BEFORE THE MINNESOTA OFFICE OF ADMINISTRATIVE HEARINGS
600 NORTH ROBERT STREET
ST. PAUL, MINNESOTA 55101

FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION
SUITE 350
121 SEVENTH PLACE EAST
ST. PAUL, MINNESOTA 55101-2147

Beverly Jones Heydinger	Chair
Nancy Lange	Commissioner
Dan Lipschultz	Commissioner
Mathew Schuerger	Commissioner
John Tuma	Commissioner

In the Matter of Further Investigation into Environmental and Socioeconomic Costs under Minnesota Statute 216B.2422, Subdivision 3

OAH Docket No. 80-2500-31888
MPUC Docket No. E-999/CI-14-643

REPLY BRIEF ON CRITERIA POLLUTANTS OF THE MINNESOTA DEPARTMENT OF COMMERCE, DIVISION OF ENERGY RESOURCES AND MINNESOTA POLLUTION CONTROL AGENCY

Dated: April 15, 2016

Respectfully submitted,

LINDA S. JENSEN
Attorney Reg. No. 0189030
Telephone: 651-757-1472
445 Minnesota Street, Suite 1800
St. Paul, MN 55101-2134

Attorney for Minnesota Department of Commerce and Minnesota Pollution Control Agency

CONTENTS

I. INTRODUCTION

The Minnesota Department of Commerce, Division of Energy Resources, (the Department or DOC) and Minnesota Pollution Control Agency (MPCA) (jointly "the Agencies") respectfully submit this Reply Brief to the Administrative Law Judges (ALJs) and the Minnesota Public Utilities Commission (Commission). Proposed Findings of Fact are separately filed.

The Agencies' Reply Brief is solely responsive to other parties' initial briefs. The Agencies do not repeat here the extensive analyses and recommendations set forth in their Initial Brief, Comments in the jointly-submitted Issues Matrix, or proposed Findings of Fact, on and for which the Agencies continue to rely and advocate. Therefore, in the interests of avoiding redundancy, the Agencies do not respond to each dispute identified in the various parties' initial post hearing briefs; rather the Agencies respond to new disputes, or disputes for which further clarification appears necessary.

II. ARGUMENT

1. DAMAGES

A. Xcel's Under-Estimation of Damages by Use of Inappropriate Geographic Assumptions Is Not Reasonable When Modern Air Modeling Methods Are Readily Available and Capable of Measuring Geographically-Specific Emissions and Concentration Changes on a National Basis.

The main justification offered by the Xcel Initial Brief for the geographic choices[1] Xcel proposed was to remain consistent with geographic decisions[2] made in the prior 1990's cost

[1] These include the choice as to geographic specificity of emission sources and the geographic scope of damages.

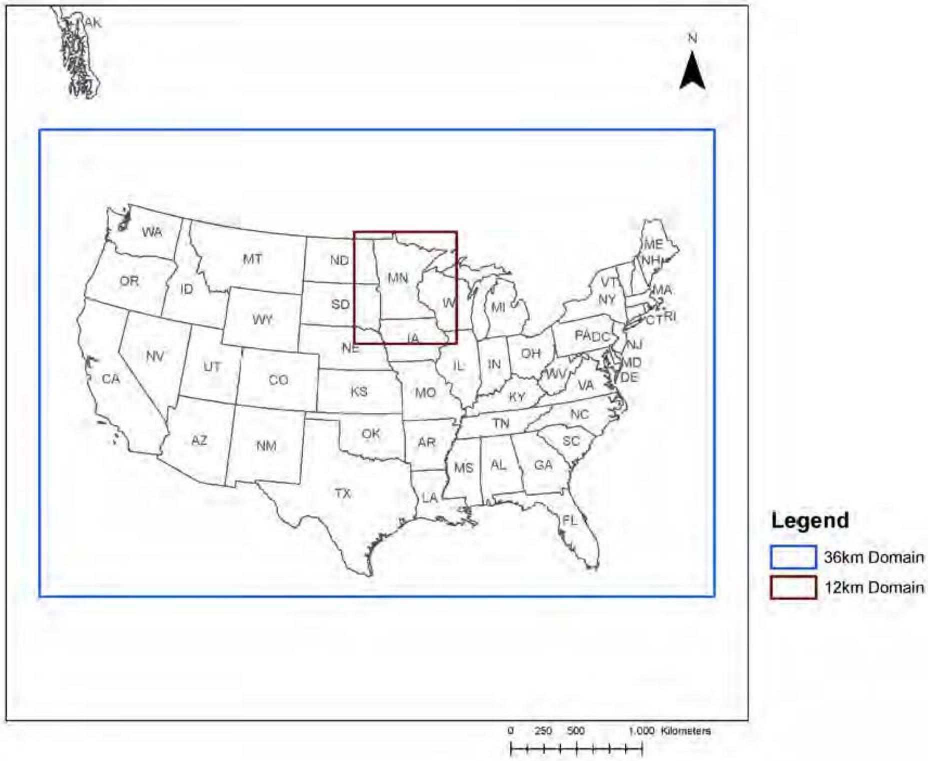
[2] As is discussed further below, Xcel in fact did not adhere to the assumptions of the 1990's docket. For instance, in this 14-643 docket, Xcel did not model, for its geographic range of impacts, the receptor locations used in the 93-583 docket. Instead, here Xcel modelled a geographic range that included parts of several other Midwestern States that were not modelled in the 1990's docket.

docket.[3] Xcel Initial Brief at 9-12, 52-53, 70. As to geographic specificity of emission sources, Xcel noted that, in the prior proceeding, "the ALJ and the Commission concluded that three different value categories – rural, metro-fringe, and urban – were appropriate, practicable, and satisfied the need to consider the geographic location of the emission source." Xcel Initial Brief at 10. While this was true based on the methods and modeling capability in the early 1990's, 20 years have passed. What is reasonable and practicable today is far different than what was reasonable and practicable then, as all three of the expert modeling witnesses have shown. Advances in modeling capability in the past 20 years now make it highly practicable to develop geographically-specific values for emission sources and the transport of emissions, as well as the remote ambient concentration changes and impacts of those emissions across North America.

As to the geographic scope of damages, Dr. Desvousges' own analysis demonstrated that SO_2, NO_x, and $PM_{2.5}$ travel outside of the State, resulting in discrete concentration changes that can be estimated in locations far distant from the emission source. First, Dr. Desvousges' Figure 2-1, (reproduced here) showed the spatial extent of the dual [national/local] grid box approach to air quality modeling that he used.

[3] Docket No. E999/CI-93-583.

Figure 2-1. 36 km CONUS and 12 km MN modeling domains used in the CAMx simulations.



Xcel Ex. 604 at WHD-1, Schedule 3, p. 19 of 95; Figure 2-1 (Desvousges Direct). Dr. Desvousges used the CAMx model to estimate baseline conditions using emissions across the United States. DOC Ex. 810 at 29 (Muller Rebuttal) (*citing* Xcel Ex. 604 at WHD-1, Schedule 3, p. 18 of 95 (Desvousges Direct)). Dr. Desvousges estimated background concentrations in Minnesota by taking into account all pollutants emitted from all locations across the Continental U.S. and estimating the amount of these emissions that are transported to Minnesota. Dr. Desvousges stated that this national domain:

> "…is used to provide background concentrations (*i.e.*, transported pollutants) into the Minnesota domain. The CONUS [Contiguous United States] domain included all emissions (*e.g.*, EGU [electric generation unit], other point, mobile, area, fires, biogenic, etc.) from **all 48 contiguous states as well as parts of southern Canada and northern Mexico."**

DOC Ex. 810 at 29 (Muller Rebuttal) (*citing* Xcel Ex. 604 at WHD-1, Schedule 3 p. 18 of 95 (Desvousges Direct)) (emphasis added). The "CONUS domain" is the larger grid box drawn around the contiguous United States in Dr. Desvousges Figure 2-1 in Xcel Ex. 604 WHD-1, Schedule 3, p. 19 of 95 (Desvousges Direct). This demonstrated that Xcel's model, CAMx, has the capacity to determine concentration changes resulting from emissions across the nation, that Dr. Desvousges was aware that emissions are transported nationally, and that concentrations outside of Xcel's spatially limited grid box have an effect within the grid box, which Dr. Desvousges estimated using CAMx. DOC Ex. 810 at 30 (Muller Rebuttal).[4]

Second, the results from Dr. Desvousges' simulations at three hypothetical power plants also depended on calculation of emissions from outside the grid box. Dr. Desvousges' explained:

> "The air quality concentration impacts due to emissions from a hypothetical electric generating unit (EGU) will depend on the reactivity in the atmosphere. This is governed by **existing sources and influences of transport, which includes continental and international transport** and stratospheric ozone intrusion. Since ozone and secondary $PM_{2.5}$ formation are nonlinear, it is important to define the proper background atmospheric reactivity conditions."

DOC Ex. 810 at 30 (Muller Rebuttal) (*citing* Xcel Ex. 604 at WHD-1, Schedule 3, p. 30 of 95 (Desvousges Direct)). As this passage explained, concentrations from Xcel's modeled hypothetical plants depend on the influences of emissions from sources within and outside of the continental U.S. *See also*, Tr. Vol. 7 at 57 (Dr. Desvousges confirmed that, in this proceeding, CAMx calculated changes in ambient concentrations of pollutants across the U.S., provided that information as part of the calculations, and predicted changes in concentrations outside of the

[4] Xcel's other witness, Mr. Rosvold, similarly agreed that emission of the criteria pollutants potentially contribute to the interstate transport of pollution and that long-distance transport of pollution across state lines could make it difficult for downwind states to achieve compliance with the EPA's $PM_{2.5}$ and ozone standards. Xcel Ex. 607 at 4:5 (Rosvold Rebuttal).

grid box.) Thus, the modeling approach Dr. Desvousges used to calculate impacts, which was limited to the grid box shown in Figure 2-1 in Xcel Ex. 604 at WHD-1, Schedule 3, p. 19 of 95 (Desvousges Direct) was inconsistent with the modeling approach Dr. Desvousges used to estimate background or baseline concentrations. In other words, Dr. Desvousges' methodology included emissions that are geographically far removed from Minnesota in estimating baseline $PM_{2.5}$ concentrations in Minnesota, but excluded the impact of Minnesota emissions on $PM_{2.5}$ concentrations in these *same geographic areas*. DOC Ex. 810 at 30-31 (Muller Rebuttal). Dr. Muller criticized these choices, explaining that the effect was to artificially lower the impacts of Minnesota emissions, and therefore, lower the environmental cost values Dr. Desvousges reported.

Third, Dr. Desvousges demonstrated that the criteria pollutants can travel long distances, well beyond the grid box Xcel proposed, when he explained that sources in countries other than Canada and Mexico may also produce emissions that impact air quality in the continental U.S. Dr. Desvousges testified that "[t]he contributions of international/global sources were accounted for through boundary conditions around the edges of the CONUS domain that were obtained from a Global Chemistry Model (GCM)." Doc Ex. 810 at 31 (Muller Rebuttal) (*citing* Xcel Ex. 604 at WHD-1, Schedule 3, p. 18 of 95 (Desvousges Direct)). Dr. Desvousges here correctly observed that emissions from distant shores may reach the continental U.S. The converse was also true: the effect of emissions produced by sources in Minnesota was not accurately accounted for if artificially limited to the small grid box shown in Dr. Desvousges' Figure 2-1.

Fourth, Dr. Desvousges mapped the out-of-state/out-of-grid box transport of emissions in his Figure 2.4, through which Dr. Desvousges intended to show the effects of emissions from the three hypothetical electric generating units on air quality within the model domain box. DOC Ex. 810 at 26-28 (citing Xcel Ex. 604 at WHD-1, Schedule 2, p. 24 (Desvousges Direct)).

Copy of Figure 2.4

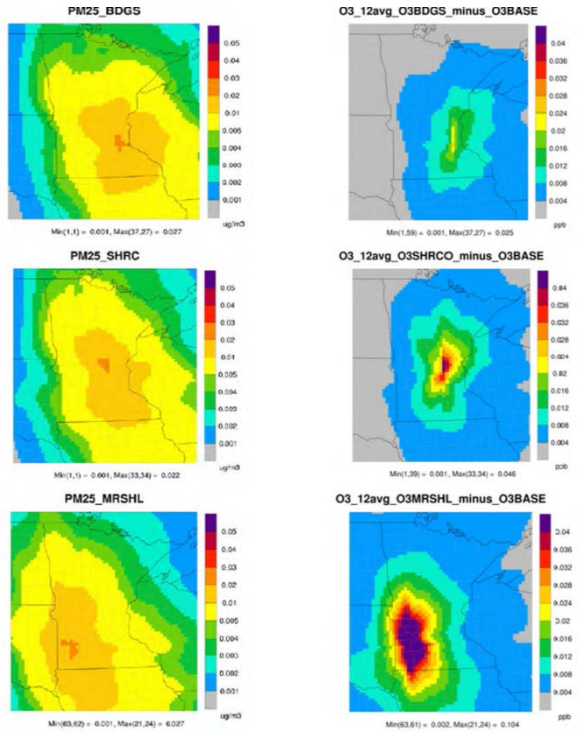


Figure ES-3. Incremental annual $PM_{2.5}$ (left) and seasonal average daylight (12-hour) ozone (right) concentrations due to the Black Dog (top), Sherco (middle) and Marshall (bottom) hypothetical EGUs.

Focusing on the left-hand column of the Figure, in the western margin of the top two graphs, concentration changes gradually decline with distance from the facility location. For the top left Figure, concentration changes decline as emissions move westward from the plant from 0.02 micrograms per cubic meter (shown in orange) smoothly to lighter orange, yellow, green, and then blue. Similar effects are observed at the western margin of the left-center plot and in the northeastern margin for the bottom left plot. *In contrast, the southern and southeastern margins of these Figures, which correspond to the spatial limits of the grid box, are artificially truncated although the effect of emissions from these plants is still between 0.005 and 0.01 micrograms per cubic meter.* DOC Ex. 810 at 26-28 (Muller Rebuttal).

Dr. Muller stated that there is no scientific or practical reason to truncate the counting of impacts to those within the small grid box, and that "[o]bviously, this approach resulted in lower environmental cost values than if impacts in areas outside of the grid box were also counted." DOC Ex. 810 at 26, 32 (Muller Rebuttal).

The primary justification Dr. Desvousges' Direct Testimony offered for this restricted spatial scope was the adherence to the methodology in the 1990's environmental cost docket. Xcel Ex. 604 at 19 (Desvousges Direct). Dr. Desvousges did not disclaim the ability to identify emission sources on a national basis, estimate their transport, and estimate impacts at distant locations. He simply failed to count them.

Further, Dr. Desvousges' restricted spatial scope does *not* strictly adhere to the methodology in the 1990's. Dr. Desvousges' Direct Testimony states, "This geographic area extends out approximately 100 miles from the borders of Minnesota; the 100-mile limit was chosen to be consistent with the Original Study, but goes beyond the Original Study area, because the CAMx model requires a rectangular grid study area. The Original Study did not include parts of Iowa, Michigan, Illinois, Nebraska, or North Dakota." Desvousges Ex. 604 at 19 (Desvousges Direct).

The damage value ranges adopted by the Commission in Docket No. 93-583 were the result of a single modeling effort based on Xcel's system only. "Radian Corporation (Radian) performed an air quality dispersion modeling analysis for Triangle Economic Research (TER) on behalf of Northern States Power Company (NSP). The analysis was performed as part of an externality costing study that TER designed to provide NSP with reliable estimates of the environmental costs of future electrical power generation . . . The study area reflects a broad range of geographic locations and was chosen to bracket the range of externality costs. . . .

Radian performed the modeling analysis for four planning scenarios. These scenarios were designed by NSP and TER. . . . All scenarios reflect projected NSP operating characteristics for the year 2006." Docket No. 93-583, Hearing Ex. 136 (TER Study) at Vol. 1, pp. 1-1 and 2-1; *see also* pp. 3-1 to 3-4 (regarding receptor selection)(Attached hereto as Attachment 1).

