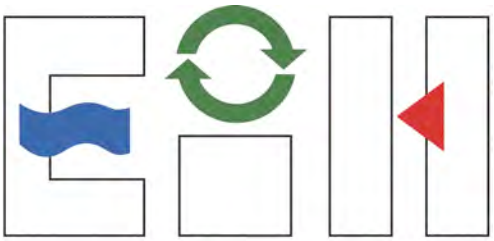
2002 Annual Report
The Environmental Institute of Houston

University of Houston-Clear Lake
and the
University of Houston
Houston, Texas



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Environmental Institute of Houston

2001-2002 Advisory Board

COVER—San Leon Hotel circa 1912—The San Leon Hotel was built in 1892; it was a three-story, seventy-five room, wooden hotel with an imitation sandstone exterior. The lower story contained two stores, a bank, the hotel office, rotunda, dining room, and kitchen. The rooms had a five-foot curly pine wainscot and were hard plaster finished. One night in 1912 the flames of a "moonshine prairie fire" exploded from the huge Galveston Bay landmark and the hotel burned to the ground.

BACK COVER—Looking east along the lake front road in Seabrook, Texas. This early 1900s photo shows a view of the area where Lakewood Yacht Club is today.

Environmental Institute of Houston

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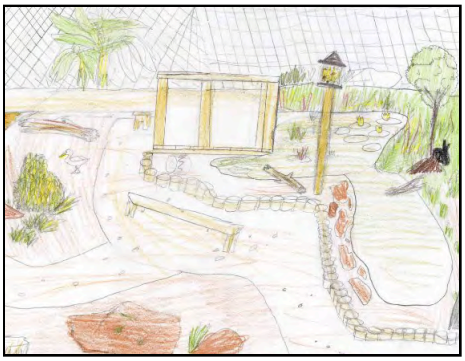


Student art work is being highlighted throughout the revised school habitat curriculum guide. (See page 8.)

Photo by Winifred Hamilton

Ozone is the only substance for which the greater Houston-Galveston area fails to meet NAAQS. (See page 30.)

Photo by Winifred Hamilton

Drums of spent chemicals were abandoned at the Many Diversified Interests Superfund Site. (See page 47.)

Interim Director's Message

Lisa B. Gossett, J.D., Interim Director, Environmental Institute of Houston and Associate Professor, Environmental Management, University of Houston-Clear Lake

In September 2002, Dr. Jim Lester, EIH's founding director, became director of the Environmental Group at the Houston Advanced Research Center. This move was an opportunity for Dr. Lester to expand on the work he has been doing for years; however, he is missed at EIH. Dr. Lester's hard work, dedication, and vision in leading EIH have created a great legacy on which to build. Increasingly, I appreciate the scope of what he accomplished, and I wish him the best in his new position. The research and accomplishments described in this report occurred under his leadership.

As Interim Director, I hope to continue the standards of excellence and cooperation that have been the hallmark of EIH. I strongly believe in the mission of EIH, and its support of research, outreach, and education as means for environmental improvement.

A few weeks ago, I attended a meeting that included well-educated community leaders and academics who do not work in the environmental field. Eventually, the discussion moved toward the environment. A participant stated that he asks "What about the people?" when a young family member discusses environmental issues. In this context, the statement surprised me with the implication that concern for "people" and concern for the environment were inconsistent with each other.

Last year, in the wake of September 11, Dr. Lester wrote in his Director's Message that "if we do not reduce ignorance and authoritarianism, people and the environment will continue to suffer." The work of EIH, its partners, and many others working in the environmental field, fundamentally relates to improving the quality of life for people. People and their environment are inevitably intertwined.

The projects supported by EIH, described in this report, cover a broad range of topics and activities that affect people. Issues such as air quality, water quality, flooding, food availability and safety, disease demographics, pollution identification and prevention, environmental education, and public outreach all have real human impacts.

White pelicans reside near offshore drilling rigs located in Galveston Bay.

EIH's research and activities increase the fundamental knowledge base relating to important environmental issues. Better information should lead to more informed environmental policies, and minimize crisis-motivated regulatory responses and the resultant inefficient or ineffective approaches to address environmental concerns.

EIH's environmental education activities deserve special note. Led by Dr. Brenda Weiser, Director of Environmental Education, this program area has had a tremendous, immediate impact in the community. EIH conducted 39 educator workshops, reaching over 800 educators and ultimately their students. Additional presentations and exhibits reached many people. EIH also has been active in developing an air and ozone curriculum for secondary science and math teachers. Under a grant, EIH developed the environmental education component of the marsh restoration project at San Jacinto State Park. The list could continue.

I am honored to serve as the interim director of EIH this year. My thanks to Dr. Glenn Aumann, Co-Director of EIH and Director of the Coastal Center, the wonderful EIH staff, EIH researchers and their students, EIH advisory board members, community partners, and the many others who are responsible for EIH's success.

Lisa Gossett, J.D., Interim Director of EIH, is in her tenth year as a faculty member in the environmental management program at the University of Houston-Clear Lake. Before entering academia, she worked as an environmental attorney and as an engineer in the petrochemical industry.

Environmental Education: A Piece of the Puzzle

Brenda Weiser, Ed.D., Environmental Education Program Manager, Environmental Institute of Houston, University of Houston-Clear Lake

Environmental education and working with local educators and community leaders are major focuses of the Environmental Institute of Houston. The environmental education program of EIH assists in achieving this goal through educator workshops and providing guidance to local community groups and corporate volunteers. This past year, EIH conducted 39 educator workshops reaching over 800 formal and non-formal educators. Included in these workshops were pre-service and in-service workshops focusing on Project Learning Tree (PLT) in the City, Project WILD, the Wonders of Wetlands (WOW), and school habitat curriculum development. Many of these workshops were conducted in partnership with Texas Parks and Wildlife Department, U.S. Fish and Wildlife Service, Texas Forestry Service, Offshore Energy Center, and the Houston Children's Museum. Reliant Energy, the Offshore Energy Center, and U.S. Fish and Wildlife Service sponsored many of these workshops.

Other workshops, presentations, and exhibits were conducted over the year, reaching over 1500 individuals. These events provided information on environmental education, Envirothon, various environmental education programs and opportunities offered by EIH, and ideas on how to build environmental education partnerships. Through representation at various local, regional, state, and national meetings, EIH participated in 12 meetings and reached over 350 leaders in EE. The environmental education staff presented at the International Project Learning Tree Coordinator's Conference and the North American Association for Environmental Education (NAAEE).

EIH's EE efforts in fundraising and sponsors resulted in nine grants and donations for the amount of $152,500. These funds were used to expand EIH's environmental education efforts and initiate new efforts. One new initiative is a partnership between EIH/UHCL and the Houston Independent School District (HISD). A week-long workshop was offered for HISD's middle school math and science teachers participating in Houston Urban Learning Initiatives in a Networked Community (HU-LINC). The workshop focused on Air, Energy, and Ozone. Participants received the Project Learning Tree activity guides, the Air and Ozone Curriculum, and the Project Learning Tree Energy and Society Kit. Funding for the workshop was provided to EIH via a National Science Foundation grant submitted by HISD.

Funding was secured from the American Forest Foundation/National Project Learning Tree to fund the Houston–PLT in the City program. EIH assumed the local coordinating role for this international program. As a component of this effort, teachers attend educator workshops and receive the PLT activity guides free of charge. Once 75 percent of the school has attended a PLT workshop, the school is recognized as a PLT in the City school.

In addition, environmental education efforts included developing an air and ozone curriculum for middle school science and math teachers; the environmental education component of the San Jacinto State Park's marsh restoration project; and continuing support for the development and use of school habitats.

EIH is considered a leader at the local, state, and national levels in the field of environmental education. Over the past year, the EE Program Manager has served on the following committees locally: Bay Day Steering Committee, Bayou Preservation Association Advisory Board, Galveston Bay Estuary Program Public Participation and Education Committee, and Water Smart Conference Planning Committee. EIH also provided volunteers for Marsh Bash, Trash Bash, and Bay Day. At the state level, the EE Program Manager represents EIH on the Texas Project Learning Tree State Steering Committee and the Texas Project Food, Land, and People State Steering Committee. At the national level, EIH is represented on the NAAEE National EE Guidelines writing team and the national EE certification effort. Through these committees and advisory boards, EIH provides environmental education expertise and assistance to other organizations.

In partnership with Texas A&M Extension, Texas Sea Grant Program, Galveston Bay Estuary Program, and others, EIH hosted a Water Smart Conference at UHCL with over 250 participants. This was the third annual conference and a fourth annual conference is scheduled for March 2003.

EIH hosted a regional environmental education certification meeting to provide a deliberate and purposeful discussion on the topic of professional development for environmental educators. Representatives from Florida, Georgia, Kentucky, Louisiana, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Texas, and Utah attended. In addition, leaders from National Project Learning Tree, the Council for Environmental Education, and the U.S. Forest Service attended the meeting. Funding was secured from the U.S. EPA Region VI, the National EE Training Foundation, and the U.S. Forest Service Southern Region.

