2) for the four WSC stations are shown on Figure 17. Unit discharge data from the two stations in the AL region, 01AL004 (Narrows Mountain Brook) and 01AL002 (Nashwaak River), compare very favourably to the unit discharge data from the Project stations, as shown on Figure 18. This is despite the much larger basin size (1450 km^2) of 01AL004. These stations have been operational since 1972 and 1966, respectively, so their datasets provide a very good basis for generating long-term flow estimates for the site basins. Data from 01AL004 were selected for more direct comparison to the site data because of this basin's small size (3.9 km^2) and close proximity to the site (10 km to the south). Simple least squares regression of data for 01AL004 with concurrent data for the various site stations indicates that flows are very strongly correlated in all cases, with R^2 values of 0.95, 0.94, and 0.90 for B-2, CL-1A, and MBB-2, respectively.

Conclusions and Recommendations

There are seven active hydrology stations placed at the outlets of basins that have the potential to be impacted by the Project. WSC have five active stations in the region, including a site approximately 10 km south of the Project with a flow record beginning in 1972. Flows at this site appear to be very well correlated to flows measured in the project basins.

Hydrometric data collection was initiated in mid to late winter of 2011 when low flow measurements were obtained. Instrumentation was installed and benchmark surveys were conducted in early May. Pressure transducers and dataloggers were installed at all active sites except SB-3A and FR-1A. Gauging sites were established at stable natural control sections along the stream channel and discharge measurements were made using a wading current meter and the area-velocity technique. Rating curves were determined empirically from estimates of stage and discharge obtained during site visits.

Measurements were made at different gauge heights to capture a range of discharge and develop as robust a relationship as possible.

All discharge measurements, except winter low flow measurements, were used as the basis for developing stage-discharge relationships. Rating curves were generated by visual curve-fitting, taking into consideration the uncertainty associated with each discharge measurement and the hydraulic parameters of the channel. All rating curves developed for active sites show a strong relationship between stage and discharge. The rating curves for discontinued sites are typically weak and the relocation and discontinuation of these sites was well justified, with the data collected and rating curves produced at the active sites being far stronger than any of the discontinued sites. Correct field protocols, such as bench mark surveying, have been integral to the collection of good quality data.

The hydrographs produced for all five continuously gauged site stations demonstrate very similar overall patterns, although there are some differences that are believed to be largely attributable to differences in basin area, shape, land-cover and storage capacity.

It is recommended that the site data collection program be continued through the remainder of 2011 and into 2012 to maintain the integrity and quality of the dataset. High and/or low flow events should be captured, and it is expected that a more streamlined data collection program can be adopted in 2012 now that the fundamental shapes of the rating curves are understood. A complete hydrometeorological analysis should be undertaken once full annual datasets are available. The preliminary relationships provided in this document indicate that the development of robust models needed to relate short term Project data to longer term WSC records will be possible and of good quality.

Stantec, and in particular, John Keizer, should be commended for their data collection efforts, as well as Northcliff field technicians, who provided valuable assistance to the Project. The excellent relationship between KPL and Stantec on this Project has proven to be very beneficial in working to establish a reliable baseline for this Project. KPL looks forward to continuing this Project with Stantec.

Should you have any questions or concerns on the data collection program to date, or if you would like any information on any aspects of the hydrometric monitoring program, please do not hesitate to contact the undersigned.

Knight Piésold
CONSULTING

Yours truly,
KNIGHT PIESOLD LTD.

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Attachments:

Table 1 Rev 0	Hydrometric Station Details – Project Stations
Figure 1 Rev 0	Water Survey of Canada Stations
Figure 2 Rev 0	Active Hydrology Stations
Figure 3 Rev 0	B-2 Preliminary Rating Curve
Figure 4 Rev 0	CL-1A Preliminary Rating Curve
Figure 5 Rev 0	MBB-2 Preliminary Rating Curve
Figure 6 Rev 0	NB-2B Preliminary Rating Curve
Figure 7 Rev 0	SB-1 Preliminary Rating Curve
Figure 8 Rev 0	MBB-1 Stage-Discharge Data
Figure 9 Rev 0	CL-1 Stage-Discharge Data
Figure 10 Rev 0	NB-2 Stage-Discharge Data
Figure 11 Rev 0	FR-1 State -Discharge Data
Figure 12 Rev 0	SB-3 Stage-Discharge Data
Figure 13 Rev 0	NR-1A Stage-Discharge Data
Figure 14 Rev 0	Discharge Hydrographs B-2, CL-1A and SB-1
Figure 15 Rev 0	Discharge Hydrographs NB-2B and MBB-2
Figure 16 Rev 0	Unit Runoff Project Stations
Figure 17 Rev 0	Unit Hydrographs WSC Stations
Figure 18 Rev 0	Unit Runoff Project and WSC Stations
Photo 1	Pressure Transducer Location at Station B-2
Photo 2	Pressure Transducer Location at Station CL-1A
Photo 3	Section Control for Gauging at Station FR-1A
Photo 4	Pressure Transducer Location at Station MBB-2
Photo 5	Pressure Transducer Location at Station NB-2B
Photo 6	Pressure Transducer Location at Station SB-1
Photo 7	Section control downstream of pressure transducer at station SB-1

Photo 8 Channel at SB-3A

/cb

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TABLE 1

NORTHCLIFF RESOURCES LTD.
SISSON PROJECT

HYDROMETRIC STATION DETAILS
PROJECT STATIONS

Print Dec/16/11 16:35:44

Active Stations							
	Location		Install Date	Site Visits	Data Logger?	Drainage Area km^2	Description
	East	North					
B-2	651363	5139077	11-May-11	9	Yes	7.7	Bird Brook at Napadogan
CL-1A	647027	5132872	27-May-11	8	Yes	4.3	Stream from Chainey Lakes Basin
FR-1A	648765	5138471	11-May-11	8	No	1.1	Stream draining potential dry-stack site
MBB-2	646406	5132706	18-May-11	10	Yes	30.8	McBean Brook
NB-2B	653297	5135556	11-May-11	10	Yes	55.7	Napadogan Brook
SB-1	651642	5137491	10-May-11	15	Yes	5.0	Sisson Brook
SB-3A	650840	5137315	11-May-11	9	No	2.6	Sisson Brook - upstream

Discontinued Stations					
	Location		Install Date	Site Visits	Description
	East	North			
CL-1	646720	5133155	11-Apr-08	35	McBean Brook
FR-1	648765	5138471	10-Apr-08	45	Stream draining potential dry-stack site
MBB-1	648526	5135108	11-Apr-08	34	McBean Brook
NB-2	653093	5135546	12-Apr-08	43	Napadogan Brook
NR-1	652169	5128274	12-Apr-08	4	Nashwaack River
NR-1A	652174	5128441	13-May-08	31	Nashwaack River - upstream
SB-3	650864	5137358	09-Apr-08	43	Sisson Brook

REGIONAL STATIONS

Station Name	ID	Location		Start of Record	Years of Record	Distance to Project	Area Km^2
		Latitude	Longitude				
Narrows Mtn Brook	01AL004	46° 16' 37" N	67° 01' 17" W	1972	39	10 km S	3.9
Becaguimec Stream	01AJ010	46° 20' 27" N	67° 27' 54" W	1973	38	33 km W	350
Middle Branch Nashwaaksis	01AK006	46° 04' 58" N	66° 43' 58" W	1966	45	41 km SE	5.7
Nackawic Stream	01AK007	46° 02' 55" N	67° 14' 22" W	1967	44	32 km SW	240
Nashwaak River	01AL002	46° 07' 33" N	66° 36' 40" W	1961	50	42 km SE	1450

M:\1\01\00447\01\A\Correspondence\VA11-01512 - Preliminary assessment of Sisson Project hydrometric monitoring program\Figures and Tables\[Table 1. Project Hydrology Stations.xlsx]T

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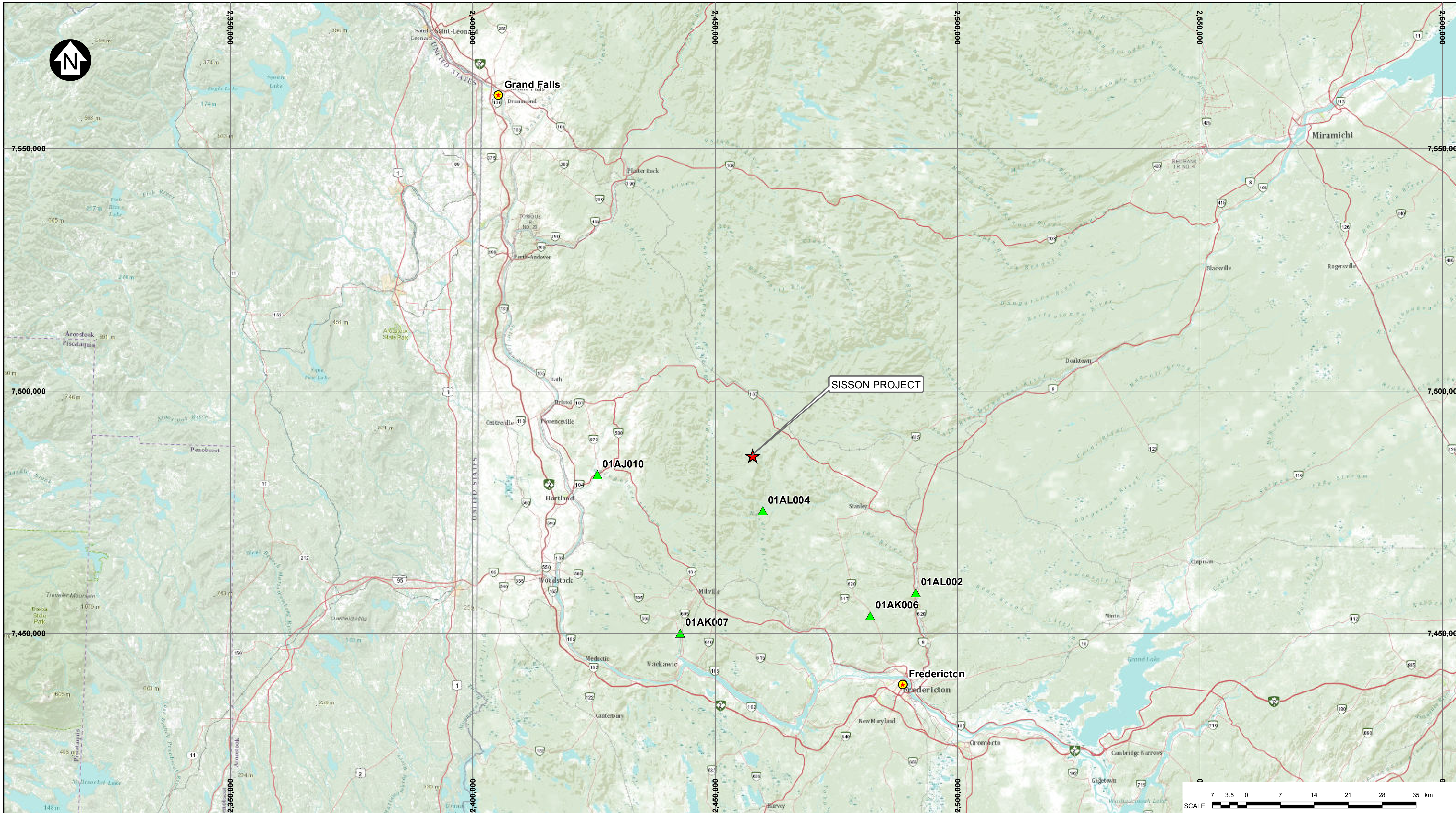
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



