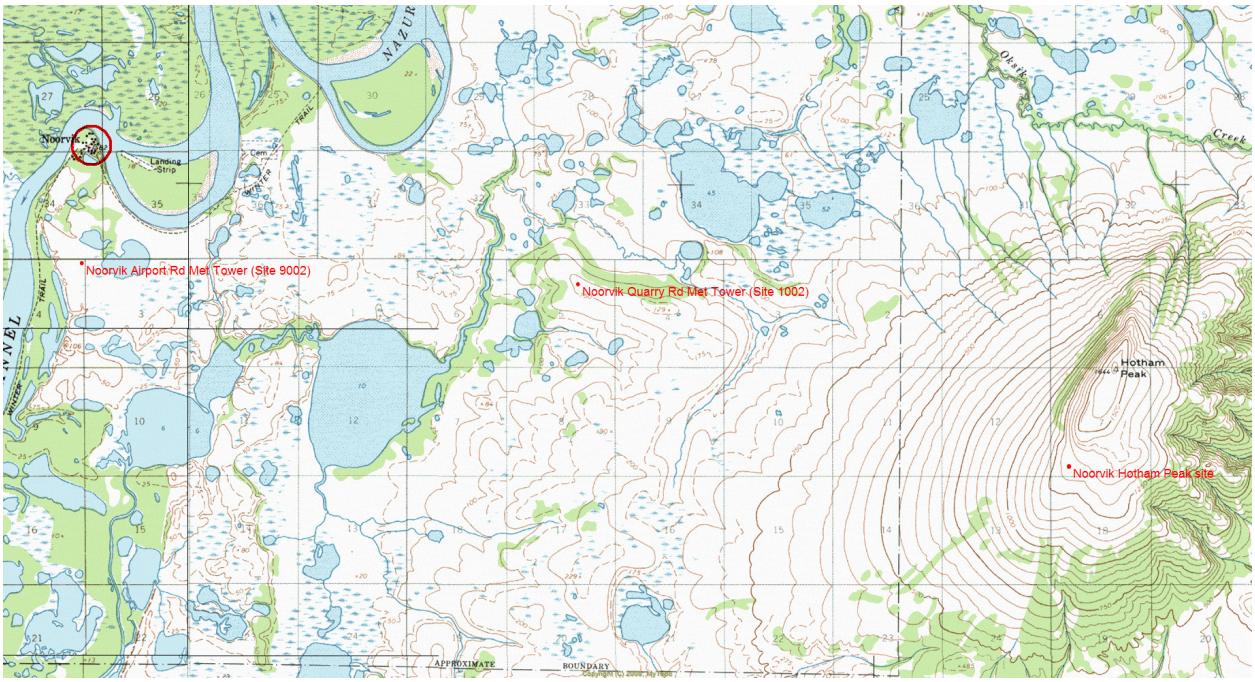
WAsP Analysis of Noorvik Met Tower Sites, rev. 1