Strict adherence to the modeling assumptions and ultimate policy decisions made by the Commission at that time are clearly not appropriate given the limitations of the state of the science, the restricted scope of the modeling, and the resulting record that was available to the Commission at the time. Those limits and restrictions are not limitations upon the record of this proceeding.

This use by Xcel and its witness of a small grid box was a fundamental flaw in Xcel's methodology. The limited geographic scope in which Dr. Desvousges counted impacts inaccurately represented the damages associated with Minnesota emissions, and, because Dr. Desvousges counted impacts only in that very limited geographic area, the damage values he reported were inaccurately low. DOC Ex. 810 at 19-20 (Muller Rebuttal).

For each of the geographic choices modeled in CAMx and proposed by Xcel – the geographic specificity of emission sources and the geographic scope of damages – Xcel made arguments based on what was reasonable and practicable to do 20 years ago to defend its current choices, even though what is reasonable and practicable today is far different than what was reasonable and practicable then. The Agencies disagree with the choice by Xcel to artificially lower values based on these unreasonable modeling and policy arguments, and do not recommend purposefully setting damage values known to be inaccurate and unjustifiably low.

B. The ALJ and Commission Should Reject Xcel's Proposal to Count only the "Majority" of Impacts and Damages.

The Xcel Initial Brief proposed that the damage value need only account for the "majority" of air quality changes and impacts from SO_2, NO_x, and $PM_{2.5}$ emissions. Xcel Initial Brief at 1, 69.

Xcel's proposal should be rejected because Xcel did not demonstrate how counting only a majority of known damages comports with Minn. Stat. § 216B.2422, subd. 3 (a) or why it would be good energy policy for the Commission to disregard known impacts and damages for resource planning, certificate of need or other Commission purposes. Xcel does not respond to the criticism that the grid box obviously truncates scientifically determinable amounts of impacts and corresponding damages. Further, depending on the pollutant, Xcel's methodology may not account for even a "majority" of impacts and damages.

Dr. Muller summarized his extensive comparison[5] of AP2 damages within the state of Minnesota as follows:

> For $PM_{2.5}$ damages in Minnesota, for each of the three source locations, the range of values reported in Table 1 of Dr. Desvousges' Direct Testimony overlaps with the range of values that Dr. Muller reported in DOC Ex. 809 at NZM-3 (Muller Direct Attachments).
> For SO_2 damages in Minnesota, for two of the three source locations, the range of values reported in Table 1 of Dr. Desvousges' Direct Testimony overlaps with the range of values that Dr. Muller reported in DOC Ex. 809 at NZM-3 (Muller Direct Attachments).
> For NO_x damages in Minnesota, the agreement between the two models was less robust with none of the ranges overlapping; however, the ranges were quite close. With these observations and considering that the range reported by Dr. Desvousges was characterized by the 25th and 75th percentiles, (Xcel Ex. 604 at 5 (Desvousges Direct)), it was very likely that the absolute ranges do overlap when counting *Minnesota-only* damages. DOC Ex. 810 at 25-26 (Muller Rebuttal). This demonstrated that the differences in damages reported nationally and in Minnesota by Dr. Desvousges were greatly reduced by Dr. Desvousges use of the grid box and the truncation of effects. Depending on the pollutant, Xcel's methodology may not have accounted for even a "majority" of impacts.

[5] Doc Ex. 810 at 22-25 (Muller Rebuttal).

DOC Ex. 810 at 25-26 (Muller Rebuttal).

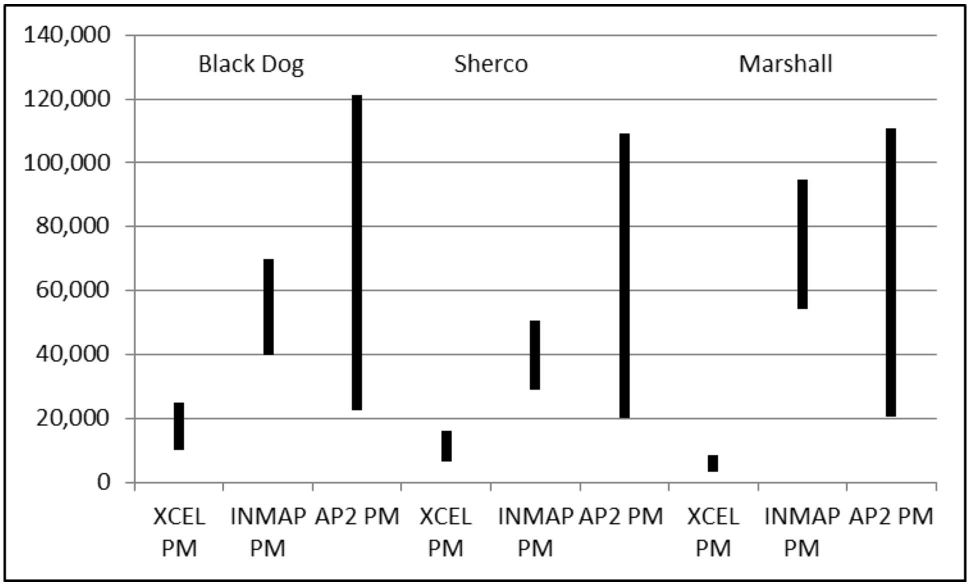
C. The Damages Estimated by AP2 and InMAP are Similar, and Vary Significantly from Xcel's Proposed Damage Estimates.

Xcel inaccurately contended that values proposed by Dr. Muller and Dr. Marshall are dissimilar. Xcel Initial Brief at 18-23.

First, some variation between Drs. Muller's and Marshall's results is to be expected; they made a variety of different modeling choices and used different air quality models. Moreover, the modelers made choices to account for uncertainty. Despite this, there was a high degree of correlation between the estimates of InMAP and AP2: For the majority of source-pollutant observations, InMAP and AP2 produced damage estimates with ranges that overlapped one another to a greater extent than Xcel's estimates overlapped with either of InMAP or AP2. Xcel's results tended to be the outlier. As discussed above, that difference was due, principally, to Xcel's decision to truncate the spatial extent of its modeling. This can be seen in Dr. Muller's Figure 13, reproduced below. DOC Ex. 810 at 21 (Muller Rebuttal).

Xcel's Initial Brief also pointed to Dr. Muller's Figure 13 (Xcel's Initial Brief at 20-21) however, Figure 13, which concerns $PM_{2.5}$ emissions, did not support Xcel's claim; it showed that the range of values provided by the Agencies and the Clean Energy Organizations (CEO) all overlap whereas Xcel's were much lower. DOC Ex. 810 at 20-21 (Muller Rebuttal).

Figure 13. Comparison of External Cost Estimates For $PM_{2.5}$ Emissions from Three Power Plants[6]



- *All values in $/U.S. short ton.*
- *For InMAP and AP2, the endpoints of each line correspond to the high and low damage estimates. The topmost point of the line reflects high-end damage assumptions. The bottommost point of the line reflects low-end damage assumptions. For Xcel, the top and bottom of the lines reflect the 75th and 25th percentiles of the damage distributions, respectively*.

Dr. Muller demonstrated that the main driver of the differences between the results of the reduced-form models and CAMx as to $PM_{2.5}$ emissions was Dr. Desvousges' choice to count only impacts occurring in the grid box. Dr. Muller explained that, in Figure 13, the predicted damage cost for the hypothetical plant at the location of the extant Sherburne County power plant reported by Dr. Desvousges was much smaller in magnitude than that reported by either Drs. Marshall or Muller. DOC Ex. 810 at 41 (Muller Rebuttal).

In summary, there is a high degree of correlation between the estimates of InMAP and AP2, and for the majority of source-pollutant observations, InMAP and AP2 produce damage estimates with ranges that overlap to a greater extent than Xcel's with either InMAP or AP2.

[6] Dr. Muller's Rebuttal Testimony had a corresponding Table 13 with the related data shown in figure 13. DOC Ex. 810 at 21 (Muller Rebuttal).

Xcel's results are the outlier. As discussed above, that difference is due primarily to Xcel's decision to arbitrarily truncate the spatial extent of its modeling for reasons not related to science or to the practicability of ascertaining the rest of the damages.

D. MLIG's Claim that Establishing New Damage Values Will Harm Ratepayers is Not Supported by the Record.

The Minnesota Large Industrial Group (MLIG) Initial Brief stated that establishing new, higher damage cost values for the criteria pollutants will have an adverse impact on Minnesota electricity ratepayers. MLIG Initial Brief at 2. This statement was not made in any of the expert witnesses' testimonies nor was it otherwise established in this proceeding that higher environmental damage cost values would result in higher electricity rates or other harm to Minnesota ratepayers. This argument by the MLIG is wholly unsupported by the record.

Furthermore, establishing accurate cost values improves information available to the Commission regarding the cost of various sources of electric generation, and allows a more fully informed Commission to make resource, need and other decisions based on accurate data.

2. MODEL PERFORMANCE

Xcel erroneously claims that the model performance evaluation (MPE) performed by Dr. Muller is not "meaningful" and "clearly inaccurate." Xcel Initial Brief at 47.

As an initial matter, Dr. Muller demonstrated that AP2 and CAMx, in fact performed equally well or that AP2 performed better than CAMx. As discussed in the Agencies' Initial Brief, Dr. Muller's Table 1 (on page 25 of his Direct Testimony) shows excellent agreement between AP2 and CAMx (for total $PM_{2.5}$), in terms of Pearson's Correlation Coefficient and in terms of Population-weighted exposures. The models are nearly perfectly correlated for population-weighted exposures within the Great Lakes and Great Plains states and within Minnesota. Similarly, Dr. Muller's Table 2 (page 27 of his Direct Testimony) shows excellent agreement between AP2 and CAMx for major species of $PM_{2.5}$ in terms of Pearson's Correlation Coefficient and in terms of Population-weighted exposures. The models are nearly perfectly correlated for population-weighted exposures within the Great Lakes and Great Plains states and within Minnesota. DOC Ex. 808 at 27-28 (Muller Direct); *See also* Tr. Vol. 8 at 151- 154.

Dr. Muller's Table 3 in his Direct Testimony compared the CAMx predictions and the AP2 predictions to monitor readings provided by the Environmental Protection Agency (EPA). DOC Ex. 808 at 28 (Muller Direct).At the national level AP2's predictions are more closely correlated with the monitor data than CAMx. Within the state of Minnesota, AP2 generated less bias and a comparable degree of error in its predictions, relative to CAMx. If there were something fundamentally biased or wrong with AP2 it would not produce comparable predictions to CAMx which is the same photochemical air quality model used by Xcel.

Table 4 of the Muller Direct showed excellent agreement between AP2 and CAMx for modeling ozone in terms of Pearson's Correlation Coefficient and in terms of Population-weighted exposures. DOC Ex. 808 at 30 (Muller Direct). Again, the models are nearly perfectly correlated for population-weighted exposures within the Great Lakes and Great Plains states and within Minnesota.

And, finally, Table 5 in Dr. Muller's Direct Testimony compared the CAMx predictions and the AP2 predictions to monitor readings provided by EPA for O_3. DOC Ex. 808 at 31 (Muller Direct). At two out of three spatial scales considered, AP2 produced less bias and lower error than CAMx. Again, if there were something fundamentally biased or wrong with AP2 in how it models O_3 it would not produce comparable predictions to CAMx.

In an effort to diminish the credibility of this strong evidence of good model performance, Xcel proffered four non-persuasive reasons why the AP2 performance results may not be correct.

First, Xcel claims, "Dr. Muller neglected to conduct the typical second step for a reduced-form model performance evaluation which is to compare the reduced form modeling results to the modeling results of a photochemical grid model, evaluating both total concentrations and predicted concentration changes associated with incremental emissions." Xcel Initial Brief at 49. This claim appears to be based on Dr. Desvousges statement that these comparisons of CAMx and AP2 performance were incomplete because they compare only the predictions of absolute concentration levels and not predictions of marginal changes in ambient air concentrations. Xcel Ex. 605 at 54-55 (Desvousges Rebuttal). These claims are not true. AP2's predicted changes in concentrations were evaluated for the three sources (Marshall, Sherco, Black Dog) that Xcel modeled in this proceeding. Specifically, Dr. Muller showed the statistical comparison between AP2's predicted changes and Xcel's run of CAMx's predicted changes for each of the three pollutants and each source. DOC Ex. 810 at 39 (Muller Rebuttal). Dr. Muller's Rebuttal Table 16 shows the results. In terms of population-weighted exposure, the predictions from both models are very strongly positively correlated. DOC Ex. 810 at 40 (Muller Rebuttal). Population-weighted exposures are the key to evaluating the models because the damages from these pollutants are almost entirely due to human health effects. This comparison directly contradicts Dr. Desvousges' claim (Xcel Ex. 605 at 55 (Desvousges Rebuttal)) that "Dr. Muller's comparison, while interesting, does not imply any degree of comparability between AP2 and CAMx in predicting changes in ambient concentrations as a result of a change in emissions."

Second, Xcel claimed that it was an error for Dr. Muller to have used 1990's weather data as inputs. Xcel Initial Brief at 48; Xcel Ex. 605 at 33 (Desvousges Rebuttal). This claim is not meritorious. It would only have been a mistake to use weather data from the 1990's if the use had biased the results of AP2 relative to the CAMx model (which was run with 2011 data) or relative to the EPA's 2011 observed values. Dr. Muller demonstrated that it did not. The reason that it did not is that much intra-annual variation in weather cancels out. It is statistical noise. Average wind direction, speed, temperature, and pressure are much more stable over time. Dr. Muller explained that the ability of the historical annual average weather data, which Dr. Muller used to reflect current annual average conditions, was demonstrated in Figures 2 and 3 in DOC Ex. 808 at 34-35 (Muller Direct); these Figures show the correspondence between predicted flows of pollution from the Sherburne County Plant and 2011 wind data from Minneapolis. Further, AP2 generates annual average predicted $PM_{2.5}$ concentrations that are more positively correlated with monitor data than CAMx does, even though CAMx used 2011 meteorological data for the run used in the Muller Direct Testimony. This greater positive correlation suggests that the use of historical average weather data from the 1990's is not fundamentally problematic. While daily weather is quite variable, long-run patterns such as annual averages in wind speed, temperature, and wind direction are less variable, year-to-year. DOC Ex. 811 at 3-4 (Muller Surrebuttal); Tr. Vol. 8 at 73. As a result, a model like AP2, which uses historic annual average weather conditions, is able to match current predictions for annual average pollution levels.

Third, Xcel questioned the propriety of Dr. Muller's conversion of daily $PM_{2.5}$ to annual averages and use of the Boylan and Russell performance goals and criteria. Xcel Initial Brief at 48-49. Dr. Muller converted daily $PM_{2.5}$ to annual averages because the mortality concentration-response functions for $PM_{2.5}$, which account for nearly all of the environmental cost values, use annual averages. Thus, it is annual averages that matter for the damage calculations. As indicated in Dr. Muller's Direct and Surrebuttal Testimonies, the concentration-response functions, which he, Dr. Marshall, and Dr. Desvousges used to estimate the health impacts associated with increased emissions, reported increased mortality per year based on *annual average* concentrations.[7] DOC Ex. 811 at 5 (Muller Surrebuttal). He explained that the air-quality modeling literature included no criteria specifically targeted to evaluating air-quality models with respect to their estimation of annual average concentrations. In the absence of such information, in his expert opinion, it was appropriate to use the most relevant and widely-used criteria available: those in Boylan and Russell (2006).

Fourth, Xcel claimed that the Boylan and Russell guidance is specific to $PM_{2.5}$ modeling evaluation only, and that Dr. Muller misused this guidance when he applied it to his ozone modeling results. Xcel Initial Brief at 48-49. Dr. Muller's use of Boylan and Russell performance criteria, however, was not so much to evaluate AP2's results on their own, but rather to provide an additional comparison of the relative performances of AP2 and CAMx. Dr. Muller subjected *both* CAMx and AP2 to the Boylan and Russell model performance criteria. (Again, the annual average performance of the models is what matters because that drives mortality damages which account for nearly all of the damages in this proceeding.) The comparison reported by Dr. Muller shows the *relative* performance of AP2 and CAMx. DOC Ex. 808 at 29 Table 3 (Muller Direct). This Table 3 shows comparable levels of error (MFE) and bias (MFB) in both models. Table 5 on page 31 (Muller Direct) shows the results for O_3. In this case AP2's predictions have lower degrees of error (MFE) and bias (MFB) than CAMx for several of the comparisons. The point of these evaluations is to discern whether there is

[7] Seasonal average concentrations were used for estimating health impacts from ozone.

something fundamentally wrong with the AP2 model's air quality predictions. The ability of AP2 to match CAMx's predicted levels of both $PM_{2.5}$ and O_3 (either in a direct comparison of the two models' predictions or in the comparisons to the EPA monitoring data) is verified in these tables.

