Final Workplan

# 2005 Community-Scale Air Toxics Monitoring Grant Proposal

# Clearing the Air: Understanding Air Toxics and Carbonyl Pollutant Sources at the Urban/Mountain Interface


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**Funding Requested: $488,933**
**Project Period: January 1, 2006 – December 31, 2007**


## *Abstract*

Boulder County sits at the confluence of the pristine high alpine wilderness of the Rocky Mountains and the heavily urbanized city of Denver, Colorado, and the agricultural and intensive oil and gas activities in neighboring counties. This urban/rural interface creates a complex air quality environment characterized by shifting upslope and downslope conditions that can intensify air toxics in relatively pristine environments.

Previous studies indicate that secondary pollutants such as acetaldehyde and formaldehyde are significant air toxics risk drivers and are also indicative of ozone formation along the Colorado Front Range (Anderson, et. al 1996). The 1996 and 1999 National Air Toxics Assessment (NATA) estimates attempt to account for secondary production of these two compounds, although EPA acknowledges that their approach is subject to considerable uncertainty and the pollutant concentrations are generally underestimated carbonyls, as indicated by local community-scale monitoring and modeling efforts.

Boulder County Public Health (BCPH) and its partners are proposing to monitor for VOC and carbonyl measurements at five locations to aid in air toxics model evaluation and air toxics source apportionment. This study will evaluate the City and County of Denver's regional air toxics model. Timely carbonyl and tracer gases will enable the county to better assess the impacts from primary and secondary air toxics pollutant sources in the urban-mountain interface.

The next section below delineates how the project meets the project-specific guidelines. Following that, background information on previous studies provides a context for the proposal.

## I. Objectives and Category-Specific Guidelines

This proposal is intended to provide targeted ambient air toxics monitoring to improve our understanding of the spatial and temporal variations of air toxics identified in previous monitoring efforts and to enhance model-to-monitor validation of a community-scale air dispersion model. The monitoring will also validate a human health assessment and evaluate the impacts of point, mobile, and area sources (e.g. wood burning, oil and gas exploration) on air toxics and carbonyls. The study will meet the category-specific guidelines as follows:

1) Delineate concentrations of local scale air toxics. Build upon previous studies that have identified levels of acetaldehyde and formaldehyde well in excess of those found in more densely urbanized neighboring areas and National Air Toxics Assessment (NATA) predictions. Use monitoring and modeling, assess the impact of secondary pollutants and understand the spatial and temporal variations of air toxics at the urban/mountain interface.
2) Evaluate and improve air quality exposure models. Use the spatial and temporal air toxics monitoring data to evaluate the NATA results for Boulder County and an established community-scale air dispersion model.
3) Support assessments of health effects. Provide timely data to address community concerns and to support and evaluate two extensive health consultations conducted in collaboration with the Agency for Toxic Substances and Disease Registry in northwest Boulder County.
4) Develop a baseline reference for longer-term measuring. Create a monitoring and modeling capability, in partnership with the University of Colorado and the City and County of Denver, which can be built upon in subsequent years.
5) Guide air quality management strategies in Boulder County.

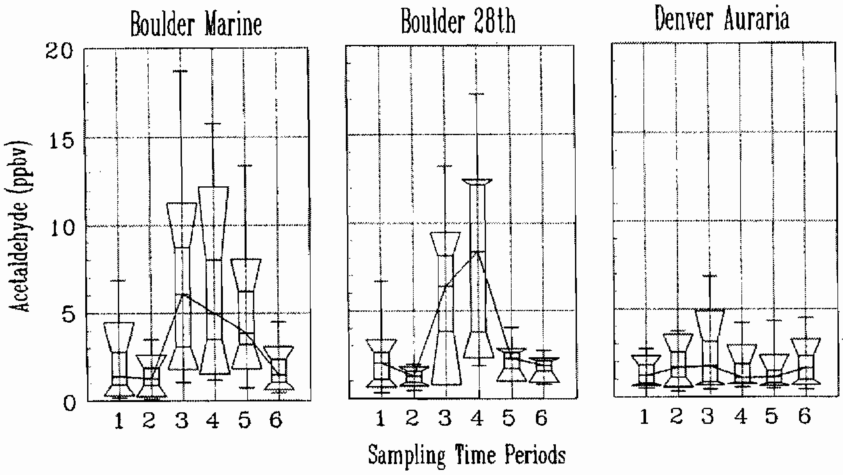
This project supports Goal 1. Clean Air and Global Climate Change, Objective 1.1 Healthier Outdoor Air, and Sub-Objective 1.1.2 Reduced Risk from Toxic Air Pollutants.

