TEXAS ENVIRONMENTAL RESEARCH CONSORTIUM

environmental improvement through research and science

Strategic Research Plan

Texas Environmental Research Consortium

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NOTE
This document will be revised from time to time to reflect research findings, stakeholder input, and on-going plan evaluation. For updated information see http://www.harc.edu/air

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Overview

Over nine million Texans live in the Houston-Galveston-Brazoria and Dallas-Ft. Worth metropolitan areas. These regions account for more than half of the State's economy and employment levels. Reducing air pollution, to comply with Federal air quality mandates, is one of the most pressing public policy challenges facing these regions today. Economic analyses[1] suggest that failure to meet federal mandates will result in hundreds of billions of dollars in lost economic development for the State. In response to this air quality challenge, government, business and community leaders in the Houston-Galveston-Brazoria and Dallas-Ft. Worth regions established a non-profit organization, the Texas Environmental Research Consortium, to improve the scientific basis for air quality decision-making.

The initial focus of TERC was on ozone formation in the East Texas Gulf Coast region, specifically, the Houston-Galveston area. This initial focus was consistent with regulatory timelines and the primary source of initial funding for the Consortium, which was dedicated to coastal environmental improvements. As the Consortium has evolved, it has broadened its activities beyond the coastal region, to include all of the urban areas in eastern Texas that are in non-attainment of the federal clean air standard for ozone, particularly the Dallas-Fort Worth non-attainment area. This expanded geographical scope of activities facilitates the transfer of improvements in air quality modeling and scientific understanding of ozone formation among regions. In addition, the Consortium has expanded its efforts to a broader range of air pollutants than just ozone. Specifically, the Consortium has expanded its charge to include fine particulate matter and hazardous air pollutants. This expansion in charge is necessary to ensure that air quality strategies for multiple pollutants are consistent and complementary.

The Charter of the Consortium[2] calls for the development of a Strategic Research Plan that guides decisions on research to be supported by TERC. The Plan is to be prepared and updated in consultation with the TERC Science Advisory Committee, the Texas Commission on Environmental Quality, and the U.S. Environmental Protection Agency. In addition, other stakeholders are afforded the opportunity to review and offer comments on the plan. The first version of the Strategic Plan was issued in August 2002, and the Plan has been updated, with the same opportunities for broad involvement, as understanding of air pollutant formation and air quality modeling in eastern Texas has evolved. The Strategic Research Plan set forth in this document identifies key issues, examines the related activities of other organizations, and recommends areas of focus and action for the Consortium.

[1] Perryman Group, Report to Texas Conference of Urban Counties, "The importance of maintaining a proper state implementation plan (SIP) to address air quality issues in Texas: An economic and fiscal impact assessment", November, 2002, available at:
[2] http://www.harc.edu/harc/Projects/AirQuality/Projects/Status/H14.aspx

Key Issues

The goals of the consortium are to improve the scientific understanding of air pollutant formation and to facilitate the development of sound air quality policies. Implicit in the scientific and policy goals of the Consortium are the need to continually assess progress and the need to effectively disseminate information. Therefore, the presentation of key issues and needs will address the following areas:

- Scientific issues
- Policy issues
- Health issues
- Methods for assessing progress and
- Information dissemination.

Key issues related to the scientific understanding of ozone and fine particulate matter formation are summarized in Table 1. The information in Table 1 is condensed from reports on the state of the science of ozone and fine particulate matter formation in Texas, prepared by the Consortium[3], TCEQ and the University of Texas. For each of the issues, critical needs are described, methods for evaluating the performance of current assessment tools are presented, and suggested project areas are identified.

Key issues related to the scientific understanding of hazardous air pollutants will emerge as the result of projects that are currently underway. Specifically, the U.S. Environmental Protection Agency is undertaking an evaluation of the costs and benefits of hazardous air pollutant regulations, using benzene in the Houston-Galveston area as a case study. This evaluation will reveal critical areas in which more information about hazardous air pollutants is needed.