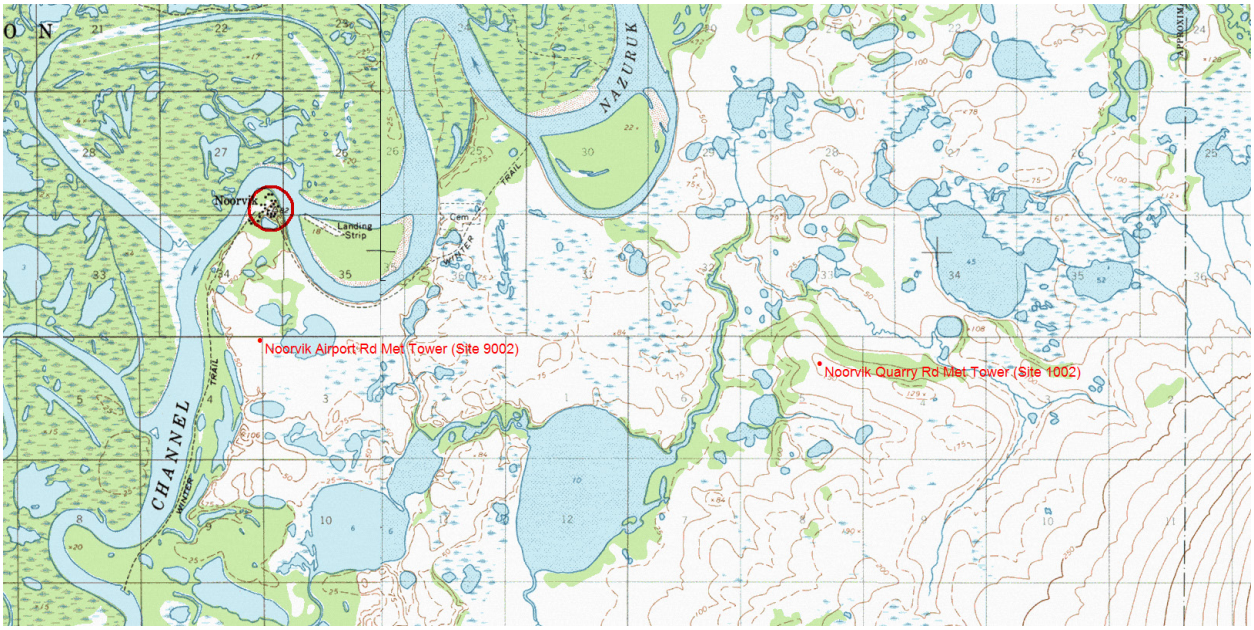
August 14, 2012

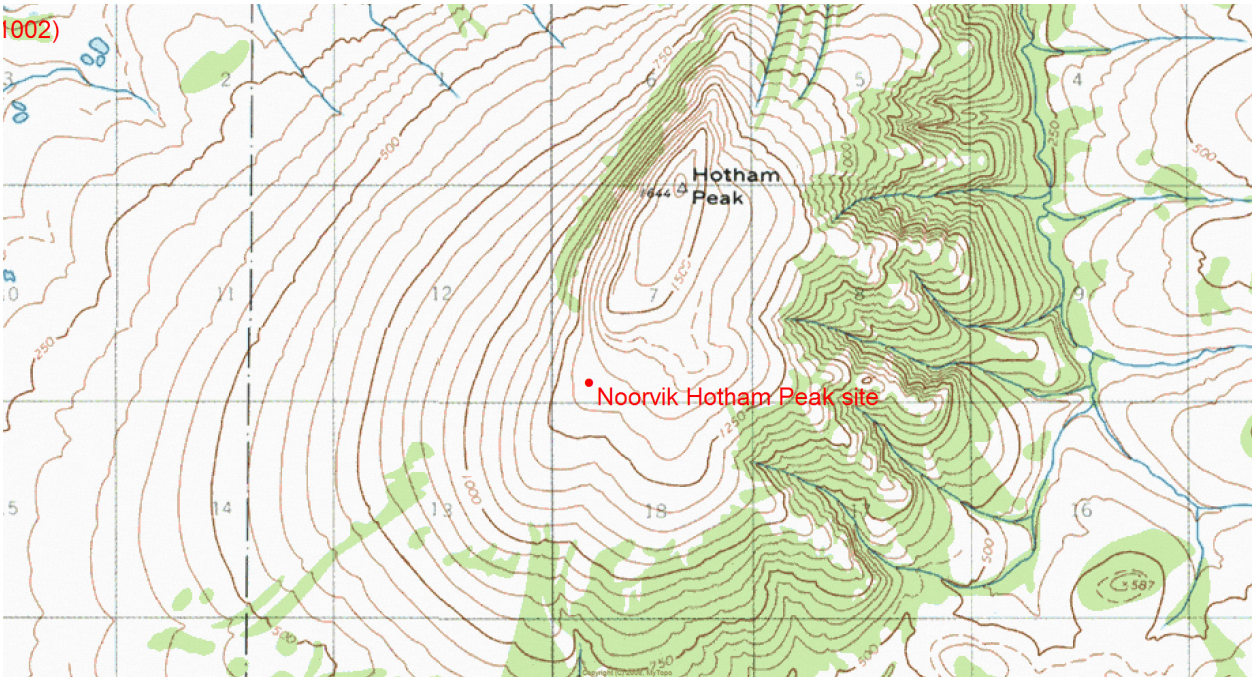
The purpose of this report is to present results of a WAsP software analysis of Noorvik Quarry Road met tower site data to predict the wind resource in the vicinity of the met tower, at the location of a newly installed met tower near the new Noorvik airport (Noorvik Airport Road site), and at a site on Hotham Peak of possible interest for wind power development. Note that the Quarry Road met tower was installed in October 2010 and the new Airport Road met tower in July 2012. Both met towers are presently operational.