LEGEND:

- PROJECT LOCATION
- COMMUNITY
- WSC STATION

NOTES:

1. BASE MAP: ESRI ARCGIS ONLINE TOPOGRAPHIC MAPS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 10 METERS.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	15DEC'11	ISSUED WITH LETTER REPORT	AMD	AMD	CMB	JPH

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

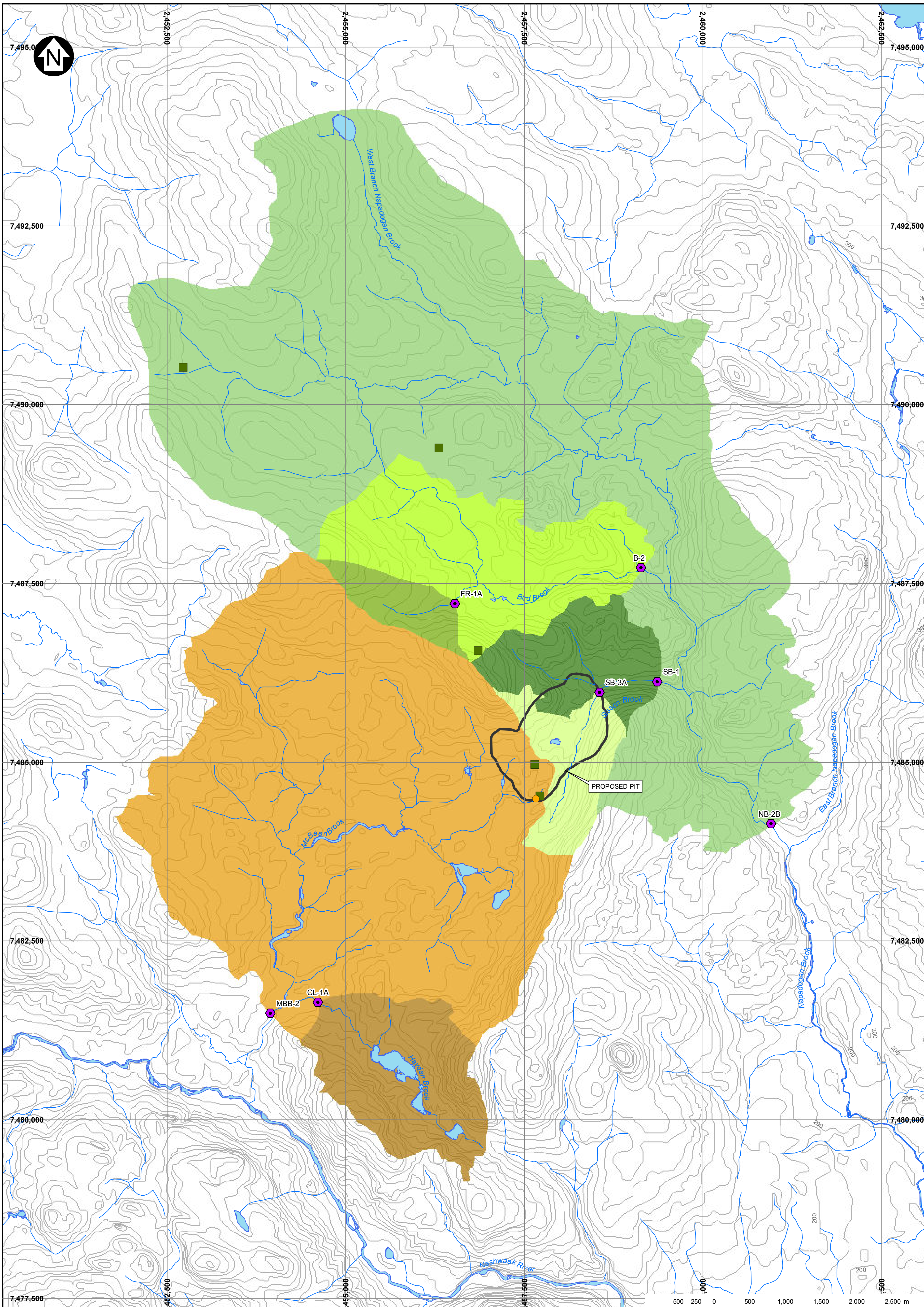
WATER SURVEY OF CANADA STATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-447/1	VA11-01512

FIGURE 1 REV 0

KP FIGURE SAVED: M:\1\01\00447\01\A\GIS\Figs\B06.mxd; Dec 22, 2011 3:02:53 PM adnca



LEGEND:

- ACTIVE HYDROLOGY STATION
- METEOROLOGICAL STATION
- SNOW SURVEY SITE
- CONTOUR (10 M)
- RIVER
- LAKE
- PROPOSED PIT

NOTES:

1. BASE MAP: CANADA NTS MAPS.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:50,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
4. CONTOUR INTERVAL IS 10 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	22DEC'11	ISSUED WITH LETTER REPORT	ALR	ASM	CMB	JGC

NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

ACTIVE HYDROLOGY STATIONS

Knight Piésold CONSULTING

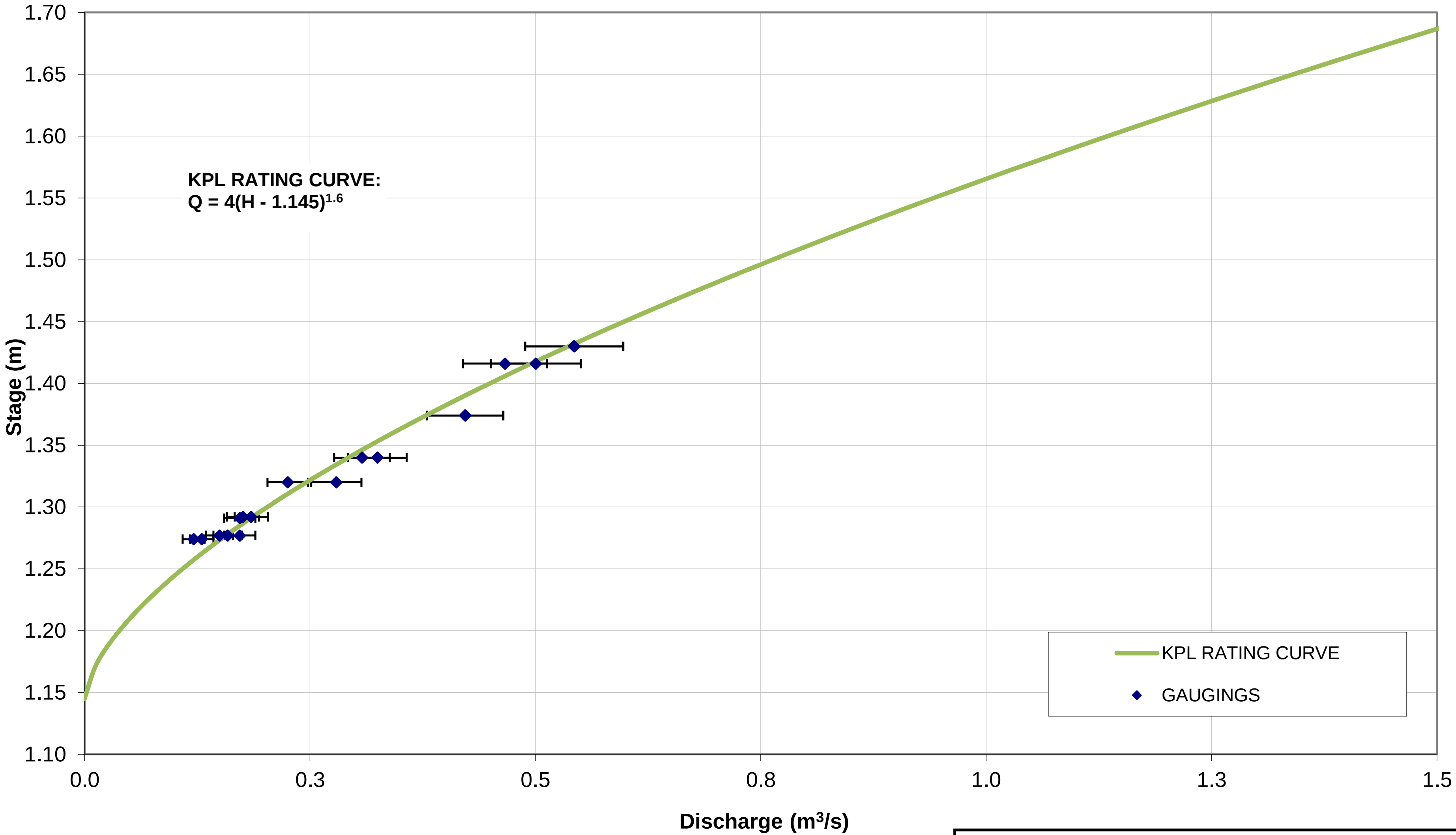
P/A NO. VA101-447/1

REF NO. VA11-01512

FIGURE 2

REV 0

KP FIGURE SAVED: M:\1\01\00447\01\A\GIS\Figs\804.mxd; Dec 22, 2011 2:59:51 PM adinca



NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

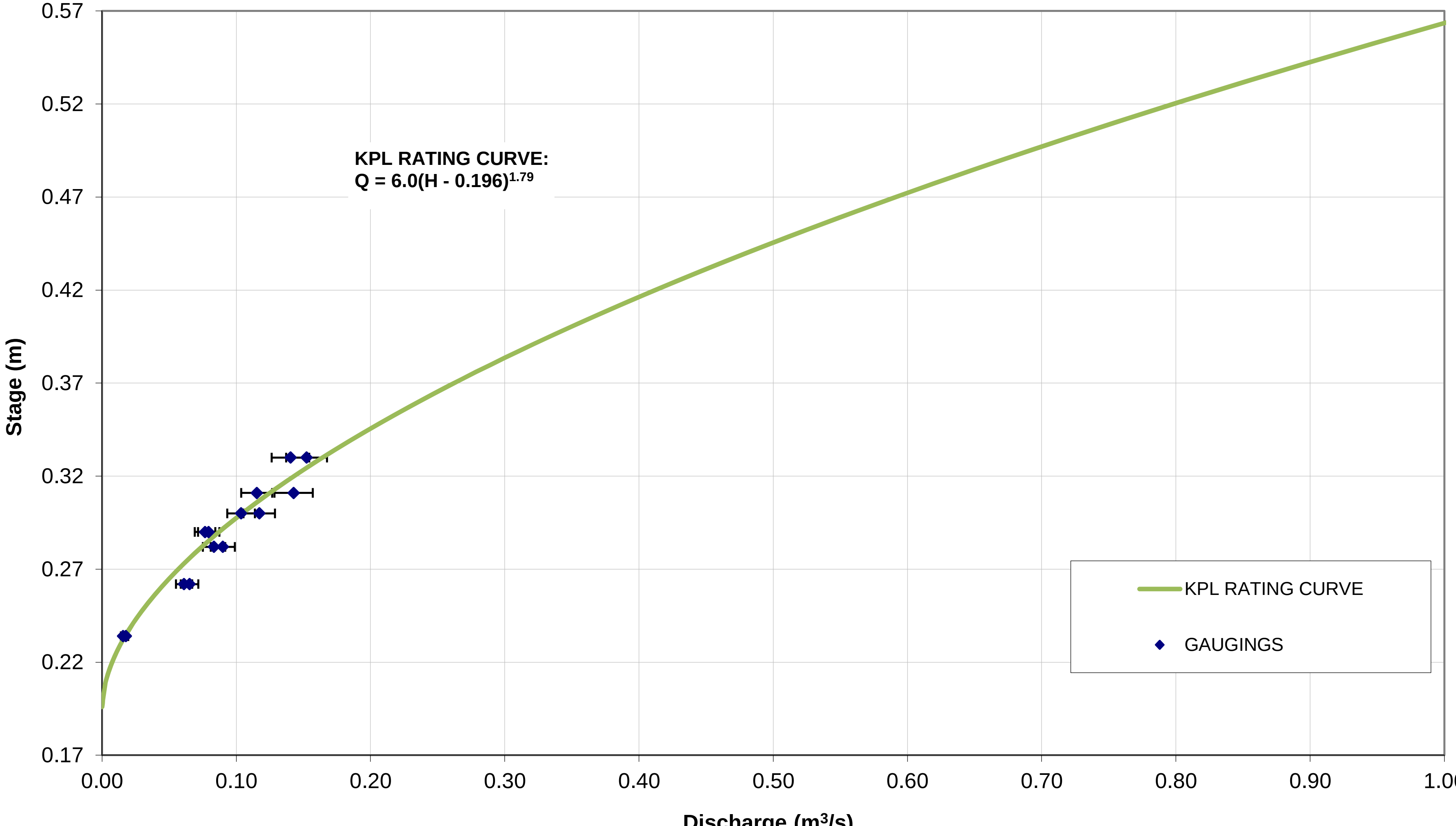
NORTHCLIFF RESOURCES LTD
SISSON PROJECT

B-2
PRELIMINARY RATING CURVE

Knight Piésold CONSULTING

P/A NO. VA101-447/01
REF. NO. VA11-01512

FIGURE 3
REV 0



NOTES:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD

SISSON PROJECT

CL-1A
PRELIMINARY RATING CURVE

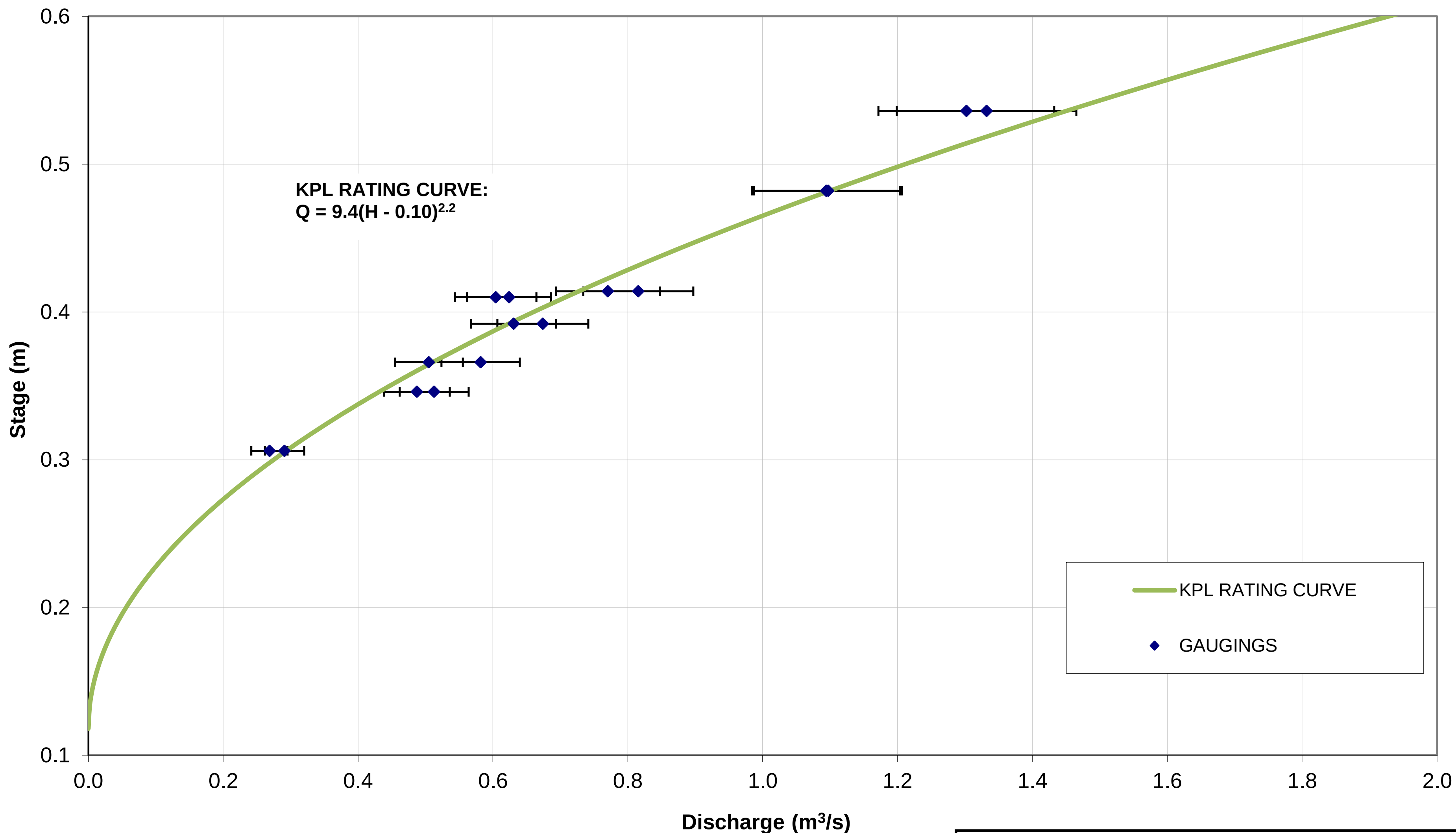
Knight Piésold CONSULTING

P/A NO. VA101-447/01

REF. NO. VA11-01512

FIGURE 4

REV 0



NOTE:
1. RATING CURVE SHOWN TO MAXIMUN RECORDED STAGE

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD

SISSON PROJECT

MBB-2
