Health Benefit Analysis
for the Confined Animal Facilities Rule

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SAN JOAQUIN VALLEY AIR POLLUTION CONTROL DISTRICT

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Introduction

Pursuant to Health and Safety Code section 40724.6(e), California air districts that are required to adopt regulations to reduce ozone precursors from large confined animal facilities ("LCAFs") must conduct an assessment of various factors related to the impacts of the regulation. While these factors largely address issues such as the feasibility of any proposed control measures and the economic impact to the regulated community, air districts must also assess the public health impacts of the regulation.

The San Joaquin Valley Air Pollution Control District (District) adopted its confined animal facility rule, Rule 4570, at a public hearing held on June 15, 2006. Prior to and during the rule adoption hearing, the District considered the feasibility of the control measures contained in Rule 4570 as well as the economic impacts associated with the rule. The District quantified reductions in ozone precursors that would result from compliance with the rule. It also considered the public health impacts of ozone and ozone precursors. However, the District did not consolidate this information into a specific discussion of the rule's impact on public health. Since the time of Rule 4570's adoption, new methods have become available that make it possible to estimate the health benefits of improved air quality with a reasonable degree of accuracy for appropriate applications. While these methods do not allow for a specific delineation of Rule 4570's health benefits, the District has prepared the following health benefit assessment of the 2007 Ozone Plan. As will be demonstrated below, VOC controls imposed by Rule 4570 make an essential, albeit indefinite, contribution to the larger ozone attainment goal of the 2007 Ozone Plan.

Summary of Rule 4570

The purpose of Rule 4570 (Confined Animal Facilities) is to limit emissions of volatile organic compounds (VOC) from large confined animal facilities (CAFs). The District's definition of a large confined animal facility was based on the California Air Resources Board's definition of a large confined animal facility and consultation with operators of these facilities. The thresholds for defining a large CAF are shown below in Table 1.

Table 1: ARB Large CAF Thresholds & Rule Applicability Thresholds

Livestock Category	Number of Animals
Dairy	1,000 lactating cows
Beef Feedlots	3,500 beef cattle
Other Cattle Operations	7,500 calves, heifers, and other cattle
Chickens-Broilers & Egg Layers	650,000 head
Turkeys	100,000 head
Swine	3,000 head
Sheep and Goats	15,000 head
Horses	2,500 head
Ducks	650,000 head
Other Livestock Not Previously Mentioned	30,000 head

The rule requires owners/operators of any large CAF to:

1. Implement Mitigation Measures:
   - Implement a specified number of mitigation measures, from the list of mitigation measures in the rule, for each emission area at their CAF. The reason the rule includes options is because the physical layout and operations of CAFs are different, therefore not all controls are feasible for all facilities.
2. Submit an Emission Mitigation Plan (EMP) and Permit Application:
   - By December 15, 2006, large CAF operators submit an EMP and permit application for each large CAF, with information on the number and types of mitigation measures that will be implemented to comply with the rule. Mitigation measures will then be made part of the large CAF operating permit.

Health Effects of Ozone

As described in Chapter 2 of the 2007 Ozone Plan, considerable research over the past 35 years has investigated the responses of humans to ozone inhalation.[1] These studies have consistently shown that ozone can lead to inflammation and irritation of airway tissue. Breathing ozone can also reduce lung function and inflame the epithelial lining of the lungs.

Symptoms and responses to ozone exposure vary widely among individuals. Typical symptoms include cough, chest tightness or pain, shortness of breath, pain when taking a deep breath, coughing, throat irritation, congestion, and increased asthma symptoms. In persons with asthma, ozone can worsen asthma symptoms. The Children's Health Study funded by the California Air Resources Board indicated that ozone may contribute to the development of asthma in children who played sports outdoors.[2] Additionally, ozone exposure also has been associated with increased premature death in elderly people with chronic diseases of the lungs and circulatory system.

Ozone in sufficient doses can also increase the permeability ("leakiness") of lung cells, making them more susceptible to environmental toxins and infection caused by microorganisms such as viruses and bacteria. In epidemiologic studies, ozone exposure has been associated with an increase in hospital admissions and emergency room visits, particularly for causes related to the lungs, such as asthma and chronic obstructive pulmonary disease (COPD). Elevated ozone exposure has also been shown to be positively associated with premature death from respiratory disease in a recent study of 448,850 subjects in 96 U.S. cities.[3]

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[1] See http://www.valleyair.org/Air_Quality_Plans/Ozone_Plans.htm#8-Hour%20Ozone

[2] Peters, John, et al. (2004) Epidemiological Investigation to Identify Chronic Effects of Ambient Air Pollutants in Southern Californa. Conducted for the California Air Resources Board. University of Southern California, Los Angeles. See http://www.arb.ca.gov/research/abstracts/94-331.htm

[3] Jerrett, M. et al. (2009) *Long-Term Ozone Exposure and Mortality*. New England Journal of Medicine Vol. 360 (11):1085-1095. March 12.

VOC Benefits of Rule 4570

As shown in the 2007 Ozone Plan (pages I-7 and B-9), the emissions inventory for confined animal facilities in 2005 was 65.4 tons per day, and the total VOC inventory for 2005 was 398.6 tons per day. Thus, in 2005, confined animal facilities accounted for 16% of the total VOC emissions for the San Joaquin Valley. The confined animal facilities rule was included as part of the District's strategy to attain the federal health-based standard for 1-hour ozone in Chapter 4 of the 2004 Extreme Ozone Attainment Demonstration Plan.[4] VOC emissions and oxides of nitrogen (NOx) emissions combine to form ground level ozone (see below for a discussion of the relative importance of VOC in the formation of ozone).

Rule 4570 is estimated to achieve approximately 9 tons per day of VOC reductions by 2009, 20 tons per day by 2012, and 24 tons per day by 2020. These values represent a significant portion of the District's overall VOC control strategy.

Table 2 shows the District's VOC controls that were adopted between mid-2005 and the end of 2006 as well as the VOC control measure commitments for the coming years. This information was also available in Chapter 6 and Appendix B of the 2007 Ozone Plan. The 72 tpd of VOC reductions achieved by these rules are a crucial part of the District's strategy to assure that all areas of the Valley make progress towards 8-hour ozone attainment as expeditiously as possible. The current version of the CAF rule will achieve 24 tpd of VOC reduction by 2020, which the District estimates to be equivalent to NOx reductions between 2.4 and 8 tpd (see discussion below on NOx-VOC equivalency). The two iterations of the CAF rule (the current version and the planned 2010 amendment) comprise 63% of the VOC reductions that were included in the District's 8-hour ozone attainment strategy. The CAF reductions make a critical contribution to the total VOC reductions, and these VOC reductions are an essential component of the overall ozone control strategy for the San Joaquin Valley.

Ozone Benefits of the Rule 4570

As summarized in Chapters 1 and 3 of the 2007 Ozone Plan, the San Joaquin Valley Air Basin's (SJVAB) summertime meteorology and emissions combine to create a photochemical regime in which reducing either NOx or VOC emissions will reduce ozone. Modeling illustrates, however, that reducing VOC is generally not as effective as reducing an equal amount of NOx. In fact, as shown in the 2007 Ozone Plan, regardless of the amount of VOC reduction, a very large NOx reduction from current levels is necessary to attain the federal 8-hour ozone standard. Additionally, although NOx reductions alone will achieve the ozone standard, VOC reductions alone will not. Nonetheless, VOC reductions have the effect of decreasing the amount of NOx reductions necessary for ozone attainment.

