DRAFT Addendum to SO_2 Monitoring Siting Plan for Expera – Kaukauna

Following the recommendations in the *SO_2 NAAQS Designations Source-Oriented Monitoring Technical Assistance Document* (Monitoring TAD), additional dispersion modeling was performed to support the location and number of monitors to be placed around Expera Specialty Solutions in Kaukauna, Wisconsin.

Model Setup

Expera-Kaukauna is a fully integrated kraft pulp and paper mill consisting of wood pulping operations, chemical recovery operations, multiple fueled boilers, papermaking, converting operations, and additional activities necessary to support these operations. Expera-Kaukauna is the largest SO_2 emission source in the Kaukauna area. Expera-Kaukauna has three power boilers designated as B07, B09, and B11, two recovery boilers designated as B08 and B10, and a lime kiln designated as P12.

Two nearby sources were included in this dispersion modeling analysis. Outagamie Clean Energy is located just over 6 kilometers west of Expera-Kaukauna. The facility has internal combustion engines that use landfill gas from the adjacent Outagamie County Landfill. Appleton Coated operates a paper mill in Combined Locks, Wisconsin, about 4 kilometers west-southwest of Expera-Kaukauna. The facility has five paper machines that are used to produce coated paper, and five boilers provide steam and electricity for the plant.

Emission rates for all sources reflect normalized 2013-2015 hourly values; emissions for boilers at Appleton Coated and Expera are hour-by-hour values as recorded on facility continuous emission monitors. To focus on facility impact, no background concentrations were included in the analysis.

Meteorological data was processed from 2013-2015 Austin-Straubel International Airport (KGRB) data with Green Bay upper air data. The raw meteorological data was processed with the regulatory options in AERMET, assuming an anemometer height of 10.0 meters above the ground. The surface wind data at KGRB is 2-minute average speed and direction reported each minute and was processed with AERMINUTE.

To address concerns regarding potential under prediction of the surface friction velocity (u*) during low-wind, stable conditions that could contribute to over prediction of ambient air impacts by AERMOD, USEPA developed the ADJ_U* beta option in the AERMET processor. As noted in the April 29, 2016 memorandum, *Model Clearinghouse Review of the Use of the ADJ_U* Beta Option in the AERMET Meteorological Processor (Version 15181) for the Schiller Station Modeling Demonstration* and the June 20, 2016 memorandum, *Model Clearinghouse Review of the Use of the ADJ_U* Beta Option in the AERMET Meteorological Processor (Version 15181) for the Herbert A. Wagner Generating Station Modeling Demonstration*, the ADJ_U* beta option in AERMET performs better than the default regulatory version when high modeled concentrations are likely to occur under low wind, stable conditions, such as for a tall stack located near complex terrain. In concert with the February 10, 2016 USEPA Model Clearinghouse approval for low and fugitive releases, ADJ_U* was used in this analysis. It is understood that the regulatory default use of ADJ_U* in AERMET is pending finalization in *40 CFR Part 51, Appendix W – Guideline on Air Quality Models*, expected in the fall of 2016.

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The instrumentation tower at KGRB is 24 kilometers north-northeast of Expera-Kaukauna and the data collected are considered representative of meteorological conditions around the facility. Austin-Straubel is at the edge of the City of Green Bay in-between residences and small farm fields, similar to the land cover around Expera-Kaukauna. There are no geographic features in between KGRB and Expera-Kaukauna that would affect the general air flow, so the wind patterns are similar between the sites. The Outagamie County Regional Airport (KATW) is not considered representative as the station does not use the same high quality equipment as KGRB, does not report wind information by the minute, and has high numbers of missing and calm winds.

Surface characteristics around KGRB were generated using AERSURFACE following the methods described in the *AERMOD Implementation Guide.* Specifically, snow cover for each month during the period 2013-2015 was derived from National Snow Analyses maps from the National Operational Hydrologic Remote Sensing Center. AERSURFACE was run both for snow and no-snow conditions. The albedo, Bowen ratio, and surface roughness was adjusted based on the number of days with snow cover during each month. Also as detailed in the *AERMOD Implementation Guide*, soil moisture conditions for each meteorological data year were based on the monthly Palmer Drought Severity Index for the area obtained from the National Centers for Environmental Information.