PRELIMINARY RATING CURVE

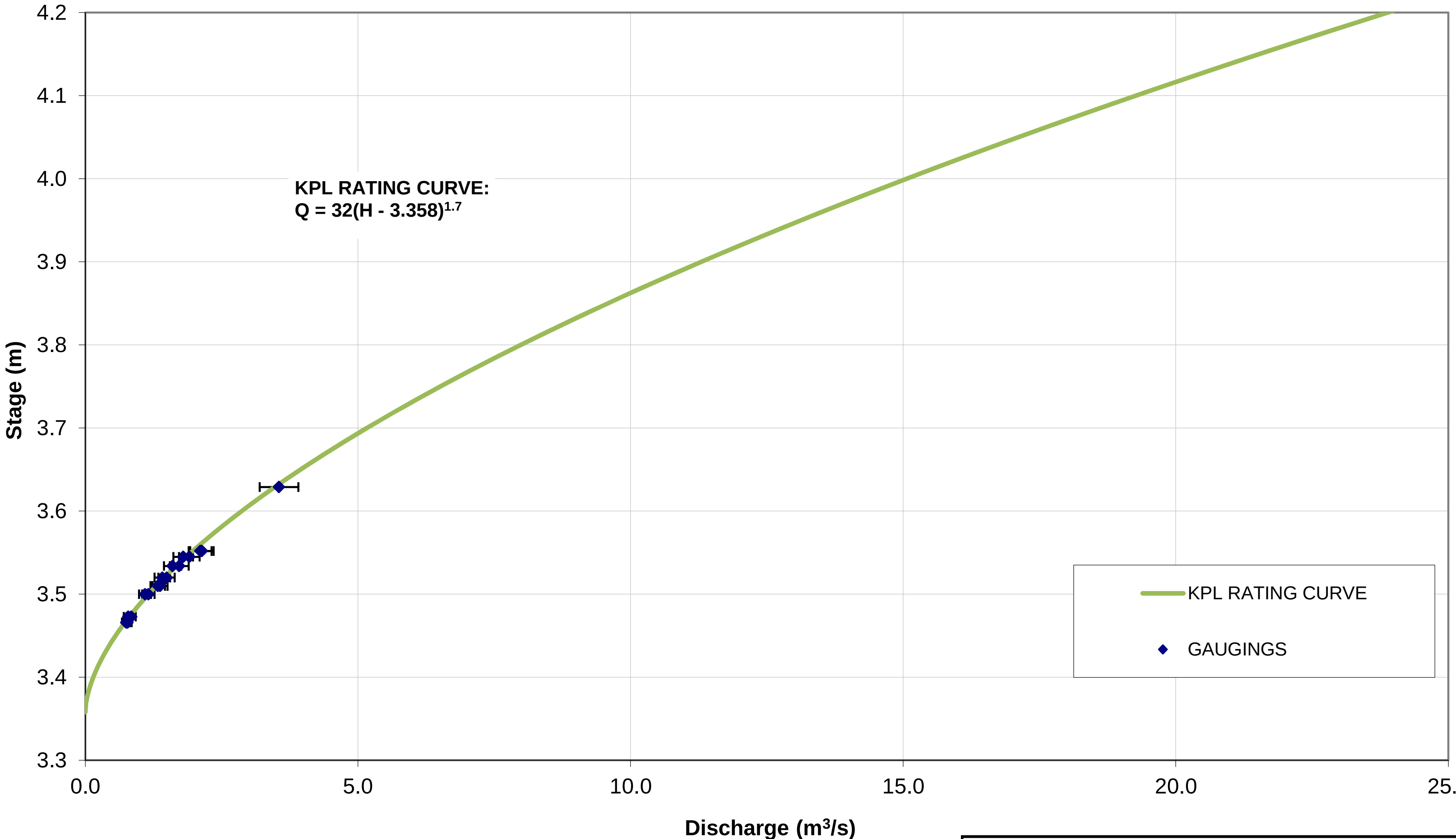
Knight Piésold CONSULTING

P/A NO. VA101-447/01

REF. NO. VA11-01512

FIGURE 5

REV 0



NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

NORTHCLIFF RESOURCES LTD

SISSON PROJECT

NB-2B
PRELIMINARY RATING CURVE

Knight Piésold CONSULTING

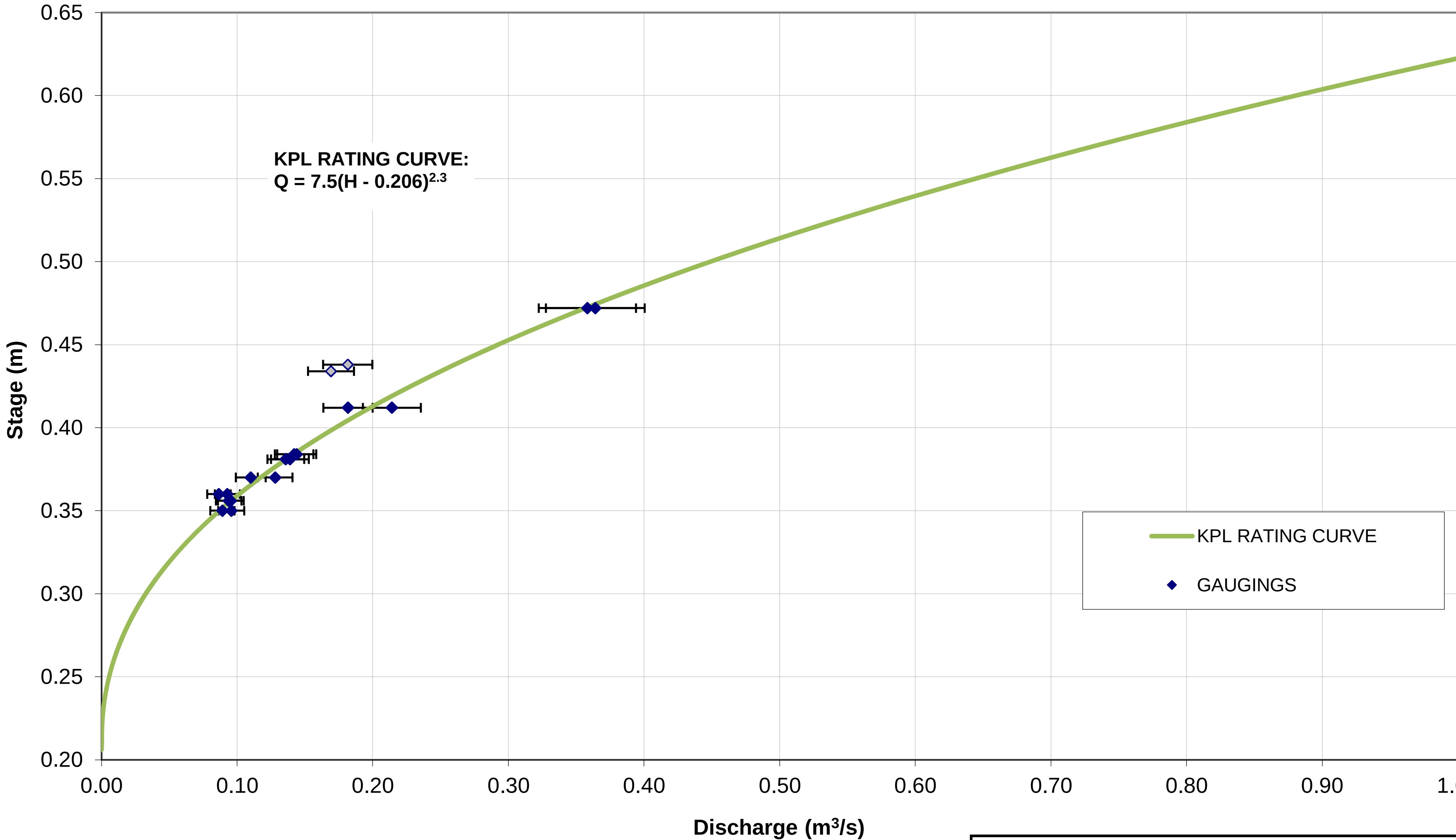
P/A NO. VA101-447/01

REF. NO. VA11-01512

FIGURE 6

REV 0

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NOTE:
1. RATING CURVE SHOWN TO MAXIMUM RECORDED STAGE.

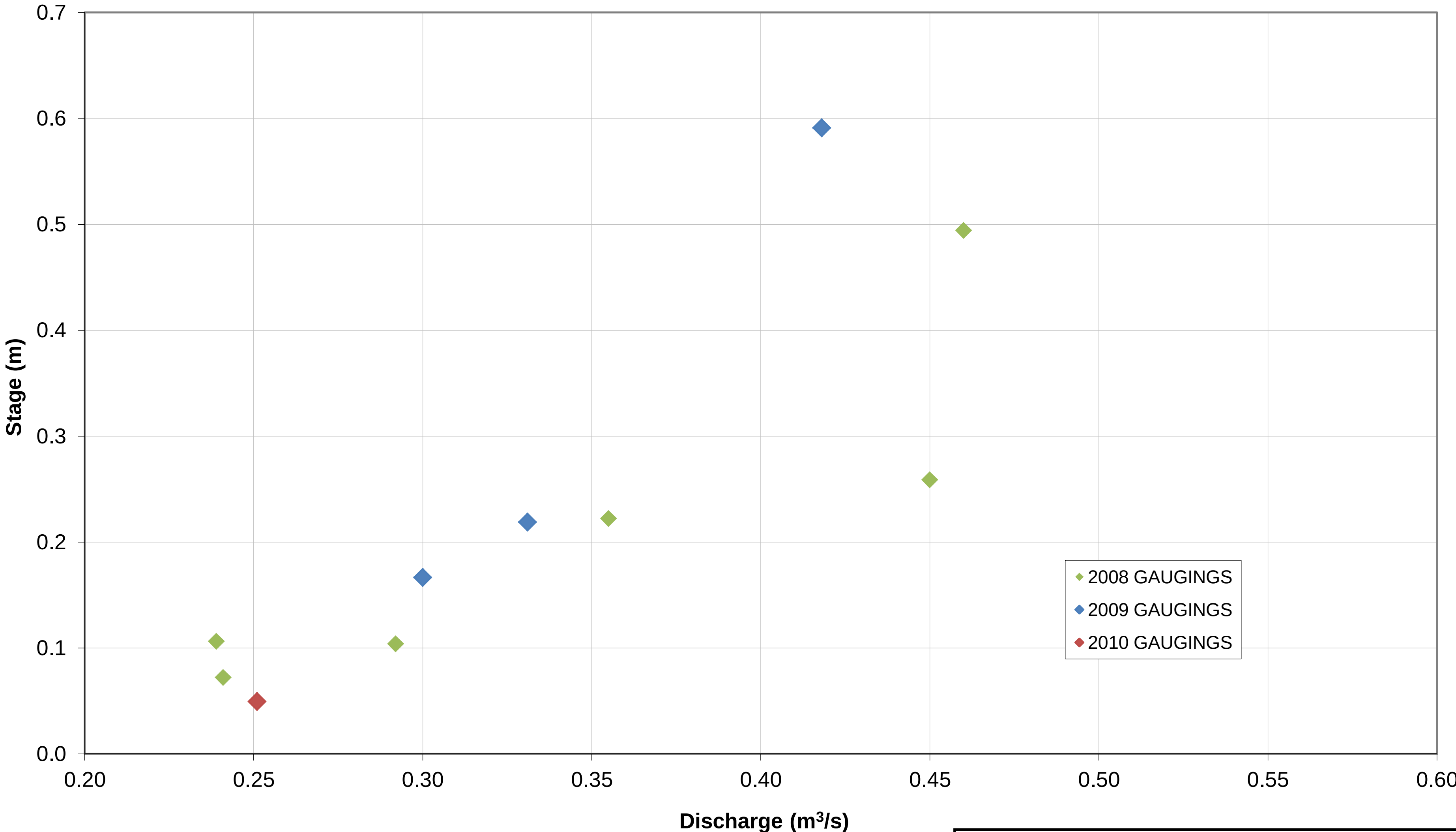
0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD
SISSON PROJECT