[3] David Allen, Report to the Texas Environmental Research Consortium, "Particulate matter concentrations, compositions and sources in southeast Texas: State of the science and critical research needs" May, 2003, available at: http://www.harc.edu/harc/Projects/AirQuality/Projects/Status/H4.aspx

Table 1. Critical scientific issues for improved scientific understanding of ozone and fine particulate matter formation

Issue	Critical needs related to ozone formation	Critical needs related to fine particulate matter	Suggested performance evaluations	Possible project areas
Emission inventories	Industrial hydrocarbon emissions are significantly underestimated; improve point source inventories, accounting for the magnitude of and the variability in emissions; assess and improve the accuracy of other significant source categories, such as on-road and non-road emissions.	Data on rates, compositions and size distributions of particulate matter emissions from point sources, mobile sources and cooking should be improved; develop emission inventories for ammonia and reactive high molecular weight organics; these emissions lead to fine particulate matter formation in the atmosphere in	Reconcile inventories with observations, using a variety of approaches; use the insights gained from the comparisons to identify inventory categories in greatest need of improvement	Develop improved emission inventories for key source categories; continue the process of comparing predictions to observations
Atmospheric chemistry	Ozone formation is rapid and extensive under conditions of high hydrocarbon concentrations; current chemical mechanisms need to be evaluated at these conditions; improve ability to represent the reactions of specific, highly reactive hydrocarbons.	Evaluate gas to particle chemical pathways and the partitioning of semivolatile species between gas and particle phases; evaluate the implications of reactions that may occur on particle surfaces	Evaluate the ability of current chemical mechanisms to predict particulate matter formation and rapid ozone formation; compare performance of multiple mechanisms and gas-particle partitioning models; collect laboratory chamber data to evaluate mechanisms and models	Develop chemical mechanisms and gas-particle partitioning models evaluated for conditions found in Texas
Meteorology	Mixing and transport of ozone precursors play critical roles in ozone formation; current models may inadequately describe these phenomena; evaluate current models and improve the ability of models to operate with fine scale spatial resolution; assess the ability of the models to characterize regional scale transport of air pollutants		Compare performance of current meteorological models; evaluate the parameterizations of physical processes in the models using process analysis	Continue to improve the parameterizations of the region used in the models that describe mixing, transport of ozone precursors, cloud cover, soil moisture and radiative transfer; develop models capable of using fine grids; continue the process of comparing model predictions to observations.
Gridded Photochemical Models	EPA requires the use of gridded photochemical models; evaluate the performance of current models, focusing on advection, deposition and diffusion processes.	Improve model descriptions of key atmospheric processes, such as the chemistry of particulate matter formation in the atmosphere, and the gas-particle partitioning of semi-volatile species.	Use the data from the Texas Air Quality Study to evaluate the ability of current models to replicate ozone and particulate matter formation; identify key processes that determine ozone and particulate matter formation in the models	Continue process analysis evaluations and improve model descriptions of key atmospheric processes.

The key scientific issues, performance evaluations and projects listed in Table 1 provide the foundation on which an evaluation of ozone and fine particulate matter formation can be built. However, improving understanding in each of the key areas, then synthesizing that information and evaluating air quality improvement strategies, is a time consuming process. While it is essential that this process proceed, there is also a compelling need to immediately address a number of questions related to policy decisions. These questions are:

- What emission reductions lead to the greatest reductions in ozone concentrations?
- Will emission reductions selected to achieve the current air quality standard for ozone (based on one-hour averaged concentrations) also reduce concentrations of particulate matter and lead to attainmentof the new ozone standard (based on 8-hour averaged concentrations)?
- How important are regional contributions to air pollutant concentrations and will emission reductions designed to achieve the current air quality standards, in Texas and elsewhere, also reduce long range transport of air pollutants?
- What new emission reduction technologies can be effectively applied in Texas?