## II. Previous Air Toxics Monitoring & Modeling Results

### A. 1996 Carbonyl Monitoring by Anderson et. al.

The most recent monitoring study conducted in Boulder County was in 1996 by Larry G. Anderson and John A. Lanning of the University of Colorado at Denver. The study provided an analysis of concentrations of formaldehyde, acetaldehyde, and acetone measured at one site in downtown Denver, Colorado; two sites in Boulder, Colorado, and one mountain site west of Boulder. The study found that the winter and summer concentrations of acetaldehyde are significantly higher in Boulder (a far less populated and urbanized area) than in Denver. (See Figure 1.) Photochemical formation is suggested as a source that contributes to both acetaldehyde and formaldehyde concentrations; much more so in Boulder than in Denver. (Riggs, Susan D; Anderson, Larry G.; Lanning, John A., 1997)

**Figure 1. Acetaldehyde Concentrations in Boulder versus Denver (4-hour averages, midnight to midnight)**




## B. 1999 National Ambient Air Toxics Assessment (NATA)

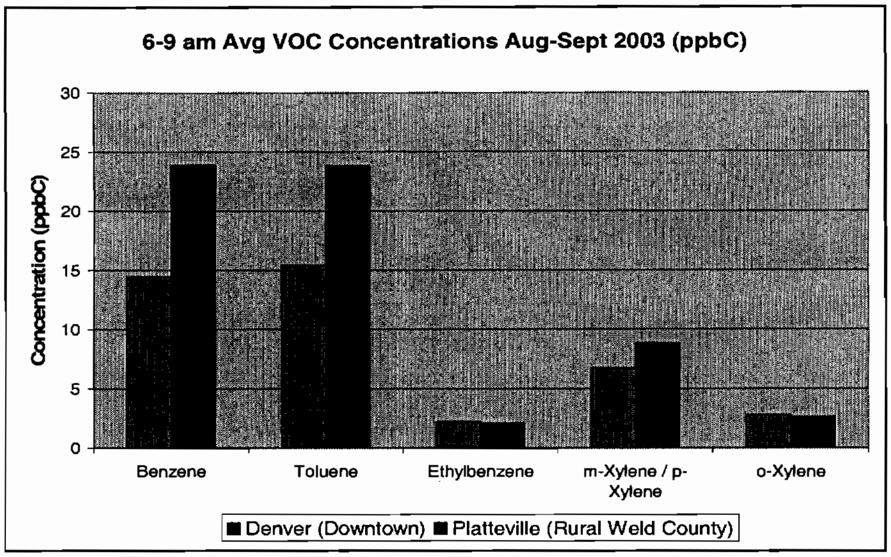
The 1999 NATA data indicates the median formaldehyde concentration for Boulder County is 0.8 ug/m3. This is an order of magnitude higher than the $1x10^{-6}$ benchmark concentration of 0.08 ug/m3 for this B1 probable human carcinogen. The median acetaldehyde concentration for Boulder County is 0.4 ug/m3. This is just below the $1x10^{-6}$ cancer risk benchmark of 0.5 ug/m3. Based on other studies (described below), there is a strong indication that secondary pollutant formation may be a significant source of air toxics in Boulder. While the NATA does attempt to assess secondary pollutants, EPA acknowledges that the approach used is subject to considerable uncertainty and generally underestimates concentrations. This may be particularly true in Front Range areas where complex terrain and meteorology can have an exacerbating effect.

## C. Summer 2003 Short-term VOC Concentrations along the Front Range

In response to the highest ozone concentrations in fifteen years along the Front Range, the Colorado Dept. of Public Health and Environment (CDPHE) conducted short-term SNMOC monitoring in August and September. Modeling work as part of the Ozone Early Action Compact indicated oil and gas condensate flash emissions were a previously unidentified source of VOC's contributing to ozone formation along the Front Range. Oil and gas exploration is booming along the Front Range, and that trend is forecast to continue.

Three-hour average concentrations of VOCs and carbonyls were collected from 6-9 a.m. and 1-4 p.m. Figure 2 shows the differences between a downtown Denver location and a rural site in Weld County. Of note, Benzene, Toluene, Ethylbenzene, Xylene (BTEX) concentrations are the same or higher from 6-9am at the rural site. This was a surprising result, even taking into account meteorological differences. Differences between ethane, propane, and n-butane were even greater (not shown due to large scale differences; example: 6-9 a.m. ethane in Platteville = 654 ppbC vs 26 in Denver). Afternoon concentrations for BTEX were usually higher in Denver, but the light alkanes were approximately three times higher in Platteville.

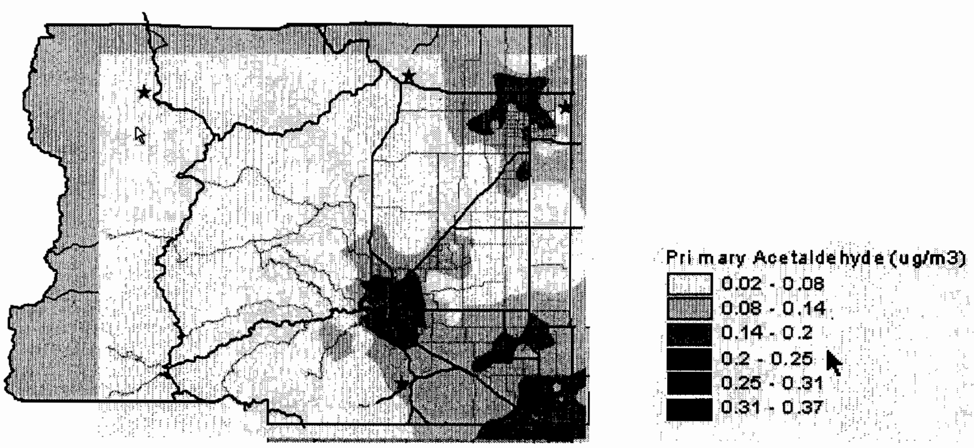
**Figure 2. 6-9 a.m. average VOC concentrations for an urban and rural site.**