SB-1
PRELIMINARY RATING CURVE

Knight Piésold CONSULTING

P/A NO. VA101-447/01
REF. NO. VA11-01512
FIGURE 7
REV 0



0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD

SISSON PROJECT

MBB-1
STAGE-DISCHARGE DATA

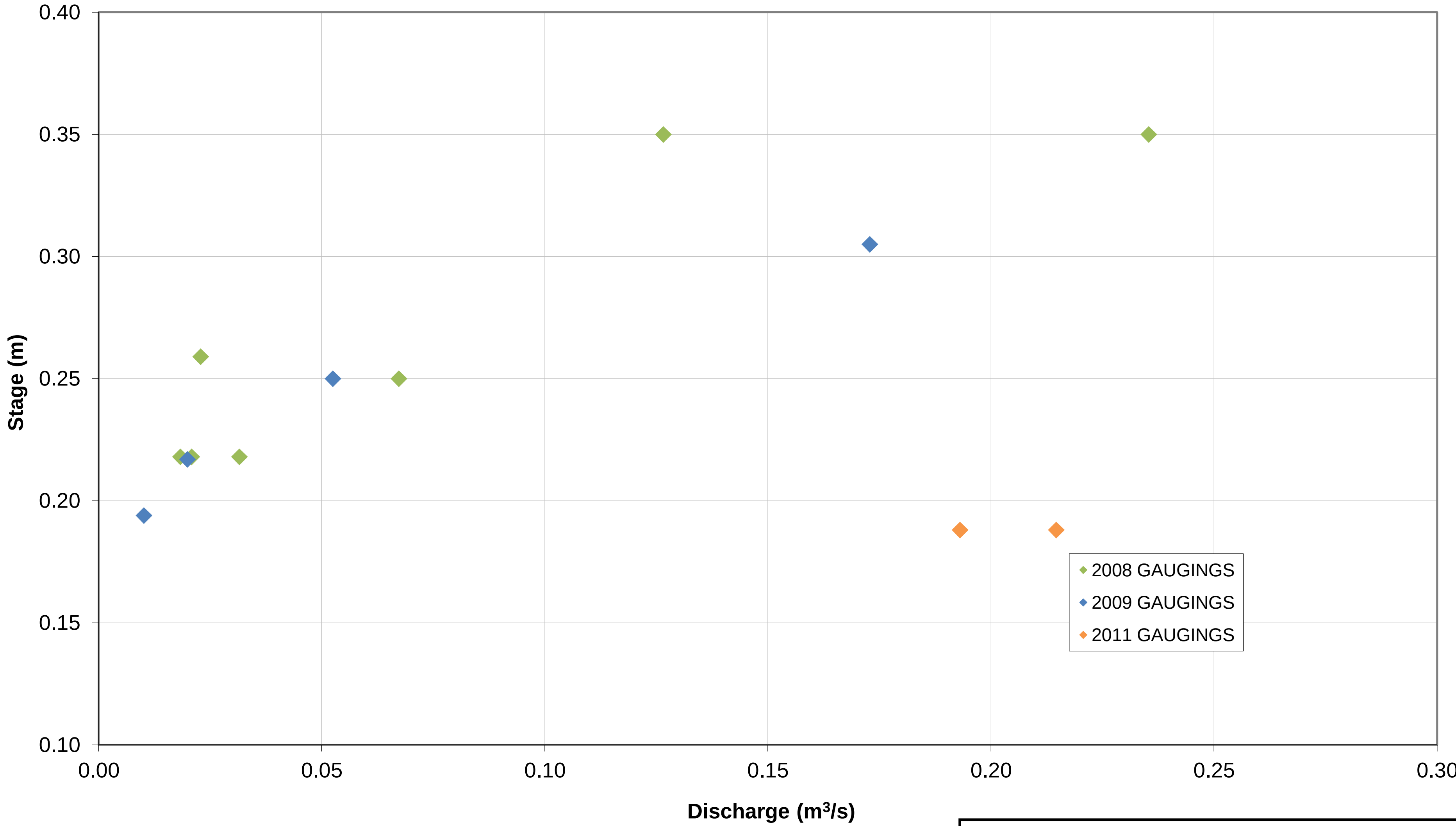
Knight Piésold CONSULTING

P/A NO. VA101-447/01

REF. NO. VA11-01512

FIGURE 8

REV 0



0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D

NORTHCLIFF RESOURCES LTD

SISSON PROJECT

CL-1
STAGE-DISCHARGE DATA

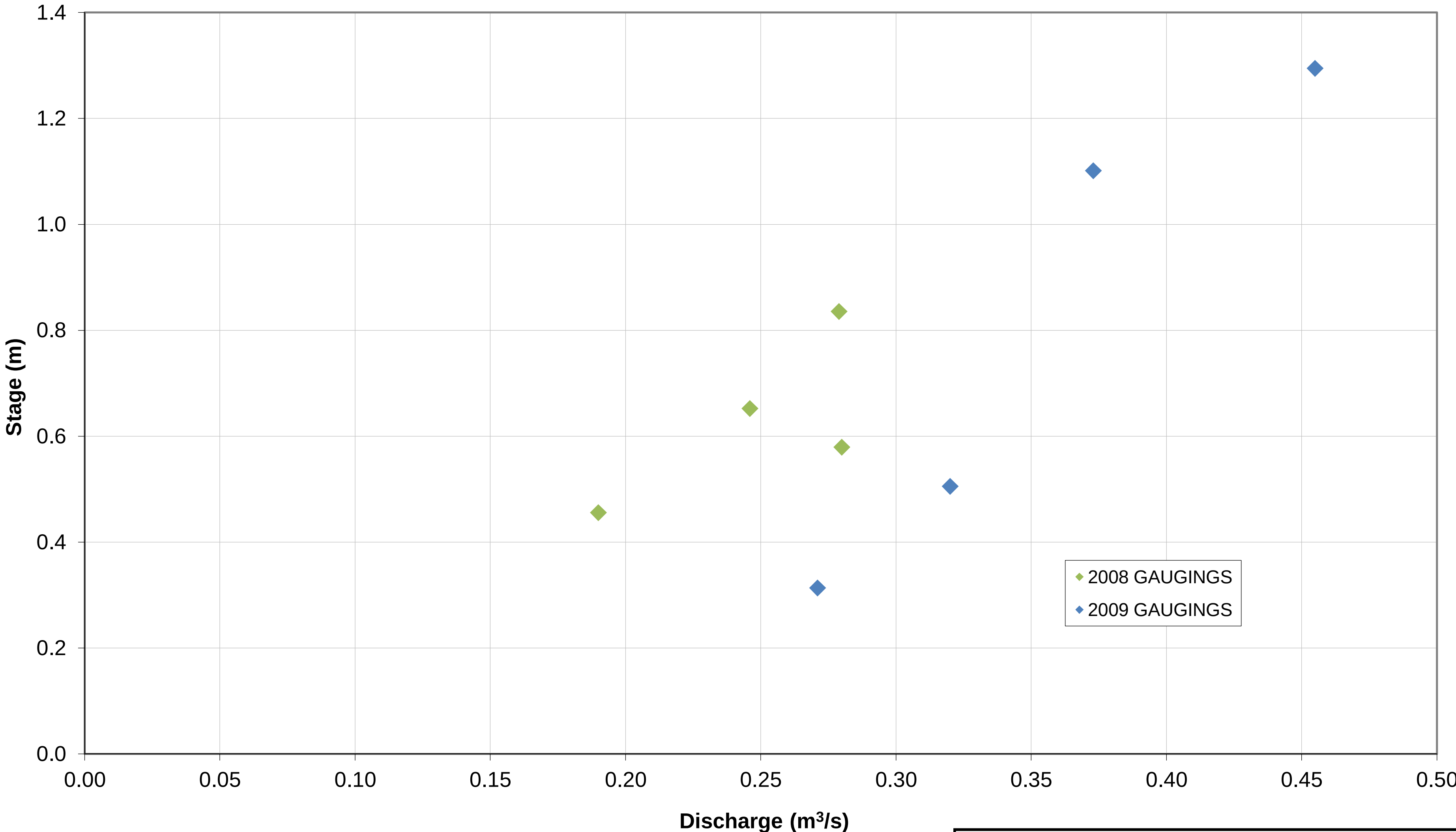
Knight Piésold CONSULTING

P/A NO. VA101-447/01

REF. NO. VA11-01512

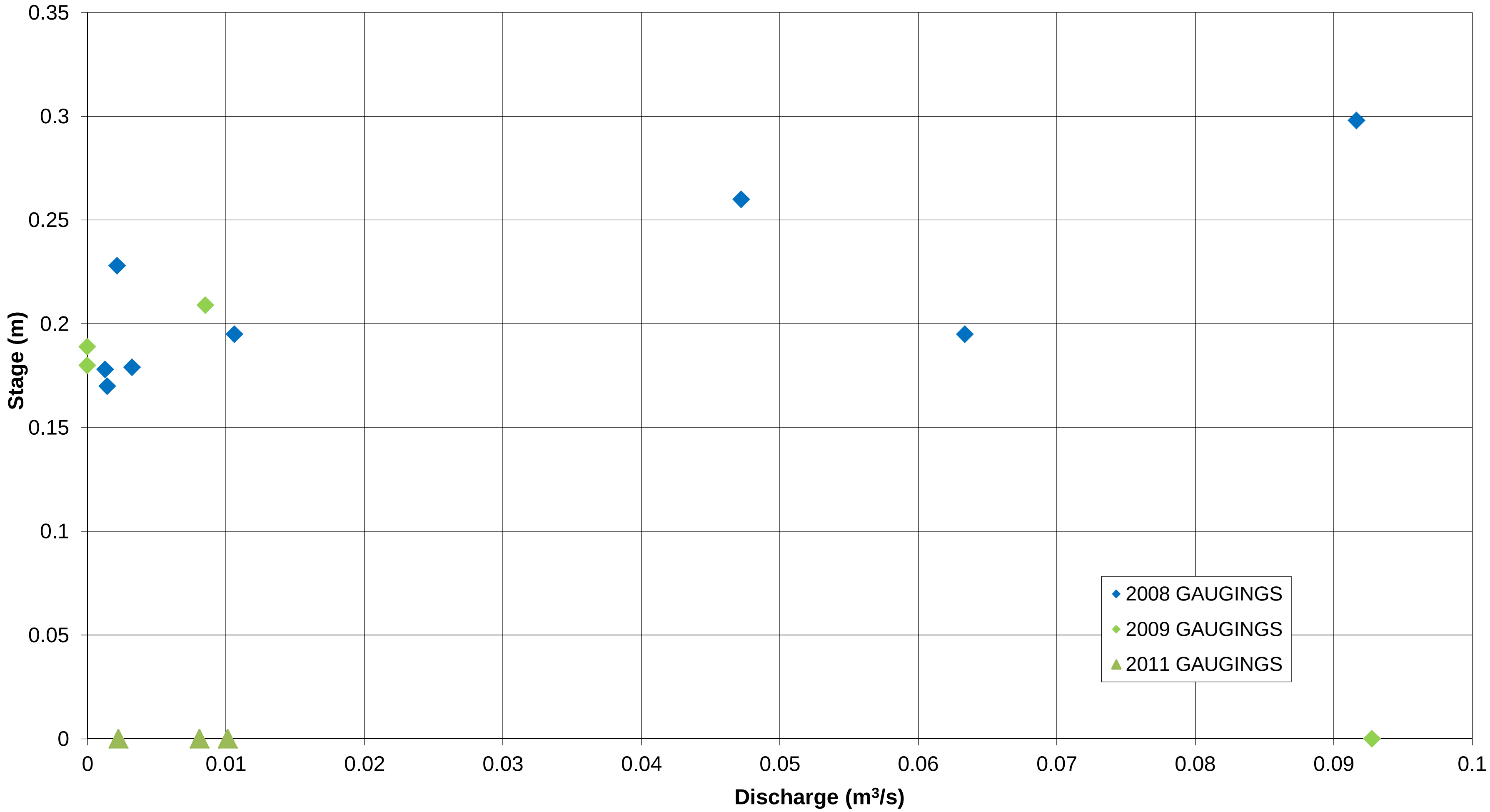
FIGURE 9