DRAFT

A traditional Cartesian receptor grid was centered on Expera Kaukauna and extended to a distance of 20 kilometers. Initial results indicated that impacts are highest close to Expera so the final receptor grid comprised 50-meter spaced points to 1500 meters, surrounded by 100-meter spaced points to 6 kilometers. Receptors were removed over water bodies, wetlands, and in areas inaccessible to the general public. Figure 1 shows the full receptor grid, and Figure 2 provides detail of the inner, 50-meter spaced points.

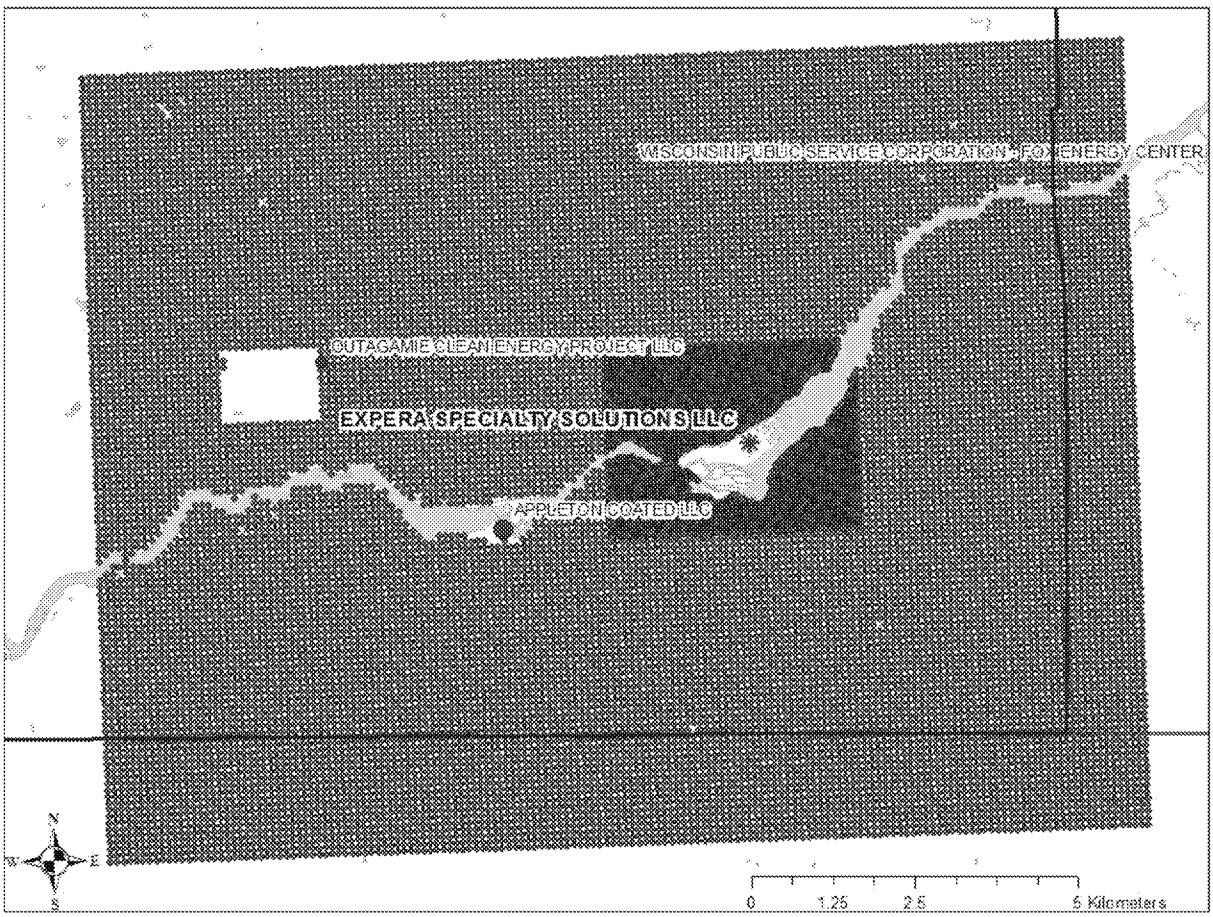

Figure 1 - Expera Kaukauna Receptor Grid with Receptors Prohibitive to Monitoring Removed