Although NOx reductions are the District's primary target because they are critical for 8-hour ozone attainment and also for PM 2.5 attainment, VOC reductions cannot be omitted from the ozone attainment strategy. VOC reductions have the effect of

[4] See http://www.valleyair.org/Air_Quality_Plans/Ozone_Plans.htm#1-Hour%20Ozone

decreasing ozone concentrations in the near-term, even if they do not solely provide for ultimate attainment of the ozone standard. Additionally, there are more emission control opportunities available to the District for VOC than for NOx: the District has more regulatory authority over larger VOC source categories, whereas the larger NOx categories, which are mostly mobile sources, are primarily under the authority of state and federal agencies. In addition, there are several remaining opportunities for controlling VOCs. In contrast, the 2007 Ozone Plan showed that many of the needed NOx reductions must be achieved as long-term measures via advanced technologies that are yet to be identified, i.e. "black box" controls.

Table 2. VOC Rule Reductions for 2020 (tpd)

Rule	**Adoption**	**2020 VOC reductions**
Rule 4694: Wine Fermentation and Storage	December 15, 2005	1.35
Rule 4103: Open Burning	May 19, 2005	0.05
Rule 4570: Confined Animal Facilities	June 15, 2006	23.92
Rule 4602 & 4612: Automotive coatings	September 21, 2006	0.87
Rule 4401: Steam Enhanced Crude Oil Production Well Vents	December 14, 2006	0.97
Control Measure Commitments from the 2007 Ozone Plan		
Rule 4565: Biosolids, Animal Manure, and Poultry Litter Operations	March 15, 2007	4.1
Rule 4103: Open Burn	May 17, 2007 2010 2Q	2.8
Solvents	September 20, 2007	1.53
Rule 4651: Soil Decontamination	September 20, 2007	0.0
Rule 4682: Polystyrene Foam	September 20, 2007	0.12
Rule 4621, 4622, and 4624: Gasoline Storage & Transfer	December 20, 2007	1.07
Rule 4624: Aviation Fuel Storage	December 20, 2007	0.05
Rule 4607: Graphic Arts	December 18, 2008	0.08
Flares	2009 2Q	0.0
Brandy & Wine Aging	2009 3Q	0.0
Architectural Coatings	2009 4Q	2.2
Confined Animal Facilities	2010 2Q	21.5
Adhesives	2010 3Q	0.13
Composting Green Waste	2010 4Q	11.0
Total VOC Reduction for 2020, May 2005 – 2010 Rules		**71.74**

The San Joaquin Valley's enormous air quality challenge has demanded the adoption and implementation of many rules and regulations. While these measures, in aggregate, yield significant air quality benefits, individual rules when evaluated in isolation cannot always show a measureable improvement in air quality. This is due to the large magnitude of the overall reductions needed, and the inherent limitations on the sensitivity and accuracy of available modeling and scientific assessment tools. The benefit of any single rule might not appear significant and the analysis could have the unintended effect of allowing the overall strategy to be broken into many "insignificant" pieces. Ultimately, however, the combined reductions from all of the control measures are projected to bring the Valley into attainment of the federal health-based standards.

Furthermore, the air quality and health benefits of an individual rule depend not just on the quantity of reductions, but also on the chemistry of the precursor and on the year in question. Benefits of reductions also vary by the location of the emission reductions in relation to where the ozone is being measured. For example, NOx controls are effective in reducing the highest ozone concentrations downwind, but can also have the effect of slightly increasing ozone near the source of the reduction. These relationships are extremely complex, but can be estimated via photochemical computer modeling (available in Chapter 3 and Appendix F of the 2007 Ozone Plan).

To conclude, photochemical modeling was used in the 2007 Ozone Plan to demonstrate that a comprehensive control strategy achieving several hundred tons of emission reductions will bring the San Joaquin Valley Air Basin into ozone attainment. The tools developed for the attainment modeling demonstration are not designed, however, for the precise, fine-grained evaluation of the ambient benefits of a single rule. In isolation, the emissions from any single rule are just not significant enough to affect the model in a reliable manner. An informative result of the modeling for the 2007 Ozone Plan is that one ton per day of NOx reductions is equivalent to between three and ten tons per day of VOC reductions, depending on the timing and location of the reductions.

Assessing the Health Benefits from Rule 4570

This section of the report presents the empirical results of the District's estimation of the health benefits from its 2007 Ozone Plan. The Plan included Rule 4570 as an integral element of its overall VOC controls. As discussed above, there are inherent scientific limitations to accurately assess an individual rule's contribution to ozone reductions. This is the case for Rule 4570 despite the fact that the rule makes a significant contribution to overall VOC reductions. For similar reasons (discussed in more detail below), separating the health benefits of a single rule from the larger body of rules that make up the District's 2007 Ozone Plan can be done but not with an acceptable level of accuracy given the statistical uncertainty in estimating the ozone emission reductions from this individual rule. This estimation error would be compounded by the estimation uncertainty that is inherent to the health benefits generated by the BenMAP model. However, the model is well-suited for estimating the overall health benefits of the substantial ozone reductions contained in the 2007 Ozone Plan.

BenMap Overview

BenMAP is a sophisticated computer software model developed by the U.S. EPA that is well-suited for estimating the health benefits from the 2007 Ozone Plan.[5] Over the course of the past decade, ongoing progress in the fields of epidemiology and geographic information systems (GIS) have resulted in the development of computer models that are capable of estimating the health benefits of improved air quality with reasonable accuracy when properly applied. These models estimate the number of avoided cases of certain diseases and other health impairment categories, known as health endpoints, which result from a specified reduction in exposure to criteria air pollutants, e.g. ozone and fine particulates (PM 2.5). This reduction could be the result of (1) an individual emission control rule with a substantial reduction in annual population exposure, or (2) a body of control rules that comprise the regional component of a state implementation plan.

For example, a BenMAP application to an individual rule has been conducted by the Central Valley Health Policy Institute, California State University, Fresno under contract to the District.[6] The study isolated the reduction in annual PM 2.5 exposure in the Bakersfield and Fresno/Clovis metro areas that is attributable to episodic restrictions in domestic wood burning in the region imposed by Rule 4901 and the resultant health benefits. Rule 4901's restrictions in wood burning were estimated to provide a large (13% or more) reduction in annual exposure to PM 2.5 in the study areas, resulting in substantial estimated reductions in premature mortality and other health endpoints, e.g. premature mortality, asthma attacks, and chronic bronchitis.

In contrast, the ozone reductions in population exposure attributable to Rule 4570 are considerably smaller, e.g. 1.5% annually or less. As discussed above, there is a large degree of uncertainty in estimating the precise level of ozone exposure reduction attributable to this single VOC control strategy. Also, estimating reductions in population exposure from a directly emitted pollutant such as PM 2.5 from wood burning is much less complex than a comparable estimation of reduced exposure to a secondary pollutant such as ozone that is created by relatively complex reactions of VOC and NOx emissions occurring across time and space. The health impacts of PM 2.5 are also proportionally much larger than ozone, given equal percentage reductions in annual population exposure.[7]

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[5] See Abt Associates Inc. (2008) BenMAP Environmental Benefits Mapping and Analysis Program: User's Manual. Prepared for the Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, NC (September). SJVAPCD Health Science Advisor, David Lighthall, Ph.D., has received BenMAP training from the Community Modeling and Analysis System in Chapel Hill, NC under contract to the U.S. EPA. See http://www.epa.gov/air/benmap/ for more information on BenMAP, downloading the program, and for technical documents.