## D. Denver Department of Environmental Health

The City and County of Denver Department of Environmental Health (DDEH) has conducted community-scale air toxics modeling throughout Denver and the surrounding Front Range counties, including neighboring Boulder County. The cumulative modeling assessment builds on the NATA using detailed local data and finer geographic resolution. In 2004, DDEH received an EPA Air Toxics grant to conduct air toxics monitoring to evaluate the model and assess the spatial and temporal distribution of specific air toxics (including VOCs and carbonyls, such as acetaldehyde and formaldehyde). When using a multiplier of 6.7 (a ratio of 87% primary to 13% secondary) and EPA's standard multiplier of 9, the model is under predicting by a factor of 2-3 for formaldehyde and much lower for acetaldehyde in Boulder. Figure 3 below show the modeling runs for Boulder County using the DDEH model. The stars indicate where additional monitoring would be conducted as proposed.

**Figures 3. DDEH Model Depicting Primary Acetaldehyde Concentrations in Boulder County and the Location of Proposed Added Monitoring**



## *III. Project Summary*

### A. Air Monitoring Plan Overview

Forty air toxics will be monitored over a one-year period at five locations in Boulder County (shown as red stars in Figure 3). The western half of the county is mountainous and sparsely populated. Depending on the meteorology, the mountains are either upwind (more typical) or downwind of the Front Range urban corridor. The proposed locations include:

1) *Niwot Ridge*. A remote mountain location to assess both the upwind air and the potential back flush of the urban corridor. (Northwest on map)
2) *City of Boulder*. A location in close proximity to the sites previously used in the Anderson study mentioned above, and near two of the busiest traffic intersections in the state. This site may be moved farther east during the second half of the sampling year to better assess industrial impacts. (Southeast of center on map)
3) *City of Longmont*. An agricultural area and adjacent to oil and gas exploration to the north to assess the agricultural burning and oil and gas. (Northeast on map)
4) *City of Lyons*. A small rural location in the mountain foothills to validate a recent health consultation and assess oil and gas activities to the north.
5) *South Boulder Creek State Ozone Monitor*. A rural location along the South Boulder Creek and collocated with a state ozone monitoring station to capture air flows occurring along water drainages and provide insights into transport.

Three complimentary analytical methods, described below, will be applied at each site. Analysis protocols will follow EPA approved procedures. Sample collection will be performed over 24 hours every 6$^{th}$ day following the EPA sampling calendar. Additionally, at each site we will conduct one day of high-resolution (3 hr) VOC and carbonyl measurements per month. Ozone will be monitored at all stations continuously, with 1-hour time resolution. Carbonyl and VOC samples will be analyzed in the University of Colorado Atmospheric Research Laboratory (ARL).

The EPA's technical monitoring coordinator will perform initial site visits at all sites, within 30 days after the start of monitoring. A Technical Systems Audit will be performed by the EPA technical monitoring coordinator during the course of the project. At least once during the project, a Proficiency Test (PT) performance evaluation shall be conducted for the VOC's and aldehydes. The PT samples (spiked samples) will be prepared by an EPA approved contractor at our expense.

### B. VOC Air Toxics

VOC collection and analysis will follow EPA Compendium Method 15. Air samples will be collected over 24 hours (under flow-controlled conditions) in Summa canisters with metal bellows air compressors. A sampling inlet will be located a minimum of 2 m above the surface and air will be delivered through a heated and continuously purged sampling line towards the canister filling station. At least ¼ of all samples will be collected in pairs for quality assurance. From each Summa canister, at least two aliquot samples will be analyzed by gas-chromatography (GC, Hewlett Packard 5890) with a custom-made inlet system for sample drying, pre-concentration and GC injection. GC detection will be accomplished by column flow splitting and with both a mass spectrometry detector (Hewlett Packard 5970) for unequivocal compound identification and with a flame ionization detector for quantification. ARL is currently conducting two VOC monitoring programs, one on the global distribution on NMHC in the NOAA-CMDL glass flask sampling network and one with continuous NMHC measurements at a free-tropospheric station in the Azores, Portugal. Established calibration procedures with several gravimetrically prepared hydrocarbon reference standards and dynamic dilution techniques that are available in ARL will be similarly applied in this project.

### C. Carbonyls

Carbonyl sampling and analysis will follow EPA Compendium Method 11A. Samples will be collected from the same sampling line that will be used for the VOC sample collection. Air will be pulled (mass-flow controlled) through commercial (Supelco, Bellefonte, PA) DNPH derivatization cartridges with an automated sampler at each station. Analysis will be performed by solvent desorption of derivatized carbonyls with subsequent HPLC-UV detection analysis. Permeation sources will be used for generation of standard atmospheres that will be administered to the entire sampling procedure. At least ¼ of all samples will be collected in pairs for quality assurance and for determination of analytical precision under field conditions.