It will eventually be possible to address these questions using comprehensive air quality models, built using better scientific understanding resulting from the types of projects listed in Table 1. However, regulatory timetables may require that some decisions be made before models are fully capable of addressing these questions. Therefore, it is desirable to use analysis tools that are currently available to provide directional guidance for policy decisions. The types of analysis tools needed are summarized in Table 2. The summary in Table 2 is based on discussions of the staff of the Texas Environmental Research Consortium with the Consortium's Science Advisory Committee and input from the Board of Directors of the Consortium.

Table 2. Key policy issues

Issue or Analyses needed	Actions needed
What emission reductions lead to the greatest reductions in ozone concentrations (1-hour averaged)?	Assess the trade-offs between controlling emissions of reactive hydrocarbons and nitrogen oxides using gridded photochemical models, lagrangian (plume) models, and other tools.
What emission reductions lead to the greatest reductions in ozone concentrations (8-hour averaged)?	Assess the trade-offs between controlling emissions of reactive hydrocarbons and nitrogen oxides using gridded photochemical models, lagrangian (plume) models, and other tools; assess whether strategies used to attain the current ozone standard will be directionally consistent with achieving the new ozone standard
How significant is regional transport of air pollutants?	Assess the trade-offs between local and regional emission control strategies using gridded photochemical models; assess the relative importance of regional transport of air pollutants in meeting current and future air quality standards
Will fine particulate matter concentrations and regional haze be reduced as a result of actions taken to reduce ozone concentrations?	Assess the trade-offs between controlling emissions of reactive hydrocarbons and nitrogen oxides using gridded photochemical models, lagrangian (plume) models, and other tools; Assess whether strategies used to attain the current ozone standard will be directionally consistent with achieving the fine particulate matter and regional haze standards

These policy assessments should be complemented with a carefully chosen group of technology demonstrations. The Texas Council on Environmental Technology (TCET) is currently preparing a strategic plan for technology demonstration and the Consortium could use that plan to select critical demonstrations to be funded.

All of the work done on characterizing the science of air pollution and identifying policies for improving air quality

should be done recognizing that the primary goal of air pollution regulations is to protect public health. Policies should be characterized by both their contribution to improving health and their contribution to meeting air quality standards. Ideally, these two goals would be identical, but at times they are not. For example, the health impacts of air pollutants emitted in regions with high densities of sensitive populations, such as children and the elderly, may be greater than identical emissions released in other locations.

Characterizing the health impacts of air pollutants requires estimates of exposures to air pollutants and the health impacts associated with exposures. In addition, individuals are rarely exposed to just a single air pollutant, so potential synergistic effects of multiple exposures must be considered, and considerable effort must be expended to identify the causal agents of health effects from the diverse array of air pollutants individuals are exposed to.

Much effort has been expended at the national level to characterize the health effects of air pollutants, so given its mission of developing sound air quality policies in Texas, the Consortium will focus on improving scientific understanding of exposure patterns and the health impacts of the specific mixtures of air pollutants found in Texas. Exposures to air pollutants in eastern Texas may be different than in other regions of the United States because of the prevalence of air conditioning, which can reduce indoor concentrations of pollutants, and because of the prevalence of mixed industrial-residential areas. The mixtures of air pollutants found in the State will also be different than in other regions because of the distinctive mix of air pollutant sources found in Texas.
Table 3 summarizes the key issues associated with characterizing the health effects of air pollution in Texas

Table 3. Key issues in the Health Effects of Air Pollution

Issues or Analyses Needed	Actions needed
Are exposures to air pollution different in Texas than in other regions of the U.S.?	Assess exposures to air pollutants using estimates of activity patterns and air pollutant concentrations outdoors, in homes, in office buildings and other workplace settings, and in automobiles; coordinate with organizations in Texas currently active in these types of programs.
What are the health effects of the specific mixtures of air pollutants found in Texas?	Identify frequencies of air pollutant related health impacts through analysis of hospital records (retrospective epidemiological studies); Monitor the health effects of cohorts of sensitive populations (cohort studies); both epidemiological and cohort studies require an extensive air quality monitoring network; coordinate with organizations in Texas currently active in these types of programs.