[6] Lighthall, D., D. Nunes, and T. Tyner. (2008) Environmental Health Evaluation of Rule 4901: Domestic Wood Burning in the San Joaquin Valley. Central Valley Health Policy Institute, California State University, Fresno. Conducted for and funded by the San Joaquin Valley Air Pollution Control District. See http//www.cvhpi.org

[7] For example, Hall et al. (2008) recently estimated the health benefits of attaining federal standards for PM 2.5 and ozone in the San Joaquin Valley and South Coast air basins. In the case of the San Joaquin

If BenMAP was used to estimate the health benefits of Rule 4570, the results would be expressed in a relatively wide range around a mean with questionable statistical value. Health benefits, particularly at the low end of that estimation range, would appear relatively inconsequential. This outcome would not reflect the fact that (1) Rule 4570 makes a substantial contribution to overall VOC reductions in the 2007 Ozone Plan and (2) VOC controls are an integral, essential component of the overall ozone control strategy.

How BenMAP Works

There are two central objectives in BenMAP analyses. First, the program estimates reductions in the incidence rates of health endpoints (i.e. avoided cases of disease, premature death, and/or impaired health) based on a specified improvement in ambient air quality for a target area and its population. The degree of improvement is based on statistical relationships between exposure to a given criteria pollutant and health that are derived from previously published epidemiological studies. The second objective involves assigning an economic value to those avoided cases of health problems, again based on previously published economic analyses of the health endpoints in question. As noted above, a similar benefit estimation model, known as REHEX, was employed in the Hall et al. (2008) study that estimated the health and economic benefits of achieving federal ozone and PM 2.5 standards in the San Joaquin Valley and South Coast air basins.[8]

Key elements of the BenMAP analysis process include the following: First, BenMAP determines the change in ambient air quality as specified by the user. BenMAP does not include an air quality model. Instead, this data is either loaded in from external modeling sources or generated from a national set of air pollution monitoring data that is pre-loaded into BenMAP. The latter was used in this analysis.

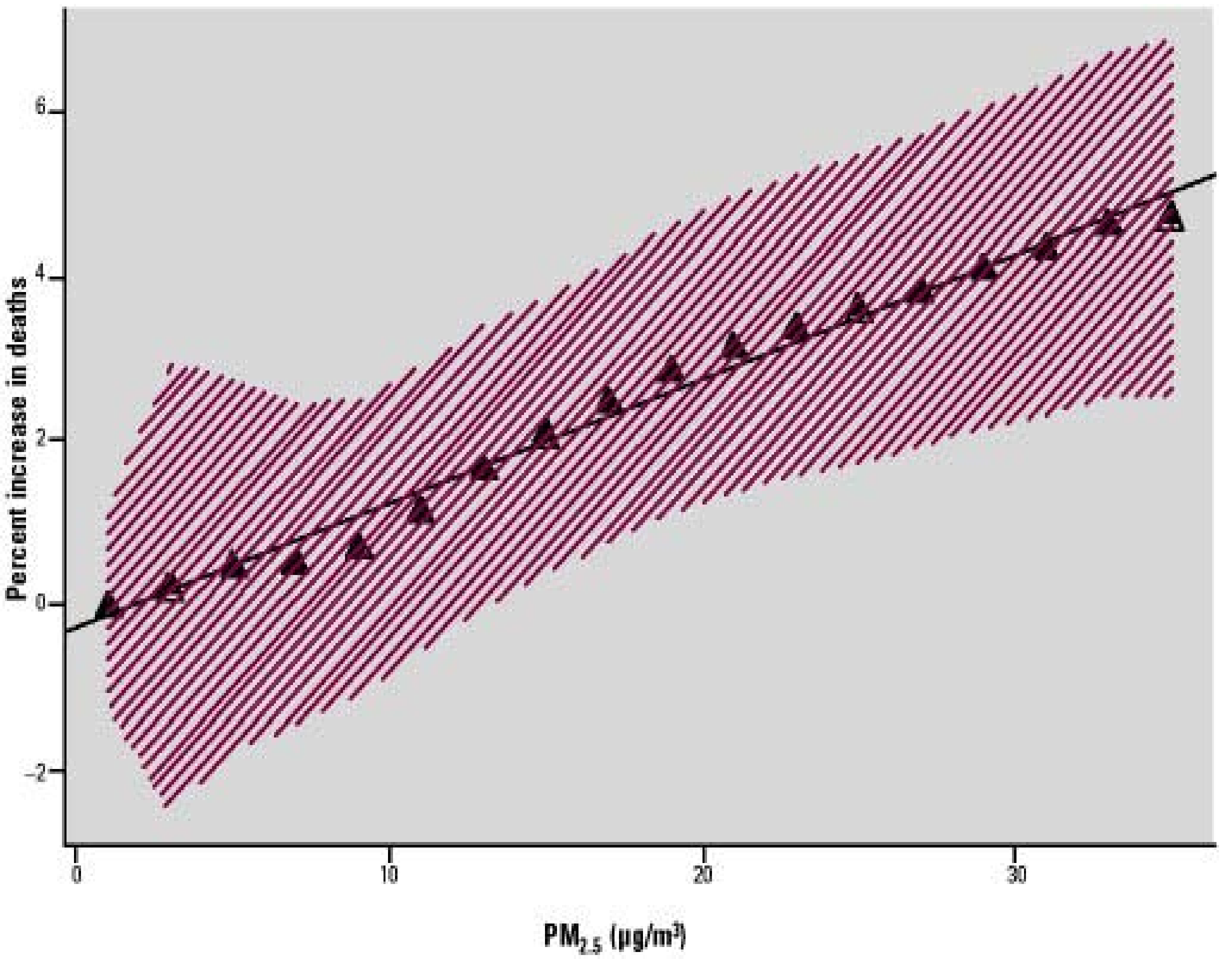
Next, BenMAP calculates the relationship between the reduction in air pollution (e.g. ozone or PM 2.5) and health endpoints. This entails the utilization of a concentration-response function based on prior epidemiological studies (shown in Figure 1). These functions determine the relative health impact of each unit increase in pollution exposure. Users select from one or more prior health studies for each health endpoint in order to derive an appropriate concentration response function.

In the final step, BenMAP estimates the incidence reduction for specified health endpoints for the target population, depending on the level of pollution reduction specified. Custom demographic information can be employed or default population data contained within BenMAP can be used for past, current, and future years based on population growth functions in the program.

Valley, the economic value of health benefits from PM 2.5 attainment was over 63 times greater than ozone attainment.

[8] Hall, J., V. Brajer, and F. Lurmann. (2008) The Benefits of Meeting Federal Clean Air Standards in the South Coast and San Joaquin Valley Air Basins. California State University--Fullerton, Institute for Economic and Environmental Studies. See http://business.fullerton.edu/centers/iees/

Figure 1: Example of Concentration Response Function for PM 2.5



A simplified example of estimating the health effect can be summarized as:[9]

Health Effect = Health Baseline Incidence X Air Quality Change X Health Effect Estimate X Exposed Population

1. Health Baseline Incidence: The health incidence rate is an estimate of the average number of people that die or become ill over a given period of time and for a standard population unit that exists prior to any change in air quality, e.g. 220 cases of asthma per 1,000 individuals per year.
2. Air Quality Change: The air quality change is the difference between the starting air pollution level (i.e. the baseline), and the air pollution level after some change, such as a new regulation (i.e. the control).

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[9] See Abt Associates Inc. (2008) BenMAP Environmental Benefits Mapping and Analysis Program: User's Manual. Prepared for Office of Air Quality Planning and Standards, U.S. EPA, Research Triangle Park, NC (September). Summary above taken from pp. 8-9. BenMAP Version 3.0.12 was used in this analysis.

3. Health Effect Estimate: The health effect estimate is an estimate of the percentage change in adverse health effect due to a one unit change in ambient air pollution. Epidemiological studies provide the source for effect estimates in BenMAP.
4. Exposed Population: The exposed population is the number of people affected by the air pollution reduction.