Further, Dr. Muller did not rely exclusively on the Boylan and Russell criteria. As reported in his Direct Testimony, to ensure that AP2's estimates of annual concentrations were reliable, Dr. Muller compared the performance of the AP2 estimation of annual average concentrations to the performance of CAMx and to air quality monitor data (as discussed above in section. DOC Ex. 808 at 23-33 (Muller Direct); DOC Ex. 811 at 5-6 (Muller Surrebuttal). Thus, even if the Boylan and Russell performance standards had not been used, the data summarized in Dr. Muller's Direct Testimony, Tables 3 and 5, show that AP2 performs comparably to the CAMx photochemical air quality model. Based on the data presented in Tables 1-5 in Dr. Muller's Direct Testimony, there is no basis for Xcel's claim that AP2 is "clearly inaccurate."

3. THE CHOICE OF AIR QUALITY MODEL SHOULD BE A REDUCED-FORM MODEL.

A. The Agencies Support the Commission's Preference to Use a Reduced-Form Model, Such as AP2, to Produce Damage Estimates

1. The Accuracy and Credibility of AP2 and CAMx

The Xcel Initial Brief devoted many pages to the incorrect claim that the estimates produced by AP2 are not credible or accurate. Xcel Initial Brief at 3, 7, 31-47. Xcel correctly observed, however, that if the first step of determining damage values — the prediction of air quality changes from emissions — is important, because, if the air quality modeling is flawed, the other steps in the damages analysis would not overcome the deficiency in air quality modeling. Xcel Initial Brief at 3. The Agencies believe the air quality modeling performed using

AP2 is accurate and credible, and the air quality modeling results produced by Xcel Witness Dr. Desvousges' application of CAMx are not.

First of all, the statements regarding AP2 and CAMx air modeling in the Xcel Initial Brief focused almost entirely on ambient $PM_{2.5}$ from NO_x emissions (not SO_2 or direct $PM_{2.5}$), presenting Xcel's position in the form of carefully drawn and selected images about NO_x, which is the criteria pollutant with the least impact, and smallest damage value. Xcel's discussion failed to refer at all to Dr. Muller's expert testimony regarding the atmospheric chemistry that leads to the irregular and counterintuitive geographic pattern of the formulation of nitrates (the component of secondary $PM_{2.5}$ formed from NO_x). The discussion in Xcel's Initial Brief relied largely on Dr. Desvousges' evaluation of the changes in $PM_{2.5}$ predicted by AP2, in which Dr. Desvousges suggested that the AP2 model was unreliable in its ability to predict pollution levels for $PM_{2.5}$. Xcel Ex. 605 at 55 to 61 (Desvousges Rebuttal).

Dr. Muller disagreed with Dr. Desvousges suggestions, and addressed the criticism in three ways: (i) Dr. Desvousges focused almost entirely on NO_x, (ii) his analysis neglected to explore population exposures, and (iii) he could only evaluate the three source locations he modeled in Direct Testimony. DOC Ex. 811 at 7 (Muller Surrebuttal).

Dr. Muller explained that, first, Dr. Desvousges' critique focused almost entirely on the NO_x emission changes. NO_x is just one of three pollutants at issue in this proceeding, and the one that is least significant in terms of damages.[8] Further, in areas with large populations, the predictions of the two models are very much alike, especially as to the other two more significant pollutants, $PM_{2.5}$ and SO_2. DOC Ex. 811 at 7 (Muller Surrebuttal). Dr. Muller's Rebuttal

[8] The fact that NO_x contributes the smallest total environmental cost of the three pollutants at issue in this proceeding was the finding of all three expert witnesses who provided testimony, Drs. Desvousges, Marshall and Muller.

Testimony documented at length that the population exposures predicted by Dr. Desvousges' runs of CAMx and Dr. Muller's runs of AP2 were nearly *perfectly positively correlated* for $PM_{2.5}$ and SO_2, and strongly positively correlated for NO_x. DOC Ex. 810 at 40-45 (Muller Rebuttal).

Second, Dr. Desvousges' analysis neglected to even explore population exposures, which is a fundamental weakness with his testimony, because this docket is not an academic exercise, but one intended to conclude with actual recommended damage values that involve population exposures. Dr. Muller stated that it is important to assess population-weighted exposure in this context because a large portion of the environmental cost values is driven by human health effects. In essence, Dr. Desvousges largely neglected the $PM_{2.5}$ and SO_2 results in his attempted critique of AP2, and he also neglected to consider population-weighted exposures for all three pollutants. DOC Ex. 811 at 7 (Muller Surrebuttal).

Third, Dr. Desvousges ability to engage in any analysis was limited because he could only evaluate the three hypothetical source locations that he modeled in his Direct Testimony. That is, he criticized the spatial pattern of the impacts of NO_x emissions, but he was able to conduct his comparison only for the three source locations to which he applied CAMx. DOC Ex. 811 at 7 (Muller Surrebuttal). Because the model is far too cumbersome to run many times, he could only execute simulations over the three source locations. DOC Ex. 811 at 27 (Muller Surrebuttal). As Dr. Muller repeated demonstrated, this trade-off between complexity and ease of use/transparency did not compromise the results of Dr. Muller's modeling results.

Dr. Muller explained that if AP2's predicted impacts from NO_x emissions were fundamentally biased, this bias would have shown up in the model performance tests Dr. Muller reported in his Direct Testimony. It did not. For example, in Minnesota, he reported that the AP2-predicted total $PM_{2.5}$ levels were just one percent lower than the CAMx predictions. DOC

Ex. 808 at 25, Table 1 (Muller Direct). For NO_x emissions, which were the focus of Dr. Desvousges' Rebuttal Testimony, Dr. Muller reported that AP2 predicted levels of ammonium nitrate that were, on average, just 16 percent lower than the levels of ammonium nitrate that CAMx predicted in Minnesota. These are very small differences. DOC Ex. 811 at 8 (Muller Surrebuttal).

Further, and perhaps most important, if AP2 was fundamentally unreliable in its ability to predict $PM_{2.5}$ concentrations, it would not produce estimated annual average $PM_{2.5}$ levels that were more strongly correlated with annual average EPA monitor data than CAMx. DOC Ex. 808 at 29, Table 3 (Muller Direct); DOC Ex. 811 at 2-3, 7-8 (Muller Surrebuttal). Again, it is the annual average $PM_{2.5}$ levels that are associated with premature mortality risks, and premature mortality risks comprise the largest share of the environmental cost values. Therefore, model predictions according to annual average $PM_{2.5}$ concentrations, not 24-hour concentrations, are the most important dimension of model performance. DOC Ex. 811 at 8 (Muller Surrebuttal).

Xcel's Initial Brief, in mischaracterizing AP2 results as "random" and "sporadic" appeared to have relied on certain claims in Dr. Desvousges' Rebuttal Testimony. Xcel Ex. 605 at 7 (Desvousges Rebuttal). There Dr. Desvousges questioned the reliability of AP2's estimation of changes in ambient $PM_{2.5}$ because the AP2 model estimated that an increase in NO_x emissions in Lyon County, Minnesota leads to increased $PM_{2.5}$ concentrations in not only 25 of the 87 counties in Minnesota but also increased $PM_{2.5}$ concentrations in places as far away as California, Arizona, Florida and other states. Xcel Ex. 605 at 7 (Desvousges Rebuttal).

Dr. Muller, however, disagreed that those results indicated that AP2 is unreliable. He stated that AP2's estimation of no change in $PM_{2.5}$ in several Minnesota counties reflects the low levels of ambient ammonium in these counties. This is because emissions of NO_x require ambient ammonium to form ammonium nitrate, which is a constituent of $PM_{2.5}$.[9] Although the finding that some counties in Minnesota did not experience a change in $PM_{2.5}$ due to the emission of NO_x from Lyon County may seem counterintuitive, this is not a scientific justification for Dr. Desvousges' claim that AP2 results are questionable. DOC Ex. 811 at 8-9 (Muller Surrebuttal). Dr. Muller noted several concerns with Xcel's evidence on this point.

First, Dr. Desvousges' criticism was largely silent on SO_2 and $PM_{2.5}$. This is because his CAMx predictions and Dr. Muller's predictions from AP2 agree quite well for these pollutants. The criticism was centered only on NO_x, which contributes the smallest total environmental cost of the three pollutants at issue in this proceeding. Further, *if* AP2 results were biased with respect to its predictions of ammonium nitrate, it would not do such a good job of matching the predictions of CAMx. Table 2 in Dr. Muller's Direct Testimony, DOC Ex. 808 at 28, Table 2 (Muller Direct), reported a thorough comparison of AP2 and CAMx for each major component of $PM_{2.5,}$ inclusive of ammonium nitrate.

- At the national level the AP2 prediction for ammonium nitrate was *just 5% higher* than the CAMx prediction.
- At the regional level (inclusive of all states in the U.S. Bureau of Economic Analysis' Great Lakes and Great Plains regions) the AP2 prediction was only 12% lower than CAMx.
- And, in Minnesota, Dr. Muller reported that AP2 predicted levels of ammonium nitrate that were, on average, just 16% lower than the levels of ammonium nitrate that CAMx predicted in Minnesota.

[9] *See also* Tr. Vol. 8 at 150-152 (Dr. Muller explains that based on knowledge, from atmospheric chemistry, ammonium preferentially reacts with sulfate, so it prefers sulfate under most conditions. And what's left over is then available for a reaction with nitrate. "So we're dealing with a simple model that reduces a complex process down to a series of relatively simple equations. And what you're seeing here is a function not just of suspended ammonium, but leftover residual ammonium after ammonium has reacted with sulfate. So it's not just a product of ammonium emissions and ammonium concentrations, but also how much SO_2 and sulfate is in the air as well.")

DOC Ex. 811 at 9 (Muller Surrebuttal). Dr. Muller explained that, in this type of modeling exercise, a 16% difference is quite small.

More generally, Dr. Muller reported that the AP2-predicted total $PM_{2.5}$ levels were just 1% lower than CAMx predictions. DOC Ex. 811 at 9 (Muller Surrebuttal) (*citing* DOC Ex. 808 at 25, Table 1 (Muller Direct)). If there were something wrong with AP2's ability to estimate levels of this pollutant it would have shown up in these tests. In fact, these are very small differences. And it is total $PM_{2.5}$ that is entered into the mortality concentration-response function which largely dictates the environmental cost values. DOC Ex. 811 at 9-10 (Muller Surrebuttal).

Further, highly conclusive independent evidence countering Xcel's characterizations, and showing that emissions from Minnesota power plants can travel to distant locations where they affect air quality, is the EPA's own testing using CAMx (without the modifications to parameters introduced by Dr. Desvousges). The EPA ran the CAMx model as part of its *ex ante* assessment of the Cross State Air Pollution Rule (CSAPR) which regulates emissions of NO_x and SO_2 from power plants across the United States. A critical aspect of the EPA's prospective analysis of CSAPR concerns the various contributions to air quality (ambient $PM_{2.5}$ and ozone) from emissions produced by power plants. The EPA published a spreadsheet showing the effect of emissions from Minnesota on ambient concentrations across the country at *http://www3.epa.gov/crossstaterule/techinfo.html.*[10] DOC Ex. 811 at 10 (Muller Surrebuttal).

The EPA's spreadsheet shows that the CAMx model predicted impacts from NO_x emissions on ambient $PM_{2.5}$ in such distant states as Colorado, Connecticut, Wyoming, Florida,

[10] The spreadsheet is in the section entitled, "Final Cross-State Air Pollution Rule (CSAPR) and Supplemental Rulemaking," is entitled "Contributions of 8-hour ozone, annual $PM_{2.5}$, and 24-hour $PM_{2.5}$ from each state to each monitoring site". The URL of the spreadsheet is: *https://www3.epa.gov/crossstaterule/pdfs/CSAPR_Ozone%20and%20PM2.5_Contributions.xls*

and Texas, among other states, due to emissions from Minnesota. This demonstrates that the long distance transport of NO_x emissions that AP2 predicts, and which Xcel claims "do not make sense and are different from the CAMx… results" (Xcel Initial Brief at 39), have been corroborated by the EPA's run of CAMx. DOC Ex. 811 at 10 (Muller Surrebuttal). It directly refutes Dr. Desvousges' claim that impacts of NO_x and SO_2 emissions are local. DOC Ex. 811 at 15 (Muller Surrebuttal). Further, it undercuts any claim by Xcel that impacts beyond the small limited grid box cannot be reliably measured and calls into question why Xcel and Dr. Desvousges failed to do so for this proceeding.

Two additional related mischaracterizations on this topic are that, first, the Xcel Initial Brief stated: "If the air quality model cannot predict ambient air concentration changes reasonably accurately and instead produces results that are clearly flawed, the results should not be used as the basis for estimating and monetizing damages." Xcel Initial Brief at 2-3. The Agencies caution, importantly, that none of the three models were evaluated against actual changes in air quality because *this cannot be done*. All models were evaluated against air quality monitor levels and for annual averages (which is what matters for the mortality concentration-response functions) and the AP2 model performed quite well relative to CAMx.

Second, the Otter Tail Power (OTP) Initial Brief incorrectly argued that "Dr. Muller's modeling of a source in Sherburne County (the home of Xcel Energy's Sherco coal generation plants) predicted no increase in $PM_{2.5}$ in that county or two of the bordering counties…" OTP Initial Brief at 10-11. The OTP Initial Brief mischaracterized NO_x emissions, and the subsequently formed *secondary* $PM_{2.5}$ as "$PM_{2.5.}$" The counter-intuitive geographic pattern is only for emissions of NO_x (not emissions of SO_2 or $PM_{2.5}$). Dr. Muller repeatedly explained, including during the evidentiary hearing, that this is a result of the atmospheric chemistry (primarily, availability of ambient ammonium) that determines the process of formation of nitrates, a component of the process leading to the formation of secondary $PM_{2.5}$ from NO_x emissions. Tr. Vol. 8 at 150-152.

2. False Statements

The Xcel Initial Brief contained characterizations and assertions with which the Agencies disagree. While this Reply Brief will not catalogue all such disagreements, we respond to the following discrete false statements.

Xcel stated that, "There is no doubt that Xcel Energy's damage cost study was more comprehensive, thorough, and scientifically robust than Dr. Muller's (the Agencies) or Dr. Marshall's (CEO) analyses." Xcel Initial Brief at 3. The Agencies have grave doubts as to the veracity of this statement because of the spatially limited scope of damage Xcel used.

Xcel stated that Dr. Muller's estimates are not based on sound science and economics. Xcel Initial Brief at 7. This is largely a matter of opinion, and it is not substantiated in Xcel's brief. The Agencies contend (and Dr. Muller certainly has done so in his testimony) that the AP2 model and Dr. Muller's choices for how to apply AP2 in this proceeding are based on sound science and solid economic principles.

Xcel falsely characterized Dr. Muller's estimates as not fully transparent and not easily replicable. Xcel Initial Brief at 7. Xcel made this statement only in its criteria table (Table 1) at the beginning of its brief and did not substantiate this claim in the body of the brief. In actuality, Dr. Muller's estimates using AP2 are fully transparent and easily replicated. AP2 is publicly available and can easily be run by anyone with very modest skill and training. The Agencies fully expect that Dr. Muller will provide the Commission and the State of Minnesota with instructions for how to do so, so that, should the Commission wish to update these values in the future, the task could be very easily done.

B. The Importance of Following EPA Guidance as to Certain Modeling Choices.

Xcel urged the Commission to adopt EPA guidance as to certain modeling choices, and to reject EPA guidance as to other modeling choices.