### D. Ozone

Ozone will be monitored with UV absorption monitors (Thermo-Environmental, Dasibi). These monitors will be calibrated every three months against the National Institute of Standards and Technology (Boulder, CO) reference monitor. Data will be recorded every minute and averaged to 1-hour data records. Ozone monitoring will be conducted according to EPA regulatory requirements and guidelines. This requires use of either ozone transfer or local primary standards with calibrations performed onsite traceability shall be to a Standard Reference Photometer. Verification to the SRP shall be conducted prior to start of monitoring. We understand EPA Region 8 will provide these services. Performance audits using separate audit standards shall be conducted on each ozone analyzer. At least one audit will be conducted on each ozone monitor during the course of the project.

## *IV. Data Analysis Plan*

As discussed above, previous monitoring studies suggest that carbonyl air toxic concentrations in Boulder County are significantly higher than those in Denver. At the same time, dispersion modeling of primary formaldehyde and acetaldehyde concentrations predicts concentrations that are much lower than the concentrations measured by Anderson in 1996. Source and sink relationships for formaldehyde and acetaldehyde are complicated, because along with having numerous primary sources, including motor vehicles, wood combustion, and cooking (Kean, A., Grosjean, E., Grosjean, D., Harley, R.A. 2005), they are also produced in significant amounts through atmospheric photochemistry (Harley, R.A., Cass, G., 1994). In some settings and seasons, secondary production is expected to be the dominant source. Furthermore, formaldehyde is lost through direct photolysis, and both formaldehyde and acetaldehyde react quickly in the atmosphere with the hydroxyl radical (Seinfeld, J.H., Pandis, S.N., 1998). To better understand the sources and sinks for carbonyls and other air toxics in Boulder County, the data collected in this study will be analyzed as discussed below. As a critical preliminary step, all data generated in this study will be archived at BCPH and on the county's website. These data will be valuable to researchers engaged in ongoing studies of ozone and secondary air pollution along the Colorado Front Range.

## A. Analysis of Spatial and Seasonal Variability and Correlation with Tracers of Primary and Secondary Pollution

All data collected in this study will be mapped for identification of spatial patterns and plotted as time series for inspection of temporal trends. Correlation coefficients will be computed across monitoring locations for each measured species. Our monitoring plan includes measurements of ozone, a purely secondary pollutant, and numerous VOCs that are strictly primary in origin, along with carbonyl compounds that have both primary and secondary sources. Pairwise correlation coefficients will be computed and analyzed for all compounds measured in this study. Additionally, a principle components analysis will be conducted to identify the underlying factors that explain the variance in the data and may represent characteristic photochemistry and transport regimes.

## B. Comparison of Measured and Modeled Concentrations

The DDEH air toxics model will be run to estimate primary concentrations of formaldehyde, acetaldehyde and other toxic organic compounds throughout the study area for the duration of the sampling period. Chemical decay rates for formaldehyde and acetaldehyde will be estimated based on the ozone concentrations that are observed during the study. In comparison to observed concentrations of formaldehyde and acetaldehyde, we expect the model to under-predict concentrations because it neglects secondary formation. However, the seasonal and spatial trends of the under-prediction will provide insight into the importance of this process. In addition, the OZIPR photochemical box model will be used to estimate secondary formation of carbonyl species in Boulder County, accounting for primary emissions of anthropogenic and biogenic volatile organic compounds and nitrogen oxides in the Front Range and transport of ozone and precursor species from upwind areas.

## C. Tracer Analysis for Apportionment of Primary Carbonyls

In addition to the modeling described above, a tracer approach can be used to better understand the origin of the air toxics. For example, if guaiacol is only emitted in significant amounts when biomass is burned, and we know the range of guaiacol/acetaldehyde emission ratios for biomass burning, then by measuring the guaiacol in the ambient air and using this known emission ratio, we can estimate the amount of the ambient acetaldehyde that came directly from biomass burning. Obviously, this can be a rough approach, as few compounds are emitted by only one source, emissions ratios for each source cover a range of values, and some of the compounds directly emitted from a source may be more reactive than others, and thus their ratio may change with age. The most effective way to proceed with this approach is to use as many tracer species as possible for each source type. The inclusion of source specific tracers to our measurement scheme is a priority. We have already begun to mine the large body of literature that has been built over the past 15 years that describes the chemical nature of emission source types in hopes of finding more potential tracers.

## V. *Responsibilities, Timeline, Benefits, Tracking and Qualifications*

### A. Responsibilities, Timeline, Outcomes, and Outputs

In summary, 40 air toxics will be monitored over a one-year period at five locations in Boulder County. Three complimentary analytical methods will be applied. Analysis protocols will follow EPA-approved procedures. Sample collection will be performed over 24 hours every $6^{th}$ day. Additionally, at each site we will conduct one high-resolution (every 3 hours) diurnal VOC and carbonyl measurement per month. Ozone will be monitored at all stations continuously, with 1-hour time resolution. Carbonyl and VOC samples will be analyzed in the ARL.

Letters of commitment from the University of Colorado and DDEH are on file with BCPH and are available upon request.