The epidemiological and cohort studies identified in Table 3 can only be done if air quality monitoring and exposure data are available to characterize the spatial distribution of air pollutants and the exposure of populations. This suggests that the health effects studies should be coordinated with large air quality field programs planned for eastern Texas.

Implicit in the scientific and policy goals of the Consortium are the needs (1) to continually assess progress and (2) to effectively disseminate information. Therefore, in addition to the activities outlined in Tables 1, 2 and 3, there is the need to pursue the assessment and information dissemination activities listed in Table 4.

Table 4. Key assessment and information dissemination activities

Issues or Analyses Needed	Actions needed
How can progress in improving air quality be assessed?	Assess the ability of the current ambient air quality monitoring network to capture high quality data on air pollution events; improve the analysis methods routinely used for interpreting ambient monitoring data; contribute to comprehensive air quality field programs conducted in Texas
Is information about air quality being effectively disseminated?	Facilitate communication between and among scientists and policymakers (for example, by holding workshops and building well documented electronic information exchange mechanisms); synthesize and summarize scientific and policy relevant findings concerning air quality in Texas; make the information broadly available to stakeholders

The issues identified in Tables 1-4 are linked and iterative. Improved scientific understanding will lead to more informed policies, and both the policies and the scientific understanding must be continually compared with observations, and that information must be disseminated. The issues in Tables 1-4 can, however, can be pursued along parallel tracks, with a regular exchange of information between the tracks. Before making recommendations for action in each of these tracks, however, it is useful to identify activities already underway through other organizations that are relevant to achieving the goals of the Consortium.

Air Quality Activities Funded by Other Organizations

The organizations currently funding research and data analysis activities relevant to ozone formation in eastern Texas are:

Texas Commission on Environmental Quality (TCEQ) The technical analysis division of the TCEQ is currently conducting a wide variety of internal and external modeling and data analysis activities. Projects include:

- Developing better estimates of emissions through "bottom-up" inventory improvements.
- "Top-down" inventory evaluations, where emission inventory data from source regions near monitors are compared to observations made at the monitors.
- Aircraft based monitoring
- Evaluations of atmospheric chemical and meteorological models, and
- Modeling analyses done in support of regulatory actions.

Most of the TCEQ's activities are summarized in the State of the Science documents at http://www.utexas.edu/research/ceer/texaqsarchive/accelerated.htm.

Texas Council on Environmental Technology (TCET) The TCET was created by Senate Bill 5 in the 77th Legislature of the State of Texas. The TCET received funding of approximately $3 million during the 2002-2003 biennium, and approximately $30 in funding is anticipated for the 2004-2005 biennium. The TCET is charged with funding the development, demonstration, certification and evaluation of technologies that can improve air quality. The Council is also charged with improving air quality modeling. In its first two years of operation, the Council funded a group of technology demonstration and certification projects, an assessment of critical technology needs for reducing emissions of oxides of nitrogen from diesel engines and the development of a strategic plan for air quality health effects research. In its second biennium of operation, the TCET has been charged to use at least 20% of its funding for air quality research relevant to the Houston-Galveston and Dallas-Fort Worth regions.

Texas Air Research Center (TARC) TARC is a consortium of Lamar University, the University of Texas, Texas A&M University and the University of Houston. Headquartered at Lamar, TARC receives a legislative appropriation, through the Lamar University budget, that has historically been approximately $2 million for the biennium. Most TARC projects address long-term research needs, such as developing better data on fine particulate matter, developing better meteorological models and better descriptions of atmospheric reactions. Some TARC projects, however, will likely have an impact on the mid-course review of the Houston-Galveston air quality plan. For example, TARC and TCEQ funded work on chlorine chemistry has identified sources of ozone precursors that may be more cost effective to control than hydrocarbon or nitrogen oxides emissions.

U.S. Environmental Protection Agency The U.S. Environmental Protection Agency has funded two cooperative agreements with Texas Universities to address air quality research needs in the region.