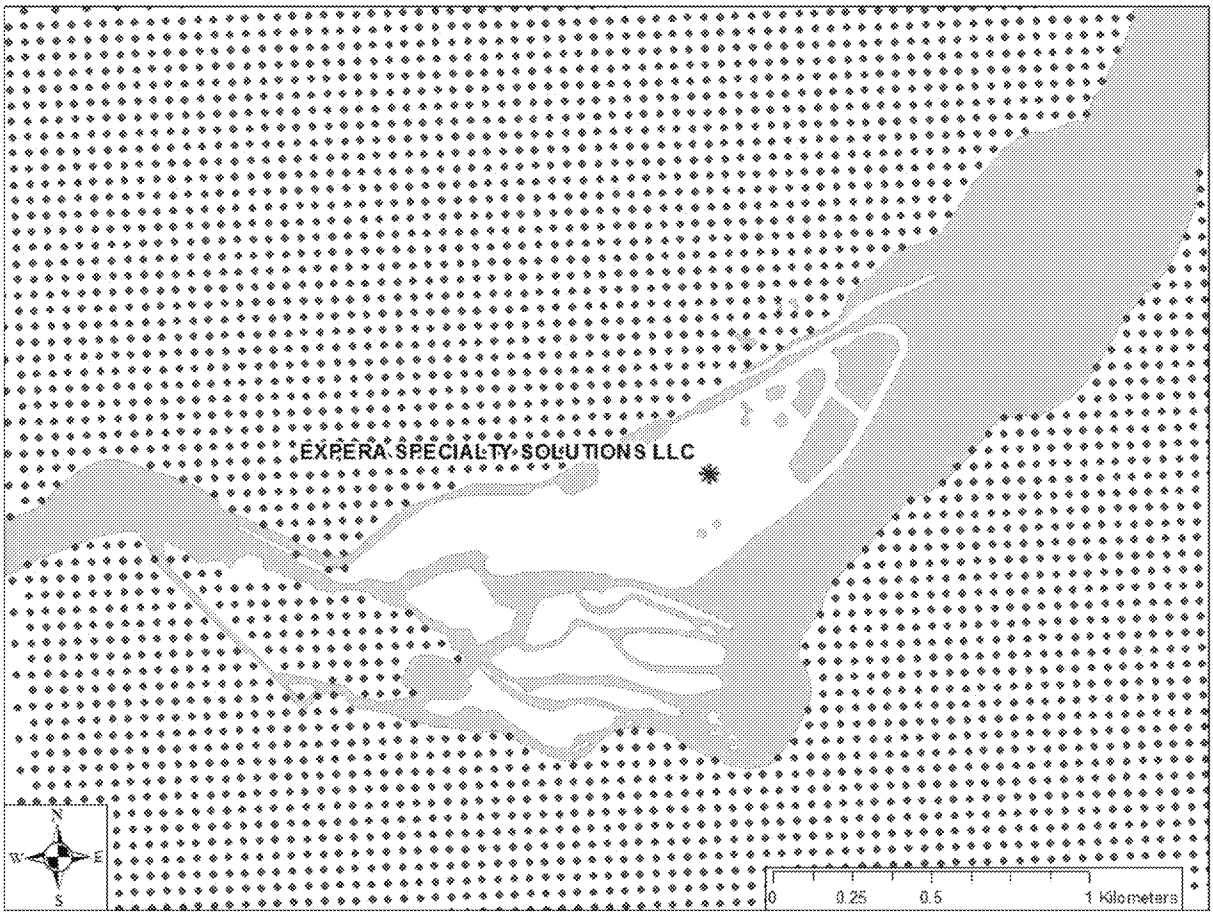

Figure 2 – Same as Figure 1 but Smaller Scale

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Model Results

Modeling the normalized hourly SO_2 emissions allows for the calculation of normalized design values (NDV). NDV do not indicate exceedance or compliance with the NAAQS, but provide a means to understand the relative magnitude of ambient concentrations cross an area. The NDV for this analysis are the 3-year average of each year's 99th percentile of daily 1-hour maximum concentrations. NDV are shown in Figure 3, along with the 3-year wind rose for the KGRB. The overall highest NDV is denoted by a red circled point north of Expera. Note that darker colored points represent relatively higher concentrations and that the dominant winds in this area are from the south and southwest.