Xcel contended that AP2 was not appropriate for use in this proceeding because it is a reduced-form model, the use of which fails to follow EPA recommended guidance regarding estimations of concentrations at distances greater than 50 kilometers from the source of emissions. Xcel Initial Brief at 25, 27-28.[11] As explained below, the referenced guidance pertains to a particular purpose for, or use of, the model (the EPA's *ex ante* assessment of CSAPR rules) and is not applicable here, and Xcel's implication, that AP2 produces results that are less reliable than CAMx, is inaccurate.

First, as to whether AP2 produces results that are less reliable than CAMx, an air quality model's *results* are the mark of the success or failure of the model. If AP2 generated unreliable pollution estimates beyond 50 kilometers, then AP2 would not have been able to estimate pollution level results that are as strongly correlated with available monitor data as the CAMx model's results, upon which Dr. Desvousges relied. DOC Ex. 811 at 5-6 (Muller Surrebuttal) (*citing* Xcel Ex. 604 at 10 (Desvousges Direct).

Second, the EPA Guidance to which Xcel pointed[12] pertains only to demonstrations of attainment with the EPA's CSAPR regulations. The EPA Guidance specifically cautions that

---

[11] The OTP Initial Brief at 8-9 echoes the contention. *See also* Xcel Ex. 605 at 21 and n. 11 (Desvousges Rebuttal) Dr. Desvousges stated that "[t]he use of the AP2 model to simulate dispersed emissions nationally…goes far beyond EPA's recommended use of this type of model and calls into question the validity of the resulting ambient concentration estimates….")

[12] See Xcel Ex. 605 at 21, note 11 Desvousges Rebuttal) (*citing* 40 CFR Part 51 Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion model and Other Revisions; Final Rule. Appendix W. Federal Register / Vol. 70, No. 216 / Wednesday, November 9, 2005 / Rules and Regulations. Pp. 68218-68261. Published at *http://www3.epa.gov/scram001/guidance_permit.htm* (the EPA Guidance).

"Models are identified for some *specific applications*. The Guidance provided here should be followed in air quality analyses *relative to State Implementation Plans*."[13] As Dr. Marshall explained, the EPA Guidance is for "Demonstrating Attainment of Air Quality Goals" within an individual state, rather than calculating the total damages caused by a source of emissions. CEO Ex. 119 at 11 (Marshall Surrebuttal). He concluded that the EPA guidance cited by Dr. Desvousges and repeated in the Xcel Initial Brief is not relevant in this specific case.[14] CEO Ex. 119 at 11 (Marshall Surrebuttal). The ALJ's decision not to admit to the evidentiary record a related attainment manual, "Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the $PM–_{2.5}$ NAAQS and Regional Haze Goals," on grounds of lack of relevance to this proceeding, was the correct decision. Tr. Vol. 8 at 79, 81 and Tr. Ex. 618.

Third, Xcel's choice to advocate for adoption of EPA guidelines in this instance contrasted with its choice to eschew EPA guidance as to other important modeling decisions, including the choices of VSL and mortality concentration-response parameters, where Xcel advocated against following EPA practices. In contrast to Dr. Desvousges' rejection of EPA guidance in these modeling choices, the AP2 model employed the EPA's VSL as one of the preferred values, and, for the concentration-response parameters, employed the same pair of

[13] *Id.* at Appendix W, section 1.0 (e).

[14] Furthermore, because "Dr. Desvousges did not report a performance evaluation for his configuration of CAMx in the continental U.S. domain, we do not know its accuracy." CEO Ex. 119 at 11 (Marshall Surrebuttal). It would be reasonable to conclude that Dr. Desvousges' results (which are limited to Minnesota) cannot be considered reliable comparative evidence of the accuracy of AP2's or InMAP's national results.

epidemiological studies that EPA routinely uses for its regulatory impacts analyses to model mortality effects from $PM_{2.5}$ exposure.[15] DOC Ex. 811 at 5-6 (Muller Surrebuttal).

C. AP2 is a Well-known, Publicly-Available, Transparent, and Peer-Reviewed Model

Xcel correctly noted that AP2 is a later version of a well-known air quality model APEEP. Xcel Initial Brief at 27. Xcel erroneously stated, however, that although AP2's temporary trade secret status had been lifted,[16] "some aspects of AP2 are still not public." Xcel apparently based this comment on a court reporter's typographical error during the contested case hearing, when transcribing a non-evidentiary colloquy between an attorney and the ALJ. The reporter has since corrected the transcript. Tr. Vol. 8 Errata Page 123 at l. 2 (The correction changed "not" to "now" in the phrase "[t]he documentation is *now* entirely public").

D. As a Reduced-Form Model, AP2 Can Accurately Reflect the High Degree of Heterogeneity in Damage Values that Depend on the Specific Source Location

1. Source Location Is Needed for an Air-Quality Model to Determine Impacts.

Dr. Muller explained that the impacts of emissions vary significantly according to the location of the emission source. To detect differences in the damage of emissions, the model must take into account where the emissions are released. DOC Ex. 808 at 10 (Muller Direct). Indeed, one of the facts most questioned by Xcel was how the predicted levels of ambient

---

[15] The OTP Initial Brief similarly expressed concern to follow EPA guidance, stating: "While Otter Tail understands Minnesota's regulatory needs and processes can differ from the EPA's … the Commission should give serious weight to EPA guidelines given that Agency's extensive experience evaluating and using air quality models" and "[t]he Commission should choose the model that complies with EPA guidelines unless there are compelling reasons to do otherwise…." OTP Initial Brief at 9. As to the use of a reduced-form model, the Agencies believe there are "compelling reasons to do so": the Commission prefers use of reduced-form model, and the AP2 model performs as well or better in comparison with CAMx, as noted in above section II.

[16] AP2 was treated as trade secret when it was provided to the parties during discovery while undergoing peer review during 2015.

ammonium nitrate in the areas into which NOx is transported influences the formation of secondary $PM_{2.5.}$ As Dr. Muller repeatedly demonstrated, the location of the emission source relative to the predicted levels of ammonium nitrate has a significant effect on the concentrations of secondary $PM_{2.5.}$ *See, e.g.*, DOC Ex. 811 at 7-8; DOC Ex. 808 at 25-29 (Muller Direct).

This topic was also raised in the cost proceeding in the 1990's; as with the present case, the evidence there showed that the proximity of human populations to the locations where emissions disperse, the surrounding air quality, and atmospheric conditions differ among emission locations. ALJ Klein observed that if these conditions vary significantly among locations, then the damages attributable to emissions at these sites will also vary. For this reason ALJ Klein recommended that the Commission employ geographically-sensitive values "to the extent practicable." Docket No. 93-583, ALJ Report at 19-20 (March 22, 1996).

In the present proceeding, Drs. Muller and Marshall have shown that it is imminently practicable to employ county-level values. Dr. Muller has also helpfully provided specific values for the six largest existing power plants in Minnesota and for certain facilities within 200 miles of Minnesota.

2. Adherence to the Geographic Decisions Made in Docket No. E999/CI-93-583 Is a Poor Justification for Today's Modeling Choices.

In contrast to the Agencies, Xcel's modeling exercise limited the location of emission sources to three general geographic land use categories; Xcel's main argument for this (and the other) geographic choices it proposes[17] is adherence to the geographic decisions made in the 1990's proceeding. *See, e.g.,* Xcel Initial Brief at 9-12, 52-53, 62, 70. For example, Xcel

[17] In addition to the geographic choice regarding the specificity of sources in Minnesota, two other geographic choices include the geographic scope of damages, and the geographic specificity for sources outside of Minnesota.

characterized its choice to model only three hypothetical source locations as being "consistent with the geographic groupings adopted in the original proceeding." Xcel Initial Brief at 62.

Although this rough geographic categorization was adopted 20 years ago as the best available methodology given the methods and modeling capabilities at that time, such a rough categorization no longer needs to be employed. All three expert witnesses in this present docket have plainly demonstrated that advances in modeling capability in the past 20 years now make it highly practicable to develop much more finely-grained geographically-specific values that correctly reflect the spatial heterogeneity in the environmental cost values. Xcel's arguments are based on what was reasonable and practicable to do 20 years ago. Today, however, it is reasonable and practicable for the Commission to use the readily available county-by-county and source-specific damages. Of course, should use of a generic value or value range be more reasonable in a particular resource planning proceeding, the county-specific values readily can be generalized or averaged in any manner the Commission may choose.

3. AP2's Ability to Predict County-Specific and Plant-Specific Values is Helpful and Practical.

The Xcel and OTP Initial Briefs argued against finely-grained plant-specific and county-specific values on grounds that they will not provide valuable information, "considering the nature of resource planning and resource acquisition … [in which] location of a new resource is open and unspecified." Xcel Initial Brief at 63; OTP Initial Brief at 10[18] (the "use of county-by-county values is generally unnecessary in resource planning."); and, Xcel Ex. 607 at 24-26 (Rosvold Rebuttal).

[18] The OTP Initial Brief also claims that plant-specific information would not be useful, mischaracterizing Dr. Muller's modelling of the Sherburne County (the location of Xcel's Sherco coal plants) as one that estimated "no increase in $PM_{2.5}$ in that county …" The estimation to which OTP points, however concerned NOx emissions and the formation of secondary $PM_{2.5,}$ not primary $PM_{2.5}$ and SO_2. *See, e.g.*, Xcel Initial Brief at Figure 5.

The Agencies agree that the specific location of a resource addition is not typically known at the resource planning stage; however we disagree that the county-by-county damage value ranges are thus rendered impracticable.

Dr. Muller proposed methods for setting more generic values. Xcel complained that, "Dr. Muller proposed specific values for nearly 500 different counties and existing power plants, but he did not propose a generic value."[19] Xcel Initial Brief at 13. This is an untrue statement. Dr. Muller reported several ways to aggregate the data to produce generic values. These include averaging all of the values to produce one generic value range (for each pollutant) or aggregating them in other easily-accomplished ways. Preserving specificity for those proceedings in which a source location is known, while enabling development of more generic ranges for proceedings in which the source location is not known, ensures that the Commission has the options and flexibility it needs to apply externality values appropriately in each future proceeding.

Dr. Muller made it clear that the location-specific values produced by AP2 or InMAP are highly practical because this method gives the Commission the greatest versatility in choosing how to apply them. DOC Ex. 811 at 25-26, 32 (Muller Surrebuttal). He explained a number of possible ways in which the county- and source-specific values that he and Dr. Marshall produced could be used by the Commission, including:

In the simplest approach, one could compute the mean environmental cost values for each pollutant over all sources. This would yield just three value ranges (one for each pollutant), and the generic value range could be applied to all plants. DOC Ex. 811 at 25 (Muller Surrebuttal).

---

[19] See also CEO Brief at 14, 32 (CEO brief at 32 notes that Dr. Marshall developed what he called "generic values" by calculating damages based on existing power plants, and developing a single weighted average of these results to produce generic values "that the Commission may apply when the location and stack height of a new resource are not yet known.") CEO Ex. 115 at 18 (Marshall Direct).

For example, Dr. Muller provided average marginal damage ranges in his Table 11 of Ex. 808 at 72 (Muller Direct).

Alternatively, the Commission could group the values according to quantiles of the distribution of values as Dr. Muller did, for example, in DOC Ex. 808 at 53 (Muller Direct). Then, facilities or source locations falling into each group would have a common, generic environmental cost value range for each pollutant – computed as the average environmental cost value range for all sources with damage values in that quantile for each pollutant. This would greatly reduce the complexity of working with county- and source-specific values and yet it would reflect the spatial heterogeneity in the environmental cost values. DOC Ex. 811 at 25 (Muller Surrebuttal).

A third approach could compute average generic environmental cost values (for each pollutant) within land-use designations, such as the ones that Dr. Desvousges proposed: urban, metro-fringe, and rural. Dr. Muller cautioned, however, that it is important to know that there is significant variation in the environmental cost values within these land-use designations and so simply relying on one source location within each, as Dr. Desvousges did, is inherently problematic. Dr. Muller admonished Dr. Desvousges for employing a methodology that reported environmental costs from only one site in each land-use category, thus missing considerable variation in exposures (based on the location of emissions). Such an approach is inaccurate, not representative, and impractical for use. DOC Ex. 811 at 26 (Muller Surrebuttal).

With respect to the concern of Xcel and OTP that small differences in environmental cost values between source locations in adjacent counties "gives the false illusion of precision," (OTP Initial Brief at 10). Dr. Muller explained that this could be easily alleviated by taking average values within either land-use designations or quantiles of the distribution – once accurate damage estimates were known, based on accurate location data. DOC Ex. 811 at 25 (Muller Surrebuttal).

In further support of retaining the ability to use county-specific value ranges, the Agencies note that, even for utility resource planning, the Commission may need to make decisions regarding specific existing generation facilities with known specific locations, and other decisions regarding new generation may also be location specific. OTP's Initial Brief, for example, cites its own 2013 Resource Plan, which evaluated "a conversion of existing coal generation to gas generation, [which] was location-specific." OTP Initial Brief at 11 and n. 44. It can only be helpful for the Commission to have site-specific damage values for the existing large coal burners such as Sherco, rather than estimated damage values based on a hypothetical plant having only some of the attributes of Sherco. The Agencies know of no reason why the Commission should reverse its decision to use reduced-form modeling and forego using the readily-available, finely-grained values produced by reduced-form models.

Finally, Xcel expressed a concern that the estimation of environmental cost values for sources outside of Minnesota is "impractical" (Xcel Initial Brief at 63-64). If the Commission wishes to know what the impacts are of emissions from power plants that may serve Minnesotans but are located outside of the state, then one needs to model the sources outside of the state. It does not suffice to simply assume, with no analysis, that an estimated environmental cost value for a rural location within Minnesota will accurately represent impacts from out-of-state sources. Xcel's position that estimated values for rural locations within Minnesota are sufficient proxies for out-of-state sources originates from Dr. Desvousges' use of the CAMx model: because the model is far too cumbersome to run many times, he could only execute simulations over three hypothetical source locations. Reduced-form models do not suffer from this limitation, and readily perform the analysis necessary to quantify the damages from out-of-state emissions, so that there is no need to arbitrarily assume that those damages are equal to those from sources located in rural Minnesota. DOC Ex. 811 at 26-27 (Muller Surrebuttal).

When calculating a "generic" damage value range for out-of-state sources the use of a reduced-form model affords the Commission a series of practicable choices (similar to in-state sources). One strategy would be to compute the average environmental cost for each pollutant over all out-of-state sources. Another approach would be to subdivide the out-of-state sources into quantiles (as described above.) There is substantial variation in the environmental cost values for the out-of-state sources, however, because not all of these sources are located in rural areas. A third approach for calculating a generic value is to group the out-of-state sources according to land-use: whether the source locations are in rural, metro-fringe, or urban locations. DOC Ex. 811 at 27 (Muller Surrebuttal).

In summary, the Commission need not be constrained by Xcel's decision not to model the impacts and damages using accurate locational information for in-state and out-of-state sources.

E. The CEO's Choice of Model.

The Agencies disagree with the CEO's assertion that InMAP is superior to AP2 in this context. CEO Initial Brief at 62-63. Dr. Muller demonstrated repeatedly in his testimony that AP2 performs at least as well as InMAP for this application when comparing its air-quality results to photochemical model results and to air monitoring data. The Agencies and Dr. Muller do agree with CEO (CEO Initial Brief at 63-64), however, that the choice of model is less important than the choices of key modeling choices and parameters (geographic scope of damages, location specificity of sources, concentration-response function parameters and VSL). DOC Ex. 813 at 3 (Muller Opening Statement); Tr. Vol. 8 at 12, 140.

In this regard, the Agencies appreciate that InMAP, like AP2, is publicly available, transparent, and straightforward to operate. Unlike InMAP, however, it is significant that AP2 (and its predecessor versions) has been extensively peer-reviewed and is well-established as a model to estimate damage costs of air pollution. As Dr. Muller explained, AP2 has existed for many years (much of this time known by its former name APEEP) and has been used in many peer-reviewed studies and in proceedings such as this one to establish the damage cost estimates of air pollution emissions.