- In January 2000, the EPA provided $3.65 million in funding to a consortium of 7 universities, led by the University of Texas, to conduct measurements of fine particle matter composition in southeast Texas. The work will be complete in November 2003; additional funding for continuing fine particulate matter measurements, and/or analysis of the data collected is possible but not assured.
- In a project to run from 2002 to 2004, a consortium involving the University of Texas, Texas A&M, and led by the University of Houston will improve air quality models for the region; funding of $3.5 million has been provided by the U.S. EPA. This work has seven major aims:(1) development of a jointly operated air quality modeling facility at the University of Houston, the University of Texas and Texas A&M University, (2) the deployment of two flux measurement stations to characterize micro-turbulence, (3) the improvement of fine particulate matter modeling capabilities, (4) the development of neighborhood scale air quality modeling capabilities, (5) improving metropolitan and regional meteorological models, (6) the improvement of chemical reaction mechanisms important in air quality, and (7) the development of a data archive for air quality field measurements.

Coordinating the activities of all of these organizations is a major challenge, since each operates independently and each is responsible to different sponsors. Nevertheless, there is reason to be optimistic about the ability of these organizations to coordinate studies of air quality in eastern Texas. Led by the TCEQ, a Science Coordinating Committee, comprised of scientific experts in air quality, representatives of organizations funding air quality research, and representatives of organizations funding technology demonstration activities, has been established and has drafted assessments of critical scientific research needs. This has enabled most organizations to identify a common set of initial goals and key scientific and technical issues. Projects have been launched with relatively little duplication of effort and communication among the organizations has been good.

Of particular importance to the TERC Board of Directors is that most research and data analysis funding available through existing organizations is confined to very specific tasks. Therefore, TERC has the unique opportunity to respond to comprehensive data analysis and research needs that emerge from on-going analyses. Further, it is important for TERC to recognize that virtually all activities sponsored by other organizations focus on scientific and technical issues. Policy analyses, evaluation of progress in air quality, and information dissemination are currently conducted almost exclusively within the TCEQ.

Recommendations

The scope of activities outlined in Tables 1-4 is too large for any single research organization to address, therefore, it is important for the Consortium to prioritize its activities. The recommendations outlined below represent the recommendations for prioritization from the Consortium's Scientific Advisory Committee (SAC), and are organized into several broad categories.

The most *significant near term scientific and technical need* is:

- **Recommendation 1:** Improve emission inventories. Improving emission inventories is critical to the understanding both ozone and fine particulate matter formation; both bottom-up and top down emission inventory improvements are needed. The sources of ozone precursors with the greatest degree of uncertainties in current emission estimates are point sources and non-road sources. The categories of fine particulate matter precursors with the greatest uncertainties are ammonia emissions and emissions of precursors of organic fine particles formed in the atmosphere. TERC is coordinating its efforts with TCEQ to implement emissions inventory projects. It is likely that continued improvements in emission inventories will be needed for the next several years.

The most immediate *policy assessment needs* are:

- **Recommendation 2:** Identify emission reductions that lead to the greatest reductions in ozone concentrations. A central issue in the evaluation of the Houston-Galveston area air quality plan is the extent to which emission reductions for nitrogen oxides can be replaced with reductions in the emissions of reactive hydrocarbons. TERC should fund projects that use a variety of observationally based modeling tools to evaluate the trade-offs between controls on reactive hydrocarbons and controls on nitrogen oxides.

- **Recommendation 3:** Evaluate the impacts of ozone driven controls on fine particulate matter concentrations and on the ability of the region to meet the new ozone standard based on concentrations averaged over 8 hours. Many of the emission reduction strategies designed to allow the Houston-Galveston and Dallas-Fort Worth areas to meet the current ozone standard have the potential to either help or hinder the region in meeting future air quality challenges. While many of the analysis tools needed to determine the impact of current strategies on future air quality objectives are not yet available, some analyses can be done. TERC should fund analyses designed to address these issues to the extent possible using currently available tools.

- **Recommendation 4:** Assess the relative importance of regional transport and local emission reductions in meeting current and future air quality standards. Analysis of air quality monitoring data and air quality modeling indicate that fine particulate matter concentrations and 8-hour averaged ozone concentrations in eastern Texas depend, to a significant extent, on regional air quality. TERC should fund ambient data collection and modeling analyses that determine the relative importance of local, in-state regional and out-of-state regional sources of air pollutants.