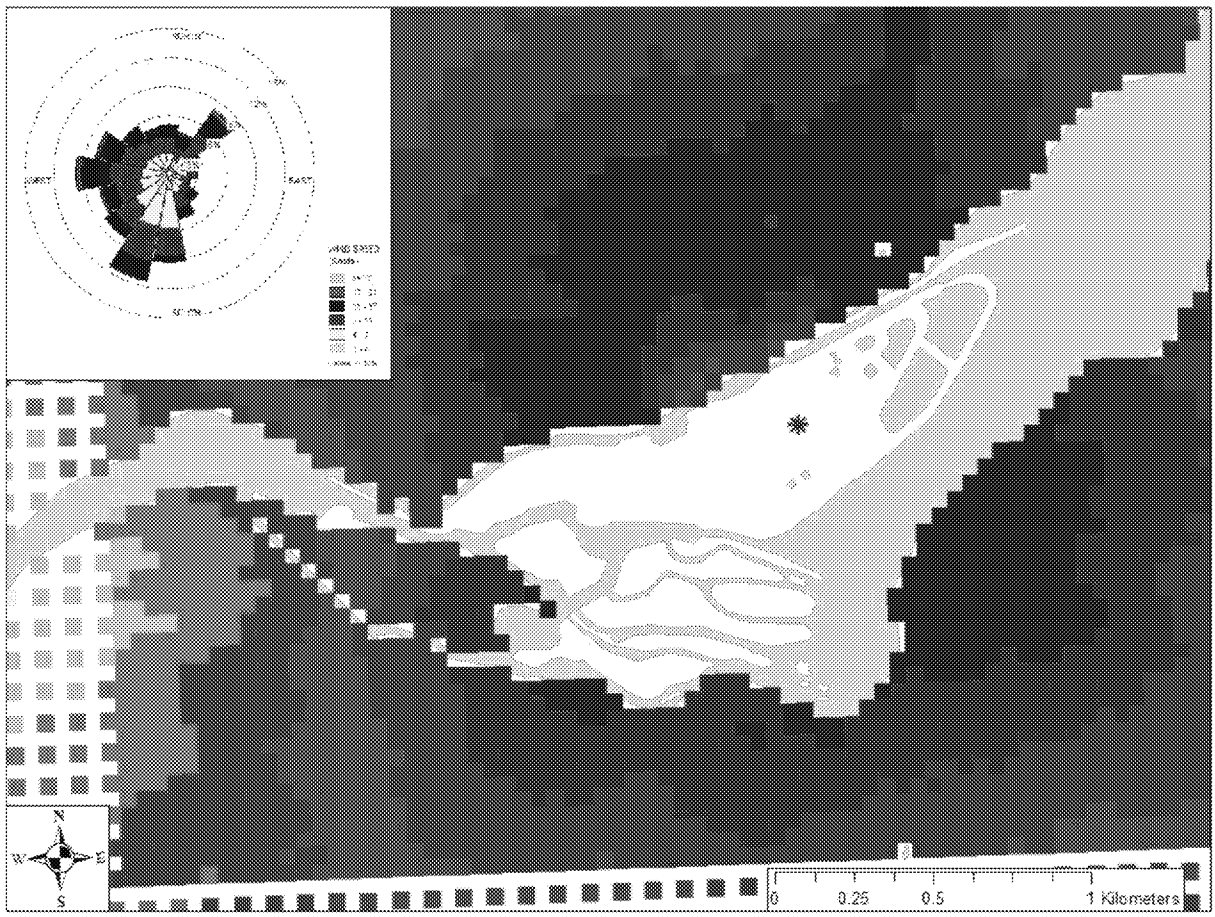

Figure 3 – Normalized Design Values for Modeled Receptors (higher values darker)

To better illustrate the relative difference between NDV across the modeled space, Figure 4 shows the ratio between each individual NDV to the overall maximum NDV. As with Figure 3, the overall highest NDV is denoted by a red circled point north of Expera.