The University of Colorado budget includes travel expenses to participate in EPA's annual Air Toxics Data Analysis Workshop (U.S. location to be determined), where they will present the project results. We understand that a maximum of two project representatives is authorized; the workshop duration will be up to three days, exclusive of travel time.

Project Outcome:

Boulder County Public Health anticipates the outcomes of the project to include characterizing air toxic concentrations in Boulder County Colorado, aiding in air toxic model evaluation, and air toxic source apportionment. Data will be used to support previous health assessments, support partnerships with adjoining areas and universities, and guide air quality management in Boulder County.

Monitoring Outputs

1. Supply an EPA approved Quality Assurance Project Plan (QAPP) with data quality objectives before monitoring begins. The QAPP will be periodically reviewed and updated as necessary.
2. Monitor according to EPA established uniform schedules, frequencies and procedures. For example, sampling will be conducted once every six days according to the National Monitoring Schedule using approved EPA methods such as TO-15.
3. All data collected should meet at least 85% data completeness.
4. All data should be supplied to the National Air Quality System within 120 days after the end of the monitored quarter.
5. An EPA Technical System Audit should be performed at least once during project.
6. Analytical laboratories must participate in the Proficiency Test program, if available.

| Major Activities | Responsible Party | Estimated Time Line (Months from Award Date) |
|---|---|---|
| 1. Equipment development | CU Boulder | 6 months |
| 2. Equipment deployment | BCPH, CU Boulder | 7 months |
| 3. Sample collection | BCPH, CU Boulder | 8 – 20 months |
| 4. Equipment maintenance | CU Boulder | 8 – 20 months |
| 5. Sample analysis | CU Boulder | 8 – 23 months |
| 6. Data management and analysis | BCPH, CU Boulder, DDEH | 11 – 23 months |
| 7. Quarterly and EO Project Reporting and Evaluation | BCPH, CU Boulder | Every 4 and 24 months |
| 8. Air Toxics Website Creation | BCPH | 8 – 24 months |
| 9. Report presentation | BCPH, CU Boulder | 25 – 28 months |

## B. Associated Work Products to be Developed

BCPH and the University of Colorado propose to develop a written report summarizing the data collection methodology and analyzing the results. This information will be disseminated to colleagues and used by BCPH to develop air toxics management strategies. In addition, BCPH proposes to create an air toxics website to make this information available to the public in a user-friendly and easy to access format. The air toxics pages will be hosted on www.BoulderCountyAir.org. Due to recent marketing efforts surrounding our summer ozone reduction contest, this website has been the second most active site at BCPH.

## C. Project Benefits to the Public

The proposed study will benefit the public in several ways including:

1. Availability of a model allowing the public and public health officials to continue efforts to better understand and assess local air toxics at the urban/mountain interface.
2. Timely data to address community concerns and to evaluate two health consultations.
3. Creation of a monitoring and modeling capability, in partnership with the University of Colorado and the City and County of Denver, which can be built upon in subsequent years.
4. Improved ability of local officials to develop and implement air quality management strategies in Boulder County and elsewhere along the Front Range.

## D. Transferability/Applicability of Project Outcomes

The information generated by this study will be applicable to all Front Range mountain communities in understanding the distinctive spatial and temporal distribution of air toxics at the urban/mountain interface. The data will also be directly transferable to DDEH to improve the capability of an established community scale air model.

## E. Progress Tracking

BCPH and CU Boulder investigators will meet monthly to review the sampling protocol and data collection and analysis efforts to ensure the project is on track and to address any problems that may arise during the project.

## F. Project Evaluation

The project will be evaluated in monthly meetings to ensure that the project objectives are being accomplished. Quarterly reports will document how each project objective is being met. The final products will include an air quality measurement database and a set of measurement data analysis tools, which will include the DDEH model as applied specifically to Boulder County. A quantitative evaluation of a database containing all measurements will include a description of the size and completeness of the measurement matrix in addition to the performance of duplicate measurements. A quantitative evaluation of the data analysis tools will be done in the final report and will be an assessment of our ability to understand the origins of the Boulder County air toxic concentrations.

## G. Partner Qualifications

### PAMELA HERMAN MILMOE

#### Professional Experience

***Air/Waste Program Coordinator, Boulder County Public Health 2002 – present***

Oversees and coordinates air pollution, pollution prevention, indoor air quality, and solid and hazardous waste programs. Accomplishments include:

- Collaboration on two health consultations using air dispersion modeling to assess potential health impacts from increased air toxics emissions resulting from the use of tires as a supplemental fuel in a local cement kiln.
- Oversight of the state air quality monitoring program in Boulder County, including the operation and maintenance of three gaseous and three particle monitors.
- Leadership role in a local government coalition testifying before two state legislative committees and the state Air Quality Control Commission on proposed changes to Clean Air Act's New Source Review Program.
- Representation of the county in state Air Toxics Stakeholder meetings and in Regional Haze rulemaking proceedings.