This past year, EIH worked closely with the University's pre-service teacher interns to launch the PLT-Technology initiative. PLT is being incorporated into the UHCL School of Education's Preparing Tomorrow's Teachers To Use Technology (PT3) program. Like the PLT activities, UHCL strives to include authentic assessment opportunities in the PT3 initiative. PLT provides the PT3 students with the opportunity to use real materials that originally did not include a technology component and determine the best approach for integrating technology into the lesson. This might include identifying websites, software, possible project-based learning

Photo courtesy of Gallaway Collection

Galveston Seawall circa 1912

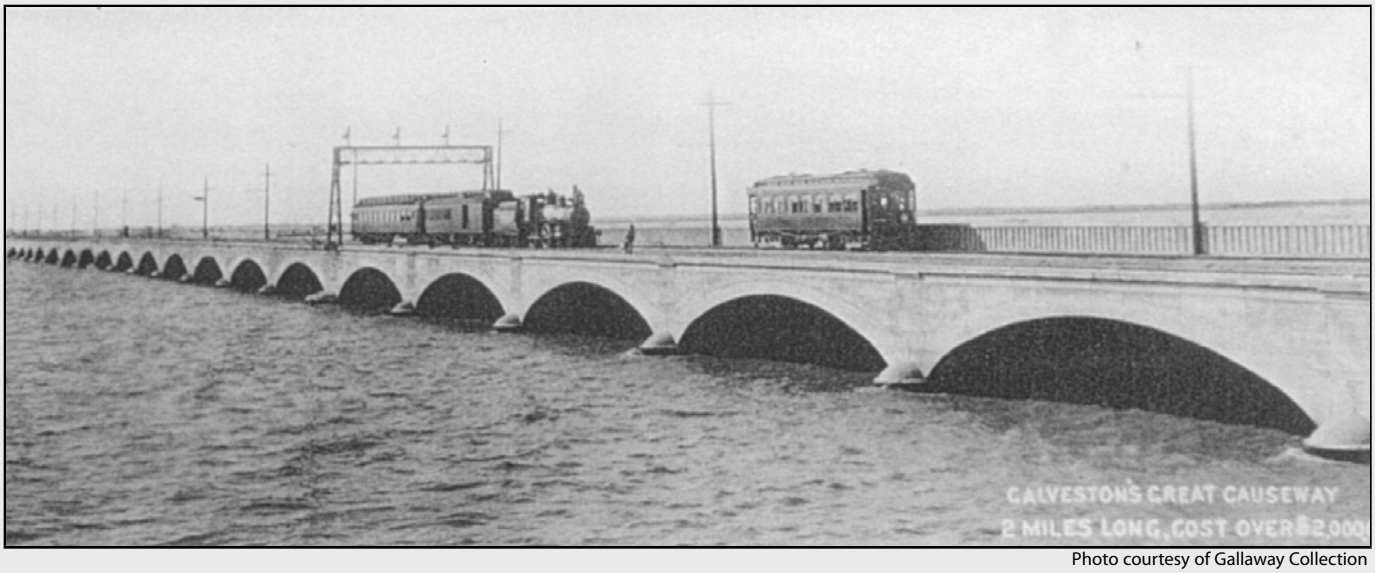


Photo courtesy of Gallaway Collection

Galveston Causeway circa 1912

topics, experts in the field, collaborative telecommunications, and final products. As a result of the partnership, PLT will have a technology component in each of the activity guides. A bigger benefit is that the UHCL interns and their mentor teachers will have received training in PLT and will be able to incorporate technology and environmental education into their lesson plans.

EIH continues to reach out and develop partnerships with a variety of organizations. In addition to those partners identified previously, EIH joined forces with Gulf Coast Waste Disposal Authority, Texas Nature Conservancy, Eddie Gray Wetlands Center in Baytown, Western Fifth Ward Community Services, Texas Forestry Association, University of Houston–Downtown, Stephan F. Austin State University, and Armand Bayou Nature Center to provide high quality environmental education to the Houston-Galveston area.

A Web-Based Extension of H.I.S.D.'s Outdoor Education Center

Kathryn Ley, Ph.D., Associate Professor of Instructional Technology, University of Houston-Clear Lake

THE FOCUS OF THIS PROJECT WAS THE creation of stand-alone web-based lessons concerning environmentally beneficial choices fifth grade students in the Houston Independent School District (HISD) can make at home and school. Designed to supplement and enhance the curriculum of the HISD's Outdoor Education Center (OEC), the lessons targeted Houston's most profound environmental problems—air pollution and conservation. To tie the two ideas together with a broad understanding of interrelationships in the natural world, the final lesson dealt with the concept of interdependency. The interactive nature of the lessons provide students with opportunities to engage in decision-making, simulated environments, and a variety of assessment activities. The formative evaluation process was employed, using fifth grade students in HISD who had attended the OEC, in order to ensure clarity of the content, age-appropriateness of the material and activities, and the general motivation of the learners as they progressed through the lessons.

The Houston Independent School District operates the OEC as part of its Magnet program. Magnet programs in HISD operate on curriculums centered on specific content areas. These programs are typically housed in elementary schools, sharing the facilities with non-magnet classes of students.

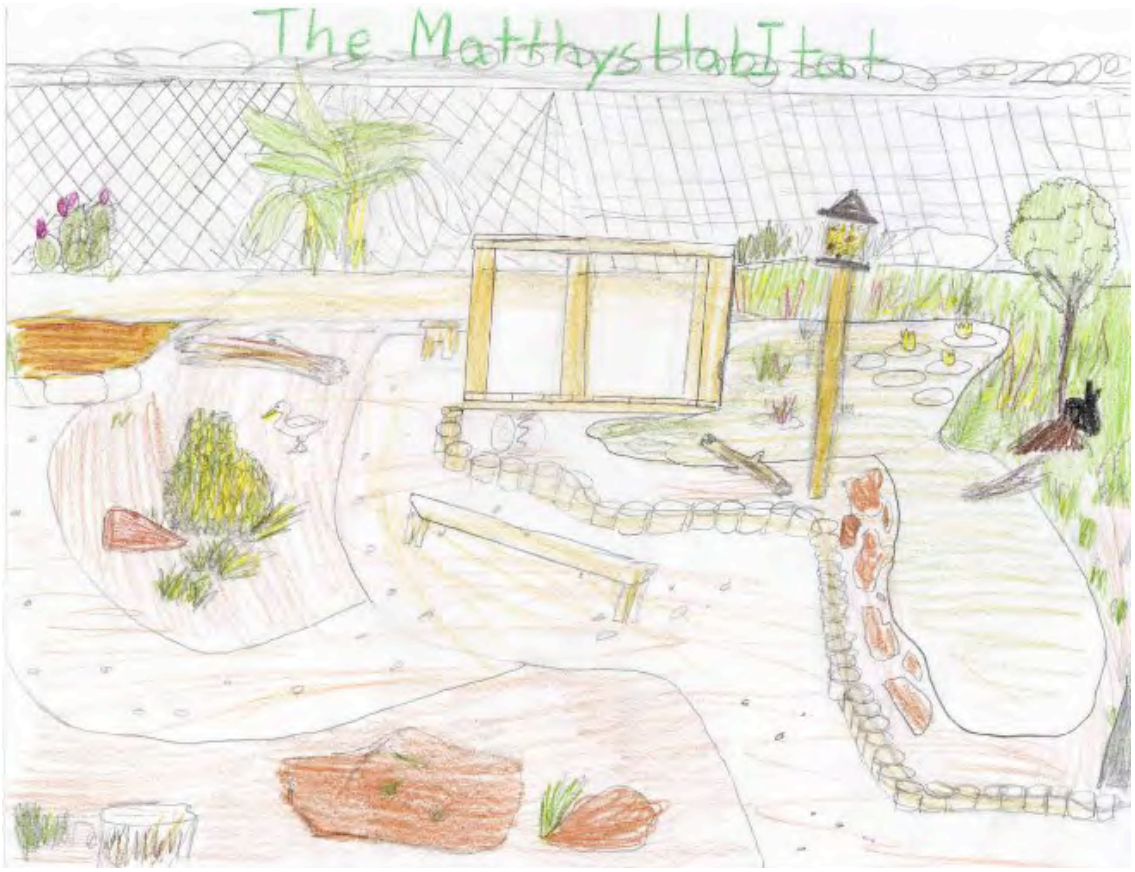
About sixty percent of HISD's fifth graders, usually 5500 a year from 110 elementary schools, are transported to the two camp locations of the OEC in Trinity, Texas. They spend four days and three nights at the facilities and go through a hands-on curriculum centered on environmental science with some outdoor recreation components. Teachers accompany their students to the facilities, but often choose not to be involved in their students' learning since the full-time OEC staff carries out instruction. In the past, teachers were given materials to use in their classrooms to follow up on the instruction that took place at the OEC. However, many teachers neglected to follow through with the instruction either because of lack of time to do so in the class or because of their own lack of knowledge about the environment and environmental issues.

The primary need for the project was for a means to connect to students who have visited the OEC in order to transfer the learning back to their own environments. Since the instruction at the OEC is very broad in scope and the physical environment is much different than that from which the students come, transferring the content of the OEC curriculum back to students' homes has traditionally been a very difficult task. At the time of writing, there were no formal attempts to achieve it. With Houston's environmental state as it is, consistently ranked among the worst in air quality and other measures in the United States, the environmental education of Houston's youth is paramount. The OEC program has an interest in furthering or extending the instruction begun at the campsite to students in their classrooms in Houston. The goal of the project was to give students tools and information about what they could do to protect or improve their urban environment, homes, and neighborhoods, in addition to information about how their own daily practices impact the environment.

Outdoor Education Center Web lessons can be accessed at: http://www.hisdoec2.org/.

School Habitat Curriculum Guide Grades K-8: Revisions and Development

Wendy Reistle, Habitat Curriculum Specialist, and Brenda Weiser, Ed.D., Environmental Education Program Manager, Environmental Institute of Houston, University of Houston-Clear Lake



Cover for the curriculum guide by a third grade student from Matthys Elementary

The goal of this project was to expand and improve the current School Habitat Curriculum guide for use by educators in their school habitats. A focus group was initiated to discuss and suggest items to be included in the updated guide. The focus group recommended (1) correlating each activity to the Texas Essential Knowledge and Skills (TEKS), (2) making each activity interdisciplinary, (3) inserting a section justifying why environmental education should be included as part of the school experience, (4) offering suggestions for finding grants, field trips, and other resources, (5) including case studies, and (6) conducting an art contest within schools that have established school habitats so that student art work may be included on the cover and within the text of the new guide.