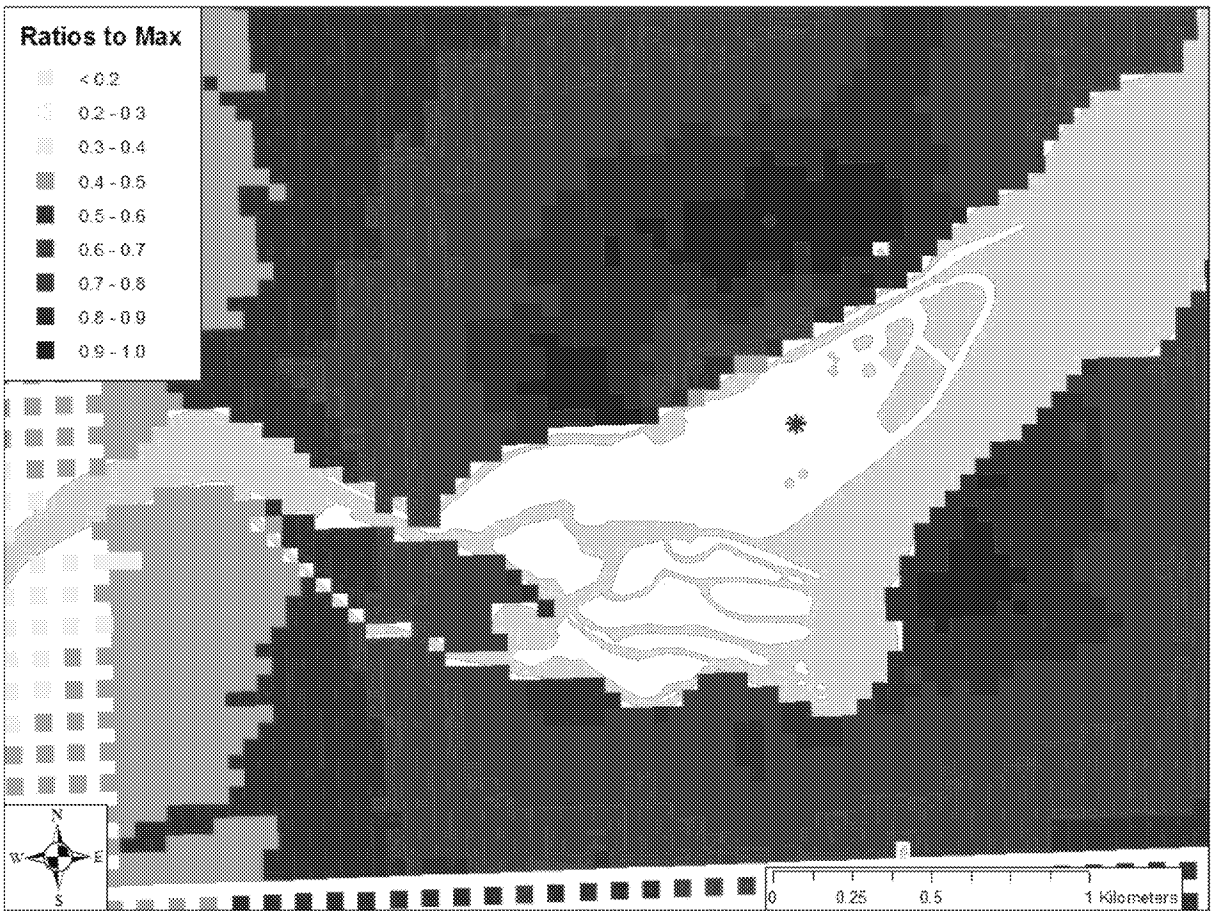

Figure 4 – Ratios of Receptor NDV to Maximum NDV (higher values darker)

The darker areas in Figure 4 represent areas where further evaluation for potential monitoring sites was performed. An additional analysis identified the receptors with the top 200, 100, 25, and 10 NDV as shown in Figure 5. The overall highest NDV location is denoted by a red circled point north of Expera.