***Senior Manager, ESOURCE Research and Consulting, Boulder, CO 2000 – 2002***

Responsibilities included:

- Oversight and direction of syndicated research on energy efficiency in industrial operations for large industrial and commercial businesses and utility companies.
- Management of a U.S. Environmental Protection Agency contract to develop and implement the agency's *Climate Leaders Program.*

***Climate Wise Team Leader, U.S. Environmental Protection Agency 1993 – 2000***

Designed and implemented the agency's *Climate Wise Program,* one of the agency's premiere pollution prevention efforts. Accomplishments included:

- Worked with more than 600 industrial companies to reduce greenhouse gas emissions through energy efficiency and process change.

- Collaborated on the creation of greenhouse gas emissions tracking software for the cement industry and the industrial sector.

### *Other Appointments, U.S. Environmental Protection Agency* *2000 – 1993*

- Served as a special assistant to EPA Administrator William K. Reilly and Deputy Administrator F. Henry Habicht, III.
- Served as assistant to two former Assistant Administrators for Policy
- Worked in the Denver Regional 8 office with six states on ground-water protection programs.

### Selected Publications

Winkelman, Steven; Seifert, Eric; Haydel, Juanita; Herman Milmoe, Pamela, *"Wise Rules for Industrial Energy Effiency,"* ACEEE Summer Study, 1997

Asrael, Joel, Herman Milmoe, Pam; Juanita Haydel, *"Use of Combined Heat and Power (CHP) to Reduce Greenhouse Gas Emissions,"* ACEEE, WASHINGTON, DC, (USA), 1999, Proc ACEEE Summer Study Energy Effic Ind, pp. 741-751, 1999

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## MICHAEL P. HANNIGAN

### Professional Preparation

| | | |
|---|---|---|
| Southern Methodist University | Civil Engineering | B.S., 1990 |
| California Institute of Technology | Environmental Engineering Science | M.S., 1991 |
| California Institute of Technology | Environmental Engineering Science | Ph.D., 1997 |
| Massachusetts Institute of Technology | Environmental Health Sciences | 1997 |
| Colorado State University | Atmospheric Science | 1998-1999 |

### Appointments

Research Professor, Department of Mechanical Engineering, University of Colorado, 2005 – current.
Research Associate, Department of Mechanical Engineering, University of Colorado, 2001 – 2005.
Assistant Research Professor, Department of Chemistry, University of Denver, 1999 – 2001.

### Selected Publications

Hannigan, M.; Busby Jr., W.; and Cass, G. Source contributions to the mutagenicity of urban particulate air pollution. *Journal of the Air and Waste Management Association*, **4**: 399-410, 2005.

Moore, K.; Sherman, D., Reilly; J., Lee, T.; Hannigan, M., Collett Jr. J. Drop size-dependent chemical composition of clouds and fogs: II. Relevance to interpreting the aerosol/trace gas/fog system, *Atmospheric Environment*, **38**: 1403-1415, 2004.

Brown, S.; Herkes, P.; Ashbaugh, L.; Hannigan M.; Kreidenweis, S.; and Collett Jr., J. Characterization of organic aerosol in Big Bend National Park, Texas, *Atmospheric Environment*, **36**: 5807-5818, 2002.

Herkes, P.; Hannigan M.P.; Trenary, L.; Lee, T.; and Collett Jr., J.L. The organic composition of radiation fogs in Davis (California), *Atmospheric Research*, **64**: 99-108, 2002.

Dutton, S.; Hannigan, M; and Miller, S. Indoor pollutant levels from the use of unvented natural gas fireplaces in Boulder, Colorado, *Journal of the Air and Waste Management Association*, **51**: 174-185, 2001.

## DETLEV HELMIG

### Professional Preparation

| | | |
|---|---|---|
| University of Bochum/Germany | Analytical Chemistry | M.S. 1986 |
| University of Duisburg/Germany | Environmental Chemistry | Ph.D. 1989 |
| University of California | Statewide Air Pollution Res. Center | 1989-1992 |
| National Center for Atmos. Research | Atmospheric Chemistry Division | 1992-1996 |
| University of Colorado | Coop. Inst. Res. Environ. Science | 1996–2000 |
| University of Colorado | Institute Alpine & Arctic Research | 2001–present |
| University of Colorado | Program Atmos. & Oceanic Science | 2002-present |

### Appointments

Associate Research Professor, Institute of Alpine and Arctic Research (INSTAAR) and Program in Atmospheric and Oceanic Sciences (PAOS), University of Colorado, 2003

Research Scientist III and fellow with the Institute of Alpine and Arctic Research, University of Colorado Boulder, 2001

Research Scientist, Chemistry Department and CIRES, University of Colorado Boulder, 1995 - 2001

Visiting Scientist, NCAR, in Boulder, Colorado, 1992-1996

Postdoctoral Fellow, Statewide Air Pollution Research Ctr, University of California Riverside, 1989-1992

### Special Honors and Awards

US EPA Young Investigator Award, 1996-2001

**Selected Publications** (For Full list see http://instaar.colorado.edu/arl/Dh_pblst.htm):

Helmig, D.; Revermann T.; and Hall B. (2004) Characterization of a Pressurized C5-C16 Hydrocarbon Gas Calibration Standard for Air Analysis. Anal. Chem. 76, 6528-6534.