With the suggestions from the focus group in mind, the K-5 curriculum guide was revised to incorporate grades 6-8 materials, to include at least two hands-on/minds-on activities per grade level, and to provide background information to assist educators in achieving productive and meaningful outdoor classroom experiences.

Many curriculum resources, including books and websites, were reviewed in order to write appropriate activities for use in the school habitat curriculum guide. Interviews were conducted and inserted as case studies in the revised guide and an art contest led to a nice selection of student artwork.

As a result of this project, teachers can receive a curriculum guide appropriate for grades K-8, which is correlated to the TEKS. This guide can be used as a model for Texas schools that are attempting to link school habitats with current learning standards.

Field-testing of the curriculum guide is planned to begin in the fall of 2002. Once the activities have been tested and approved by educators, the guide will be distributed in schools who request a habitat workshop for their faculty.

Air Education in Houston: Changing Our Image

Brenda Weiser, Ed.D., Environmental Education Program Manager, and Sally Wall, Air/Energy Curriculum Specialist, Environmental Institute of Houston, University of Houston-Clear Lake

Houston is in a battle with Los Angeles for the city with the worst air quality. The air quality in Houston impacts many lives, especially those of children in the urban setting. The type of information students in public schools receive about air quality is limited, due to the fact that the seriousness of the problem was not recognized until Houston's air quality became national news. The Environmental Institute of Houston embraced the challenge to develop an air quality curriculum designed for Texas Educators addressing the air education needs in Texas.

The curriculum was developed based on the needs of the population that will be utilizing it. In the Houston-Galveston area, 22 percent of the state's students live in seven counties being served by 54 school districts with 28 percent of the teacher population. The students demographically are African-American (22 percent), Hispanic (35 percent), economically disadvantaged (45 percent), and limited English proficiency (15 percent). These students benefit from hands-on laboratory activities, interactive lessons that are informative about air quality and are presented in a nonbiased format.

The curriculum has been developed to target teachers of middle school Science, Integrated Physics and Chemistry, and Environmental Systems. The lessons meet the North American Association of Environmental Educators (NAAEE) guidelines for good environmental education. This includes the methodology of the lessons and the nonbiased approach of the activities.

The curriculum covers the topics that were considered important by area teachers. Topics include: what is ozone and how does it form; how does one contribute to everyday air pollution; conservation practices that impact the air quality; green spaces and air quality; environmental health issues as they relate to air; air quality and ecosystems; and indoor air quality. The lessons contain background information and laboratory activities that teachers can use throughout the year, or they can be taught as stand-alone units.

Teachers throughout the Houston-Galveston area have had an opportunity to perform activities from the curriculum and to receive copies to field test in their classrooms. This has been accomplished through a series of teacher workshops. Some of the workshops have been one to two hours in length at conferences while others were six hours with more intense training. The curriculum was offered and exhibited to a special strand of Houston Independent School District teachers who participated in the Houston Urban Learning Initiatives in a Networked Community (HU-LINC) program for math and science educators. The curriculum will continue to be offered through all of the above venues. Currently, the curriculum is being field tested by over 50 teachers.

The demand for the curriculum has spring-boarded from the Houston-Galveston level to the national level and Mexico. Selected activities have been presented at several National Environmental Education conferences. The participants were anxious for more and have requested copies to field test and use.

This curriculum provides accurate, balanced educator workshops that encourage teachers to incorporate air education into their classrooms. It teaches students how to think, not what to think. As with all good environmental action, it starts locally and is moving globally.

What is ozone and how does it form?

How does one contribute to everyday air pollution?

Statistical Analysis and Demographic Patterns of Respiratory Diseases in Houston

Raj S. Chhikara, Ph.D., Professor, Departments of Mathematics and Statistics, and Sarat C. Puram, Graduate Student, Statistics, Department of Mathematics, University of Houston-Clear Lake

Demographic variation in respiratory diseases in Houston is investigated using hospital patient data for 1999. It is shown that there is a significant difference in the occurrence rate of respiratory diseases and also the intensity, across different parts of Houston; and that certain environmental and demographic factors seem to account for this significant variability.

A RELATIONSHIP BETWEEN AIR QUALITY and the occurrence of respiratory diseases among the population of an industrialized city such as Houston is self-evident. Climatic conditions such as heat, humidity, and wind direction are factors as well. Houston currently has the highest level of ozone pollution in the country and is experiencing an explosion in respiratory health problems. Recently, the Texas Commission on Environmental Quality (TCEQ) has requested the city of Houston to reduce the levels of gasses, which cause air pollution, so that it does not lose federal funding. Houston's climate is humid, which further increases risk for occurrence of a respiratory disease such as asthma.

Macdonald (1976)[1] investigated the effect of air pollution on cancer occurrence in the city and reported the outcome of her in-depth analysis carried over almost an entire decade. This study showed a significant increase in cancer occurrence as a result of deterioration in Houston's air quality starting after World War II. She showed that the rate of cancer in different parts of the city was influenced by weather patterns, traffic flow, and the location of refineries and chemical plants in the Houston area.

Macdonald's monumentally significant study was reported a quarter of a century ago. There may have been other significant studies analyzing health data from Houston; however, the authors are not aware of them, particularly for the respiratory diseases. The present UHCL study is undertaken to examine the occurrence of respiratory diseases, and also their intensity, across different area zones of Houston. Analysis is made to determine whether there are any differences in occurrence of respiratory diseases between male and female groups, Hispanic and non-Hispanic groups, and between age groups.

The research team sought to analyze the respiratory health data for Houston and determine whether or not there is a significant difference in occurrence of respiratory diseases between different areas of Houston. Length of hospital stay is also analyzed for the various areas and respiratory diseases. Whether the air quality and demographic factors have any effect on the occurrence rate of respiratory diseases is discussed.

Respiratory Health Data

The data analyzed was provided by Texas Health Care Information Council via a Texas Hospital In-patient Discharge Public Use Data File for 1999. It contains information for patients in Houston who were hospitalized during 1999. There were a total of 103 different variables for each patient. The patient information of particular interest was identified and was extracted from the data file. Since demographic factors play an important role in people's health, the demographic variables were included in the selection and analysis of the data.

The variables selected are as follows:

Length of stay. Length of stay represents the duration (number of days) of hospitalization due to an occurrence of diagnosed respiratory disease/symptom. This provides information about the intensity of the disease; longer hospital stays indicate the severity of the disease.

Diagnosis code. Each disease was assigned a diagnosis code. There were a total of 23 different diagnosis codes that were available for the respiratory diseases. Occurrences of many of those diseases were negligible and only seven were prominent in the Houston area. Only seven are considered in this study; their codes and names are as follows:

464 Acute laryngitis and tracheitis
466 Acute bronchitis and bronchiolitis
491 Chronic bronchitis
493 Asthma
496 Chronic airway obstruction
507 Pneumonitis due to solids and liquids
511 Pleurisy

Age group. Patient ages are divided into seven groups as follows:

Ages	Age code
0-4	1
5-9	2
10-17	3
18-34	4
35-54	5
55-69	6
70+	7

Ethnicity. Only two categories, Hispanic and non-Hispanic, were recorded on the data file. Code 1 refers to Hispanic, and Code 2 for non-Hispanic.

Sex. Patient gender was coded as 1 for male and 0 for female.

Zip code. There were 128 different zip codes for the Houston area. The zip codes were stratified into 11 zones in order to achieve potential homogeneity in the occurrence of respiratory diseases by areas. Zoning was done based on the zip codes, population size, income, and other factors which reflect upon the diverse socio-economic, geographical, and envi-

ronmental conditions. Population sizes in the zones were achieved to be as close as possible so that there is some uniformity across zones in regard to the size of population. The median income weighted across zip codes in a zone was determined. Table 1 gives the zone code, the zone location or area, the zip codes, the population size, and the median income in each zone. In terms of population size, complete uniformity could not be achieved: the East zone is the smallest, which is followed by the Southeast, the Central, and the South zones in that order, where as the West zone is the largest of all and has population almost three times that of the smallest zone.

Table 1. Houston area zones with population size and median income.

Zone code	Houston area	Zip codes	Population size	Median income
1	Southeast	77034,77058,77059,77062,77075, 77089,77546,77598	157,284	43,643
2	East/Southeast	77012,77017,77061,77087,77502, 77503,77504,77505,77506,77536, 77587	261,508	27,369
3	South	77033,77035,77045,77047,77048, 77051,77053,77054,77085,77459	174,035	30,914
4	East	77013,77015,77029,77044,77049, 77078,77530,77547	146,993	30,372
5	Central	77002,77003,77004,77006,77011, 77020,77021,77023	169,963	20,558
6	Westcentral	77005,77019,77025,77027,77030, 77031,77036,77056,77063,77071, 77074,77081,77096,77098,77401	331,139	33,109
7	West	77042,77072,77077,77079,77082, 77083,77084,77094,77099,77449, 77450,77477,77478,77479,77493, 77494	424,340	48,068
8	Northwest	77024,77040,77041,77043,77055, 77064,77065,77070,77080,77092, 77095,77375,77429	334,895	45,659
9	Northcentral	77007,77008,77009,77018,77022, 77026,77028,77037,77076,77088, 77091	297,685	25,089
10	Northeast	77016,77032,77039,77050,77057, 77060,77093,77338,77339,77345, 77346,77396	258,593	36,768
11	North	77014,77038,77066,77067,77068, 77069,77073,77086,77090,77371, 77379,77380,77381,77386,77388, 77389	256,410	47,823

Data Analysis

Length of stay in hospital is used in determining both the occurrence and the intensity of a diagnosed symptom. Data for both the rate of occurrence (computed as the ratio of the population that has been affected) and the length of hospital stay were analyzed. Analysis of variance (ANOVA) was carried out with zone as the blocking effect and other variables of ethnicity, sex and age group as main effects, as well as their interactions considered. Test of homogeneity was performed for blocking and main effects using Student-Newman-Keuls (SNK) method, which is a multiple range test based on the studentized range statistic. (See Kuehl[2] for further discussion on SNK and other multiple range tests.)