4. SELECTION OF THE MORTALITY CONCENTRATION-RESPONSE FUNCTION

A. Air Concentration Changes and Accounting For Uncertainty

Xcel's Initial Brief at 53-54, asserted that it is critical to make a distinction between air concentration changes and the monetized damages that are estimated from those changes. Xcel noted that when the air quality changes occurring farther away from Minnesota are predicted by the models to be very small, and these changes are multiplied by the large populations of people exposed, then these very small predicted changes in air quality will make a significant contribution to damage values. Xcel appeared to take the position that these damage values are not reliable due to the uncertainty in these small air quality changes, and should therefore not be counted.

As an initial matter, Xcel's position is not consistent with that of its expert witness, who failed to count not only remote or uncertain concentration changes, but who also truncated his analysis, and failed to count impacts where the concentration changes predicted by CAMx were still quite high, between 0.005 and 0.01 $\mu g/m^3$ (micrograms per cubic meter). DOC Ex. 810 at

26-28 (Muller Rebuttal).[20] This is discussed in Section II (1) (A) above, regarding Dr. Desvousges' Figure 2.4.

Furthermore, it is well accepted in the literature that there is a linear concentration response, even at very low concentrations. All three expert witnesses used linear concentration-response functions, and as Drs. Muller and Marshall have pointed out, the preponderance of the relevant epidemiological literature as well as studies by the EPA have shown that these relationships are linear and that there are no known safe thresholds.[21] Tr. Vol. 7 at 141-42; Tr. Vol. 8 at 44-45. Moreover, the most widely-accepted, landmark epidemiological literature (notably the American Cancer Society and Harvard Six Cities studies) have examined health responses for $PM_{2.5}$ concentrations below 12 μg/m^3.[22] DOC Ex. 809 at Attachment 2, p. 6 (Muller Direct Attachments); DOC Ex. 811 at 33 (Muller Surrebuttal); CEO Ex. 117 at Schedule 3, pp. 967–68 (Jacobs Rebuttal). While there may be uncertainty as to the magnitude of impacts at low ambient concentrations, there is no evidence to support a claim that there are no impacts.

[20] Dr. Desvousges's *average* change in concentration in $PM_{2.5}$ within 100 mile radius of Minnesota was the much smaller amount of .0000198 μg/m^3 and some concentrations that he used to calculate damages were much lower inside the small grid box. ((Ex. 608 at 43 (Desvousges Surrebuttal); Tr. Vol. 7 at 141.

[21] The MLIG Initial Brief at 3-4, 23-29 similarly claimed that there is no proof of a linear relationship between changes in ambient $PM_{2.5}$ and health impacts at baseline concentrations below the current NAAQS of 12 μg/m3 (annual average). As noted above, this is inaccurate. Dr. McClellan observed that the EPA's expert advisors on the NAAQS, "when commenting on the science undergirding the Standard, had noted that it had not identified a threshold in the ambient exposure concentration–response relationship for $PM_{2.5}$." MLIG Ex. 441 at App, McClellan, Role of Science and Judgment in Setting National Ambient Air Quality Standards, 5 *Air Qual. Atmos. Health* 243 at 252 (2011).

[22] MLIG and Dr. McClellan also point out that because most epidemiological studies consider the impacts from larger changes in ambient $PM_{2.5}$ concentrations, that the small changes to concentration used by all the witnesses to estimate damage values are not credible or statistically different than zero. MLIG Initial Brief at 26-29. This is related to the linear relationship issue described above. If the concentration-response relationship is **linear**, as the epidemiological literature suggests, then the health impact response will be proportionate to the change in concentration. Large concentration changes will lead to large health responses and small concentration changes will lead to small, but not zero, health responses.

This then amounts to a question about how science (and regulatory authorities) deal with uncertainty: should the damages that are known to exist, but for which uncertainty exists, be entirely uncounted and not monetized at all (as Xcel has proposed), or should uncertainty be accounted for by using a range of values within which the actual value is highly likely to be located? The Agencies believe the latter to be the better approach, because accounting for a reasonable amount of uncertainty is an ordinary aspect of this type of modeling, and protocols such as those used by Dr. Muller have been developed by experts in the field to address uncertainty and provide tools for regulators. The Agencies note that Dr. Desvousges employed similar techniques for accounting for uncertainty when developing his unique VSL and concentration-response function. Tr. Vol. 8 at 45. Furthermore, the Commission in the last environmental cost values proceeding accepted witnesses' similar proposals for addressing uncertainty[23] and the Commission's decision was affirmed in *In the Matter of the Quantification of Environmental Costs Pursuant to Laws of Minnesota 1993, Chapter 356, Section 3,* 578 N.W.2d 794, 800–01 (Minn. Ct. App. 1998).

B. OTP's Criticism of Mortality Concentration-Response Function

OTP criticized Dr. Muller's (and Dr. Marshall's) choice to not use the most recent evaluation of the American Cancer Society (ACS) cohort study (Jerrett et al (2013))[24] to represent the relationship between $PM_{2.5}$ concentration and premature mortality. OTP Initial

[23] Docket No. E999/CI-93-538, Order Establishing Environmental Cost Values (Jan. 3, 1997).
[24] Jerrett, Michael, Richard T. Burnett, Bernardo S. Beckerman, Michele C. Turner, Daniel Krewski, George Thurston, Randall V. Martin, Aaron van Donkelaar, Edward Hughes, Yuanli Shi, Susan M. Gapstur, Michael J. Thun, and C. Arden Pope III, "Spatial Analysis of Air Pollution and Mortality in California," *American Journal of Respiratory and Critical Care Medicine*, Sept. 1, 2013, Vol. 188, Issue 5, pp. 593-599.

Brief at 15. Drs. Muller and Marshall used the Krewski et al (2009) study[25] while Dr. Desvousges used Jerrett et al (2013).

This criticism is not persuasive because the Jerrett study involved only a small subset of the ACS cohort living in Los Angeles,[26] whereas the Krewski study is the most recent comprehensive analysis of the entire ACS cohort, and is still one of the two recommended concentration-response parameters for increased premature mortality risk from $PM_{2.5}$ exposure recommended by the EPA (the other being the Lepeule et al (2012)[27] value, which is the other concentration-response parameter used by Drs. Muller and Marshall).

It should be noted that Dr. Muller does not disagree with the unique process and the function that Dr. Desvousges used,[28] because the value at which Dr. Desvousges ultimately arrived overlapped at least part of the range found in peer-reviewed evidence regarding the effect of $PM_{2.5}$ exposure on adult mortality rates. Dr. Muller explained that Dr. Desvousges developed his estimate of the mortality effect of $PM_{2.5}$ exposure such that a 1 µg/m3 increase in $PM_{2.5}$ yields a 0.6 percent increase in adult mortality rates. This value is nearly identical to the results from the Krewski et al (2009) study, one of the two studies that Dr. Muller used to develop a

---

[25] DOC Ex. 810 at 8 (Muller Rebuttal) (*citing* D. Krewski, M. Jerrett, R.T. Burnett, R. Ma, E. Hughes, Y. Shi, et al. 2009. "Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality." *HEI Research Report*, 140, Health Effects Institute, Boston, MA).

[26] The ACS involved a nationwide cohort of nearly 1.2 million adults followed for mortality since 1982, while Jerrett et al (2013) involved data of only 73,711 subjects who resided in Los Angeles, California. *Abstract of "Spatial Analysis of Air Pollution and Mortality in California,"* published at *http://www.atsjournals.org/doi/full/10.1164/rccm.201303-0609OC* (visited April 6, 2016).

[27] DOC Ex. 810 at 8 (Muller Rebuttal) (*citing* J. Lepeule, F. Laden, D. Dockery, J. Schwartz, 2012,"Chronic Exposure to Fine Particles and Mortality: An Extended Follow-Up of the Harvard Six Cities Study from 1974 to 2009." *Environmental Health Perspectives* 120 (7):965-70).

[28] It is noteworthy that the various input and parameter choices Dr. Desvousges made in his adaptation of CAMx for this proceeding were not subject to any peer-review process, nor did they result from any identified peer-reviewed methodology.

range of estimates of the effect of exposure to $PM_{2.5}$ on adult mortality rates. Although the unique process and the function employed by Dr. Desvousges was not peer-reviewed, because the value Dr. Desvousges ultimately selected was in accord with at least part of the range of peer-reviewed evidence regarding the effect of $PM_{2.5}$ exposure on adult mortality rates, Dr. Muller was comfortable with Dr. Desvousges' value. He cautioned that the current epidemiological evidence, however, suggests two viable values for the concentration-response parameter governing mortality risk from $PM_{2.5}$ exposure: the values reported in Krewski et al (2009) and Lepeule et al (2012). Accordingly, and as stated in DOC Ex. 808 at 39 (Muller Direct), a preferred approach is to use both of these studies to produce a range of damage values. DOC Ex. 810 at 18-19 (Muller Rebuttal).

C. The Agencies Recommend Consideration of Non-Mortality Risks.

Dr. Muller and the Agencies, unlike the CEO (CEO Initial Brief at 41) continue to recommend including non-mortality risks from $PM_{2.5}$ exposure in the damage estimates. Although the $PM_{2.5}$ mortality risk comprises the vast majority of damages in monetary terms, it is nonetheless important to also consider non-mortality impacts – morbidity and environmental impacts – of $PM_{2.5}$ as well as mortality, morbidity, and environmental impacts of ozone. It has consistently been the Agencies' recommendation that the Commission should take impacts into account if there are credible and accurate methods and models to do so.[29] AP2 is able to credibly and accurately estimate these impacts and damages, and so these additional impacts should be included when determining damages.

[29] Docket Nos. E999/CI-00-1636 and E999/CI-14-643, "Comments of the Minnesota Department of Commerce, Division of Energy Resources and the Minnesota Pollution Control Agency" at 5 (June 10, 2014) (Addressing the question about whether non-human health impacts should be considered, the Agencies stated, "Whether these impacts can be accurately quantified and monetized depends on whether whoever ultimately does the analysis to estimate these values … *has credible and defensible methods* for doing so" (emphasis added).

D. The MLIG Criticisms Regarding Concentration-Response Function

1. Whether There Have Been Overall Reductions in Air Pollution and Emissions in Minnesota is Immaterial in this Proceeding.

MLIG went to great lengths to show that overall emissions and ambient pollutant concentrations have improved in Minnesota (MLIG Initial Brief at 8-23). This is true, but irrelevant to estimating the per-ton marginal damages of emissions.

In response to Mr. Rosvold's inaccurate statement that "Minnesota emissions are not significantly contributing to air concentrations in any other states now that CSAPR has been fully implemented," (Xcel Ex. 607 at 14 (Rosvold Rebuttal)), Dr. Muller noted that the EPA's modeling documentation[30] shows that the CAMx model predicts that NO_x and SO_2 emissions released within Minnesota impact ambient $PM_{2.5}$ levels in many states (Colorado, Connecticut, Wyoming, Florida, and Texas and others). Further, the present proceeding is not defined in terms of impacts on the National Ambient Air Quality Standards (NAAQS) attainment and therefore an assessment of the impacts of emissions on concentrations should not be limited to instances when NAAQs violations occur because of particular emissions. Emissions from Minnesota affect ambient $PM_{2.5}$ concentrations for areas that do not achieve the NAAQS as well as those that do achieve the NAAQS. DOC Ex. 811 at 32 (Muller Surrebuttal).

2. "Causation" Versus "Correlation"

Although its expert witness, Dr. McClellan, agreed with the other expert witnesses that "the basic approach used by" Drs. Desvousges, Marshall and Muller "to mathematically estimate monetized damages for $PM_{2.5,}$ SO_2 and NO_x released from hypothetical new sources *is consistent with recent and current practices in the air pollution field*," (MLIG Ex. 441 at 20 (McClellan Rebuttal)), MLIG argued the semantics of medical "causation" versus "correlation" or

[30] The EPA's modeling documentation for CSAPR is published online at *http://www3.epa.gov/crossstaterule/techinfo.html.*

"association" in the relationship between ambient $PM_{2.5}$ and health responses. MLIG Initial Brief at 27-29.

Contrary to its witness' opinion that Drs. Desvousges', Marshall's and Muller's methodologies comport with conventional "practices in the air pollution field," MLIG argued that, for damage values to be credible in this proceeding, the correlation of increases in air pollution to increases in health impacts should be rejected, and that "causation in the medical sense" must be established for the concentration-response function to be credible for purposes of setting damages in this proceeding. *Id.*; *see also* Tr. Vol. 8 at 58 to 61. Nothing in the record supports the MLIG argument. Dr. Muller, however, offered during cross-examination that it is not necessary to establish causation; it is accepted in the relevant epidemiological literature and in studies by the EPA that higher concentrations of air pollution are correlated with higher adverse environmental and health impacts to affected populations. Tr. Vol. 8 at 17-18.

3. Minnesota's Attainment of the NAAQS Level of 12 µg/m3 Is Immaterial in this Proceeding.

The MLIG repeatedly pointed out that the estimates in this proceeding are all based on concentration-response relationships derived in national studies and are not specific to Minnesota, which is in attainment of the NAAQS level of 12 µg/m3. MLIG Initial Brief at 4, 24-25, 38. This is true, but, as noted above, irrelevant. It is common to apply epidemiological relationships found in other areas. There is no reason to expect, and nothing in the record to suggest, that the epidemiological response will be different in Minnesota than it is nationally. The fact that these are nationally-derived concentration-response relationships gives them greater credibility due to the larger sample size than if they had been based only on concentration-response studies derived from studies in Minnesota.

4. EPA Determinations of the $PM_{2.5}$ NAAQS Are Not Intended to Eliminate All Health or Other Environmental Impacts.

The MLIG argued that the EPA, in setting the NAAQS,[31] has established an air concentration standard intended to eliminate health risks. MLIG Initial Brief at 39-48. This is inaccurate and inconsistent with its witness's testimony. While health risk is a primary factor in setting the standards, there are other factors involved when an EPA Administrator exercises his or her judgment in setting the NAAQS standards, including acceptable risk and margins of safety. 42 U.S.C. § 7409(b)(1). The NAAQS are based not only on science, but also on policy considerations of "welfare, social, economic, and energy impacts." 42 U.S.C. § 7409(d)(2)(C). As discussed in section II 4 A above, Dr. Muller testified that EPA studies show health risks at concentrations below the NAAQS, and both he and Dr. Marshall have shown that the preponderance of the relevant epidemiological literature as well as EPA studies have shown that these relationships are linear and there are no known safe thresholds or zero risk at the level of its standards. As Dr. McClellan testified, the EPA Administrator instead makes "policy judgments as to acceptable levels of risk if the science does not identify a threshold level below which there are no identifiable health risks." MLIG Ex. 441 at App, McClellan, Role of Science and Judgment in Setting National Ambient Air Quality Standards, 5 *Air Qual. Atmos. Health* at 243 at 243 (2011). Dr. McClellan opined that, when the EPA administrator sets the NAAQS:

> [S]cience alone cannot identify an acceptable level of health risk, since such levels inherently represent a policy judgment call. Sound science can only inform what are ultimately policy judgments or political decisions. This is especially the case for the setting of NAAQS, in the absence of a clearly defined threshold, which involve decisions as to acceptable health risks which are linked to the level (and form) of the Standard.

Id. at 254.

---

[31] MLIG also discussed an analogous situation of the California Air Resources Board in establishing a regulation for the State of California.

Furthermore, the EPA has been continually lowering the NAAQS for both $PM_{2.5}$ and ozone[32] as more and more evidence has arisen to show health risks at lower and lower concentrations.[33] It is reasonable to expect that these standards will continue to be tightened in the future as the EPA learns more about the health impacts and as improvements increase what is technically feasible in emissions reductions. Addressing this same argument, ALJ Klein's Report in Docket No. E999/CI-93-583 observed that the argument assumes that there is indeed a discrete threshold concentration of the criteria pollutants below which no costs occur, and that the NAAQS are set at or below that threshold. The ALJ rejected the veracity of these assumptions, observing that the record in that case (as is also the case in the present docket) showed that there were "no defined thresholds below which no effects occur" and that "there is substantial evidence of health effects or other environmental costs at concentrations below the NAAQS for several of the criteria pollutants." Docket No. 93-583, ALJ Report at ¶ 46 (March 22, 1996). He further noted that:

> As science progresses, pollution concentrations previously thought to be safe are determined to cause negative effects. This has been acknowledged by both the EPA and Congress in the legislative history to the Clean Air Act Amendments of 1977.