The most immediate *assessment needs* are:

- **Recommendation 5:** Evaluate and synthesize emerging information. Projects funded by TERC and other organizations are producing a wealth of information. If this flood of information is to inform policy development, the results must be continually evaluated and integrated into concise and clear sets of scientific findings. TERC should be involved in the synthesis of air quality information, involving multiple stakeholders and coordinating with synthesis activities undertaken by other organizations, such as the TCEQ.

- **Recommendation 6:** Participate in future air quality field programs. The Texas Air Quality Study, conducted in the summer of 2000, is having a profound impact on the direction of policies designed to

bring southeast Texas into attainment for the current air quality standard for ozone. The scientific insights provided by the study and the effect of those insights on the direction of policy have made clear the need for sound scientific data in guiding air quality policies. In the next 5 years, Texas will face a new set of air quality challenges, reducing regional ozone concentrations and reducing regional haze and concentrations of fine particulate matter. The policies developed to meet these objectives should be informed by the best available scientific information, so, a broad based effort is underway to plan, implement, and analyze the results from another air quality field program. This program is currently being planned for an 18 month period in 2005-2006 and is referred to as the Second Texas Air Quality Study (STAQS). TERC should be a participant in the STAQS program; its precise role will depend on the roles undertaken by other participants.

The most immediate *health effects assessment needs* are:

- **Recommendation 7:** Initiate health effects research, coordinating with major air quality field studies. Epidemiological and exposure studies should be initiated. The design of these programs should be coordinated with the design of large air quality field programs planned for eastern Texas, such as the field study identified in Recommendation 5. Again, the precise role for TERC will depend on the roles undertaken by other participants.

- **Recommendation 8:** Coordinate health effects research on hazardous air pollutants with on-going analyses of benzene exposures in the Houston-Galveston area. The U.S. Environmental Protection Agency is undertaking an evaluation of the costs and benefits of hazardous air pollutant regulations, using the benzene in the Houston-Galveston area as a case study. This evaluation will reveal critical areas in which more information about hazardous air pollutants is needed. TERC should be a participant in this case study; its precise role will depend on the roles undertaken by other participants.

The most immediate *information dissemination need* is:

- **Recommendation 9:** Launch a permanent data and information exchange infrastructure. Past experience has shown that substantial confusion can result if the observational measurements, emission inventories and meteorological modeling on which analyses are based are not from a single, well-documented source.

- In addition to scientific, policy, assessment, and information dissemination needs, the TERC Board of Directors has a strong interest in *mobile source emission reduction technologies* that can be broadly applied in Texas.

- **Recommendation 10:** Incorporate mobile emissions reduction technologies demonstration programs, projects and strategies in TERC activities. New mobile source emission reduction technologies could be widely applied across Texas; selection of such projects should be coordinated with the Texas Council on Environmental Technologies and others engaged in this area of research, development and demonstration.

The most *immediate operational need* is:

- **Recommendation 11:** Develop a research prioritization process. To this point, projects funded by TERC have been selected based on the needs associated with the mid-course review of the plan for attaining the NAAQS for ozone (due in mid-2004). While this has been both desirable and appropriate, TERC's new work will be based on the broader set of issues outlined in this Strategic Research Plan. To develop the next set of research priorities, TERC will need to prioritize and further refine the needs identified in Tables 1-4. A proposed prioritization mechanism would require the Consortium's Science Advisory Committee to rank research areas based on scientific and technical criteria. This ranking would be reviewed by a diverse group of stakeholders through workshops and other mechanisms. These two sets of inputs would serve as the basis for recommendations to the TERC Board.

Summary

Taking action on the recommendations outlined above will position TERC as the focal point for the continuing scientific study of atmospheric processes in eastern Texas, as the focal point for scientific data exchange and information dissemination, and as a leader in future air quality planning efforts.