Rate of Occurrence

For each zone, the proportion of the population that was diagnosed having a respiratory symptom is calculated by dividing the total number of people diagnosed with the symptom in a zone to the total population of the zone. The logit transformation, which is the natural logarithm of the ratio p/(1-p), where p is the proportion, and which satisfies the assumption of ANOVA, is then utilized.

Table 2 gives the F value and the associated p-value obtained from ANOVA for each diagnosis. Clearly the zoning and other factors considered have a significant effect in all but diagnosis codes 464 and 511. Table 3 gives ratio of the population (per 1000) diagnosed in each of the zones.

A combined evaluation across all diagnosis codes was made and the zones were ranked according to the combined levels of low, moderate, above average, and high for the rate of occurrence. The combined levels were developed based on the following probabilities assigned to various diagnosis:

Table 2. ANOVA F values and p-values for different diagnosis for the ratio.

Diagnosis	F value	p-value
464	1.66	0.1026
466	3.97	0.0001
491	6.47	<0.0001
493	3.73	0.0002
496	4.03	<0.0001
507	2.08	0.0324
511	1.6	0.1155

Code	Probability
464	0.1
466	0.2
491	0.2
493	0.2
496	0.2
507	0.05
511	0.05

The resulting ranks for various zones from the best to the worst are obtained as shown in Table 4.

Length of Hospital Stay

ANOVA was performed with length of stay in hospital as the response and zone, age, sex and ethnicity as the main effects. The interaction effects due to the demographic factors were also considered, but it was found that the interaction effects were

Table 3. Ratio of population (per1000) diagnosed.

Zone	Diagnosis 464	466	491	493	496	507	511
Southeast	0.127159	0.36876	0.82653	0.998194	0.464129	0.241601	0.241601
East/Southeast	0.091775	0.718907	1.728437	0.925402	0.481821	0.344158	0.217967
South	0.103427	0.499899	0.580343	1.907662	0.287299	0.316028	0.178125
East	0.081637	0.55785	0.836775	1.197336	0.898002	0.115652	0.15647
Central	0.047069	0.376553	0.558945	1.147309	0.370669	0.217694	0.135324
Westcentral	0.066437	0.320107	0.419763	0.845566	0.289908	0.202332	0.160054
West	0.127585	0.562319	0.498527	1.077385	0.337864	0.226818	0.127585
Northwest	0.120763	0.497429	0.845343	0.991984	0.382417	0.235776	0.158142
Northcentral	0.070544	0.67521	1.145506	1.148865	0.346003	0.231789	0.228429
Northeast	0.064715	0.701081	1.333851	1.07499	0.532102	0.147407	0.18336
North	0.077735	0.344254	0.519157	0.577459	0.274848	0.124931	0.091616

Table 4. Zone ranking with all diagnosis combined for the ratio of occurrence.

Zone	Weighted value	Level
Westcentral	1.10	Low
North	1.10	Low
West	1.65	Moderate
Central	1.80	Moderate
Northwest	2.10	Above average
South	2.15	Above average
Southeast	2.20	Above average
East	2.35	Above average
Northeast	2.50	High
Northcentral	2.55	High
East/Southeast	2.70	High

Table 5. F values and p-values for different diagnosis for the length of stay.

Diagnosis	F value	p-value
464	1.88	0.0494
466	1.79	0.0577
491	3.03	0.0008
493	2.6	0.0038
496	2.44	0.0071
507	2.35	0.0101
511	1.23	0.2688

not significant. Table 5 gives the F value and the p-value obtained from ANOVA for each of the diagnosis for the length of stay. Table 6 gives the average length of stay for each of the diagnosis for different zones. Again the zoning and other factors have a significant effect in all but the diagnosis code of 511.

Similar to the variable of rate of occurrence, a combined evaluation across all diagnosis was made for the length of hospital stay and the zones were ranked as shown in Table 7.

Respiratory Disease Patterns

Table 4 shows the zones ranked from best to worst for the occurrence rate and Table 7 for the length of hospital stay. (Zones are ordered in each case from the best to the worst.) A composite map is constructed in each case showing patterns of low, moderate, above average, and high levels of respiratory diseases in Houston. A colored map was developed according to the levels; red color was used for the high, yellow for the above average, blue for the moderate, and green for the low level. Map 1 shows it for the occurrence rate and Map 2 for the length of hospital stay.

The two maps show that except for the zones located in west and northwest areas of Houston, there is an inverse relationship between the rate of occurrence and the length of hospital stay. Zones having a lower ratio of occurrence tend to have a longer hospital stay. Northcentral zone is a major exception to this phenomena since it has both a high rate of occurrence and a high intensity (length of stay). The inverse relationship may be explained in terms of socio-economic parameters. For example, the central zone shows only a moderate rate of occurrence, but a high level of intensity due to longer hospitalization of patients. This may be attributed to poorer socio-economic conditions of people in this zone, since they are disposed to seeking hospitalization only when it becomes a critical health issue. Another possible reason may be the population age. The older people are relatively more in the central zone as compared to other zones.

Table 6. Mean values for the length of hospital stay in days.

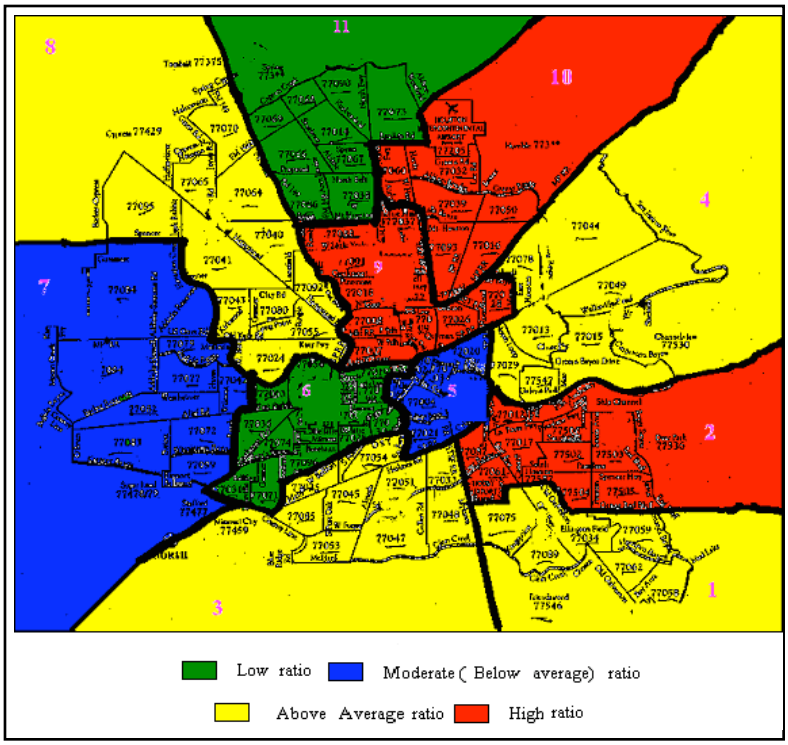
Zone	Diagnosis 464	466	491	493	496	507	511
Southeast	3.00	4.88	5.55	2.94	8.73	9.13	5.34
East/Southeast	2.50	3.54	5.38	3.32	11.02	9.57	6.47
South	2.61	4.00	4.11	3.38	5.38	11.76	8.16
East	6.58	4.18	6.89	3.71	8.14	9.00	8.35
Central	4.12	4.50	7.66	3.63	7.81	14.00	11.70
Westcentral	2.05	3.48	5.88	3.63	5.94	11.09	8.40
West	2.35	3.43	5.84	3.11	7.99	9.23	8.59
Northwest	2.19	3.62	6.66	3.50	8.50	9.80	8.71
Northcentral	3.67	3.58	6.62	3.83	9.52	15.48	8.78
Northeast	2.22	3.52	6.08	3.02	7.78	13.15	8.39
North	2.61	3.98	6.67	3.26	12.98	11.09	9.61

Table 7. Zone ranking with all diagnosis combined for the length of hospital stay.