Note that WAsP (Wind Atlas and Application Program) is PC-based software for predicting wind climates, wind resources and power production from wind turbines and wind farms. WAsP software sees widespread use in the wind industry and is the calculation "engine" for other wind power software such as WindFarmer and WindPro.

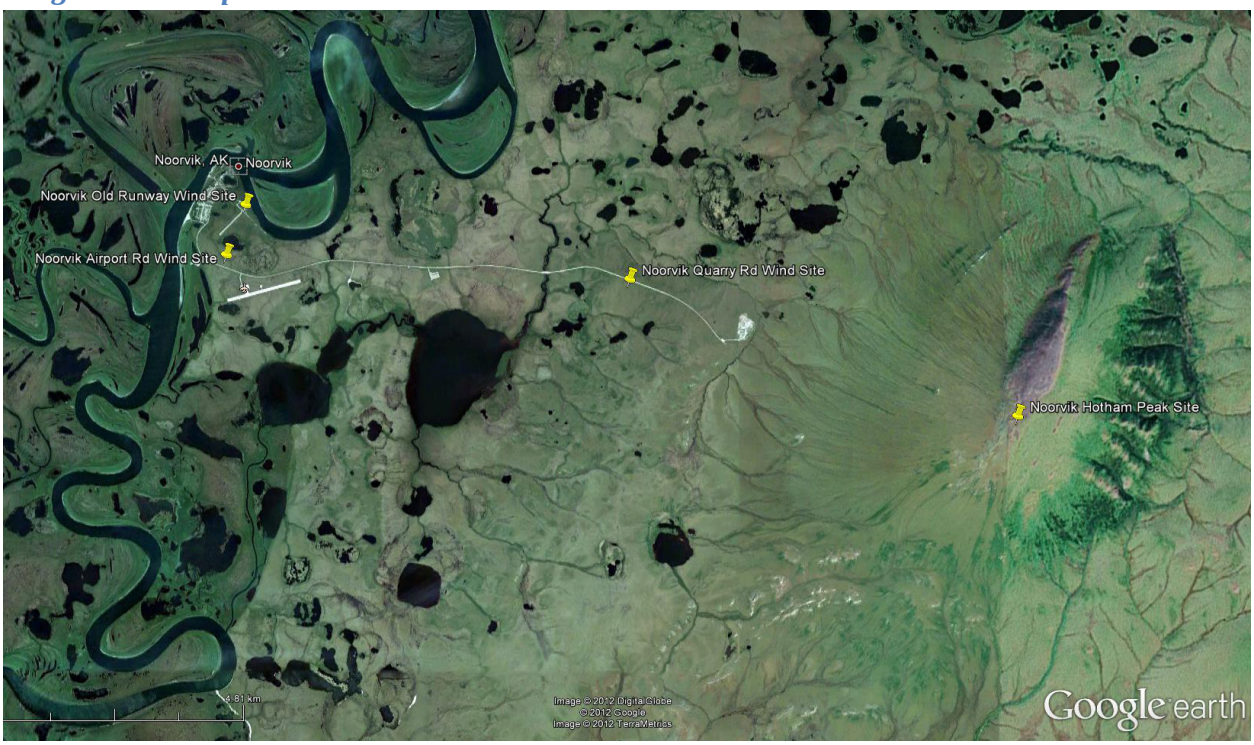
Topographic maps

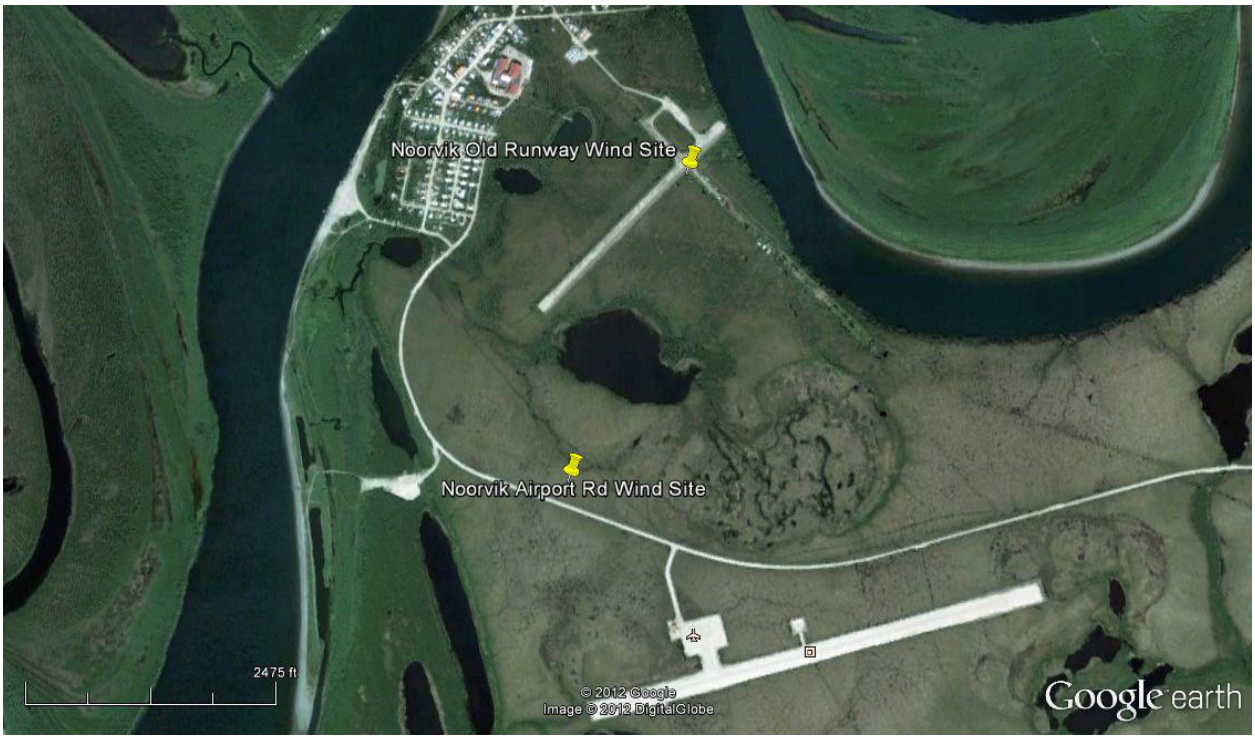



NAZURUK
CHANNEL
Noorvik
Landing Strip
Cem.
TRAIL
Noorvik Airport Rd Met Tower (Site 9002)
Noorvik Quarry Rd Met Tower (Site 1002)