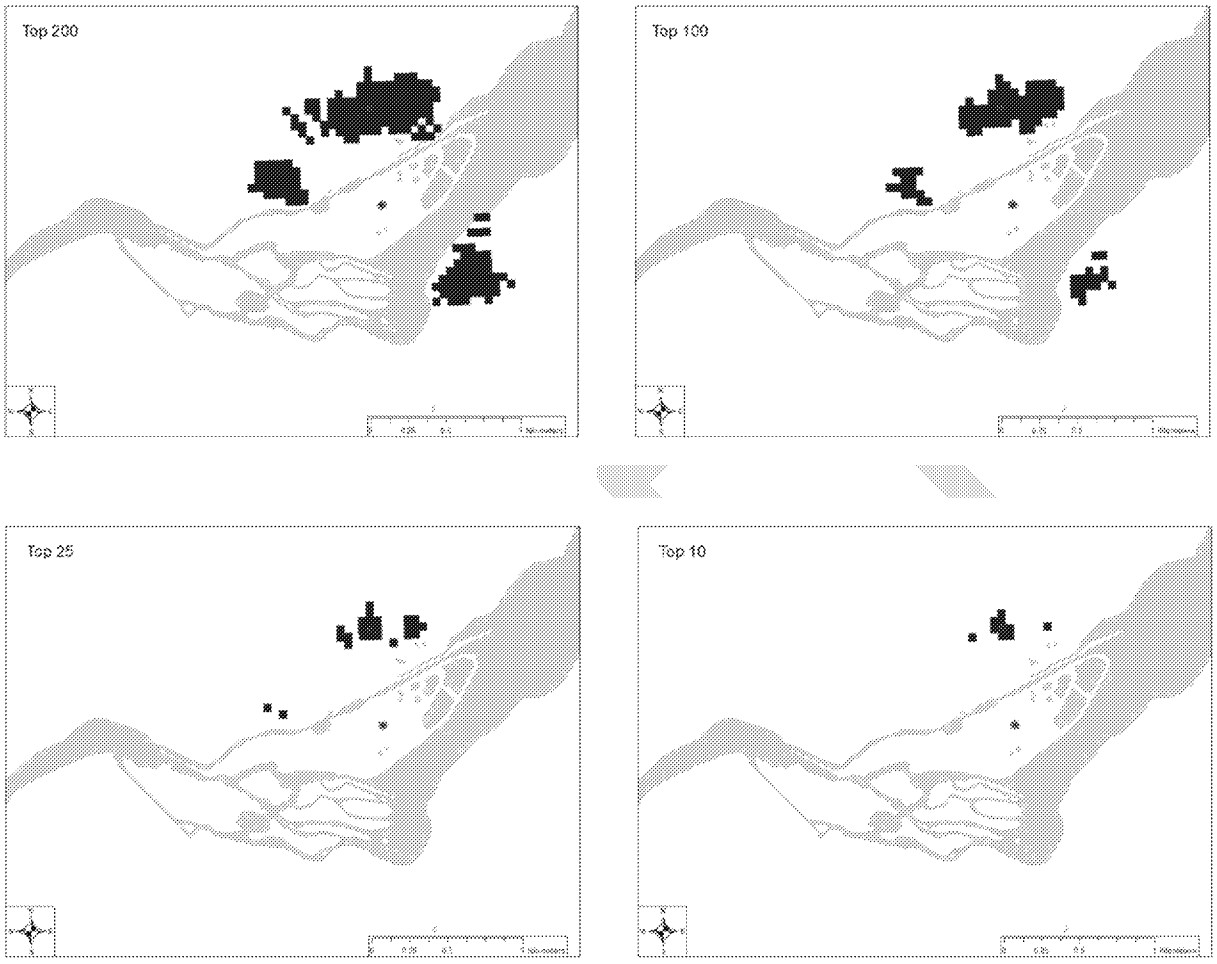

Figure 5 – Locations of Top 200, 100, 25, and 10 Normalized Design Values

In order to assess the frequency of occurrence of concentration maxima at a given receptor, an analysis was performed on the top 200 receptors where the AERMOD output option MAXDAILY was used to obtain the maximum 1-hour concentration for each receptor for each day. This output was used to determine the number of days for which each receptor was the overall highest concentration for the day. Figure 6 shows the cumulative number of days that each receptor had the highest 1-hour concentration.