Helmig, D.; Bocquet, F.; Pollmann, J.; and Revermann, T. (2004) Analytical techniques for sesquiterpene emission rate studies in vegetation enclosure experiments. Atmos. Environ. 38, 557-572.

Helmig, D.; Revermann, T.; Pollmann, J.; Kaltschmidt, O.; Jiménez, Hernández A.; Bocquet, F.; and David, D. (2003) Calibration system and analytical considerations for quantitative sesquiterpene measurements in air. J. Chrom. 1002, 193-211.

## JANA MILFORD

Associate Professor, Department of Mechanical Engineering, University of Colorado at Boulder

### Education

B.S., Engineering Science, Iowa State University, May 1983
M.S., Civil Engineering, Carnegie Mellon University, May 1985
Ph.D., Engineering and Public Policy, Carnegie Mellon University, May 1988
J.D., University of Colorado School of Law, May 2004

### Professional History

Associate Professor, Dept. of Mechanical Engineering, University of Colorado at Boulder, 8/97 - present (Part-time since 8/03).
Senior Scientist and Staff Attorney (part-time), Environmental Defense, 5/04 – present.
Director, Environmental Engineering Program, University of Colorado, 6/98 – 7/01.
Assistant Professor, Dept. of Mechanical Engineering, University of Colorado, 1/94 – 7/97.
Assistant Professor, Department of Civil Engineering and Environmental Research Institute, University of Connecticut, 9/89 – 12/93.
Congressional Fellow and Analyst, Office of Technology Assessment, U.S. Congress, 9/87 – 7/89.

### Publications

More than 80 total publications on photochemical air quality modeling, environmental modeling and policy. For a list of recent publications, see http://me-www.colorado.edu/.

## IV. Detailed Itemized Budget

| | | | |
|---|---|---|---|
| Institution: Boulder County Public Health | | Title: | Clearing the Air: Understanding Air Toxics and Carbonyl Pollutant Sources at the Urban/Mountain Interface |
| Principal Investigators: Pamela Milmoe | | Duration: | 01/01/06 - 12/31/07 |

| | Year 1 | Year 2 |
|---|---|---|
| **A. Salaries and Wages** | | |
| Principle Investigator: Pam Milmoe | | |
| .8 FTE in 12 months | 5,261 | 5,524 |
| Intern BCPH | | |
| .3 FTE in 12 months | 10,200 | 10,506 |
| *Total Salaries and Wages* | 15,461 | 16,030 |
| **B. Fringe Benefits** | | |
| Principal Investigator: 28.6% | 1,505 | 1,580 |
| Intern: 20% | 2,040 | 2,101 |
| *Total Fringe Benefits* | 3,545 | 3,681 |
| **C. Supplies** | | |
| 1) Chemical supplies (storage, standards) | 3,500 | 1,500 |
| 2) Cannisters (15 x $600) | 9,000 | 0 |
| 3) Carbonyl sorbent cartridges ($7 x 5 x 60 x 2 + 10%) | 4,620 | 0 |
| *Total Supplies* | 17,120 | 1,500 |
| **D. Equipment** | | |
| 1) Cannister sampler (5 x $3k) | 15,000 | 0 |
| 2) Carbonyl samplers (4 x $14k) | 56,000 | 0 |
| 3) Ozone monitors (2 x $1.5k) | 3,000 | |
| 4) Data analysis computer | 1,500 | 0 |
| *Total Equipment* | 75,500 | 0 |
| **E. Travel** | | |
| 1) 1 trip/wk to each sampling site (75 mi/trip x 32 trip/yr x $0.405/mi) | 972 | 972 |
| *Total Travel* | 972 | 972 |
| **F. Other Direct Costs** | | |
| 1) Subcontract to CU (See Proposed CU Budget Details) | 208,242 | 130,902 |
| 2) Telephone, printing | 250 | 250 |
| *Total Other Direct Costs* | 208,492 | 131,152 |
| **G. Total Direct Costs** | **321,090** | **153,335** |
| **H. Indirect Costs** | | |
| Boulder County, indirect rate, 18.3% | 10,403 | 4,105 |
| State of Colorado Approved Indirect Rate | | |
| **I. Total Costs** | $331,493 | $157,440 |
| **Total for Project** | | **$488,933** |

# Detailed Itemized Budget for Subcontract to CU

CU Proposal No. 0805.12.1252B

Institution: The Regents of the University of Colorado
Boulder, CO 80309-0572

Principal Investigator: Michael Hannigan
Co-Principal Investigators: Jana Milford and Detlev Helmig