Finally, BenMAP calculates the economic value of avoided health effects due to reduced ozone or PM 2.5 air pollution. To summarize:

Economic Value = Health Effect X Value of Health Effect

There are several ways to calculate the value of health effect changes. For example, the value of an avoided premature mortality is generally calculated using the Value of a Statistical Life (VSL). The VSL is an economic estimate of the social value of premature death that is used to guide policy makers in making public investments in public health or safety. VSL estimates range from $3.8 to $8.9 million per case.[10] VSL estimates are based on either contingent valuation surveys or wage risk studies.[11] For other health endpoints, the medical costs of the illness may be the only valuation available. In other cases, prior research has provided survey-based generalizations about participants' willingness to pay (WTP) for avoidance of health symptoms and/or diseases. These economic valuation functions for key health endpoints are contained within BenMAP and can also be imported for custom analyses.

BenMAP Application

Rule 4570 was instituted in 2006 and the benefits of its VOC reduction have been estimated to accrue until 2020, the point at which VOC reductions no longer provide any reduction in ozone (see discussion above regarding the 2007 Ozone Plan). For these reasons, the BenMAP analysis uses 2006 as the starting point of the health benefit analysis and 2020 as its terminus. The benefits of VOC control measures in the 2007 Ozone Plan begin to accrue in 2007 and do not achieve their full benefits until 2020. The end result of the analysis, therefore, is the total number of avoided cases of premature death (mortality) and other ozone-related health endpoints (morbidity) that will occur in the year 2020 as a result of the 2007 Ozone Plan control measures.[12]

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[10] For a further discussion of the VSL, see BenMAP Technical Appendices. Office of Air Quality Planning and Standards, U.S. EPA. Prepared by Abt Associates, Inc. September 2008. Available at: http://www.epa.gov/air/benmap/docs.html

[11] Contingent valuation studies are based on surveys that ask how much individuals would be willing to pay to avoid a given health problem. Wage risk studies estimate the value of a single life by looking at the premium paid to workers in occupations that face an increased risk of occupational mortality. For example, a high rise steel worker accepts a 1 in 1,000 (0.001 probability) greater chance of occupational mortality in return for an annual wage premium of $5,000. The VSL in this situation is then based on multiplying that incremental risk to equal a probability of 1, i.e. 1,000 X $5,000 = $5,000,000.

[12] The following counties comprise the San Joaquin Valley: Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare. BenMAP automatically adjusts the regional population to 2020 in the analysis, based on current demographic projections.

Creating baseline and control air quality grids: The 2006 air quality exposure grid contained within BenMAP serves as the baseline population exposure to ozone. In order to estimate the health benefits of ozone reductions from the Plan, reductions in ozone design values have been derived from the 2007 Ozone Plan for all ozone monitors in the Valley (see Table 3). The ozone design value is defined as the 3-year average of the annual 4th highest daily maximum 8-hour ozone concentration.[13] Next, for each county an average reduction in ozone in parts per billion (ppb) is derived and converted to a percentage reduction from the 2006 baseline value. A control air quality exposure grid is then constructed in which each county is selected as a sub-region for the regional analysis. Average county by county percentage reductions in ozone exposure shown in Table 3 are specified in the control grid.

It is important to note that this BenMAP analysis is based on the assumption that percentage reductions in design values translate into a comparable percentage reduction in average seasonal exposure to ozone, which is typically based on the 8-hour maximum exposure metric. It is theoretically possible to make a monitor-by-monitor adjustment in seasonal ozone exposure levels but District air chemistry specialists have indicated that the seasonal air chemistry modeling needed to make that adjustment currently does not exist. Because 2006 was chosen as the baseline year from which to estimate health benefits in subsequent years, 2006 air quality monitor data was used. These data were slightly elevated (3.9%) above the average monitor values for 2004, 2005, and 2006. Together, these analytical assumptions introduce a modest upward bias in health benefit estimation.

Incidence estimation: In the next phase of the analysis, the baseline and control incidence rates for each county are calculated for all relevant health endpoints. Within each health endpoint category, the user has the option to select from a roster of epidemiological studies that have been reviewed and verified by the EPA. Some studies may be more relevant to the application in question because of their geographic and/or demographic focus. Each study has what is termed a beta coefficient which is a mathematical representation of the slope of the concentration response function derived from that study. The higher the beta coefficient, the steeper the slope, indicating the relative health impact of each additional unit of pollutant exposure. It is also possible to select multiple studies for a given health endpoint. The BenMAP program has the capability to pool or average the different beta coefficients, resulting in an incidence rate that reflects the middle ground of health impacts based in the scientific literature. The specific health studies selected for this analysis are listed in Appendix A, along with the other relevant technical specifications of this particular application.

[13] Design values are a metric of ozone exposure that is representative of excess ozone exposure beyond a current health standard. The 2007 Ozone Plan control measures are designed to insure that ozone peaks do not exceed the health standard. In addition, these control measures have the effect of creating ozone concentration reductions in general, although not in perfect proportion to their percentage reduction in design values.

Table 3. Ozone Design Values in 2006 and 2020 for San Joaquin Valley Monitors

	2006 Design Value	2020 Design Value	2020 % Reduction
Fresno			
Clovis	93	79	15.1%
Fresno-1st	100	82	18.0%
Fresno-Drummond	94	80	14.9%
Fresno-Sierra Sky Park	99	87	12.1%
Parlier	97	82	15.5%
			County Avg. 15.1%
Kings			
Hanford	89	74	**County Avg. 16.9%**
Tulare			
Visalia	94	75	20.2%
Lower Kaweah	98	75	23.5%
Ash Mountain	104	87	16.0%
			County Avg. 19.9%
Kern			
Arvin	113	93	17.7%
Bakersfield-California	98	82	16.3%
Bakersfield-Golden	91	80	12.1%
Oildale	98	84	14.3%
Edison	99	85	14.1%
Shafter	90	75	16.7%
Maricopa	92	79	14.1%
			County Avg. 15.0%
San Joaquin			
Stockton	75	63	**County Avg. 16.0%**
Stanislaus			
Modesto	84	71	16.0%
Turlock	89	77	13%
			County Avg. 14.7%
Merced			
Merced	96	78	**County Avg. 18.8%**
Madera			
Madera	83	71	**County Avg. 14.5%**

For ozone, BenMAP health endpoints include the following:

1. Mortality: There are a number of epidemiological studies that have analyzed the impact of elevated ozone exposure on respiratory mortality in the U.S. population. The mechanism whereby ozone can and does trigger premature death could include a severe asthma attack. Premature death is defined in epidemiological studies as someone who dies from an air pollutant-related cause prior to their expected age of death, based on actuarial research. Typically this period falls between 10 and 15 years before normal life expectancy. After a review of beta coefficients and several sensitivity analyses, a study was selected that was conducted by well-respected authors and had a mid-range beta coefficient.
2. Respiratory Emergency Room Visits: As described above, elevated ozone often triggers a strong pulmonary response in individuals with pre-existing pulmonary conditions, such as those with asthma or chronic bronchitis. Numerous studies have analyzed this impact, and concentration response functions have been developed for emergency room visits related to individual pulmonary conditions as well as visits for combined respiratory distress.
3. Respiratory Hospital Admissions: This endpoint category and the related epidemiological studies are closely related to the ER Visits category, except that the extent of ozone-triggered health trauma is more severe, resulting in hospital admission.
4. School Loss Days: As a region, the San Joaquin Valley has a very high rate of childhood asthma. Days of elevated ozone have been shown by a number of studies to result in a statistically elevated and proportional rate of school absences.
5. Acute Respiratory Symptoms: Individuals with pulmonary vulnerability such as asthmatics often experience respiratory impairment that does not result in medical treatment or lost work but are nonetheless real and detrimental to the individual. Studies have shown that the frequency of these symptoms, including wheezing, coughing, and shortness of breath, is relatively high.
6. Reduced Worker Productivity: While ambient ozone concentrations are often much lower within indoor work environments, especially those that are air conditioned, outdoor workers engaged in strenuous activity are vulnerable to its effects. Research has demonstrated that there are modest but measurable impacts of elevated ozone on worker productivity. It should be noted that the San Joaquin Valley, because of its extensive acreage devoted to labor-intensive crops, has one of the highest concentrations of outdoor labor in the United States.