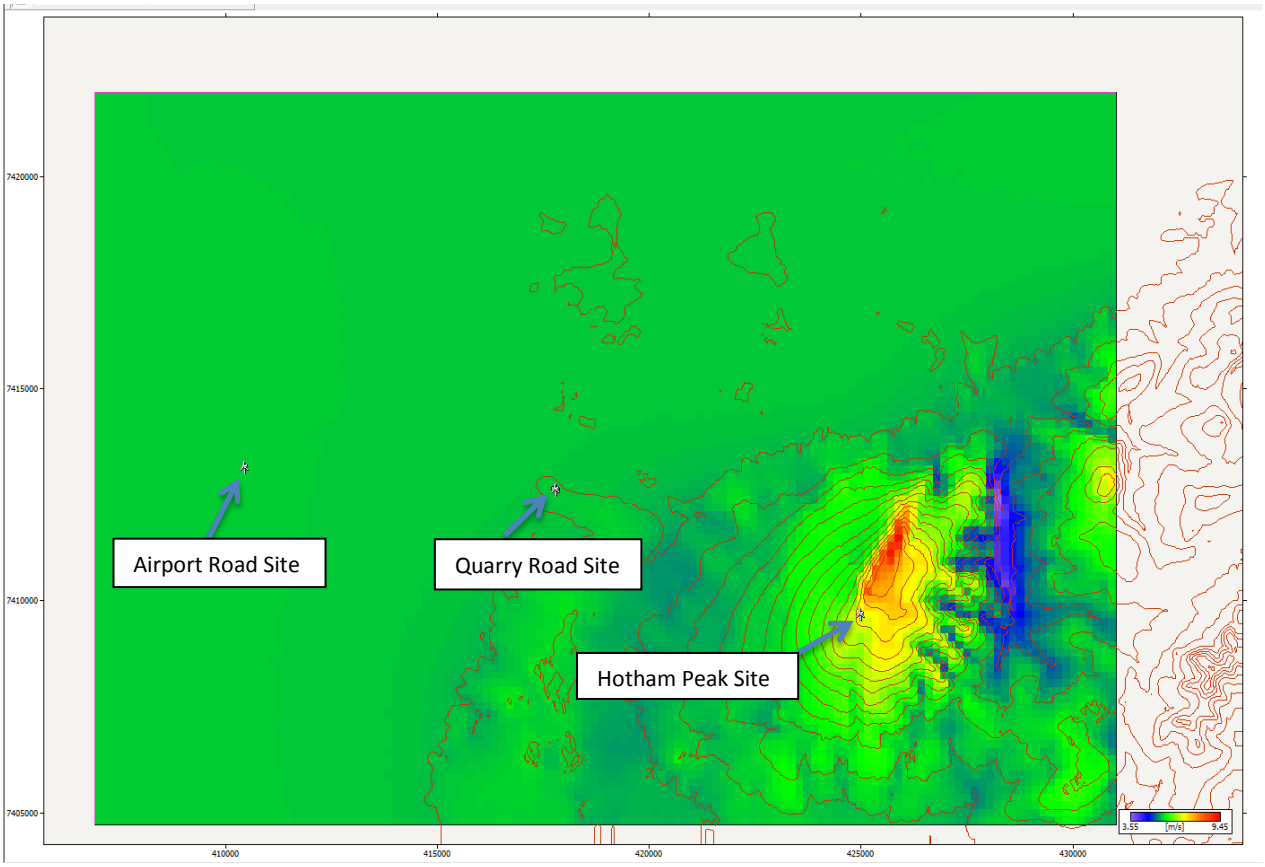

1002)
Hotham Peak
1644
Noorvik Hotham Peak site

Google Earth maps





WAsP wind speed map



Predicted site wind speed and turbine performance

Wind speed and turbine annual energy production (AEP) are calculated by the WAsP software. Turbine AEP is based on the NW100B turbine at a 37 meter hub height. Note that the height of the upper level anemometers on the new met tower at Noorvik Airport Road wind site is 33.5 meters while the anemometer height at the Quarry Road met tower is 30 meters. Using nineteen months of Quarry Road met tower as the reference met station, with seasonal data bias removed (data was normalized to a 12 month period), wind speed data was adjusted with sector-specific shear values to 37 meters.