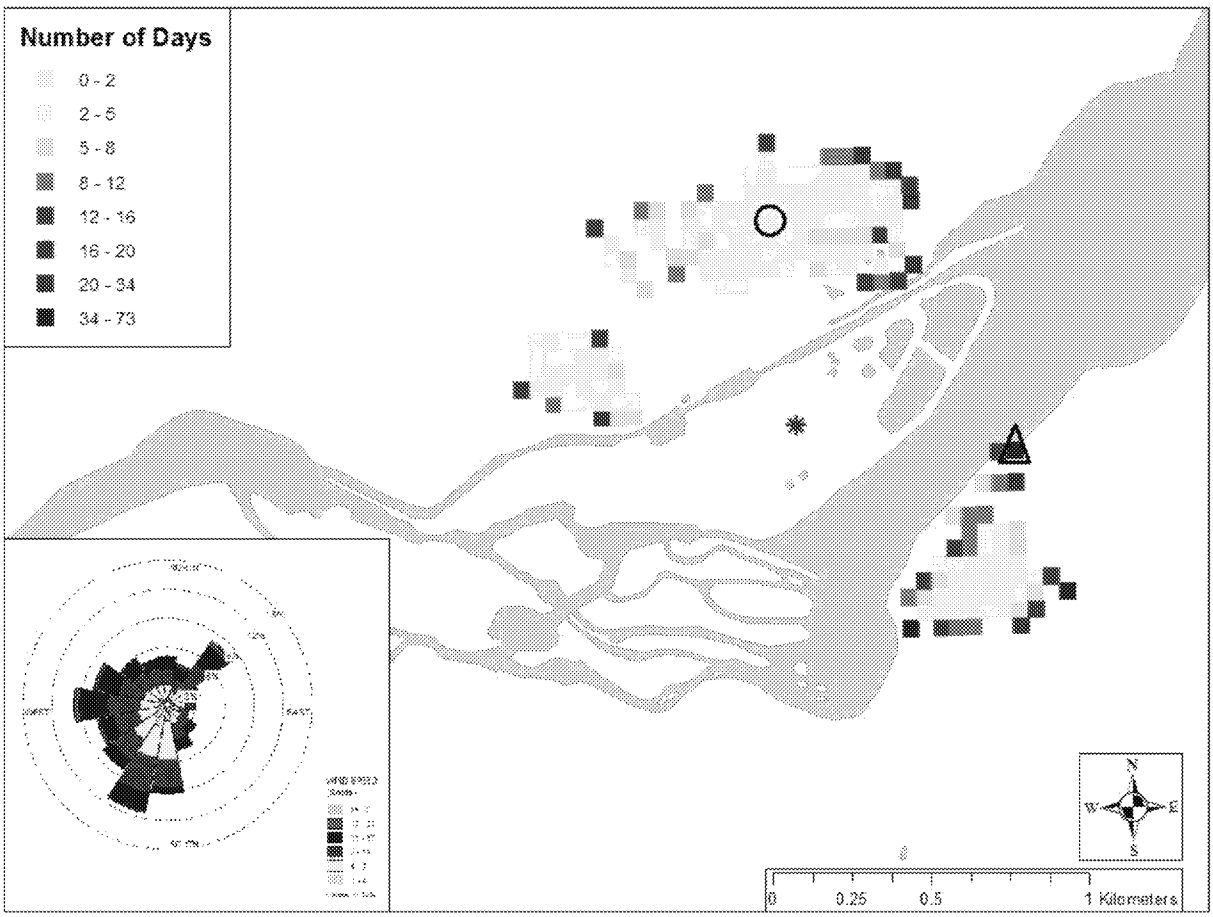

Figure 6 – Cumulative Number of Days Each Receptor was Highest

The overall highest NDV location is denoted by a black circle around a point north of Expera. The receptor with the most days as the highest 1-hour concentration is denoted by a black triangle around a point to the southeast of Expera. In examining the wind rose, westerly winds occur regularly as is expected for locations in the middle latitudes. But these winds do not result in the highest NDV as shown in Figure 5 where the area to the southeast of Expera does not have top 10 or even top 25 NDV. Given that the objective of monitoring is to characterize the highest ambient impact, the frequency with which a receptor measures the daily 1-hour high value, alone, is unsufficient basis for site selection.

To account for both NDV and the frequency of daily occurrence, receptor locations were prioritized by using a ranked sum index. First, NDV was used to rank the top 200 receptor locations, with a rank of 1 being the highest NDV. Then, the top 200 receptors were then separately ranked based on the cumulative number of days that each receptor had the highest 1-hour concentration (i.e. frequency of daily occurrence) with a rank of 1 being the highest number of days. The two rankings were summed for each receptor and the highest ten ranked sum receptor locations provided in Table 1.

Coordinate	ndays	ndays_Rank	ndv_Rank	Rank_Sum	Direction
399850,4904650	7	48	9	57	NNW
400400,4904650	14	21	38	59	NE
400350,4904650	8	43	24	67	NE
400300,4904650	6	59	13	72	NE
399900,4904650	5	68	11	79	NNW
400100,4904650	5	71	8	79	NNE
399450,4904150	5	65	16	81	WNW
400050,4904750	4	84	2	86	NNE
400250,4904650	7	51	35	86	NNE
400200,4904650	7	50	37	87	NNE

Table 1 – Ten Lowest Ranked Sums of NDV and Number of Days Highest Value
ndays = number of days receptor highest 1-hr concentration
NDV = normalized design value

DRAFT

Figure 7 illustrates the results of this ranked sum calculation, with the lower ranked sums in yellow. The color gradient is based on the standard deviation of the ranked sums. The receptor with the highest ranked sum is denoted by a black and white hexagon to the north of Expera. The overall highest NDV location is denoted by a black circled point north of the facility. The receptor with the most days as the highest 1-hour concentration is denoted by a black triangle around a point to the southeast.