Docket No. E999/CI-93-583, ALJ Report at ¶ 45 (*citing Lead Industries Ass'n v. Environmental Protection Agency*, 647 F.2d 1130, 1152-1154 (D.C. Cir. 1980), *cert. den*, 449 U.S. 1042 (Dec. 8, 1980).

---

[32] Tables showing the EPA's tightening of the NAAQS for several decades are published at *https://www3.epa.gov/ttn/naaqs/standards/pm/s_pm_history.html* ($PM_{2.5}$) *https://www.epa.gov/ozonepollution/table-historical-ozone-national-ambient-air-quality-standards-naaqs* (ozone)

[33] See also MLIG Ex. 441 at 254 (McClellan Rebuttal) (Dr. McClellan noted that "substantial new scientific information on ozone…has been published in the 5 years since the Criteria Document (EPA 2006c) was prepared [as] is documented in the recently released Integrated Science Assessment (EPA 2011b)."

5. CHOICE OF VSL

A. Xcel's and CEO's Witnesses Proposed Reasonable Values for VSL, but Each Inappropriately Proposed a Single VSL Value, Rather Than a Range.

Dr. Muller was comfortable with each of the VSL values proposed by the CEO and Xcel. DOC Ex. 810 at 7-8, 17-18 (Muller Rebuttal). He disagreed, however, with the methods they used.

VSL is a parameter for which uncertainty needs to be accounted, both because there are two general approaches to estimating the VSL, stated-preference and revealed-preference approaches, and because study populations and time periods vary. Because the VSL is not a single number known or calculable with certainty, Dr. Muller, to account for these uncertainties, recommended the use of two different meta-analysis studies, each of which was predominantly based on individual studies of each type, stated- and revealed-preferences. This resulted in a range of defensible values, from $3.7 million to $9.5 million, expressed in year-2011 U.S. dollars. DOC Ex. 810 at 17-18 (Muller Rebuttal). The upper end in 2015 dollars is $10.1 million. *Id*. at 7-8.

One of the two studies on which Dr. Muller relied was the EPA's chosen VSL, which is based predominantly on revealed-preference studies (21 out of the 26 studies considered.) DOC Ex. 811 at 17 (Muller Surrebuttal). The use of the EPA VSL as an upper bound of a range of values was appropriate because it is a credible VSL estimate that the EPA has employed in many regulatory impact analyses and benefit-cost analyses for air pollution (see EPA, 1999; 2011)[34].

[34] U.S. Environmental Protection Agency (EPA). 1999. *The Benefits and Costs of the Clean Air Act, 1990–2010. Prepared for U.S.* Congress by U.S. EPA, Office of Air and Radiation/Office of Policy Analysis and Review, Washington, DC, November; EPA report no. EPA-410-R-99-001. Available at <http://www.epa.gov/air/sect812/1990-2010/fullrept.pdf>.
USEPA. 2011. *The Benefits and Costs of the Clean Air Act 1990 to 2020: EPA Report to Congress*. Office of Air and Radiation, Office of Policy, Washington, DC. March. Available at <*http://www.epa.gov/oar/sect812/feb11/fullreport.pdf*>.

DOC Ex. 811 at 16 (Muller Surrebuttal). Confidence that the EPA's VSL was an appropriate high-end value was increased by Dr. Muller's further step of comparing it to a recent peer-reviewed meta-analysis of revealed-preference studies by Viscusi (2015)[35] that produced a VSL range of $7.2 million to $10.5 million in 2015 dollars. DOC Ex. 808 at 42 (Muller Direct). The second study on which Dr. Muller relied for his low-end value is a more recent stated-preference meta-analysis, the Kochi et al, (2006) study. DOC Ex. 808 at 41-42 (Muller Direct). CEO Witness, Dr. Polasky agreed that use of these two studies by Dr. Muller was reasonable. DOC Ex. 811 at 31 (Muller Surrebuttal) (*citing* CEO Ex. 118 at 8 (Polasky Rebuttal)).

As noted above, Dr. Muller was comfortable with each of the VSL values proposed by the CEO and Xcel. DOC Ex. 810 at 7-8, 17-18 (Muller Rebuttal). Xcel's Dr. Desvousges developed a VSL of $5.6 million in 2011 U.S. dollars, the year for which Dr. Muller recommended a VSL range of $3.7 million to $9.5 million. Dr. Muller testified that he is comfortable with Dr. Desvousges' chosen VSL value because it lies in the center of the range of values that Dr. Muller used, but that, methodologically, it was inappropriate that Dr. Desvousges used only one (non-peer-reviewed) central VSL. DOC Ex. 810 at 17-18 (Muller Rebuttal).

Dr. Muller was also comfortable with Dr. Marshall's chosen VSL value of $9.8 million in year-2015 U.S. dollars, because it, too, falls within the range of values Dr. Muller endorsed. DOC Ex. 810 at 7-8 (Muller Rebuttal). Like Dr. Desvousges' VSL, however, the choice of VSL proposed by Dr. Marshall was based on a value from a single meta analysis, which, while it has the advantage of being credible, as the EPA's chosen VSL, (CEO Initial Brief at 5, 15, 17) it is based predominantly on revealed-preference studies, and does not appropriately reflect a range

[35] Viscusi, W. K. 2015, The role of publication selection bias in estimates of the value of a statistical life, *American Journal of Health Economics* 1(1): 27-52.

that would result from employing a meta-analysis of stated-preference studies.[36] DOC Ex. 810 at 7-8 and n.1 (Muller Rebuttal); DOC Ex. 811 at 31 (Muller Surrebuttal). Just as "Dr. Marshall recommend[ed] using [] two concentration-response functions to frame the high- and low-end damage estimates for the uncertainty involved in estimating increased premature mortality risk attributable to increases in $PM_{2.5}$ concentrations" (CEO Initial Brief at 42) it is important to account for uncertainty in the VSL in a similar matter.

The contention in the CEO's Initial Brief, that "Dr. Muller created a range that obscured the difference between … revealed-preference … and stated-preference studies when he used a value based on both as the high end of a range" (CEO Initial Brief at 53) rather overstated the concern, because, while the EPA study's VSL – Dr. Muller's high-end assessment – included some stated-preference studies, it was predominantly skewed towards revealed-preference studies (21 of 26 were revealed-preference studies).

B. OTP's Criticism of the Agencies' Choice of VSL Lacks Merit.

OTP pointed out that one of the two VSLs used by Dr. Muller (and the only VSL used by Dr. Marshall) was derived from a meta-analysis of studies more than 20 years old. OTP Initial Brief at 17. OTP does not mention, however, that this VSL value continues to be the value that the EPA considers to be the most credible, nor does OTP acknowledge that it corresponds very closely to a recent meta-analysis by Viscusi (2015) that produced a VSL range of $7.2 million to $10.5 million (DOC Ex. 808 at 42 (Muller Direct)) which suggests that the passage of 20 years has not rendered the data unreliable.

[36] Dr. Muller contrasts this with his choice of using two measures of central tendency from two different collections of studies to attempt to bracket a range of reasonable VSLs. DOC Ex. 811 at 31 (Muller Surrebuttal).

III. CONCLUSION

The Agencies continue respectfully to request that the Commission issue an Order consistent with the principles, analyses and recommendations addressed in the Agencies' testimony, Initial Brief, this Reply Brief, and the proposed Findings submitted herewith, including a determination that:

(1) The results formulated by the Agencies' witness Dr. Nicholas Z. Muller, using the AP2 model are appropriate environmental cost values for the criteria pollutants under Minn. Stat. § 216B.2422;

(2) The AP2 model, and the related data sources, parameters, and assumptions proposed by the Agencies, are reasonable and practicable to use because:

- AP2 is a reliable, peer-reviewed model;
- use of a reduced-form model such as AP2 appropriately balances simplicity and accuracy in the prediction of ambient pollutant concentrations;
- the modeling results are based on accurate spatial variability assumptions and data regarding emission source locations and attributes and accurately capture the distribution of damages across source locations;
- the modeling results are based on reliable data;
- AP2 has an appropriate scope with regard to the impacts analyzed, including exposure to both ambient $PM_{2.5}$ and ground level ozone (O_3);
- the modeling results reflect the significant impacts of these pollutants, including not only mortality risk but also morbidity (illness) states and environmental impacts;
- the modeling results are based on reliable, transparent parameters for the concentration-response functions (which link exposures to estimated physical effects such as impacts on mortality rates) and the value of a statistical life (VSL) (which reflects the monetary value to an individual of a small change in their mortality risk);
- uncertainties in key parameters such as mortality risk and VSL were appropriately addressed by using different choices for these parameters to estimate ranges of marginal damages that bracket what could be considered reasonable values for the per-ton damage estimates, rather than a single point;

- the modeling results reflect marginal (rather than average) damages;

- the modeling results are a reasonable reflection of all damages caused by the criteria pollutants, including damage occurring outside of Minnesota, and are not constrained to reflect damages only within an arbitrarily defined grid-box;

- because of its relatively simple structure, reduced-form models such as AP2 can perform multiple sensitivity analyses around a variety of different modeling assumptions so that the Commission can readily see how damages change when modeling assumptions are changed;

- AP2 performed as well as or superior to other proposed models, including in its ability to match its modeled ambient air concentrations with observed monitored air-quality data.

Dated: April 15, 2015

Respectfully submitted,

s/ **Linda S. Jensen**

LINDA S. JENSEN
Attorney Reg. No. 0189030
Telephone: 651-757-1472
445 Minnesota Street, Suite 1800
St. Paul, MN 55101-2134
Attorneys for Minnesota Department of Commerce
and Minnesota Pollution Control Agency

Ex 136

Assessing Environmental Externality Costs for Electricity Generation

Final Report

Triangle Economic Research

William H. Desvousges
F. Reed Johnson
H. Spencer Banzhaf
Randy R. Russell
Erin E. Fries
Kevin J. Dietz
Susan C. Helms

Radian Corporation

David Keen
Jay Snyder
Howard Balentine
Venus Sadeghi

Research Triangle Institute

Sheila A. Martin

Assessing Environmental Externality Costs for Electricity Generation

Volume 1:
Air Pollutant Dispersion in Minnesota

SECTION 1
INTRODUCTION

Radian Corporation (Radian) performed an air quality dispersion modeling analysis for Triangle Economic Research (TER) on behalf of Northern States Power Company (NSP). The analysis was performed as part of an externality costing study that TER designed to provide NSP with reliable estimates of the environmental costs of future electrical power generation.

The externality costing study analyzed the potential damage from air pollution associated with four scenarios for future power generation. In this study Radian calculated air quality changes for each power generation scenario using air quality dispersion models. TER then used the relative changes in air quality attributable to each scenario to evaluate damages and to estimate the externality costs of power production.

The study area for this analysis consisted of Minnesota, western Wisconsin, and southeastern South Dakota. The study area reflects a broad range of geographic locations and was chosen to bracket the range of externality costs. The Radian air quality modeling task involved calculating discrete concentrations of six pollutants for 619[1] locations (receptor points) in the study area. Emissions were modeled for carbon monoxide (CO), nitrogen oxides (NO_x), lead (Pb), particulate matter less than 10 micrometers in diameter (PM_{10}), sulfur dioxide (SO_2) and ozone (O_3). Selected receptors were used to estimate potential air quality impacts due to pollutant emissions from electrical power generation for a cross section of the population in the study area and for selected natural resources. The modeling analysis produced a file of hourly concentration estimates for one year for CO, NO_x, Pb, PM_{10}, and SO_2 at each receptor for the four power generation scenarios. Radian also estimated the potential impact of each power generation scenario on O_3 concentrations in the study area resulting from NO_x emissions.

[1]Because U.S. Census information was not available for one of these receptor locations, 618 sites were used in damage calculations.

SECTION 2
EMISSION PLANNING SCENARIOS

Radian performed the modeling analysis for four planning scenarios. These scenarios were designed by NSP and TER. The scenarios include various source technologies located at different sites. The objective of the scenarios was to bracket the range of damages which may be reasonably possible and to identify the effect of key parameters on the valuation of externalities.

The scenario design focused on the choice of technologies and fuels and the choice of resource sites when constructing the scenarios. The selection of future technologies and fuel determines the emission rates. The choice of sites also may have a significant effect on the range of externality costs because the sites can range from those with relatively good ambient air conditions to those with relatively poorer ambient air conditions. In addition, the sites selected for future resources also influences the type of exposure, such as population and agriculture. The key parameters were technology and fuel use, ambient air quality, and population effects versus agricultural effects.

All scenarios reflect projected NSP operating characteristics for the year 2006. Because NSP's earliest need for new base resources is not until about 2005 under the median forecast, the year 2006 was selected in order to allow the impact of new base resources to be examined.

The production modeling for these scenarios was performed by NSP. The demand and energy forecast used for production modeling is the median forecast presented in NSP's 1993 Resource Plan submitted to the Minnesota Public Utilities Commission. In addition, all scenarios include the DSM goal ordered by the Commission in NSP's 1991 Resource Plan.

A description of the scenarios developed by NSP is provided below.

2.1 PLANNING SCENARIO 1. COMPARISON

This scenario is used in this study as the Comparison Scenario. That is, the subsequent scenarios include modifications to this scenario and are compared to it in order to identify specific effects.

In this scenario, NSP retains all existing generation. The locations of existing NSP generation are shown on Figure 2-1. Future peak resource needs are provided by nine 107 mW gas-fired combustion turbines located in a semi-circle around the Minneapolis-St. Paul metropolitan area. Five of the turbines are located 15 kilometers from downtown Minneapolis and four are located 100 kilometers from downtown Minneapolis. The locations of these new combustion turbines are shown on Figure 2-2.

Future intermediate resource needs are met with new non-emitting renewables and future base resource needs are met with new non-emitting renewables. The intermediate resources are assumed to be gas-fired combined cycles and coal-fired integrated gasification combined cycles. The intermediate resources used for subsequent scenarios are assumed to have the same energy output and operating characteristics as the intermediate resources used in the Comparison Scenario. No location is shown for the immediate and base resources on Figure 2-2 because they have no emissions and location is not a factor.

2.2 PLANNING SCENARIO 2. RURAL IMPACT

This scenario is intended to identify the possible damages related to rural and agricultural effects by locating all future intermediate and base generation in agricultural areas. Similar to the Comparison Scenario, NSP retains all existing generation and future peak resource needs are met with gas-fired combustion turbines. These turbines are located at the same sites as those in the Comparison Scenario.

Intermediate resource needs are met with four 192 mW gas-fired combined cycles located in western Minnesota about 150 kilometers from downtown Minneapolis. Base resources are met with a 400 mW pulverized-coal unit located in western Minnesota about 200 kilometers from downtown Minneapolis. The pulverized-coal technology was selected rather than a lower emitting clean coal technology such as coal-fired integrated gasification combined cycle in an attempt to identify maximum impacts.

The locations of the new resources included in the Rural Scenario are provided in Figure 2-3.