Site comparison table, WAsP calculations

	Mean Wind speed, 37 m level, m/s	Mean Power Density, 37 m level, W/m^2	AEP, NW100B, 37 m hub ht., MWh/yr	AEP compared to Quarry Road met tower, %
Quarry Road reference site (Site 1002)	5.66	326	211.4	-
Airport Road met tower site (Site 9002), predicted by WAsP	5.65	328	210.9	99.7%
Hotham Peak site, predicted by WAsP	7.03	678	286.8	135.6%

Discussion

Hotham Peak Site

WAsP modeling predicts, as one would expect, that the prospective wind site on Hotham Peak experiences markedly stronger winds than the Quarry Road (met tower) site. Although the mean power density on Hotham Peak is predicted to be over twice that measured by the Quarry Road met tower, predicted turbine AEP is only 35 percent greater. This is due to the non-linear relationship between wind power density and energy production of wind turbines.

Due to the significant vertical relief of the surrounding terrain, wind shear at the Hotham Peak site is likely significantly lower than at the Quarry Road met tower site. This is significant in that vertical extrapolation of wind speed at Quarry Road is based on the measured 0.135 power law exponent shear coefficient. The power law exponent at the Hotham Peak site will be much less, possibly near zero. So, predicted performance of a turbine at a high hub height, for example 75 meters, will be biased very high if using Quarry Road met tower data without consideration of shear differences. For the analysis in this report, considering that 37 meters is only approximately 20 percent higher elevation than 30 meters, shear was assumed to be equivalent at all three sites. But, prediction of wind resource and turbine AEP at the Hotham Peak site for elevations higher than 37 meters should be approached with caution. The preferred solution, of course, is to install a met tower at the Hotham Peak site to directly measure site-specific wind shear.

Airport Road Site

WAsP modeling predicts that the new Airport Road met tower site will yield equivalent mean wind speed, power density and turbine AEP as at the Quarry Road site. This may prove true, and comparative analysis of data collected over the next twelve months from both sites will verify or refute the prediction, but there is reason to believe in this circumstance that the WAsP model is over-predicting the wind resource and turbine AEP at the Airport Road met tower site compared to the Quarry Road met tower site.

From 2008 to 2010, a 30 meter met tower had been installed on the old Noorvik airport. Unfortunately, the data logger for that met tower suffered a number of significant problems and only a partial year data set was recovered. Comparing the data that was recovered, however, to the Quarry Road site met tower data indicated a consistently lower wind resource at the old airport. The new Airport Road met tower site may have better winds though than the old airport site due to its more open terrain and better exposure to easterly winds. Additionally, the old airport met tower site is surrounded by black spruce trees and heavy brush and local residents have remarked that the old airport area experiences lighter winds than at the location of newly-installed met tower at Airport Road.

Should the sites prove over the next year not to have equivalent winds, the most likely reason for a modeling error will be the digital elevation map (DEM) imported into WAsP for the analysis. DEM's available for most of rural Alaska are hampered at present by relatively crude elevation contour interval height and precision. These maps are being significantly upgraded this year through a combined effort

of the USGS and UAF, but new DEM's of the Noorvik area reportedly will not be available on the National Elevation Database until spring or summer 2013.

Note that at present then that the available DEM for Noorvik has the following elevation errors for the Quarry Road and Airport Road met tower sites:

Site	Actual elevation (Google Earth), meters	Digital Elevation Map elevation, meters
Quarry Road (Site 1002)	41	32.3
Airport Road (Site 9002)	15	30.5

Given that the presently available DEM does not distinguish the two sites with respect to elevation, and with no significant obstructions or surface roughness features between them, WAsP modeling predicts that the Airport Road site has a nearly identical wind regime as at the Quarry Road site. When the new DEM for Noorvik becomes available in 2013, revision of the WAsP analysis is recommended.