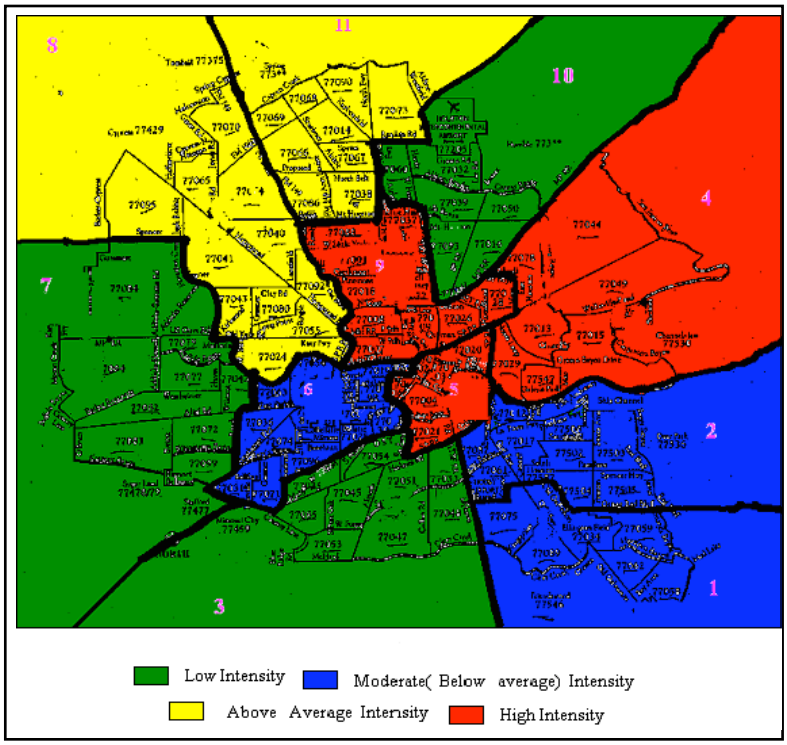
Zone	Weighted value	Level
West	1.55	Low
South	1.55	Low
Northeast	1.55	Low
Westcentral	1.70	Moderate
Southeast	1.70	Moderate
East/Southeast	1.70	Moderate
Northwest	2.10	Above average
East	2.45	Above average
North	2.60	High
Northcentral	2.60	High
Central	2.80	High

The suburban area zones mostly show low to moderate intensity (length of stay) with the exception of the Ship Channel area zone, but an above average or high rate of occurrence. Again this may be due to the age factor. Relatively more children reside in suburban areas, and children tend to recover faster than adults when hospitalized.

Overall the west and northwest parts of Houston have relatively a lower occurrence rate and intensity than the other parts. This seems to explain the effect of air quality and industrial environment on health. A similar pattern was obtained by Macdonald[1] in regard to occurrence of cancer in Houston. She explained in detail the role of weather, particularly wind direction, and air pollution played in regard to cancer in Houston. Similar analysis and outcomes seem to apply here, as well.



Map 1. Houston area map showing patterns of occurrence rate for all the respiratory diseases combined.



Map 2. Houston area map showing patterns of length of hospital stay due to all respiratory diseases considered.

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Depositional and Geotechnical Properties of the Beaumont Formation, Brazoria County, Texas

William R. Dupre, Ph.D., Associate Professor, and Christopher Angel, Research Assistant, Department of Geosciences, University of Houston

THE PURPOSE OF THIS STUDY IS TO describe the physical and hydrologic properties of the various lithofacies of the late Pleistocene Beaumont Formation, which underlies much of the Houston-Galveston Region. The area studied is the Manvel and Liverpool Quadrangles in Brazoria County Texas (Fig. 1). Existing maps of this unit[1-3] are too small a scale (1:250,000–1:125,000) to be of much use in predicting geotechnical properties and groundwater flow conditions. This problem is exacerbated by the fact that the lithofacies are highly heterogeneous,[4] and seemingly minor variations can significantly affect groundwater flow conditions (e.g. R. Jan[5]). In order to complete this study, it was necessary to obtain remotely sensed data, subsurface borehole data and field outcrop data to better understand the three-dimensional architecture of the various lithofacies of the Beaumont Formation.

Distortion-free Color Infrared air photos (Digital Orthogonal Quarter Quadrangles) were used to identify the region to be studied and identify the various lithofacies of point bars, natural levees, channel plugs, and floodbasins (Fig. 2). The quadrangles selected for detailed study were chosen on the basis of having well-defined fluvial lithofacies and a lack of urban development. Additionally, black and white stereo pair air photographs from 1944 and soil survey maps were used to further map fluvial systems. Satellite images were used to obtain the spectral characteristics of the fluvial environment of the Beaumont Formation. Data from two different satellite systems (Landsat and Aster) were obtained for the study area. Landsat data contains spectral data in seven bandwidths ranging from the visible spectrum to thermal infrared. Aster data contains fourteen bandwidths of spectral data, also from the visible to the thermal infrared. Based on the remotely sensed data, 19 subsurface

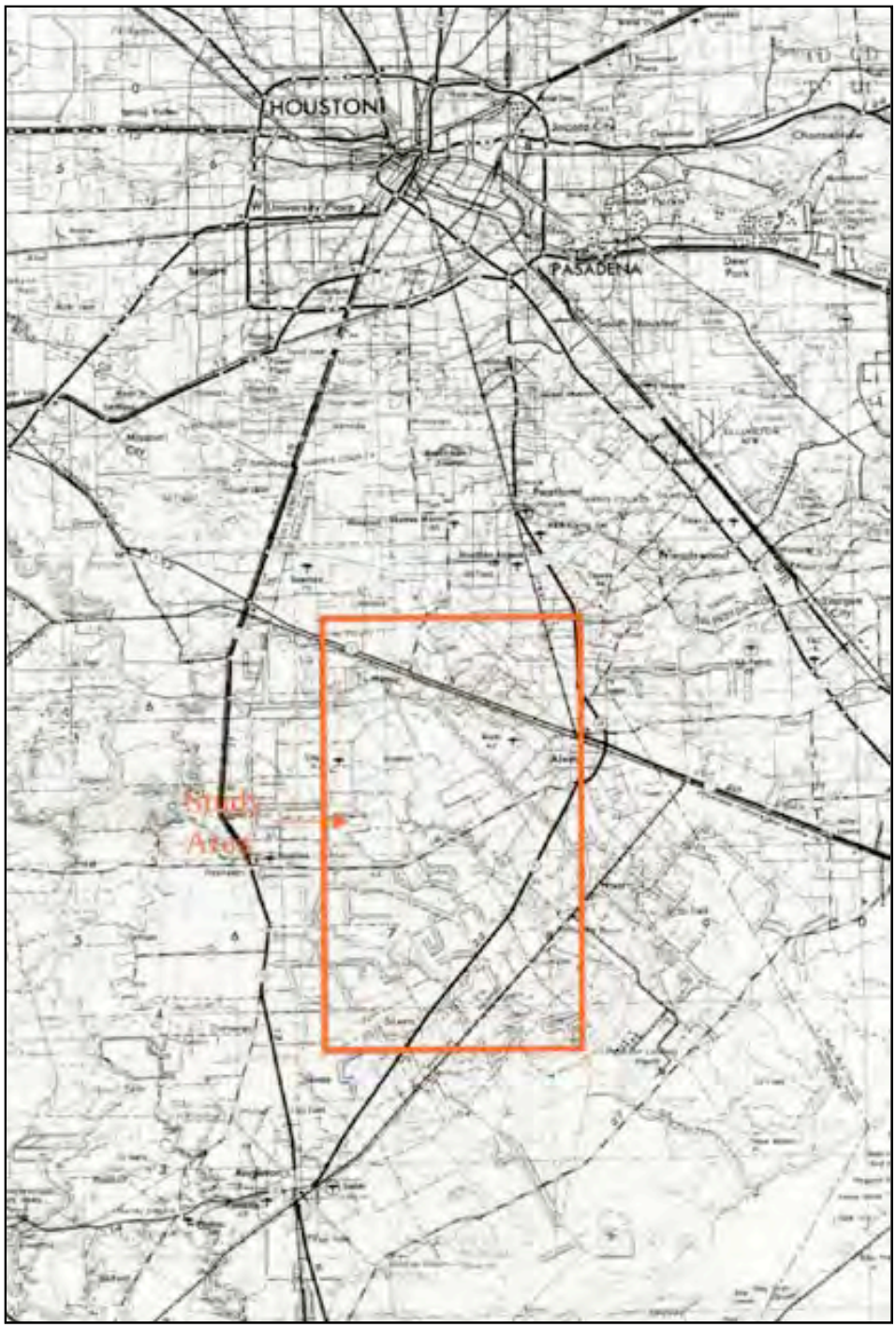

Figure 1. Site Location Map
Source: 1975 Houston, Texas 1:250,000 USGS Topographic Map

boreholes were located and drilled across a meander belt ridge and in a suspected crevasse splay. Drilling across this region indicated a fine-grained sand is located across the region, ranging from the surface at the point bars to depths of 17 feet below the surface at locations of the natural levee and the floodbasin in 18 of the 19 boreholes.

A sand pit study has revealed that much of the clayey over-bank deposits are highly burrowed (by crawfish). In some cases, the burrows continue to the sand below. Several of the burrows appeared to have void spaces along the outside of the burrow fill possibly from intermittent drying of sediments. Burrow sediments were wetter and softer than the surrounding sediment. These regions may indicate areas of recharge and/or preferential paths for contaminant transport. Additionally, swale fills have thin (5-10 mm) zones of silty sand between hard clays that may aide in allowing contaminants to spread horizontally. An unexpected zone of either lacustrine or bay faunas was found in what appears to be an oxbow. Samples collected from both the borehole investigation and sand pit study will be analyzed for total organic carbon and textural properties to aid in determining potential retardation of contaminant transport and permeability. Mineralogical analyses are also being performed to aid in the spectral characterization of the Beaumont Formation.