REV 0



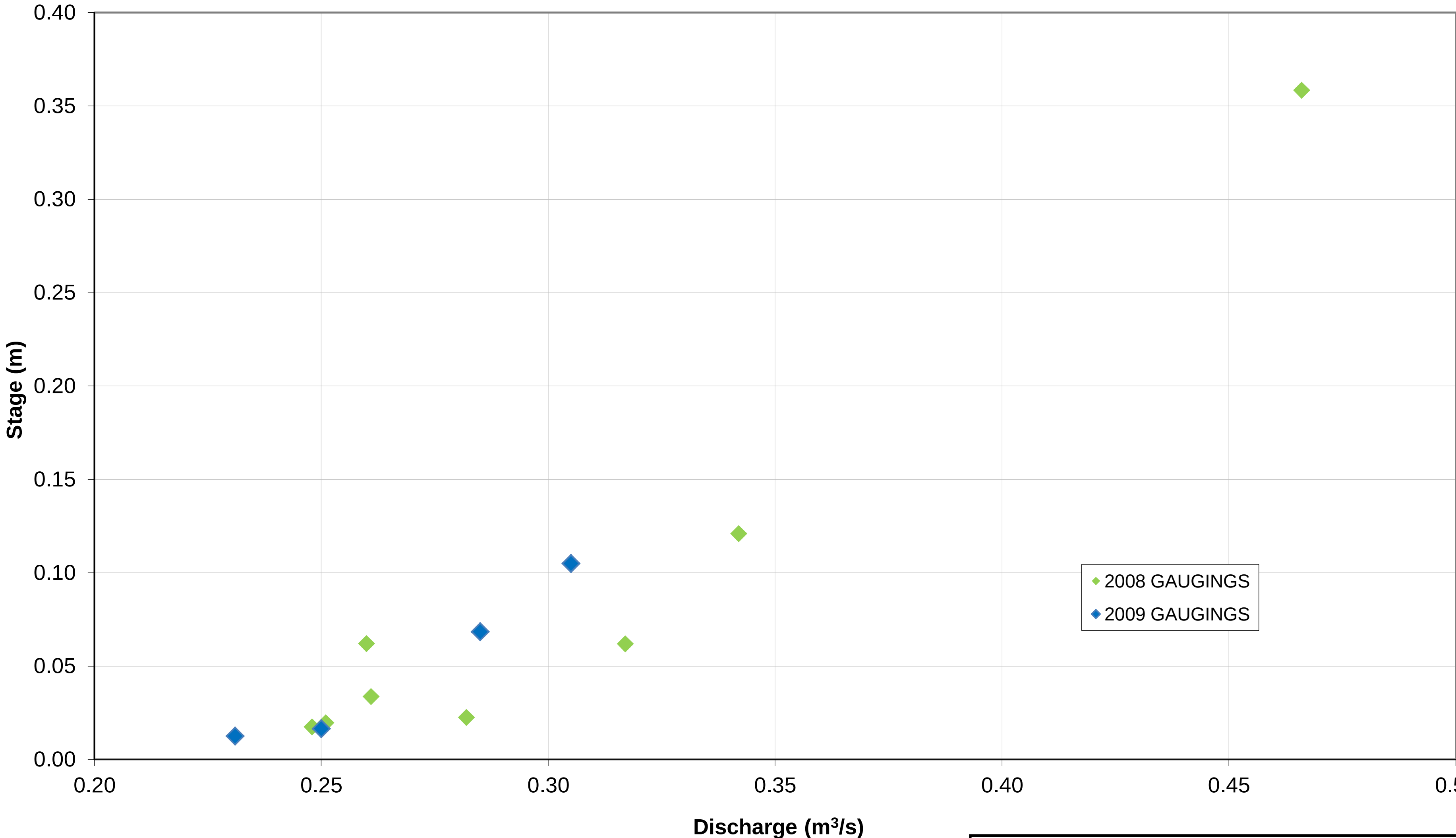
NORTHCLIFF RESOURCES LTD	
SISSON PROJECT	
NB-2 STAGE-DISCHARGE DATA	
Knight Piésold CONSULTING	P/A NO. VA101-447/01; REF. NO. VA11-01512
	FIGURE 10; REV 0

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD		
SISSON PROJECT		
FR-1 STAGE-DISCHARGE DATA		
Knight Piésold CONSULTING	P/A NO. VA101-447/01	REF. NO. VA11-01512
	FIGURE 11	REV 0

0	14DEC11	ISSUED WITH LETTER	BW	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD

SISSON PROJECT

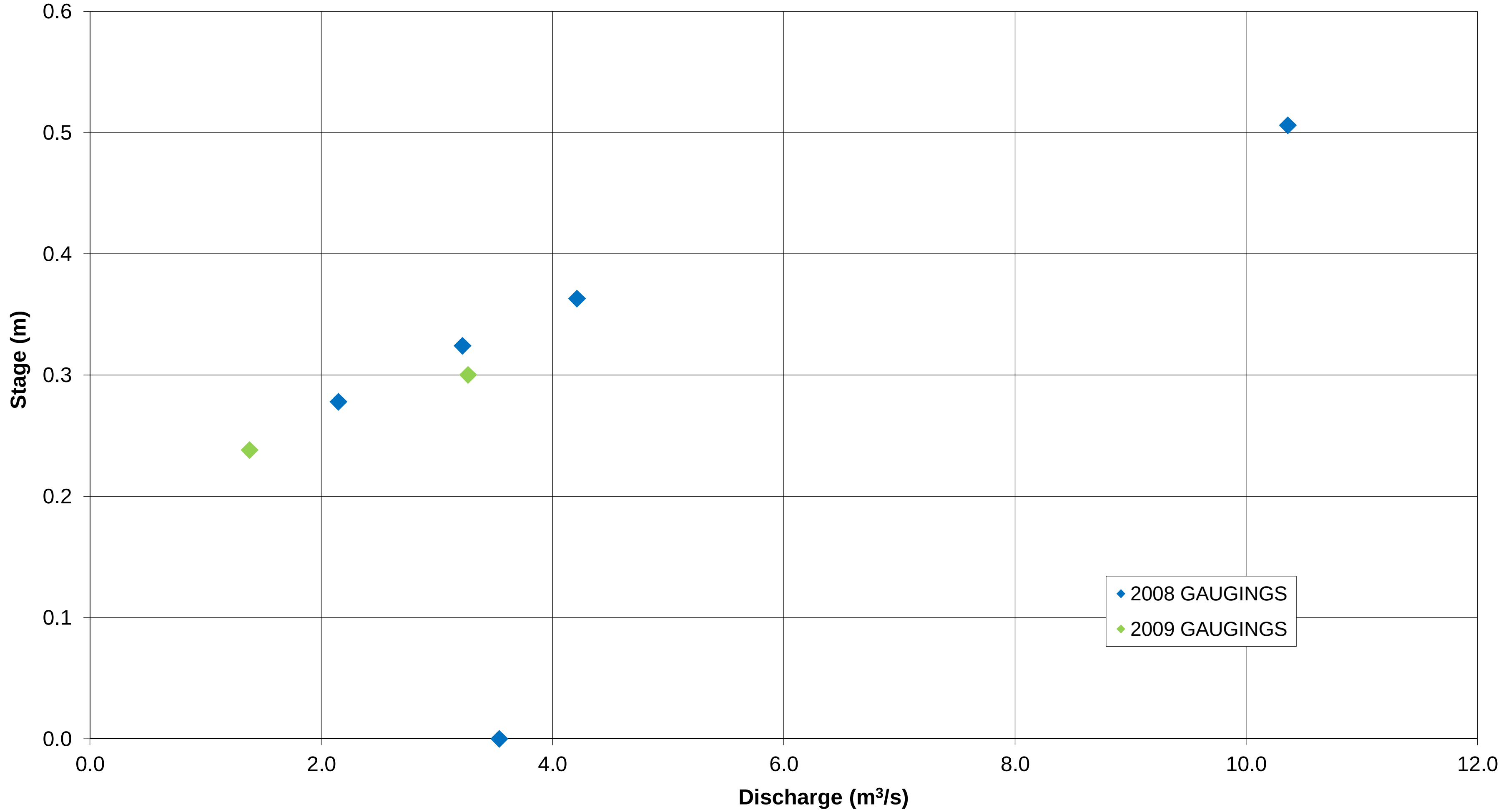
SB-3
STAGE-DISCHARGE DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-447/01	VA11-01512