Pooling and Aggregation: Once the appropriate health studies have been selected as the basis for the county-by-county incidence rates for each health endpoint category, BenMAP then pools (averages) the beta coefficients in cases where multiple studies were selected. The result is an aggregated incidence rate for each county for each health endpoint. In other cases, different studies within a single endpoint apply to different age groups, and therefore must be pooled and aggregated.

Valuation: In the final phase of the BenMAP analysis, an economic value is assigned to the number of cases of avoided health trauma or premature death that result from the control strategy specified by the user. This calculation draws on a parallel body of economic studies that, as described above, use actual health care costs, lost wages, and/or surveys of willingness to pay for individual cases of avoided health trauma such as an asthma attack.

Results of the BenMAP Analysis

Reduced Incidence

The results of the BenMAP incidence analysis are presented in Table 4. As a result of the total control measures contained within the 2007 Ozone Plan, these figures represent the number of avoided cases of premature death or health trauma that would apply to the San Joaquin Valley county populations in the year 2020. 2020 is selected as the terminus of health benefits from the Plan because VOC controls from measures such as Rule 4570 no longer result in ozone decreases beyond that year. In other words, if the control measures in the Plan were not put in place, we would expect to see a proportional level of ozone concentration for the estimated population in 2020, resulting in these additional cases of premature death and health trauma.

Values in each cell reflect (1) the amount of reduced ozone exposure specified in Table 3; (2) the demographic characteristics of each county, particularly its population size; and (3) the concentration response function (or pooled functions) selected for each health endpoint category. These values are means representing the mid-point of a range of health endpoint cases. With the exception of Worker Productivity, the standard deviation for each county endpoint value is estimated by BenMAP and is presented below the mean totals in Table 4.[14] It is important to note the standard deviations. In several cases, these values are relatively large by statistical standards, reflecting the fact that the studies upon which the incidence reductions are based have a comparable level of uncertainty in estimating the health effects of ozone exposure.

Valuation Results

Valuation results for all health endpoint categories in each county are presented in Table 5. The total annual economic cost savings is $159,636,286 in 2006 dollars. A comparable analysis of the economic benefits of ozone attainment conducted by Hall et al. (2008) reported an annual value of $88,880,000 in 2007 dollars for the 2007 Valley population. In addition to the population increase between 2007 and 2020, one reason for the higher figure in this analysis is the higher annual mortality benefits in this study (21 cases vs. 9 in the Hall et al. estimate). Other health endpoint estimates are similar when scaled for population differences, although the terms used to describe the endpoints differ in some cases.

Table 6 presents the economic estimations after being adjusted for inflation to the year

[14] BenMAP does not provide a standard deviation for this health endpoint.

Table 4. Avoided Cases of Premature Death and Health Trauma in 2020

	Mean Totals	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
Mortality	**21**	6	6	1	1	1	3	2	3
Respiratory Emergency Room Visits	**78**	20	22	3	2	3	8	8	12
Respiratory Hospital Admissions	**286**	75	76	8	9	11	32	30	45
School Loss Days	**79,532**	20,194	22,051	2,301	2,241	3,193	8,661	7,647	13,246
Acute Respiratory Symptoms	**91,402**	23,613	25,867	3,109	2,705	3,480	9,651	9,081	13,896
Worker Productivity	**11,828,748**	1,887,918	4,818,409	151,810	258,283	586,901	107,985	114,763	3,902,679
	Standard Deviation								
Mortality		2	2	0	0	0	1	1	1
Respiratory Emergency Room Visits		6	7	1	1	1	3	2	4
Respiratory Hospital Admissions		23	23	3	3	3	10	9	14
School Loss Days		10,599	11,546	1,213	1,182	1,686	4,565	4,030	6,927
Acute Respiratory Symptoms		6,582	7,202	868	756	972	2,695	2,535	3,867
Worker Productivity		NA	NA	NA	NA	NA	NA	NA	NA

15

Table 5. 2020 Estimated Economic Value of Avoided Cases of Premature Death and Health Trauma

	Mean Totals	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
Mortality	**$132,737,821**	$34,347,752	$35,678,672	$3,442,470	$3,442,470	$5,144,200	$16,179,052	$15,347,849	$19,155,356
Respiratory ER Visits	**$20,240**	$5,215	$5,689	$586	$586	$798	$2,159	$2,024	$3,183
Respiratory Hospital Admissions	**$4,489,142**	$1,172,315	$1,199,208	$139,995	$139,995	$172,402	$498,364	$464,291	$702,572
School Loss Days	**$5,960,435**	$1,514,521	$1,653,807	$168,065	$168,065	$239,443	$649,562	$573,539	$993,433
Acute Respiratory Symptoms	**$4,599,900**	$1,193,650	$1,307,585	$136,725	$136,725	$175,911	$487,836	$459,037	$702,431
Worker Productivity	**$11,828,748**	$1,887,918	$4,818,409	$151,810	$258,283	$586,901	$107,985	$114,763	$3,902,679
	$159,636,286								
	Standard Deviation								
Mortality		$26,481,582	$27,506,864	$2,654,342	$2,654,342	$3,966,557	$12,474,714	$11,833,775	$14,767,801
Respiratory ER Visits		$1,622	$1,767	$183	$183	$249	$673	$631	$988
Respiratory Hospital Admissions		$360,096	$363,451	$43,276	$43,276	$52,548	$152,490	$142,488	$212,474
School Loss Days		$794,929	$865,914	$88,654	$88,654	$126,424	$342,401	$302,250	$519,502
Acute Respiratory Symptoms		$445,659	$487,890	$51,108	$51,108	$65,767	$182,320	$171,530	$261,997
Worker Productivity		NA	NA	NA	NA	NA	NA	NA	NA

Table 6. 2020 Estimated Economic Value of Avoided Cases of Premature Death and Health Trauma (in 2020 Dollars)

	Mean Totals	Fresno	Kern	Kings	Madera	Merced	San Joaquin	Stanislaus	Tulare
Mortality	**$179,938,502**	$46,561,586	$48,365,767	$4,666,583	$4,666,598	$6,973,444	$21,932,231	$20,805,469	$25,966,871
Respiratory ER Visits	**$27,437**	$7,069	$7,712	$794	$794	$1,082	$2,927	$2,744	$4,315
Respiratory Hospital Admissions	**$6,085,451**	$1,589,182	$1,625,638	$189,776	$189,777	$233,707	$675,579	$629,391	$952,402
School Loss Days	**$8,079,926**	$2,053,075	$2,241,890	$227,828	$227,828	$324,587	$880,543	$777,487	$1,346,691
Acute Respiratory Symptoms	**$6,235,594**	$1,618,104	$1,772,553	$185,343	$185,344	$238,464	$661,308	$622,268	$952,211
Worker Productivity	**$16,034,971**	$2,559,249	$6,531,803	$205,793	$350,127	$795,599	$146,384	$155,572	$5,290,446
	$216,401,880								
	Standard Deviation								
Mortality		$35,898,255	$37,288,127	$3,598,208	$3,598,208	$5,377,039	$16,910,639	$16,041,798	$20,019,107
Respiratory ER Visits		$2,199	$2,395	$248	$248	$338	$912	$855	$1,339
Respiratory Hospital Admissions		$488,144	$492,692	$58,665	$58,665	$71,234	$206,714	$193,156	$288,028
School Loss Days		$1,077,600	$1,173,827	$120,179	$120,179	$171,380	$464,156	$409,728	$704,234
Acute Respiratory Symptoms		$604,132	$661,380	$69,282	$69,282	$89,153	$247,152	$232,525	$355,162
Worker Productivity		NA	NA	NA	NA	NA	NA	NA	NA

2020.[15] By 2020, the annual estimated economic benefits resulting from the 2007 Ozone Plan is $216,401,880. Of this total, $36,463,379 (16.8%) is ascribed to morbidity-related costs and the rest is associated with reduced premature mortality.

