APPENDIX A: Climate and Meteorology

A-2. Design Storm Events

MEMORANDUM

To:	Greg Magoon	Date:	June 26, 2015
		File No.:	VA101-460/3-A.01
From:	Brendan Worrall	Cont. No.:	VA15-02672
Re:	Design Storm Events		

Estimated design storm events for the Black Butte Copper Project (the Project), at elevation 1737 masl, are presented in this memorandum as part of the design basis for the proposed mine facilities. Corresponding storm events for different elevations should be determined on the basis of expected orographic patterns, which are not discussed in this memorandum.

1 – 24 HOUR EXTREME RAINFALL

1.1 24 HOUR EXTREME RAINFALL

Annual daily extreme rainfall values were obtained from the Western Regional Climate Data Center (WRCC) for several regional climate stations that are located in reasonably close proximity to the Project area. The mean and standard deviation of the annual daily extreme values for the regional stations were averaged and the results were applied to a Gumbel distribution to generate corresponding return period daily extreme rainfall estimates. These results were then scaled by the standard factor of 1.13 (Miller, 1963) to convert them to equivalent 24 hour extreme values, as summarized in Table 1.

Table 1 24 Hour Extreme Rainfall

Return Period (years)	Extreme Rainfall (mm)
2	35
5	49
10	58
15	64
20	67
25	70
50	79
100	88
200	96

These values were compared to regional 24 hour return period rainfall figures, which can be accessed through the following link: http://www.wrcc.dri.edu/pcpnfreq/, and were found to be similar. As a result, the above values are considered to be reasonable and appropriate estimates of 24 hour return period rainfall for the Project site.

1.2 PROBABLE MAXIMUM PRECIPITATION

Guidelines for estimating Probable Maximum Precipitation (PMP) for the United States, as presented by the National Oceanic and Atmospheric Administration (NOAA) (http://www.nws.noaa.gov/oh/hdsc/studies/pmp.html), were used to determine a PMP value for the site. Specifically, the project is located in the region indicated in light blue on Figure 1 and the corresponding PMP guidelines are detailed in HMR 55a (Hansen et al., 1988).

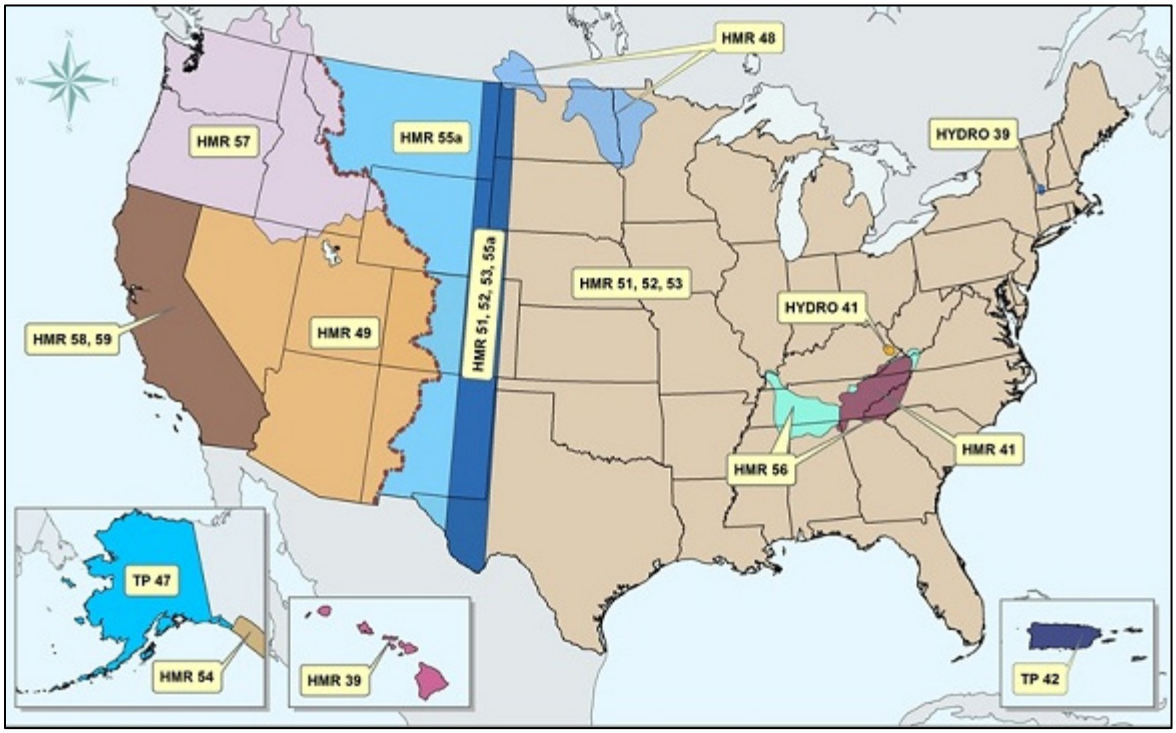

Figure 1 NOAA PMP Regions and Guideline Documents

The PMP for the Project area is estimated to range from 21 to 22 inches. A value of 22 inches was selected for the Project, which equates to 560 mm.

2 – PROBABLE MAXIMUM FLOOD

The methodology used to calculate the Probable Maximum Flood (PMF) for the Black Butte Copper Project follows the Canadian Dam Association (CDA) 2007 guidelines, which state that the PMF is the largest flood resulting from the following two cases:

1. Probable Maximum Precipitation (PMP) + 1:100 year snow accumulation.
2. Probable Maximum Snow Accumulation (PMSA) + 1:100 year rainfall event.

The PMP and 1:100 year rainfall event are 560 mm and 88 mm, respectively. Snow course and snow telemetry data from six regional sites were obtained from the National Water and Climate Center website to determine the 1:100 year snow accumulation for the project. The mean annual maximum snow water equivalent (SWE) and coefficient of variation (Cv) were determined for each station and suitable values for the project were selected on the basis of proximity and elevation. These values were used as inputs for a Gumbel distribution in order to calculate the 1:100 year snow accumulation. The PMSA was estimated as 2 times the 100 year snow accumulation, according to directions provided in the Guidelines on Extreme Flood Analysis (Alberta Transportation, 2004). These approaches resulted in 1:100 year snow accumulation and PMSA values of 290 mm and 580 mm, respectively.

The maximum moisture inputs for the two PMF scenarios are summarized as follows:

1. PMP + 100 year snowpack = 560 mm + 290 mm = 850 mm.
2. PMSA + 100 year rainfall = 580 mm + 88 mm = 668 mm.

The maximum moisture input to be used for calculating the PMF for the Project site is 850 mm.

We trust that the calculated design storm values are suitable for your needs as this time. Please contact the undersigned if you have any questions or comments.

Prepared:

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June 25, 2015

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Approval that this document adheres to Knight Piésold Quality Systems:

References:

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Hansen, E.M., D.D. Fenn, L.C. Schreiner, R. W. Stodt and J.F. Miller, 1988. *Probable Maximum Precipitation Estimates – United States Between the Continental Divide and the 103rd Meridian*, Hydrological Report 55a, US Department of Commerce – NOAA, Silver Spring, MD.

Miller, J., 1963. *Probable Maximum Precipitation and Rainfall-Frequency Data for Alaska*, Technical Paper No. 47, US Department of Commerce – Weather Bureau, Washington, DC.

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