Figure 2-1. Existing NSP Fossil Generating Sites

RTI8STCK.FH3 - VMG 10/27/94 SAC

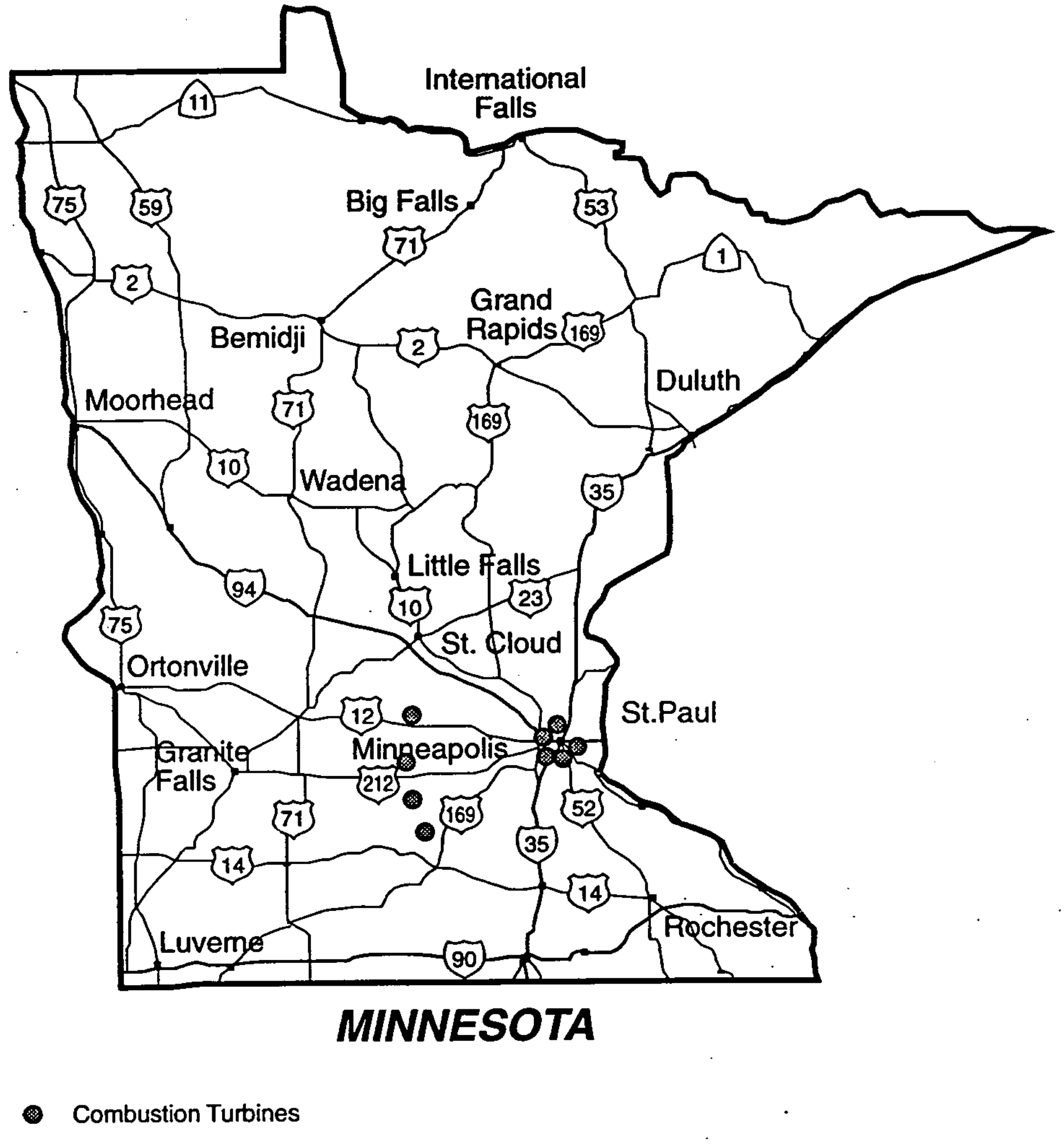


Figure 2-2. New Combustion Turbine Locations for Comparison Scenario

RTI8MAPS.FH3 - VMG 9/9/94 SAC

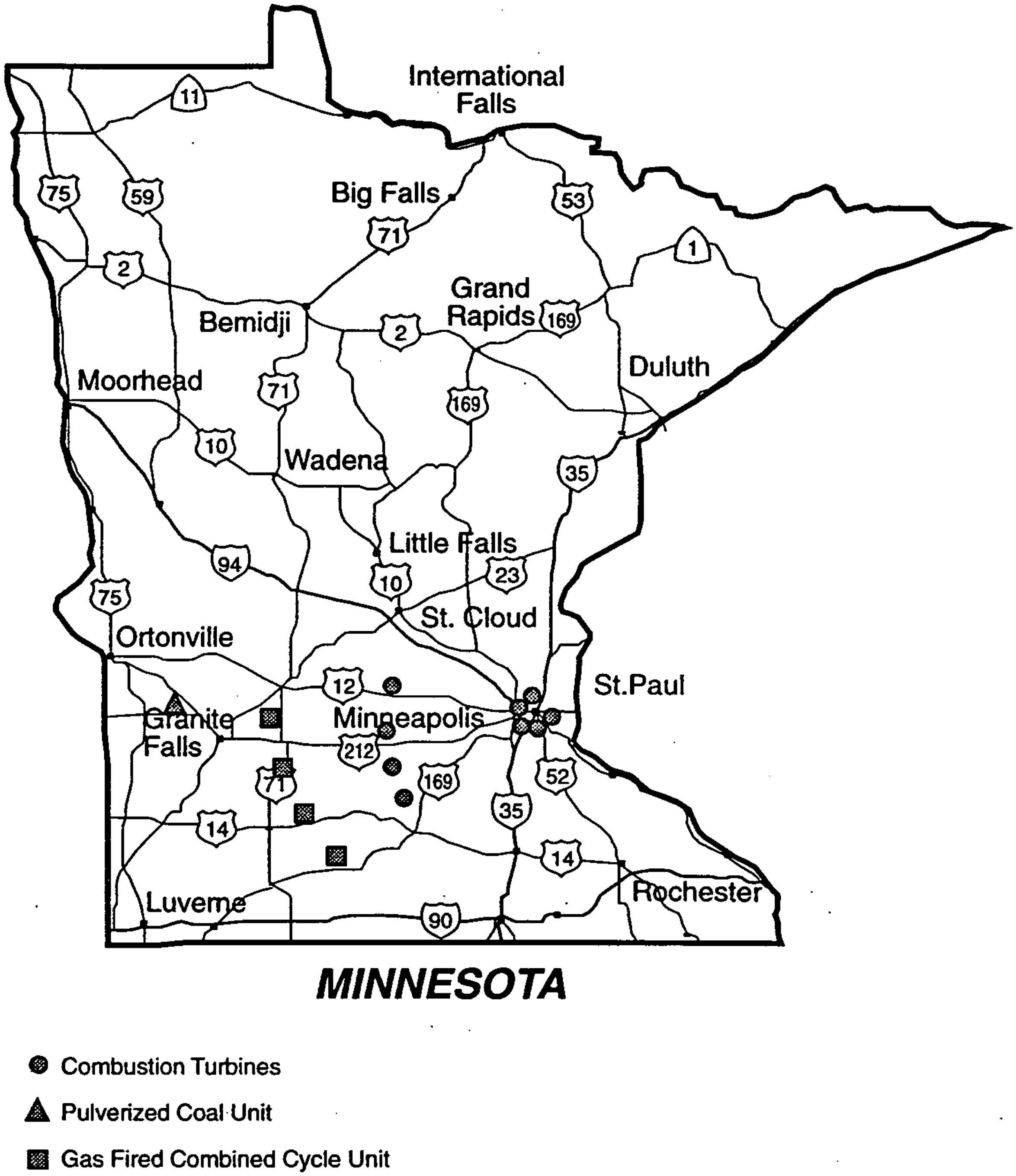


Figure 2-3. New Combustion Turbine and Other Source Locations for Rural Impact Scenario

RTI8MAPS.FH3 - VMG 9/9/94 SAC

2.3 PLANNING SCENARIO 3. METROPOLITAN FRINGE IMPACT

This scenario is intended to identify the possible damages related to locating all future resources closer to metropolitan areas. Although the resources are the same as those in the Rural Scenario, they are located closer to the metropolitan area rather than in rural areas.

Similar to the Comparison Scenario and the Rural Scenario, NSP retains all existing generation, and future peak resource needs are met with gas-fired combustion turbines at the same sites. Intermediate resource needs are met with four 192 mW gas-fired combined cycles located in a semi-circle around the metropolitan Minneapolis-St. Paul area about 30 kilometers from downtown Minneapolis. Base resources are met with a 400 mW pulverized coal unit located in the proximity of NSP's existing Sherburne County Units, about 50 kilometers northwest of downtown Minneapolis.

The locations of the new resources included in the Metropolitan Fringe Scenario are provided in Figure 2-4.

2.4 PLANNING SCENARIO 4. URBAN IMPACT

This scenario is intended to identify the possible damages related to locating future generation in urban areas. One approach considered to identify these impacts was to use the same resources as those in the Rural Scenario and the Metropolitan Fringe Scenario, but locate them in Minneapolis and St. Paul. This approach was not used, however, because we did not believe it is reasonable to assume that much generation with those emission characteristics would be sited in Minneapolis and St. Paul. It is more likely that emission changes related to electric generation in the Twin Cities will be due to modifications to existing generation such as repowering at existing generation sites. Therefore, we constructed such a scenario by modifying the emissions at two of NSP's existing generation sites. To identify the maximum possible impacts of repowering at existing sites, we increased the emissions from the Black Dog and High Bridge stations.

As in the Comparison Scenario, the Rural Scenario and the Metropolitan Fringe Scenario, future peak resource needs are met with gas-fired combustion turbines in the same locations. In addition, intermediate and base resource needs are met with non-emitting renewable resources in order to allow this scenario to be directly compared to the Comparison Scenario.

The locations of the peak resource included in the Urban Impact Scenario are provided on Figure 2-5.

2.5 RESOURCE NEEDS

The mix of resources included in the planning scenarios is based on the Comparison Scenario NSP included in its 1993 Resource Plan. This mix of resources included nine 107 MW gas-fired combustion turbines, four 192 MW gas-fired combined cycles and one 400 MW pulverized coal resource.

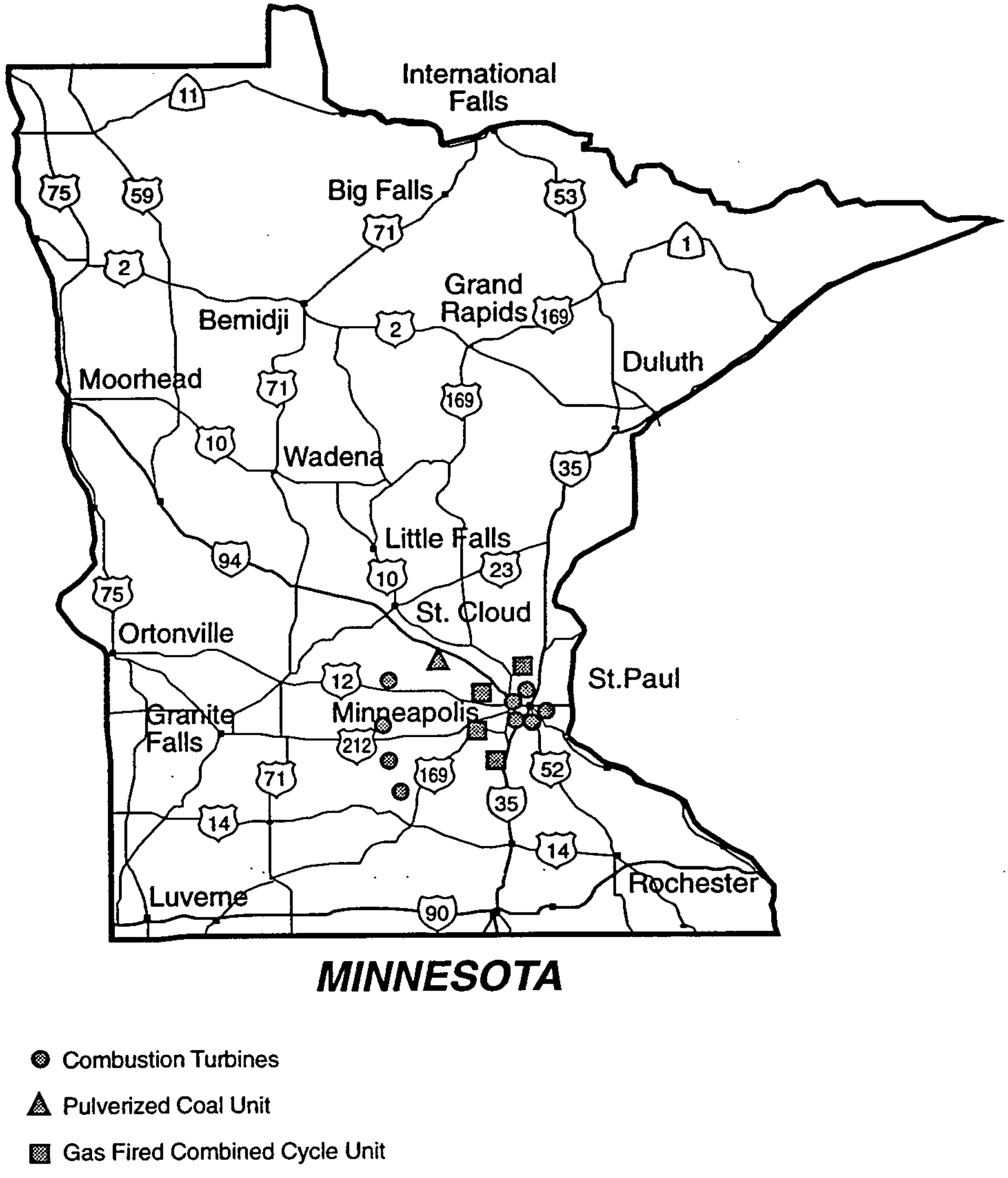


Figure 2-4. New Combustion Turbine and Other Source Locations for Metropolitan Fringe Impact Scenario

RTI8MAPS.FH3 - VMG 10/26/94 SAC

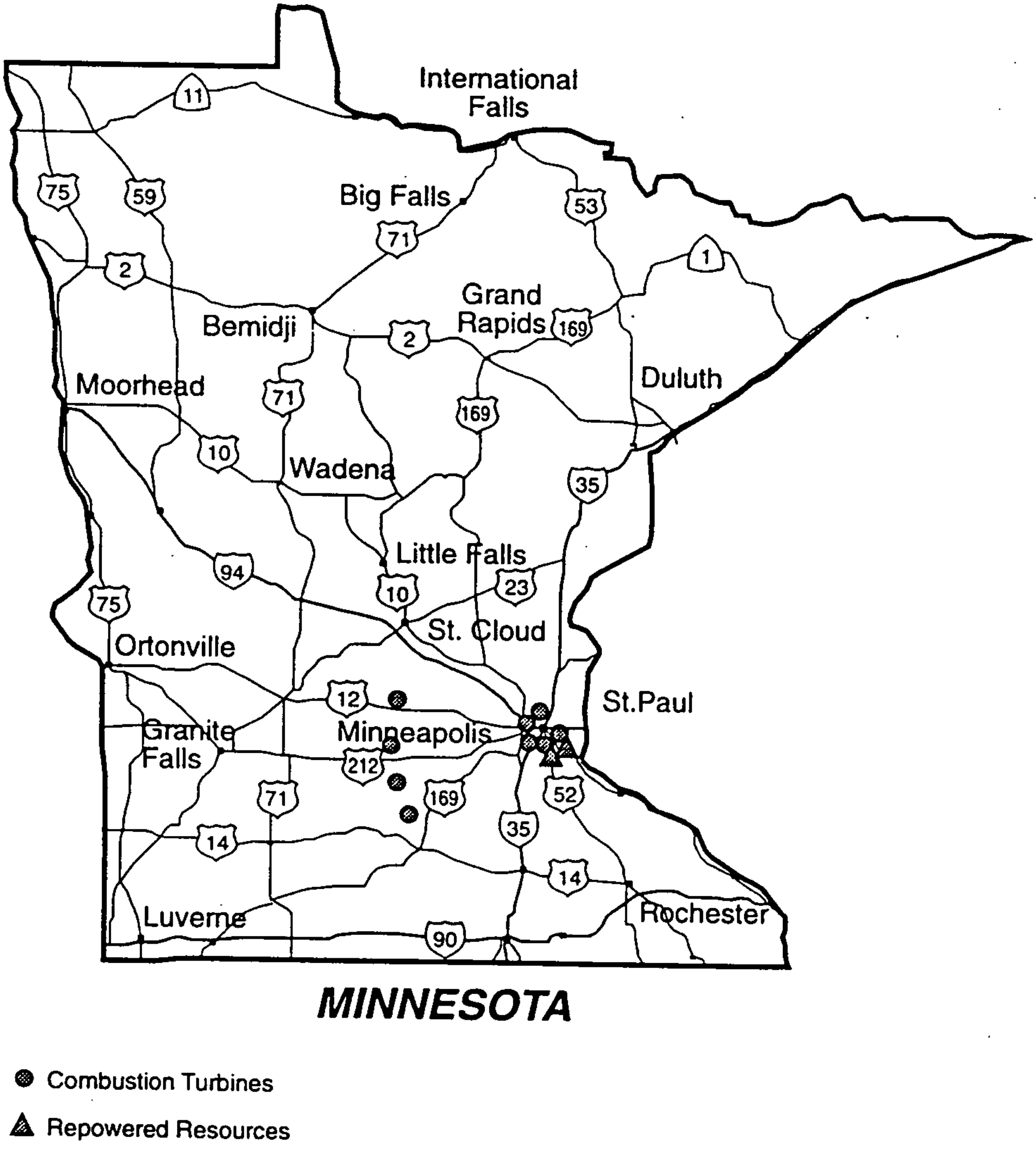


Figure 2-5. New Combustion Turbine and Other Source Locations for Urban Impact Scenario

RTI8MAPS.FH3 - VMG 9/9/94 SAC

SECTION 3
RECEPTOR SELECTION

Once the scenarios have been defined, the next step in the air modeling process is to identify receptor locations. A receptor is simply the location at which pollution concentrations are estimated using the model. These concentrations are subsequently used to determine the exposures. The remainder of this section describes the receptor selection methodology and an assessment of the uncertainty in receptor location.