Discussion of Incidence and Valuation Results

This section overviews the results of the BenMAP modeling for each health endpoint along with some comments about the performance of the model and the studies employed to derive the incidence and valuation estimates. Details regarding the specific health and economic studies employed, technical details for the baseline and control air quality grids, and methods used for pooling and aggregating results within each end point category are available in Appendix A.[16]

Mortality: Avoided incidence of pre-mature mortality due to ozone reductions is based on a study of more than 1 million deaths in 14 U.S. cities that found an increased risk of death in correlation with warm season increases in ozone. These results underscore the important contribution of the 2007 Ozone Plan to the protection of public health in the San Joaquin Valley. While ozone mortality benefits are considerably less than those ascribed to PM 2.5, the avoidance of 21 cases of premature death is a noteworthy reminder that the investments in ozone control measure yield important, and some would argue, immeasurable mortality benefits.[17] These mortality benefits are consistent with recent epidemiological findings.[18]

A value of $6.32 million in 2006 dollars is ascribed to each case of premature mortality. This figure represents a middle-range estimate based on 26 mortality valuation studies compiled by EPA and, as discussed above, is generally known as the value of a statistical life or VSL. Five of the 26 studies are based on contingent valuation studies (CV) and the rest are based on wage-risk studies. This per case estimate does not represent actual health care costs, lost wages, or any direct economic cost to society. It is also not scaled on the basis of the actual years of life lost per individual case. When inflation-adjusted to 2020 dollars, the value of each case is $8,568,500.

Respiratory Emergency Room Visits: During the sensitivity analysis phase of this study, a number of studies were used as the basis for the concentration response function for

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[15] The inflation index used to calculate economic costs in 2020 was 1.356. This index is based on recent U.S. inflation data derived from the Consumer Price Index. Medical costs have been rising faster than the CPI, however. As such, these values will likely understate future health endpoint estimates in categories such as emergency room visits that are based on health care costs. See http://www.halfhill.com/inflation.html

[16] A complete discussion of each health study and its methodological incorporation into BenMAP can be found in BenMAP Technical Appendices. Office of Air Quality Planning and Standards, U.S. EPA. Prepared by Abt Associates, Inc. September 2008. See http://www.epa.gov/air/benmap/docs.html

[17] In comparison, the BenMAP analysis of mortality benefits resulting from PM 2.5 reductions attributable to restrictions on domestic wood burning in the region resulted in mid-range estimates of 35 and 63 avoided annual cases for Bakersfield and Fresno/Clovis, respectively.

[18] See Jerrett, M. et al. (2009) *Long-Term Ozone Exposure and Mortality*. New England Journal of Medicine Vol. 360 (11):1085-1095 March 12.

this BenMAP health endpoint. Incidence levels did not vary significantly. The study that was selected was based on respiratory visits in Portland, Maine. The annual frequency of avoided ER visits for respiratory trauma would seem on the surface to be relatively low for a region of over 4 million people that is characterized by excessive ozone concentrations and a correspondingly high asthma prevalence rate. This apparent anomaly, if it is indeed an anomaly, underscores the need for further epidemiological research on air quality and ER admissions in California and/or the San Joaquin Valley.

The valuation estimate is derived from a national study of asthma admissions and the cost of those admissions to hospitals ($351 in 2020 dollars). Because this value is not based on the cost charged to individuals or insurance companies, it arguably understates total economic outlays for this health endpoint.

Respiratory Hospital Admissions: The concentration response function for this health endpoint was derived (1) from a study of adults conducted in Tacoma, Washington that examined hospital admissions from all respiratory conditions as related to variations in ozone concentrations, and (2) a study of children two years or less conducted in Toronto, Canada. BenMAP has the capability to apply different concentration response functions to different age segments within each of the counties in the study region. The unit cost per visit in 2020 dollars is estimated at $21,278, and includes both the cost estimate of the hospital fees plus lost wages per day of stay.

School Loss Days: Incidence estimation for this health endpoint was based on a study of school absences in Southern California that resulted from respiratory symptoms during the period January through June of 1996. Absences were only treated as absences if the child was in attendance on the previous day. The standard deviation for the incidence estimation is the highest of all study health endpoints, just exceeding 50% of the mean estimate. The economic value per daily loss in 2020 dollars is $102. Because the CPI inflation index, rather than a wage inflation index, was used to project 2020 values in all endpoints, this figure may underestimate daily wages in 2020.[19] This is based on estimates of lost wages for parents, and scaled downward to reflect the fraction of parents who are not in the workforce.

Acute Respiratory Symptoms: This endpoint incidence estimation is based on a study of minor restricted activity days (MRAD) related to respiratory symptoms such as shortness of breath. MRADs are defined as days where health is impaired but does not result in lost work. The study population was a national sample of adults age 18 to 65 residing in metropolitan areas who participated in the Health Interview Survey conducted by the National Center for Health Statistics. The per unit cost of a MRAD associated with ozone is $68 inflated to 2020 dollars. This value is derived from willingness to pay (WTP) studies that estimate the value that individuals place on avoiding respiratory symptoms.

Reduced Worker Productivity: The incidence estimation for this health endpoint was based on a study of how elevated ozone levels affected the productivity and resultant

[19] Recent wage growth in the U.S. has slowed considerably in the past decade, however, and may continue to contract. The growth in the CPI has been subject to less variation and this is the rationale for applying the CPI index to all health endpoints in the study.

wages of outdoor citrus workers. BenMAP contains county level data on the number of workers engaged in farming, forestry, and fishing for whom this effect is applied. The effect on productivity and wages is relatively modest, resulting in a per unit daily cost of $1.36 inflated to 2020. Workers in the construction sector are not included but arguably should be included. No information was available for quantifying the uncertainty in the mean incidence and valuation estimate. As a result, there is no standard deviation listed for this endpoint.

Conclusion

The health benefits for the population of the San Joaquin Valley associated with the reductions in ambient ozone exposure from the 2007 Ozone Plan are considerable. The results of this analysis underscore the continued validity of the public policy framework established by the U.S. Clean Air Act and the California Clean Air Act that requires continual and often very expensive investments in air pollution control measures as the means of achieving federal air quality standards. Empirical research such as this report provide decision makers and the public with more detailed information for judging the difficult balance that regulatory agencies such as the San Joaquin Valley Air Pollution Control District must strike between public health protection and economic viability.

However, it is also very important to acknowledge the fact that health benefit estimation modeling exercises such as this one are inherently subject to a number of factors that create estimation uncertainty. Epidemiology is in essence an exercise in statistical inference where the level of estimation accuracy is dependent on the frequency of observations. As such, large study population cohorts are most amenable to precise correlation estimates. Unfortunately, such data sets are not available for some health endpoints that are affected by excess exposure to air pollutants. In addition, existing studies may differ from the area being investigated in terms of their populations, climate, and pollution sources. Unknown biases, false assumptions, and estimation errors are likely to occur, despite the best efforts of well-trained scientists and their peers. In the case of this report, a review of the standard deviations associated with the health endpoints assessed make it clear that the mean values reported are subject to real-world variation.