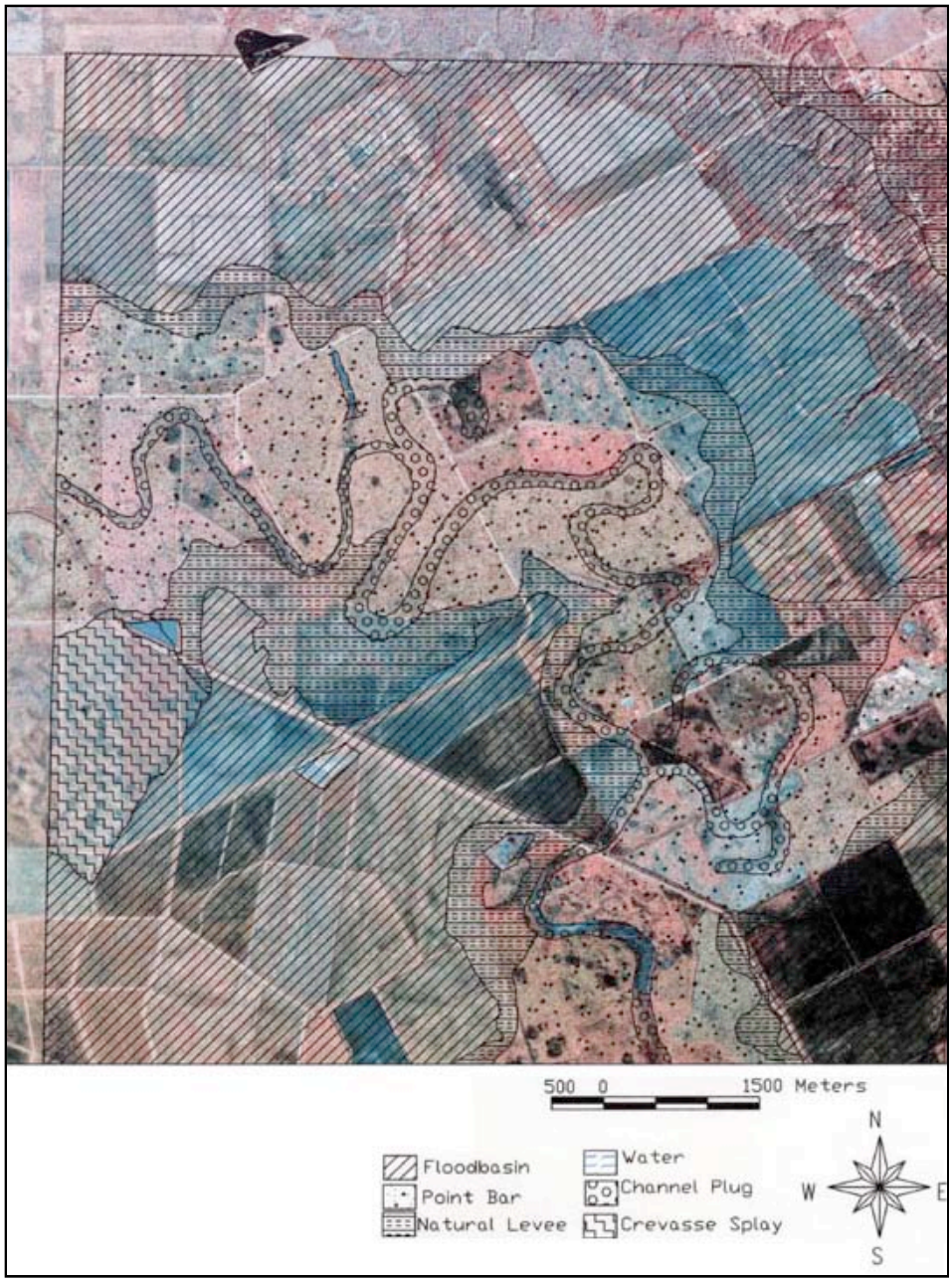

Figure 2. Interpreted Color Infrared Air Photograph

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TexAQS 2000 Aircraft Datasets Assimilation Based on Lagrangian Kalman Filtering Techniques

Jiwen He, Ph.D., Assistant Professor, and Joël Wagner, Research Assistant, Department of Mathematics, University of Houston

Uncertainties in initial conditions, emissions and reaction rate constants lead to uncertainties in the predictions of a photo-chemical mechanism for ozone formation. There are a number of numerical methods available for quantifying the effects of these uncertainties. The Monte Carlo method has been applied to determine the uncertainties in predictions of stratospheric ozone depletion. A second approach is the adjoint method, which is more efficient than the Monte Carlo method, but the CPU time required can still be large. A third approach is Kalman filtering/smoothing methods.

The Kalman filter for air quality models can be formulated within both the Eulerian and Lagrangian frameworks. The Eulerian filter calculate the distributions of both the constituent field and the error covariances for fixed spatial grids, while in the Lagrangian or trajectory filter forecast error propagation is calculated along air parcel trajectories. Grid-based Eulerian filters are potentially the most powerful, and involve the least-restrictive assumptions, but are also the most computationally intensive. For large scale CTMs, the prohibitive computational requirements makes Eulerian filters impracticable in its full form. The Lagrangian filter is more computationally efficient than the Eulerian filter because of the simple forecast error propagation step. It offers the possibility of reducing the complexity compared with the Eulerian filter.

In this project, we have developed a Lagrangian Kalman filter for a chemistry-transport model. The focus was on theoretical aspects and practical analyses of the influence of the model error on the Kalman filter performance. Our Lagrangian filters may be thought of as an extension of the well-known methods such as tracer mapping. The performance of the Lagrangian filter was compared against

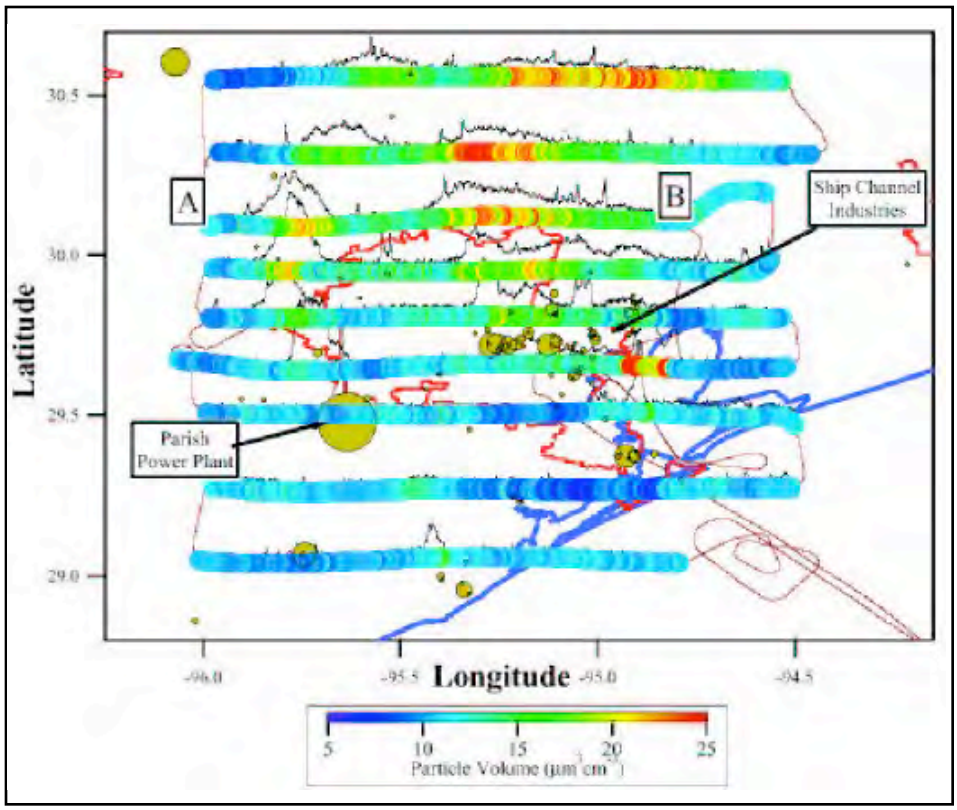

Figure 1. NCAR-electra observations (Trainer et al, 2001)

that of the suboptimal Eulerian Kalman filters. The role of the model error and the influence of the perturbations introduced by the chemical reactions in the assimilation results were also analyzed.

One of our objectives in this study was also to simulate atmospheric dispersion of the reactive plume from a point source. More complicated models involved interaction between chemical reactions and turbulence diffusion will be considered in the year 2002-2003. As this project is preparatory for a larger project, namely Mr. Joel Wagner's Ph.D. thesis, this preliminary study focuses on establishing a basic but solid foundation for building up more complex models.

In the year 2002-2003, further developments are planned:

- apply efficient four-dimensional variational data assimilation algorithms (4D-var) to exploit observations with beneficial impact for analyses of non observed species, which are chemically closely related to observed constituents
- implement the adjoint code by combining automatic differentiation tools (Odyssee) with symbolic processing (KPP), which leads to exact computation of the gradients and allows exibility for the chemical model.

In the near future, more and more observations of tropospheric species from the Texas 2000 Air Quality Study will become available, which may considerably improve the data assimilation results, possibly leading to new insights into the distribution of surface emissions of chemical

species and on their spatial and temporal variability.