| | Year 1 | Year 2 |
|---|---|---|
| **A. Salaries and Wages** | | |
| Principal Investigator: Michael Hannigan | | |
| 100% time, 1 month | 5,896 | 6,121 |
| Co-Principal Invesigator: Jana Milford | | |
| 50% time, 1 mo. Summer in Y2 | 0 | 5,368 |
| Co-Principal Invesigator: Detlev Helmig | | |
| 100% time, 2 mo. Y1, 1 mo. in Y2 | 15,808 | 8,207 |
| Professional Research Assistant: David Tanner | | |
| 100 / 50% time, Years 1 / 2 | 42,000 | 21,804 |
| Graduate Research Assistant: (ME) To Be Named | | |
| 50% time, 12 months | 20,754 | 21,549 |
| System Administrator: Chad Stoffel | | |
| 2.1% time, 12 months | 895 | 929 |
| Project Accounting Assistant: Mary Fentress | | |
| 4.8% time, 12 months | 1,860 | 1,930 |
| *Total Salaries and Wages* | 87,213 | 65,908 |
| **B. Fringe Benefits** | | |
| Principal Investigator: 21.6% | 1,273 | 1,322 |
| Co-Principal Investigator Milford: 23.6% | 0 | 1,267 |
| Co-Principal Investigator Helmig: 21.6% | 3,415 | 1,773 |
| Graduate Research Assistant: 6.3% | 1,308 | 1,358 |
| Professional Research Assistant: 21.6% | 9,072 | 4,710 |
| System Administrator: 21.6% | 193 | 201 |
| Project Accounting Assistant: 19.8% | 368 | 382 |
| *Total Fringe Benefits* | 15,629 | 11,013 |
| **C. Supplies** | | |
| 1) Chemical supplies (solvent) | 1,000 | 500 |
| 2) GC columns | 1,200 | 0 |
| *Total Permanent Equipment* | 2,200 | 500 |
| **D. Equipment** | | |
| 1) HPLC (used, refurbished) | 15,000 | 0 |
| 2) GC Inlet (for existing GC/FID/MS) | 20,000 | 0 |
| *Total Permanent Equipment* | 35,000 | 0 |
| **E. Travel** | | |
| 1) Project personnel to scientific conference to present results | 0 | 1,550 |
| 2) Mileage to sampling sites: 75 mi./trip, 65 trips/yr | 1,365 | 1,365 |
| *Total Travel* | 1,365 | 2,915 |

**(Subcontract budget continued)**

| | | Year 1 | Year 2 |
|---|---|---|---|
| **F** | **Other Direct Costs** | | |
| | 1) Communication Costs | 625 | 625 |
| | 2) Supplies: HPLC and GC analysis supplies | 4,000 | 1,000 |
| | 3) Tuition Remission: Resident | 7,803 | 8,778 |
| | *Total Other Direct Costs* | 12,428 | 10,403 |
| **G.** | **Total Direct Costs** | 153,835 | 90,739 |
| **H.** | **Indirect Costs** | | |
| | On Campus: 48% of MTDC, predetermined for the period 7/1/02-6/30/04; 48.5% of MTDC, predetermined for the period 7/1/04-6/30/05; 49% of MTDC predetermined for the period 7/1/05-6/30/06. Per HHS agreement dated 4/21/05. | 54,406 | 40,162 |
| **I.** | **Total Costs** | $208,241 | $130,901 |
| | **Total for subcontract to CU:** | | **$339,143** |

## In-Kind Contributions

A number of equipment items that will be required for the monitoring portion will be provided by ARL at no cost to this project for the one-year monitoring period. These include the GC-MS/FID instrument (valued at ~ $60K), quantitative NMHC standards for VOC calibration (~ $6K), gas dilution system for generating dynamic dilution calibration series (~ $3K), gas permeation calibration system (~ $20K) and two UV ozone monitors (~ $14K).

## VII. Quality Assurance Narrative

If successful in securing funding, we will develop a Quality System and that System will be described in detail in the Quality Management Plan and the Quality Assurance Project Plan. These Plans will be developed as a team and all investigators will contribute. The goal of the System will be to give us the ability to determine the uncertainty of the data.

Some aspects of this System were described briefly above, for example, ¼ of all samples will be collected in duplicate, and duplicates will go parallel analysis. Blank samples will be collected at each site at least once every month by applying zero air (hydrocarbon and carbonyl free air) to the sampling stack inlet and by collecting this sample in the same way as actual air samples. For the carbonyl sampling, 1/10 of all cartridges will be collected with backup tubes to test and validate the quantitative sampling of carbonyls on the primarily cartridge. Calibrations will follow previously developed procedures in our laboratory and which are in compliance with EPA TO compendium methods. In addition, we will document our air flow calibrations, chemical analysis calibrations, collection of blank samples, sample storage and handling.

We understand acceptable Quality Assurance documentation must be submitted to EPA Project Officer within 90 days of this agreement. No work involving direct measures or data generation, environmental modeling, compilation of data from literature or electronic media, and data supporting the design, construction and operation of environmental technology shall be initiated under this project until the EPA Project Officer, in concert with the EPA Quality Assurenace Manager, has approved the Qualuty Assurance ocumentation. (See 40 CFR 30.54 or 31.45, as appropriate). Additional information on these requirements can be found at the EPA Office of Grants and Debarment Web site: http/www.epa.gov/ogd/qa.htm

The QAPP shall include associated Standard Operating Procedures (SOP's) for all steps of the monitoring. The QAPP/SOP's shall include all monitoring and analytical laboratory procedures, QA/R-5 and QA G-6 will be used as a framework for developing the QAPP and SOP's. We understand that EPA Region 8 will respond in writing within 60 days of receipt of QAPP and SOP submittal.