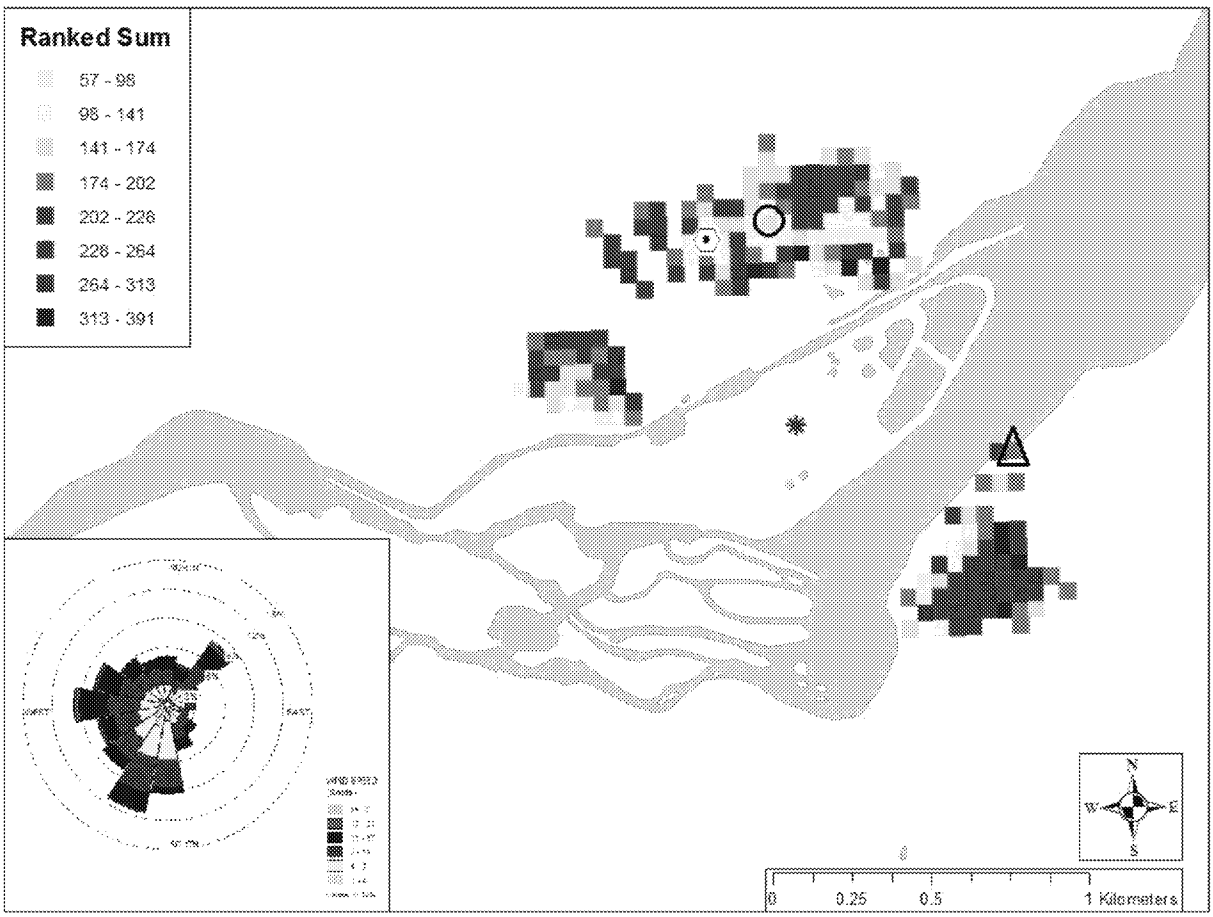

Figure 7 – Ranked Sum of NDV and Cumulative Number of Days Each Receptor Highest

Model Conclusions

The primary target for an SO_2 monitor location would be at, or near, the receptor having both the highest NDV and frequency of 1-hour daily maxima. The receptor with highest frequency is located southeast, but both the highest NDV and the highest ranked sum of NDV and frequency occur north of Expera. In addition, the wind most often blows from the south-southwest, as shown by the wind rose, and unstable atmospheric conditions (convective conditions) result in downward transport of an elevated plume such as exist at Expera. Therefore, the area to the north of Expera, near the point of highest NDV and ranked sum, is the preferred location for an SO_2 monitor.