It is also critical to note at this juncture, however, that the history of environmental health science has shown that the unintended consequences of air pollution continue to mount over time as new studies reveal heretofore unknown health impairments. In other words, there is a very high probability that a comparable BenMAP analysis of the San Joaquin Valley conducted in 10 years time would include new health endpoint categories and a larger overall health benefit estimation. For this reason, the health benefits contained in this report are likely to underestimate the real world benefits of the 2007 Ozone Plan.

Returning to the question of the health benefits of Rule 4570 and its limits on VOC emissions from confined animal facilities, the preceding discussion about estimation uncertainty underscores why it is so difficult to disentangle the health effects of a single VOC control measure within the larger Plan. It would be possible at this point to derive a fractional estimation of incidence and cost benefits from the BenMAP findings based on the estimated contribution of Rule 4570's VOC controls to 2020 ozone levels. But as explained above, the latter estimation is itself subject to considerable error in estimation because of the complex air chemistry interactions between NOx and VOC that are variable over time and space. Instead, the report has been structured according to (1) the categorical importance of VOC controls to ozone reductions required for Clean Air Act compliance, and (2) the contribution that Rule 4570 makes to necessary reductions in VOC emissions. In conclusion, this report shows that the reductions in ozone precursor emissions resulting from Rule 4570 make a critical contribution to the District's overall strategy to meet the health-based standards for ozone.

Appendix A:

Technical Specifications of the BenMAP Modeling Analysis

C:\Program Files\BenMAP 3.0\Configuration Results\2006\2006 O3 #5 2020 Pop 3-8-09.apvr					
	Configuration Results: C:\Program Files\BenMAP 3.0\Configuration Results\2006\2006 O3 #5 2020 Pop 3-8-09.cfgr				
		Latin Hypercube Points: 10			
		Population Dataset: United States Census - County			
		Year: 2020			
		Threshold: 0			
		Grid Definition			
			Name: County		
			ID: 0		
			Columns: 56		
			Rows: 840		
			Grid Type: Shapefile		
			Shapefile Name: County		
		Selected Studies			
			CR Function 0		
				CRFunction DataSet: EPA Standard Health Functions	
				Endpoint Group: Mortality	
				Endpoint: Mortality, Non-Accidental	
				Pollutant: Ozone	
				Metric: D1HourMax	
				Metric Statistic: None	
				Author: Schwartz	
				Year: 2005	
				Location: 14 US cities	
				Qualifier: Warm season.	
				Reference: Schwartz, J. How sensitive is the association between ozone and daily deaths to control for temperature? Am J Respir Crit Care Med, 2005. 171(6): p. 627-31.	
				Start Age: 0	
				End Age: 99	

				Baseline Functional Form: Incidence*POP*A	
				Functional Form: (1-(1/((1-Incidence)*EXP(Beta*DeltaQ)+Incidence)))*Incidence*POP*A	
				Incidence DataSet: 2020 Mortality Incidence	
				Beta: 0.000370000000000011	
				Beta Distribution: Normal	
				P1Beta: 0.000130102040816328	
				P2Beta: 0	
				A: 0.0027397	
				Name A: Scalar to convert annual mortality rate to daily rate	
				B: 0	
				C: 0	
				Percentile: 0	
			CR Function 1		
				CRFunction DataSet: EPA Standard Health Functions	
				Endpoint Group: Emergency Room Visits, Respiratory	
				Endpoint: Emergency Room Visits, Asthma	
				Pollutant: Ozone	
				Metric: D8HourMax	
				Metric Statistic: None	
				Author: Wilson et al.	
				Year: 2005	
				Location: Portland, ME	
				Reference: Wilson, A.M., C.P. Wake, T. Kelly et al. 2005. Air pollution and weather, and respiratory emergency room visits in two northern New England cities: an ecological time-series study. Environ Res. Vol. 97 (3): 312-21.	
				Start Age: 0	
				End Age: 99	
				Baseline Functional Form: Incidence*POP	
				Functional Form: (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP	
				Incidence DataSet: 2000 Incidence and Prevalence	
				Beta: 0.003	
				Beta Distribution: Normal	
				P1Beta: 0.001	
				P2Beta: 0	
				A: 0	
				B: 0	
				C: 0	

				Percentile: 0	
			CR Function 2		
				CRFunction DataSet: EPA Standard Health Functions	
				Endpoint Group: Hospital Admissions, Respiratory	
				Endpoint: HA, All Respiratory	
				Pollutant: Ozone	
				Metric: D8HourMax	
				Metric Statistic: None	
				Author: Schwartz	
				Year: 1995	
				Location: Tacoma, WA	
				Other Pollutants: PM10	
				Qualifier: Warm season. 8-hour max from 24-hour mean.	
				Reference: Schwartz, J. Short term fluctuations in air pollution and hospital admissions of the elderly for respiratory disease. Thorax, 1995. 50(5): p. 531-538.	
				Start Age: 65	
				End Age: 99	
				Baseline Functional Form: Incidence*POP	
				Functional Form: (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP	
				Incidence DataSet: 2000 Incidence and Prevalence	
				Beta: 0.00493143346816288	
				Beta Distribution: Normal	
				P1Beta: 0.0017701386388408	
				P2Beta: 0	
				A: 0	
				B: 0	
				C: 0	
				Percentile: 0	
			CR Function 3		
				CRFunction DataSet: EPA Standard Health Functions	
				Endpoint Group: Hospital Admissions, Respiratory	
				Endpoint: HA, All Respiratory	
				Pollutant: Ozone	
				Metric: D8HourMax	
				Metric Statistic: None	
				Author: Burnett et al.	

				Year: 2001	
				Location: Toronto, CAN	
				Other Pollutants: PM2.5	
				Qualifier: Warm season. 8-hour max from 1-hour max.	
				Reference: Burnett, R.T., et al. Association between ozone and hospitalization for acute respiratory diseases in children less than 2 years of age. Am J Epidemiol, 2001. 153(5): p. 444-52.	
				Start Age: 0	
				End Age: 1	
				Baseline Functional Form: Incidence*POP	
				Functional Form: (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP	
				Incidence DataSet: 2000 Incidence and Prevalence	
				Beta: 0.00817699115044248	
				Beta Distribution: Normal	
				P1Beta: 0.00237703231117514	
				P2Beta: 0	
				A: 0	
				B: 0	
				C: 0	
				Percentile: 0	
			CR Function 4		
				CRFunction DataSet: EPA Standard Health Functions	
				Endpoint Group: School Loss Days	
				Endpoint: School Loss Days, All Cause	
				Pollutant: Ozone	
				Metric: D8HourMean	
				Metric Statistic: None	
				Author: Gilliland et al.	
				Year: 2001	
				Location: Southern California	
				Reference: Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi	
				Start Age: 5	
				End Age: 17	
				Baseline Functional Form: Incidence*POP*A*B	
				Functional Form: (1-	

				(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B	
				Incidence DataSet: 2000 Incidence and Prevalence	
				Beta: 0.00815	
				Beta Distribution: Normal	
				P1Beta: 0.00463010204081633	
				P2Beta: 0	
				A: 0.3929	
				Name A: Scalar for % of school days in ozone season	
				B: 0.945	
				Name B: Population of school children at-risk for a new absence	
				C: 0	
				Percentile: 0	
			CR Function 5		
				CRFunction DataSet: EPA Standard Health Functions	
				Endpoint Group: Acute Respiratory Symptoms	
				Endpoint: Minor Restricted Activity Days	
				Pollutant: Ozone	
				Metric: D8HourMax	
				Metric Statistic: None	
				Author: Ostro and Rothschild	
				Year: 1989	
				Location: Nationwide	
				Other Pollutants: PM2.5	
				Qualifier: 8-hour max from 1-hour max.	
				Reference: Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res, 1989. 50(2): p. 238-247.	
				Start Age: 18	
				End Age: 64	
				Baseline Functional Form: A*POP	
				Functional Form: (1-(1/EXP(Beta*DELTAQ)))*A*POP	
				Beta: 0.002596	
				Beta Distribution: Normal	
				P1Beta: 0.00077644	
				P2Beta: 0	
				A: 0.02137	
				Name A: mRAD18to64; Ostro and Rothschild, 1989, p 243.	
				B: 0	