FIGURE 12 REV 0

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



NORTHCLIFF RESOURCES LTD

SISSON PROJECT

NR-1A
STAGE-DISCHARGE DATA

Knight Piésold CONSULTING

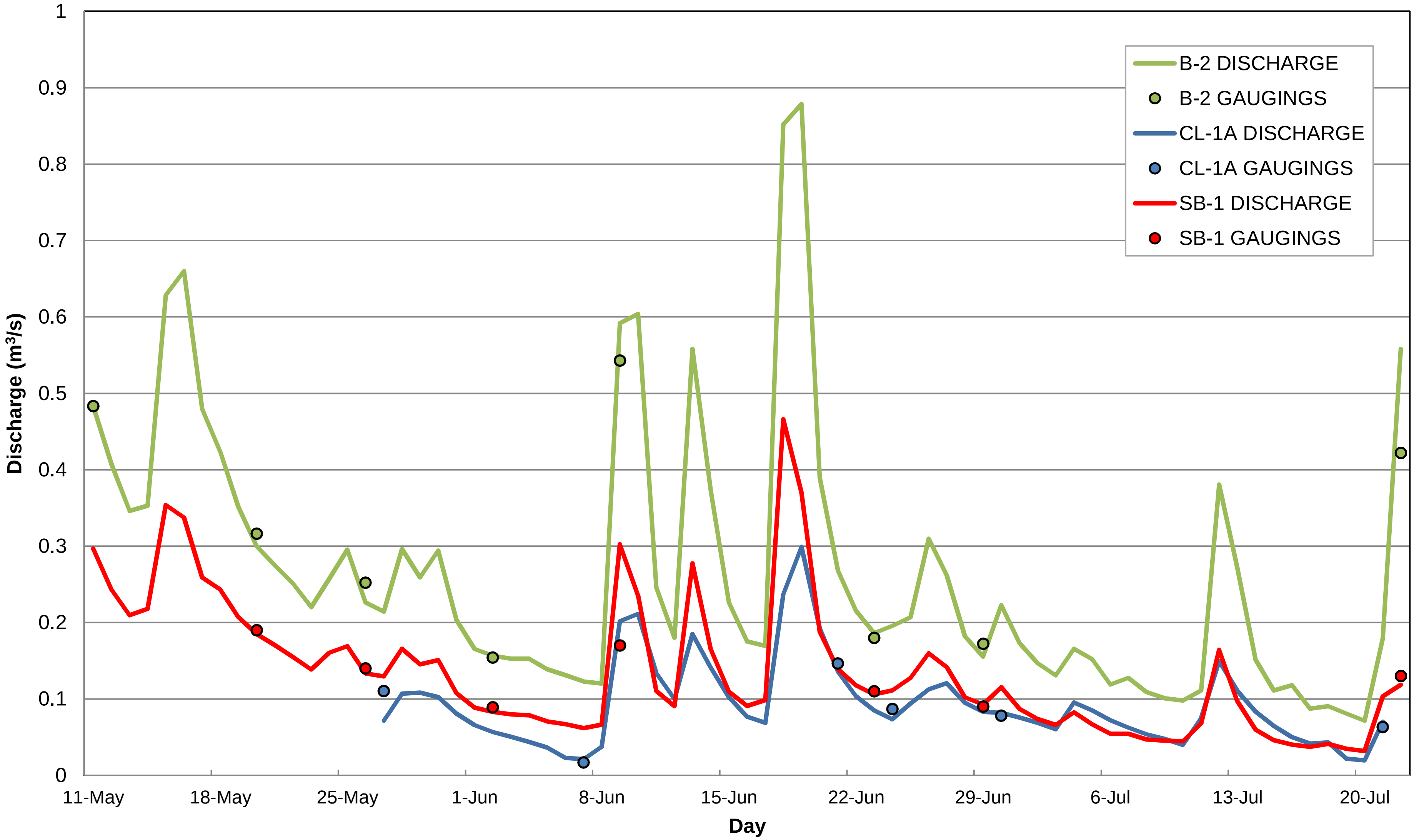
P/A NO. VA101-447/01

REF. NO. VA11-01512

FIGURE 13

REV 0

0	14DEC11	ISSUED WITH LETTER	BW	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHK'D	APP'D



0	2 NOV 11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D

NORTHCLIFF RESOURCES LTD.