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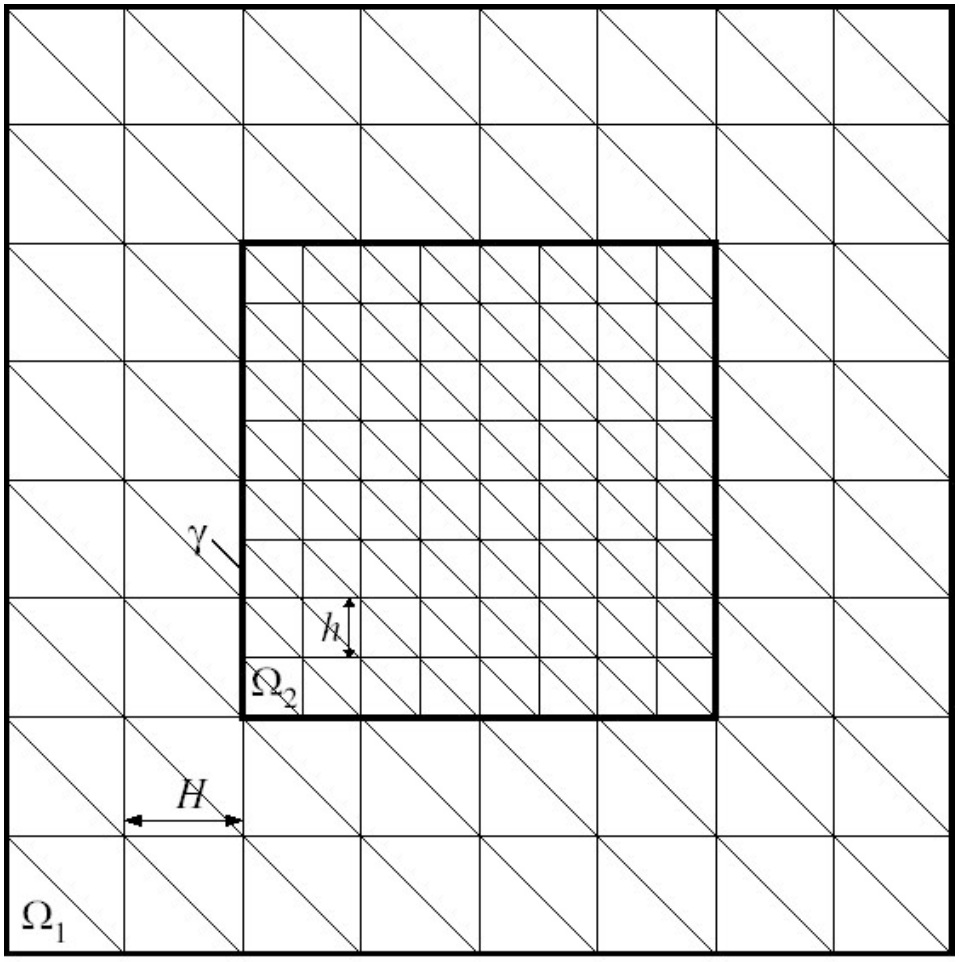

Figure 2. Triangulation of coarse and refined domains

Photo courtesy of Gallaway Collection

Seabrook Train Station, a line of the Southern Pacific Railroad, circa 1910

An Environmental History of Houston: Conference and Book Project

Martin V. Melosi, Ph.D., Professor, Department of History, University of Houston

This project for an environmental history of Houston will lead to the convening of a conference built around original research papers on various topics related to that theme, and the subsequent completion of a book based on the conference papers.

The conference will be held March 14-15, 2003 at the Hilton Hotel on the University of Houston campus. This event will be the first of its kind for Houston. We have identified, contacted, and commissioned presenters, all of whom will deliver a presentation at the conference and some of whom will be asked to complete quality papers to be included in the proposed book.

We are operating under the assumption that the conference appeals not only to academics, but to the local environmental, professional, business, and political community. The keynote address will help reflect the breadth of issues that the conference will attempt to confront.

The list of presenters and their topics are as follows (those with an * by their name are tentatively scheduled):

Regional Issues

David Snyder (Virginia Tech University), *The Impact of the Culture of the Oil Industry on Houston's Geography and Environment*

Diane Bates (Sam Houston State University), *Suburban Sprawl and Deforestation; Community Responses in a Southeast Texas Watershed*

Robert Fisher (University of Connecticut) and Janice Harper (University of Houston), *The Politics of Air Pollution in Houston*

Infrastructure

Gary Garrett (Rice University), *Brays Bayou and Flooding in Houston*

Martin Melosi (University of Houston), *Sanitary Services in Houston*

Barry Moore* (University of Houston), *Architectural History of Houston*

Energy

James McSwain (Tuskegee University), *Storage of Oil in Galveston*

Joseph Pratt (University of Houston) and Christopher Castaneda (California State University, Sacramento), *Natural Gas and the Environment in Houston*

Hugh Gorman (Michigan Tech University), *The Houston Ship Channel*

Environmental Justice

Robert Bullard (Atlanta University), *Environmental Justice Issues in Houston*

Elizabeth Blum (Troy State College), *Norwood Manor and Environmental Justice*

Kimberly Youngblood (Houston), *Brio Superfund Site*

Galveston Bay

William Barnett (University of Wisconsin), *Galveston's Changing Environmental Relationship with Houston*

Alecya Gallaway (University of Houston-Clear Lake), *Galveston Bay*

Environmental Movement

David Todd (Texas Legacy Project, Austin), *Environmental Movement in Houston*

Steven Klineberg* (Rice University), *Houston Attitudes Concerning the Environment*

Miscellaneous

Kenneth Brown* (University of Houston), *Archeological Perspective on Houston*

Upon completion of the conference, the papers will be edited and presented to the University of Pittsburgh Press for consideration as part of their urban environmental biographies series. Dr. Melosi is currently preparing a proposal for the press and he anticipates that they will issue a contract for such a book. The completion of the book will likely take at least one year from the initial submission of the manuscript. Dr. Melosi will serve as editor of the book along with Dr. Joseph Pratt, Cullen Professor of History and Business.

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—. "Expanding Frontiers in African American Environmental History: Land Conservation, Social Activism, and Leisure in the Early Twentieth Century," commentator, American Historical Assoc. Conv., San Francisco, CA, 2002.

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(*Continued on page 19.*)

Drainage Forum: The Allison Experience

Theodore G. Cleveland, Ph.D., P.E., Associate Professor, Department of Civil and Environmental Engineering, University of Houston

Tropical Storm Allison caused significant damages to the Houston area. The Drainage Forum was a one-day technical seminar that explained how the drainage system worked during Allison, how it was supposed to work, and what changes are needed for the future improved performance. The seminar audience was engineers, managers, and appointed and elected officials who are responsible for the design and operation of drainage systems in the Houston area.

The Drainage Forum was a mechanism to present technical issues and facts about the storm with the political ramifications and political failures downplayed. The seminar was organized around four sessions with speakers from government and private industry.

Session I was a history of flooding in the Houston area and a history of the Allison event(s). Session I speakers were Steve Fitzgerald, Chief Engineer, Harris County Flood Control, Bill Read, Meteorologist-in-Charge, National Weather Service, and Dwayne Culp, Senior Engineer, Department of Public Works & Engineering.

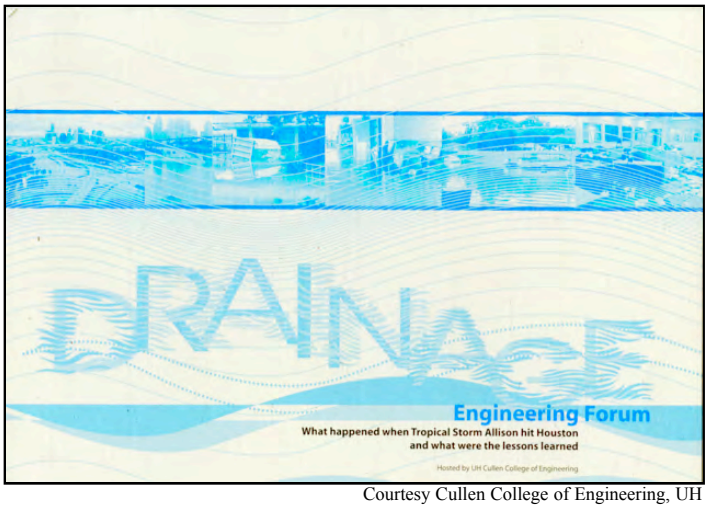
Session II was a description of how the bayou/drainage system was supposed to work and how it actually performed. Topics were presented by Gary Struzick, vice president/chief engineer, Klotz Associates, Inc., and Jim Thompson, Thompson Professional Group and Steve Fitzgerald, Chief Engineering, Harris County Flood Control.

Session III was an impact assessment on the operations and functions of specific sectors of society, particularly those that need to function even during a disaster: transportation, public safety, health care delivery. Speakers for Session III were Gary Oradat, Deputy Director, Department of Public Works & Engineering, Frank Gutierrez, Operations Manager, Harris County Office of Emergency Management, Delvin Dennis, Deputy District Engineer, Texas Department of Transportation, Thomas C. Lambert, Vice President/Chief of Police, METRO, Charles Penland, Principal/Manager of Civil Engineering, Walter P. Moore & Associates, Inc., and David Passey, FEMA.

Session IV, was a review of major ongoing flood control programs and plans for the future. Speakers included Gary Green, Director of Operations, Harris County Flood Control, Diana Laird, Chief of Planning Section, U.S. Army Corps of Engineers, Charles Penland, Principal/Manager of Civil Engineering, Walter P. Moore & Associates, Inc., and Jim Thompson, Thompson Professional Group.

Other forum speakers included Dr. Raymond W. Flumerfelt, Dean, UH Cullen College of Engineering, Dr. Arthur K. Smith, UH System Chancellor/UH President, Herb Lum, Deputy Director, Department of Public Works & Engineering, and Dr. Neil Frank, chief meteorologist, KHOU-TV Channel 11.

About 150 people attended the forum from industry, local government, FEMA, and the media. The exclusion of political issues was generally well respected and the forum was a good starting point for going forward.



Courtesy Cullen College of Engineering, UH

Streaming media archive of the forum is available at:
www.uh.edu/admin/media/newsroom/webcast/webcastinfo/2001/drainage.html

Drainage Forum program and downloadable presentations are available at:
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(Continued from page 18.)

