ATTACHMENT B

Dr. Nieber's Memorandum

September 10, 2012

TO: Randall Doneen, Minnesota DNR
FROM: John Nieber, University of Minnesota
SUBJECT: Effect of snowmaking on erosion.

The WEPP model Version 2010.100 was applied to calculate the sediment yield from a ski slope located at the Lutsen ski area. The slope angle is about 35%, the slope length is 680 feet and the slope width is 2177 feet. The soil on the slope is mapped as Quetico, a shallow soil with bedrock close to the surface. The average solum thickness is about 5 inches. The saturated hydraulic conductivity of the soil was assumed to be 4 inch/hour. Vegetative cover was varied in the calculation results summarized below using short grass prairie as the model vegetative cover. The density of the cover was varied as well as the fraction of residue cover. The density of the vegetative cover was represented by the leaf area index (LAI). Of course the higher the residue cover and the higher the LAI the better the vegetative cover will protect the soil from raindrop impact and overland flow shear stress. The model itself calculates the change of vegetative cover during the growing season using these input vegetative parameters.

The climate data input to the model was a five-year series of weather data derived for the Lutsen site using the density meteorological network. The input includes daily precipitation amount and duration of storm, daily max/min temperatures, daily solar radiation and wind speed, and dewpoint temperature. To account for artificial snow applications the precipitation in the weather input file was augmented with added precipitation on days when the air temperature was below zero degrees thereby producing snow in the model. The actual monthly water withdrawal records (provided by Randall Doneen) for the five-year period were used to fix the amounts of artificial snow produced.

One limitation of the model is that it assumes that snow formed (natural or artificial) has 10% water equivalent. Actually artificial snow is more at the 50% water equivalent value (and natural snow is not always at 10% either). This means that the artificial snow produced in the model will produce deeper snowpacks, an effect that will insulate the soil more and thereby perhaps reduce soil freezing. This will have the effect to potentially reduce surface runoff. Thus the sediment yields presented in the following might be underestimated. However, the sensitivity to the vegetative cover and to slope length will be similar to that which would be expected if the exact snow water equivalent were used.

The results of the simulations are summarized in Table 1. It is clear from this result that it is greatly beneficial to increase the vegetative cover for a slope, and it is also very beneficial to reduce the slope length.

Table 1. Mean annual sediment delivered to the toe of the hillslope for various conditions of added artificial snow (given as depth of snow water equivalent), vegetative cover, and slope length. The slope length used for nearly all of the calculations was 680 feet, and the slope width was 2177 feet.

Short prairie cover; initial residue and LAI	Snow water equivalent of artificial snow (inches)			
	0	10.8	20.9	31.5
40%; 0.5	4.7	7.2	23.6	100.1
40%; 2.0	1.1	1.4	2.6	8.7
40%; 4.0	0.3	1.2	1.3	4.0
80%; 1.0	4.0	6.1	17.0	73.1
80%; 2.0	1.1	1.5	1.9	5.7
80%; 4.0	0.3	1.2	1.1	2.9
40%; 0.5 with half slope length (340 feet)	0.3	0.8	0.5	0.6
Tall prairie – 80%; 4.0	0.3	0.9	0.9	2.1