3.1 METHODOLOGY

TER selected receptors with the intent to represent a cross section of the area's population and natural resources, and to capture variations in air quality from one location to another. Zip codes were used as the geographical unit for this task, with receptors placed in the town in which the post office was located.

A total of 619 receptors were selected in the states of Minnesota, Wisconsin, and South Dakota. Figure 3-1 presents the modeling domain, existing and future scenario source locations, and receptors used in the modeling analysis. To begin the receptor analysis, 50- and 100-km radii were drawn around each current and proposed power plant. Receptors were then placed in each county based on the population in the county and the number of radii overlapping the county. Five criteria were used to determine the number of receptors in each county. These criteria are:

- If a county fell within one or more 100-km radii but not a 50-km radius, receptors were assigned to all zip codes with 2,500 or more people (as of the 1990 U.S. Census);
- If the county fell within one to two 50-km radii, receptors were assigned to all zip codes with 1,300 or more people;
- If the county fell within three to four 50-km radii, receptors were assigned to all zip codes with 1,000 or more people;
- If the county fell within five or more 50-km radii, receptors were assigned to all zip codes with 800 or more people; and
- If the county was farther than 100 km from any of the modeled power plants, one receptor was created for the zip code with the largest population.

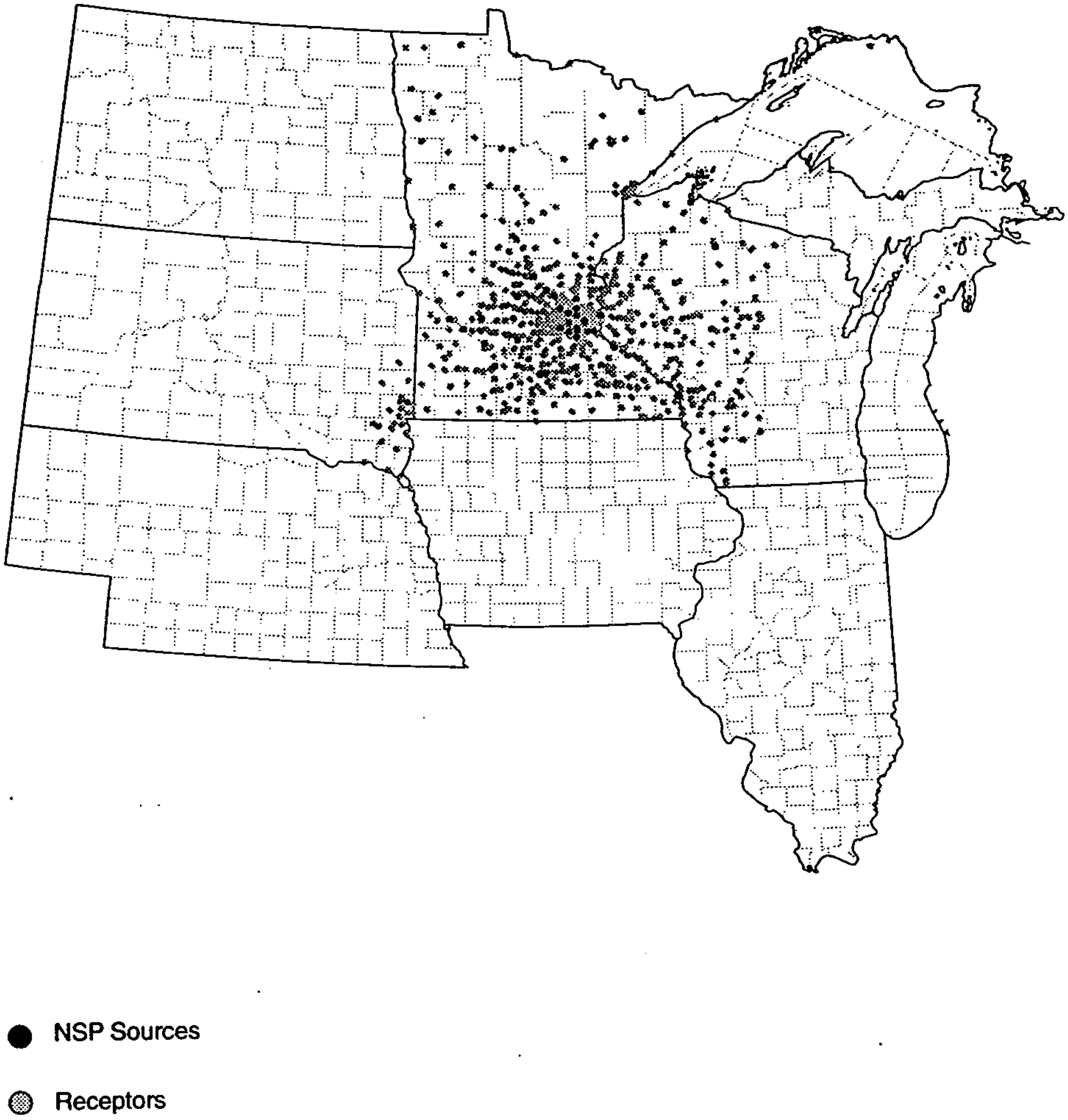


Figure 3-1. Existing and Proposed NSP Source Locations and Modeling Receptors for the NSP Externality Analysis

RTIMAP7.FH3 - VMG 9/1/94 SAC

In cases where different parts of the county fell under different criteria, TER used the criteria yielding the largest number of receptors to assign receptors for the entire county. These population criteria were designed to ensure that densely-populated areas and areas close to power plants contained more receptors than other areas. The criteria were also designed so that the total number of receptors adequately blanketed the area of analysis without being too cumbersome. The selected receptor sites represent 89 percent of the area's population, with the remaining people being allocated to receptors in their county of residence.

The specific latitude, longitude, and elevation for each receptor were derived using transparent overlays of receptor locations made from state maps for each of the three states. These overlays were placed on an equivalent-scale state topographical map, and the corresponding latitude, longitude, and elevation for each receptor location were recorded.

The air dispersion modeling used in this study was based on a rectangular grid system. Therefore, all receptor locations (latitudes and longitudes) were converted to Universal Transverse Mercator (UTM) coordinates using a modified version of the U.S. EPA program CONCOR (U.S. EPA, 1990b). Because of the large longitudinal extent of the modeling domain, receptor locations occurred in UTM Zones 14, 15 and 16. For consistency, all receptor locations were converted to UTM Zone 15 using the CONCOR program.

3.2 RECEPTOR LOCATION UNCERTAINTY

The source location and elevation data used in the modeling analysis were obtained from relatively large-scale statewide maps for Minnesota, Wisconsin, and South Dakota. In a previous externality costing study conducted in Wisconsin, Radian examined the error associated with using a statewide map to extract these data when compared to using a more detailed, smaller-scale map. Radian randomly checked 10% of the source Universal Transverse Mercator (UTM) coordinate locations and elevations derived from a state-wide map against those values obtained from more detailed, 1:100,000 scale maps. The average difference in source locations between the two methods was 0.97 ±0.81 km (± one standard deviation) in the easting UTM, 0.90 ±1.1 km in the northing UTM, and 30 ±32 feet in elevation. Differences ranged from 2.7 to -1.4 km for the easting UTM, 1.9 to -3.7 km for the northing UTM, and 147 to -150 ft for the elevation. For the current study, the accuracy of the coordinate location procedure was verified for one receptor in each county. The conclusion was that the error associated with the use of the large-scale map was within the uncertainty of the air dispersion modeling analysis.

Table A-1 (Appendix A) lists the receptors modeled along with each receptor's UTM coordinates and elevation.

STATE OF MINNESOTA

OFFICE OF THE ATTORNEY GENERAL

SUITE 1800
445 MINNESOTA STREET
ST. PAUL, MN 55101-2134
TELEPHONE: (651) 297-2040

April 15, 2016

The Honorable LauraSue Schlatter
Administrative Law Judges
Office of Administrative Hearings
600 North Robert Street
P.O. Box 64620
St. Paul, MN 55164-0620

RE: In the Matter of the Further Investigation in to Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3
PUC Docket No. E-999/CI-14-643;
OAH Docket No. 80-2500-31888

Dear Judge Schlatter:

Enclosed please find Proposed Findings of Fact and the Reply Brief on Criteria Pollutants of the Minnesota Department of Commerce, Division of Energy Resources, and the Minnesota Pollution Control Agency.

Respectfully submitted,

s/ **Linda S. Jensen**
Linda S. Jensen

Attorney for the Minnesota Department of Commerce and Minnesota Pollution Control Agency

445 Minnesota Street, Suite 1800
St. Paul, MN 55101-2131
Telephone: (651) 757-1472

Enclosure
cc: Service List

AFFIDAVIT OF SERVICE

RE: In the Matter of the Further Investigation in to Environmental and Socioeconomic Costs Under Minnesota Statute 216B.2422, Subdivision 3 (2014)
PUC Docket No. E-999/CI-14-643;
OAH Docket No. 80-2500-31888

STATE OF MINNESOTA)
) ss.
COUNTY OF RAMSEY)

I, Annabel Foster Renner, hereby state that on the April 15, 2016, I filed by electronic eDockets the attached **Proposed Findings of Fact** and **Reply Brief on Criteria Pollutants of the Minnesota Department of Commerce, Division of Energy Resources, and the Minnesota Pollution Control Agency** and eServed or sent by US Mail, as noted, to all parties on the attached service list.

See attached service list for PUC Docket No. E-999/CI-14-643;
OAH Docket No. 80-2500-31888

/s/ **Annabel Foster Renner**
ANNABEL FOSTER RENNER

Subscribed and sworn to before me on
this 15th day of April, 2016.

/s/ **LaTrice Woods**
Notary Public – Minnesota
My Commission Expires January 31, 2020.

Electronic Service Member(s)

Last Name	First Name	Email	Company Name	Delivery Method	View Trade Secret
Aafedt	David	daafedt@winthrop.com	Winthrop & Weinstine, P.A.	Electronic Service	No
Ahern	Michael	ahern.michael@dorsey.com	Dorsey & Whitney, LLP	Electronic Service	No
Al	Marc	marc.al@stoel.com	Stoel Rives LLP	Electronic Service	Yes
Brown	Hugh	brown.hugh@dorsey.com	Dorsey & Whitney LLP	Electronic Service	No
Brown	B. Andrew	brown.andrew@dorsey.com	Dorsey & Whitney LLP	Electronic Service	No
Cronin	Carl	carl.cronin@xcelenergy.com	Xcel Energy	Electronic Service	Yes
Currie	Leigh	lcurrie@mncenter.org	Minnesota Center for Environmental Advocacy	Electronic Service	No
DeBleeckere	Patricia	tricia.debleeckere@state.mn.us	Public Utilities Commission	Electronic Service	Yes
Denniston	James	james.r.denniston@xcelenergy.com	Xcel Energy Services, Inc.	Electronic Service	Yes
Dexter	Jessica	jdexter@elpc.org	Environmental Law & Policy Center	Electronic Service	No
Draxten	Brian	bhdraxten@otpco.com	Otter Tail Power Company	Electronic Service	No
Duncan	Tristan	tlduncan@shb.com	Shook Hardy & Bacon, L.L.P.	Electronic Service	No
Eknes	Bret	bret.eknes@state.mn.us	Public Utilities Commission	Electronic Service	Yes
Erickson	Jim	jim.g.erickson@xcelenergy.com	Xcel Energy	Electronic Service	Yes
Gerhardson	Bruce	bgerhardson@otpco.com	Otter Tail Power Company	Electronic Service	No
Gratz	Emerald	emerald.gratz@state.mn.us	Office of Administrative Hearings	Electronic Service	Yes
Grever	Thomas J.	tgrever@shb.com	Shook, Hardy &Bacon L.L.P.	Electronic Service	No
Hamilton	J Drake	hamilton@fresh-energy.org	Fresh Energy	Electronic Service	No
Jensen	Linda	linda.s.jensen@ag.state.mn.us	Office of the Attorney General-DOC	Electronic Service	Yes
Johnson	Kevin D.	kdjohnson@stoel.com	Stoel Rives LLP	Electronic Service	No
Johnson Phillips	Sarah	sjphillips@stoel.com	Stoel Rives LLP	Electronic Service	No
Kingston	Hudson	hkingston@mncenter.org	MN Center for Environmental Advocacy	Electronic Service	No
Klein	Brad	bklein@elpc.org	Environmental Law & Policy Center	Electronic Service	No
Lee	Kevin	kevin@kevinleelaw.com	N/A	Electronic Service	No
Massey	Jonathan	jmassey@masseygail.com	Massey & Gail LLP	Electronic Service	No
Moeller	David	dmoeller@allete.com	Minnesota Power	Electronic Service	No
Moratzka	Andrew	apmoratzka@stoel.com	Stoel Rives LLP	Electronic Service	No
Oxley	Jeff	jeff.oxley@state.mn.us	Office of Administrative Hearings	Electronic Service	Yes
Rebholz	Michelle	michelle.rebholz@state.mn.us	Public Utilities Commission	Electronic Service	Yes
Reuther	Kevin	kreuther@mncenter.org	MN Center for Environmental Advocacy	Electronic Service	No
Ross McCalib	Laureen	lrossmccalib@grenergy.com	Great River Energy	Electronic Service	No
Schlatter	LauraSue	LauraSue.Schlatter@state.mn.us	Office of Administrative Hearings	Electronic Service	Yes
Shaddix Elling	Janet	jshaddix@janetshaddix.com	Shaddix And Associates	Electronic Service	Yes
Stalpes	Sean	sean.stalpes@state.mn.us	Public Utilities Commission	Electronic Service	Yes
Stephenson	Donna	dstephenson@grenergy.com	Great River Energy	Electronic Service	No
Swanson	Eric	eswanson@winthrop.com	Winthrop Weinstine	Electronic Service	No
Thompson	SaGonna	Regulatory.records@xcelenergy.com	Xcel Energy	Electronic Service	Yes
Vaughn	Erin	evaughn@shb.com	Shook, Hardy &Bacon L.L.P.	Electronic Service	No
Wicker	Colin	wicker.colin@dorsey.com	Dorsey & Whitney LLP	Electronic Service	No
Williams	Alexis	williams@fresh-energy.org	Fresh Energy	Electronic Service	No
Winton	Cam	cwinton@mnchamber.com	Minnesota Chamber of Commerce	Electronic Service	No
Wolf	Daniel P	dan.wolf@state.mn.us	Public Utilities Commission	Electronic Service	Yes