				C: 0	
				Percentile: 0	
		Baseline Air Quality Grid: C:\Program Files\BenMAP 3.0\Air Quality Grids\2006 analyses\2006 O3 BL SJV % RB 3-5-09.aqg			
			Pollutant: Ozone		
			Interpolation Method: Voronoi Neighborhood Averaging		
			Library Monitors: True		
			Monitor Year: 2006		
			Grid Definition		
				Name: County	
				ID: 0	
				Columns: 56	
				Rows: 840	
				Grid Type: Shapefile	
				Shapefile Name: County	
			Advanced		
				Neighbor Scaling Type: Inverse Distance	
			Monitor Filtering		
				Methods: 11, 14, 19, 47, 53, 56, 78, 87, 91, 103, 105, 112	
				Objectives: .	
				Maximum POC: 4	
				POC Preferences: 1, 2, 3, 4	
				Minimum Lat, Long: 20, -130	
				Maximum Lat, Long: 55, -65	
				Start Hour: 8	
				End Hour: 19	
				Observations Required Per Day: 9	
				Start Day: 120	
				End Day: 272	
				Valid Days Required Per Year: 76	
		Control Air Quality Grid: C:\Program Files\BenMAP 3.0\Air Quality Grids\2006 analyses\2006 O3 Control SJV % RB 3-5-09.aqg			

			Pollutant: Ozone		
			Interpolation Method: Voronoi Neighborhood Averaging		
			Library Monitors: True		
			Monitor Year: 2006		
			Grid Definition		
				Name: County	
				ID: 0	
				Columns: 56	
				Rows: 840	
				Grid Type: Shapefile	
				Shapefile Name: County	
			Advanced		
				Neighbor Scaling Type: Inverse Distance	
			Monitor Rollback		
				Region: (6,77)	
					Rollback Method: Percentage
					Percentage: 0.16
				Region: (6,99)	
					Rollback Method: Percentage
					Percentage: 0.147
				Region: (6,47)	
					Rollback Method: Percentage
					Percentage: 0.188
				Region: (6,19), (6,39)	
					Rollback Method: Percentage
					Percentage: 0.151
				Region: (6,31)	

					Rollback Method: Percentage
					Percentage: 0.169
				Region: (6,107)	
					Rollback Method: Percentage
					Percentage: 0.199
				Region: (6,29)	
					Rollback Method: Percentage
					Percentage: 0.15
			Monitor Filtering		
				Methods: 11, 14, 19, 47, 53, 56, 78, 87, 91, 103, 105, 112	
				Objectives: .	
				Maximum POC: 4	
				POC Preferences: 1, 2, 3, 4	
				Minimum Lat, Long: 20, -130	
				Maximum Lat, Long: 55, -65	
				Start Hour: 8	
				End Hour: 19	
				Observations Required Per Day: 9	
				Start Day: 120	
				End Day: 272	
				Valid Days Required Per Year: 76	
	Advanced				
		Sort Incidence LHPs: True			
		Default Advanced Pooling Method: Round Weights to Two Digits			
		Default Monte Carlo Iterations: 5000			
		Random Seed: -1			
		Currency Year: 2006			
		Skip QALY Weights: True			
		Incidence Aggregation			
			Name: County		

		ID: 0		
		Columns: 56		
		Rows: 840		
		Grid Type: Shapefile		
		Shapefile Name: County		
	Valuation Aggregation			
		Name: County		
		ID: 0		
		Columns: 56		
		Rows: 840		
		Grid Type: Shapefile		
		Shapefile Name: County		
Incidence Pooling Windows				
	Incidence Pooling Window: Pooling Window 1			
		Mortality, Mortality, Non-Accidental, Schwartz, Warm season., 14 US cities, 0, 99, 2005, , Schwartz, J. How sensitive is the association between ozone and daily deaths to control for temperature? Am J Respir Crit Care Med, 2005. 171(6): p. 627-31., , , , (1-(1/((1-Incidence)*EXP(Beta*DeltaQ)+Incidence)))*Incidence*POP*A, Ozone, D1HourMax, , None, EPA Standard Health Functions, 0: []		
		Emergency Room Visits, Respiratory, Emergency Room Visits, Asthma, Wilson et al., , Portland, ME, 0, 99, 2005, , Wilson, A.M., C.P. Wake, T. Kelly et al. 2005. Air pollution and weather, and respiratory emergency room visits in two northern New England cities: an ecological time-series study. Environ Res. Vol. 97 (3): 312-21., , , , (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP, Ozone, D8HourMax, , None, EPA Standard Health Functions, 0: []		
		School Loss Days, School Loss Days, All Cause, Gilliland et al., , Southern California, 5, 17, 2001, , Gilliland, F.D., K. Berhane, E.B. Rappaport, D.C. Thomas, E. Avol, W.J. Gauderman, S.J. London, H.G. Margolis, R. McConnell, K.T. Islam and J.M. Peters. 2001. The effects of ambient air pollution on school absenteeism due to respiratory illnesses. Epidemi, , , , (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP*A*B, Ozone, D8HourMean, , None, EPA Standard Health Functions, 0: []		
		Acute Respiratory Symptoms, Minor Restricted Activity Days, Ostro and Rothschild, 8-hour max from 1-hour max., Nationwide, 18, 64, 1989, PM2.5, Ostro, B.D. and S. Rothschild. Air Pollution and Acute Respiratory Morbidity - an Observational Study of Multiple Pollutants. Environ Res,		

			1989. 50(2): p. 238-247., , , , (1-(1/EXP(Beta*DELTAQ)))*A*POP, Ozone, D8HourMax, , None, EPA Standard Health Functions, 0: []		
			Hospital Admissions, Respiratory, HA, All Respiratory [Pooling Method: Sum (Dependent)]		
				Burnett et al., Warm season. 8-hour max from 1-hour max., Toronto, CAN, 0, 1, 2001, PM2.5, Burnett, R.T., et al. Association between ozone and hospitalization for acute respiratory diseases in children less than 2 years of age. Am J Epidemiol, 2001. 153(5): p. 444-52., , , , (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP, Ozone, D8HourMax, , None, EPA Standard Health Functions, 0: []	
				Schwartz, Warm season. 8-hour max from 24-hour mean., Tacoma, WA, 65, 99, 1995, PM10, Schwartz, J. Short term fluctuations in air pollution and hospital admissions of the elderly for respiratory disease. Thorax, 1995. 50(5): p. 531-538., , , , (1-(1/EXP(Beta*DELTAQ)))*Incidence*POP, Ozone, D8HourMax, , None, EPA Standard Health Functions, 0: []	
	Valuation Pooling Windows				
		Valuation Pooling Window: Pooling Window 1			
			Mortality, VSL, based on 26 value-of-life studies.: []		
			Emergency Room Visits, Respiratory, COI: Standford et al. (1999): []		
			Hospital Admissions, Respiratory, COI: med costs + wage loss: [Pooling Method: Sum (Dependent)]		
			School Loss Days, : []		
			Acute Respiratory Symptoms, WTP: 1 day, CV studies: []		
	QALY Pooling Windows				
		QALY Pooling Window: Pooling Window 1			