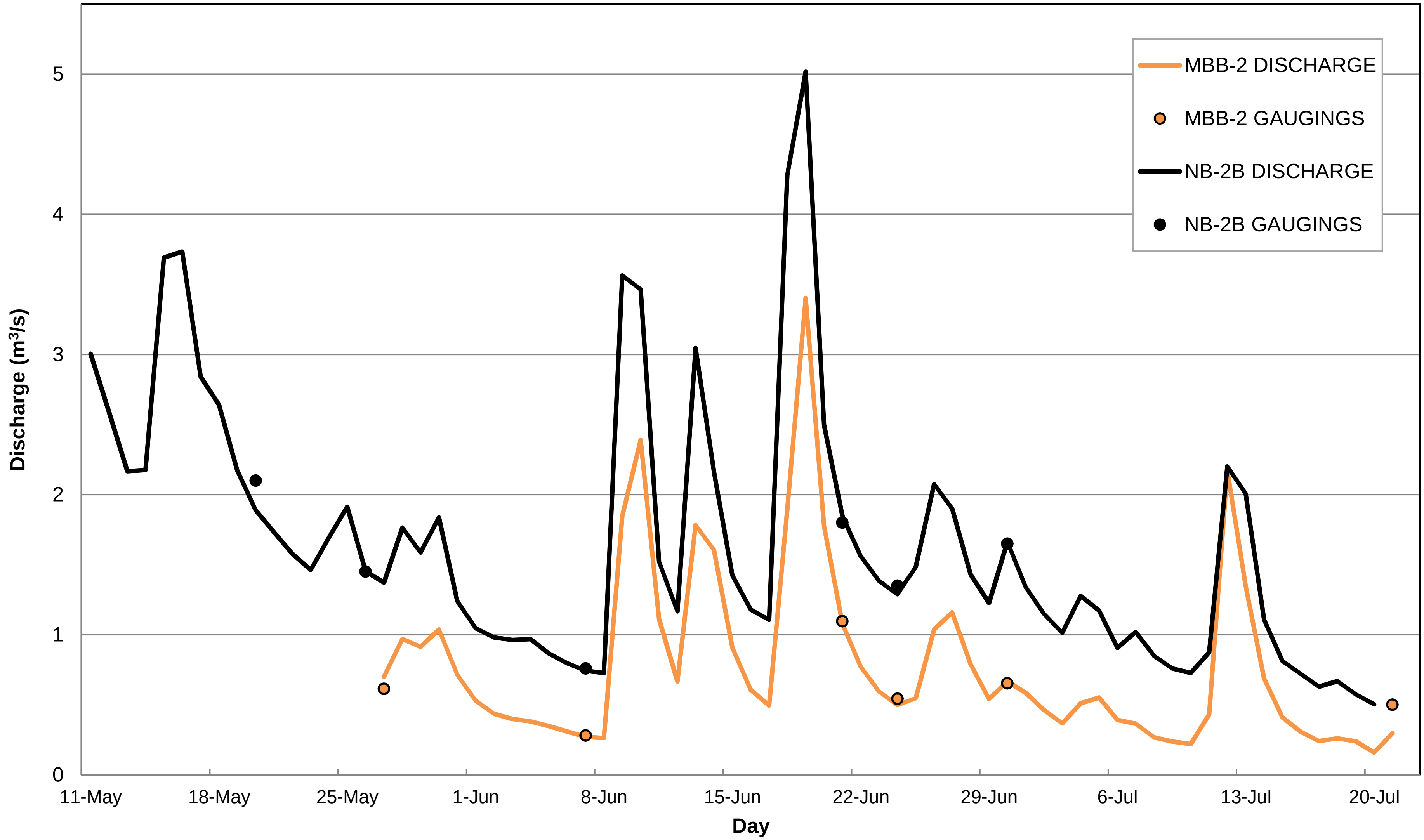
SISSON PROJECT

DISCHARGE HYDROGRAPHS B-2, CL-1A and SB-1

Knight Piésold CONSULTING

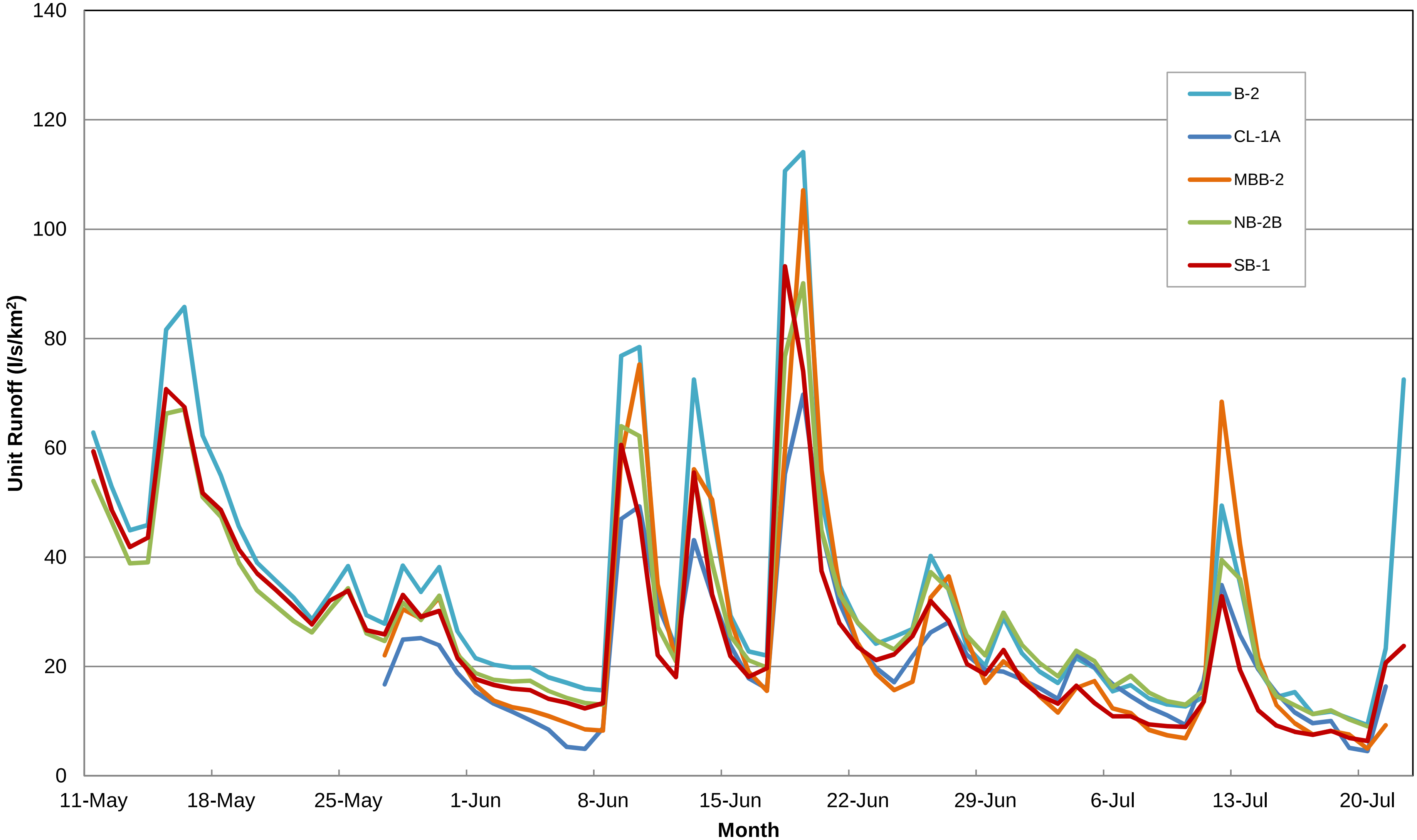
P/A NO.	REF. NO.
VA101-447/1	VA11-01512

FIGURE 14 REV 0



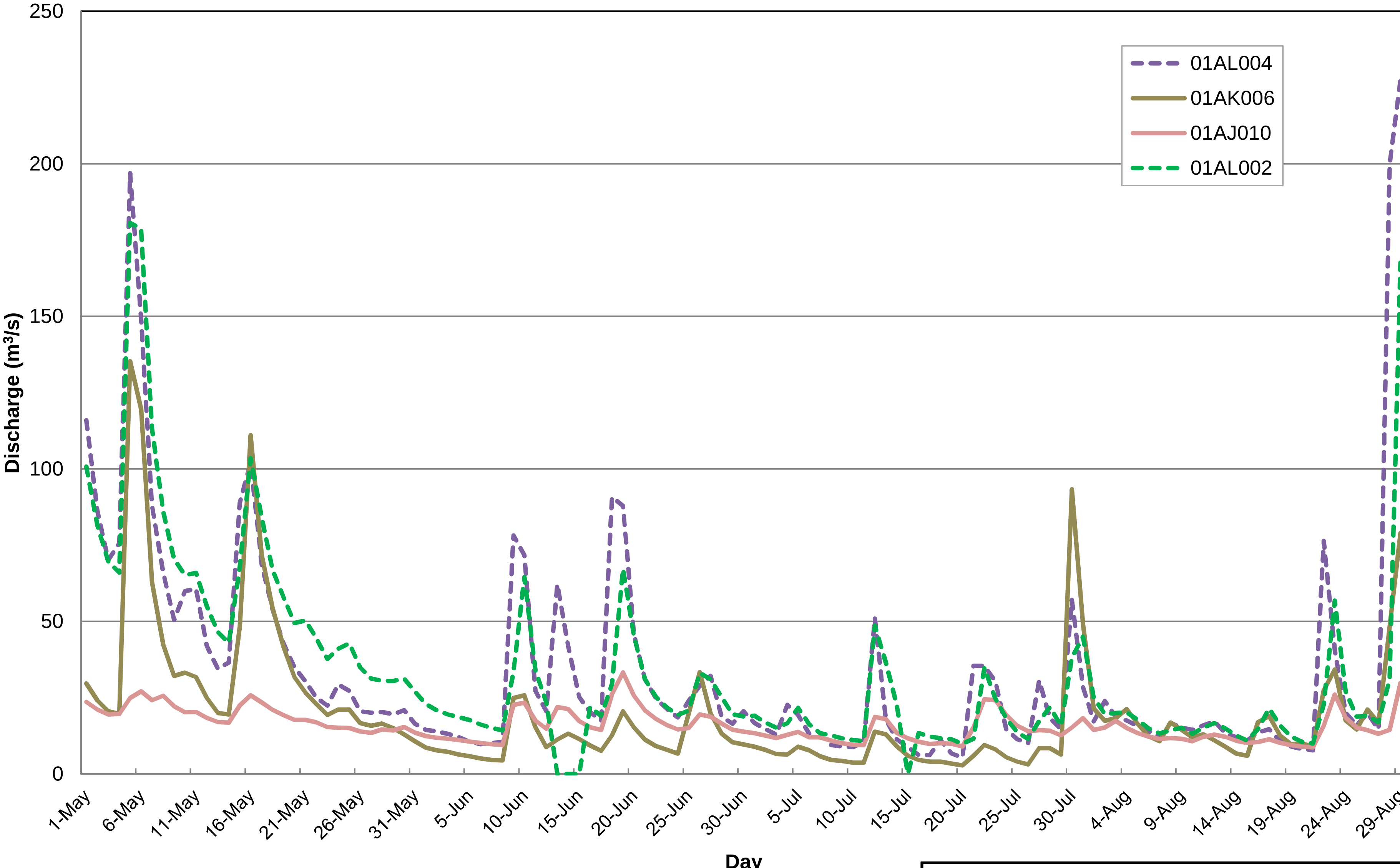
0	2 NOV 11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D

NORTHCLIFF RESOURCES LTD.		
SISSON PROJECT		
DISCHARGE HYDROGRAPHS NB-2B AND MBB-2		
Knight Piésold CONSULTING	P/A NO. VA101-447/1	REF. NO. VA11-01512
	FIGURE 15	REV 0



NORTHCLIFF RESOURCES LTD.	
SISSON PROJECT	
UNIT RUNOFF PROJECT STATIONS	
Knight Piésold CONSULTING	P/A NO. VA101-447/1 — REF. NO. VA11-01512
FIGURE 16	REV 0

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

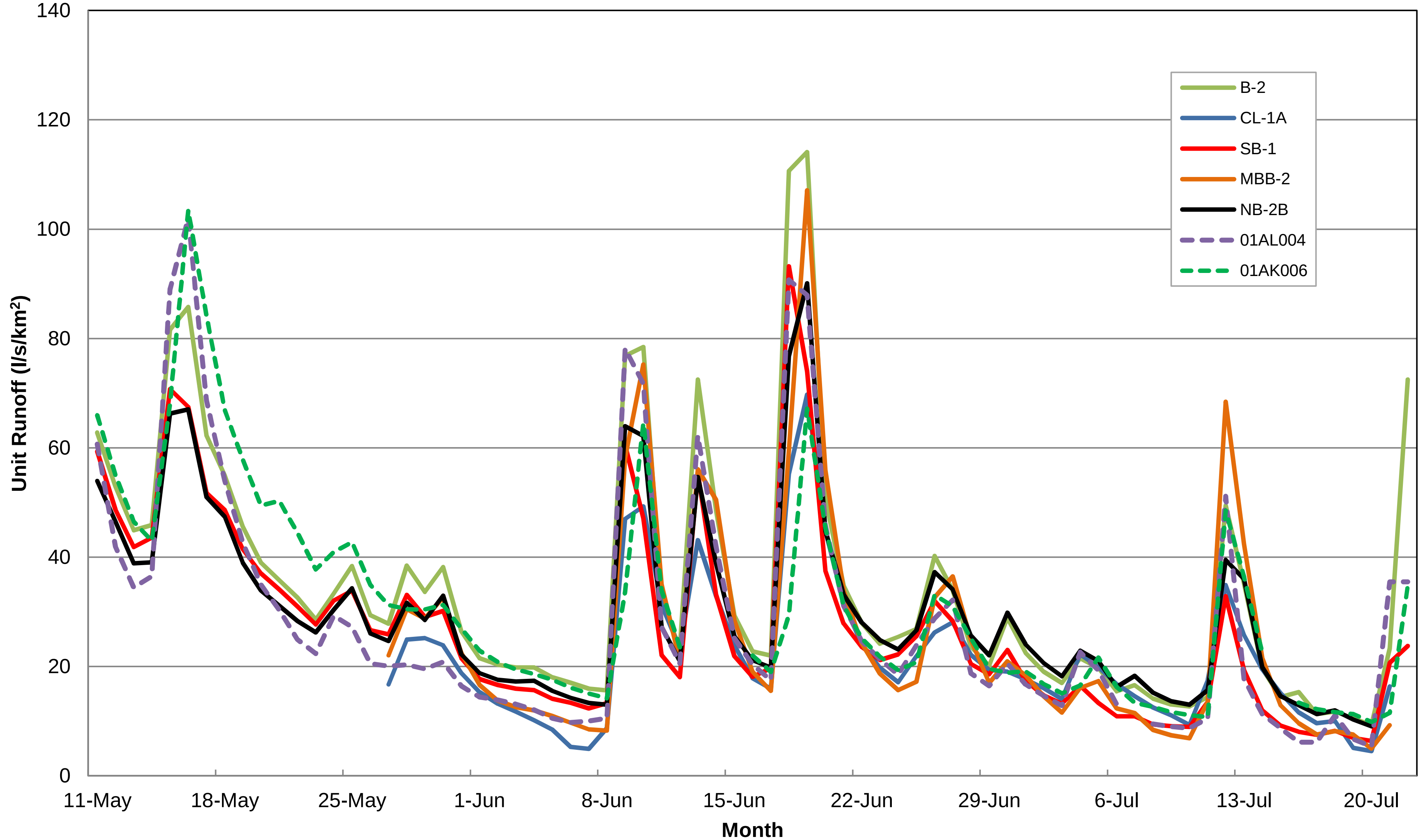
UNIT HYDROGRAPHS WSC STATIONS

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-447/1	VA11-01512

FIGURE 17 REV 0

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D



NORTHCLIFF RESOURCES LTD.

SISSON PROJECT

UNIT RUNOFF PROJECT AND WSC STATIONS

Knight Piésold CONSULTING

P/A NO. VA101-447/1

REF. NO. VA11-01512

FIGURE 18

REV 0

0	2NOV'11	ISSUED WITH LETTER	ALR	CMB	JGC
REV	DATE	DESCRIPTION	PREP'D	CHECKED	APPR'D

PHOTO 1 – Pressure Transducer Location at Station B-2

PHOTO 2 – Pressure Transducer Location at Station CL-1A

NORTHCLIFF RESOURCES
SISSON PROJECT HYDROLOGY

PHOTO 3 – Section Control for Gauging at Station FR-1A

PHOTO 4 – Pressure Transducer Location at Station MBB-2

NORTHCLIFF RESOURCES
SISSON PROJECT HYDROLOGY

PHOTO 5 – Pressure Transducer Location at Station NB-2B

PHOTO 6 – Pressure Transducer Location at Station SB-1

NORTHCLIFF RESOURCES
SISSON PROJECT HYDROLOGY

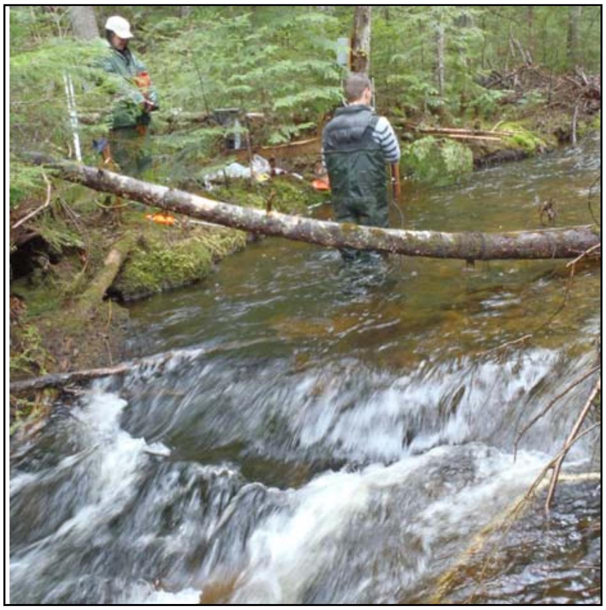


PHOTO 7 – Section control downstream of pressure transducer at station SB-1

PHOTO 8 – Channel at SB-3A