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Metallothionein Induction in Grass Shrimp: Effect of Multiple Metal Exposure and Exposure Time

Cindy Howard, Ph.D., Associate Professor of Biology and Environmental Science; Charles F. Dingman, Graduate Student; Richard Jahan-Tigh, Graduate Student; and Jason Berninger, Graduate Student, University of Houston-Clear Lake

When exposed to heavy metals in their environments, many estuarine fish and invertebrate species display specific proteins that function as biomarkers of exposure, adaptation and/or toxicity. Metallothioneins (Mt) are small proteins that, under normal conditions, regulate zinc and copper homeostasis in animal cells. Exposure to high levels of these and certain other heavy metals, e.g., mercury and cadmium, induces synthesis of additional metallothioneins and larger molecular weight metal-binding proteins,[1-5] which then sequester the excessive metal ions inside the cell. This process circumvents damage to critical enzymes and metabolic processes, as long as induction and accumulation of the proteins keep pace with metal exposure.

The purpose of this study was to determine how simultaneous exposure to low levels of multiple heavy metals affects three aspects of Mt accumulation in the grass shrimp, *Palaemonetes pugio*: (1) the total amount of accumulated Mt, (2) the time between exposure and induction, and (3) the partitioning of the metals between Mt and other metal-binding proteins. As heavy metal contamination is a common problem in the sediments of Galveston Bay, this work provides information on how the indigenous fauna adapt.

Grass shrimp were exposed in 96-hour bioassays to one of 16 combinations of cadmium, copper, mercury and lead. Cadmium, copper and mercury all induce the synthesis of Mt; lead was tested as a non-protein binding control. The test concentration of each metal was determined in prior toxicity tests to ensure sublethal exposures at all metal combinations. All four of the test metals were found to bioaccumulate in whole grass shrimp.

Shrimp tissue homogenates were evaluated for metals bound to Mt and other proteins. The total amount of Mt accumulated by grass shrimp was directly related to the total amount of metal exposure, indicating that this species is able to adapt to low levels of these metals in its environment. The accumulation of Mt began in the first 24 hours following exposure to heavy metals and reached their maximum levels by 48 hours.

Work on the third objective is still in progress. Samples of grass shrimp from each exposure group have been subjected to gel filtration chromatography, followed by metal analysis by ICP (*Cd*, *Cu*, *Pb*) or FIMS (*Hg*) to determine which proteins are binding each of the metals and in what proportions. Preliminary results indicate that the grass shrimp Mt more efficiently binds copper than cadmium or mercury; resulting in cadmium and mercury binding to other proteins under multiple exposure conditions. This could be one explanation for why cadmium and mercury are more toxic to grass shrimp than is copper.

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Local and Geographic Variation in Palatability of Coastal Salt Marsh Plants

Steven C. Pennings, Ph.D., Assistant Professor; Chad McNutt, Graduate Student; and Nilam Dave, Undergraduate Student, Department of Biology and Biochemistry, University of Houston

UH researchers addressed two issues in this study: palatability of plants across gradients of stress and palatability of plants across geographic regions. For unavoidable logistic reasons (common marsh herbivores are mature and are most abundant in the late summer and early fall), the experimental work is ongoing. The research team has identified study sites, selected appropriate plant and herbivore species to work with, obtained necessary supplies, and begun the palatability comparisons. Experimental work will be completed by the end of November 2002.

Gradients of stress. Current theories of plant-herbivore interactions suggest that plants should differ in palatability to herbivores along gradients of stress.[1,2] Work by Goranson and Pennings[3] supported this hypothesis for eight common salt marsh plants that occurred across orthagonal salinity and elevation (waterlogging) stress gradients in Georgia salt marshes. The generality of this result is unknown. The team is repeating similar preference experiments in Texas salt marshes. This study will provide an important test of the generality of the previous results. If similar results are obtained, it will suggest that the results are general despite marked variation in the physical environment (particularly tidal regimes) between Georgia and Texas wetlands. In contrast, if different results are obtained, it will open the door to future studies exploring how differences in the physical environment change the nature of the plant-herbivore interactions.

Geographic variation. A fundamental paradigm of biogeography is that consumer-prey interactions vary across latitude, with predation and herbivory more intense, and prey defenses better developed, in the tropics than in the temperate zone.[4-8] Work by Pennings et al.[9] strongly supported this hypothesis for Atlantic salt marsh communities (ten plant species and 13 herbivore species were studied). Dr. Pennings recently received funding from the National Science Foundation (NSF) to continue his work on geographic variation in marsh plant palatability. The NSF-funded research is focusing on two issues. First, is herbivore pressure greater in southern than in northern Atlantic coast salt marshes? If so, this could provide a selective explanation for the lower palatability of southern plants. Second, do latitudinal differences in palatability persist in a common garden environment? In other words, are they constitutive, as opposed to being induced by variation in the environment? With EIH funding, Pennings is expanding these studies by including comparisons with Gulf coast plants. Most of the Atlantic coast plants that Pennings et al.[9] worked with also occur in salt marshes along the Gulf coast despite striking differences in abiotic regimes. Because the Gulf coast is at roughly the same latitude as the southeastern study sites, basic biogeographic theory would predict that Gulf coast plants will be less palatable to herbivores than New England plants, but will not differ from southeastern plants. If so, this would extend the generality of earlier results.[9] An intriguing alternate hypothesis, however, is that Gulf coast plants will differ in palatability from southeastern plants because of differences in the tidal regime in the two geographic areas. If so, this discovery would open up exciting new avenues for research that are not predicted by existing biogeographic theories.

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Photo courtesy of Gallaway Collection

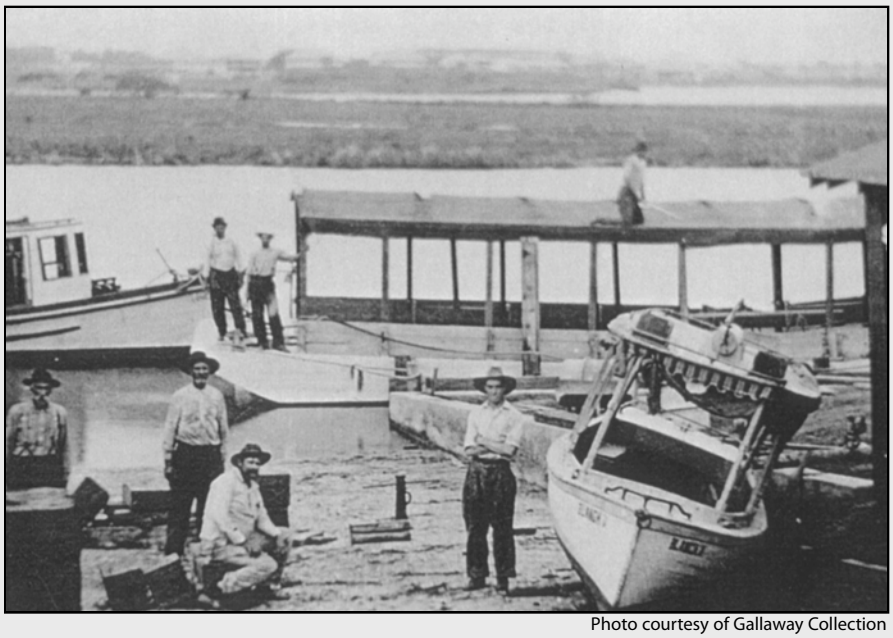

Photo courtesy of Gallaway Collection

Top: Cottages on the Clear Lake shoreline, Seabrook, Texas circa 1910

Above: Derrick boat yard, located where Jimmie Walkers Restaurant is today circa 1910

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"Human Activities and the Dynamics of Coastal Salt Marsh Vegetation." University of Houston Coastal Center, $7,195.

"Latitudinal Differences in Plant-Herbivore Interactions in Europe." National Geographic Society, $ 16,500; *pending*.

Ribosomal DNA variation in *Porites* spp.; The Relationship Between the Texas Flower Garden Banks National Marine Sanctuary and the Caribbean Province

Gerard M. Wellington, Ph.D., Professor, and Zac Forsman, Research Assistant, Department of Biology and Biochemistry, University of Houston

We are examining the geographic variability of the nuclear ribosomal Internally Transcribed Spacers (ITS region) of *Porites* that occur in the Texas Flower Garden Banks National Marine Sanctuary (FGBNMS). Evaluation of the potential long-term effects of chronic disturbance or global change, requires an understanding of population dynamics. Little is known about the relationship of the Texas Gulf Coast corals to the greater Caribbean province. If FGBNMS is an isolated population, it is less likely to recover from disturbance. This information is particularly germane to the Gulf of Mexico, given the heavy industrial usage in the form of transportation and processing of hydrocarbons in close proximity to the National Marine Sanctuary. The data derived from this study will also be combined with a Pacific data set, providing a rare opportunity to calibrate rates of molecular divergence with the well documented closure of the American Seaway 3 MYA (*Porites* is the most commonly occurring genus present on both sides of the Isthmus).

Preliminary data indicates that there are consistent fixed differences between species, and strong geographic patterns within species. The molecular clones from Flower Gardens individuals are on average slightly more similar to those from individuals in Belize than to individuals from Panama or Brazil (see Fig. 1). Interestingly, *P. astreoides* contains two clades; one clade contains individuals from the Texas Flower Gardens, Belize, and Brazil, while another contains individuals only from Panama and Brazil. This may result from cryptic species occurring within *P. astreoides*, or from a sampling effect of an ITS allele that occurs at markedly different frequencies in some individuals. Geographic patterns consis-

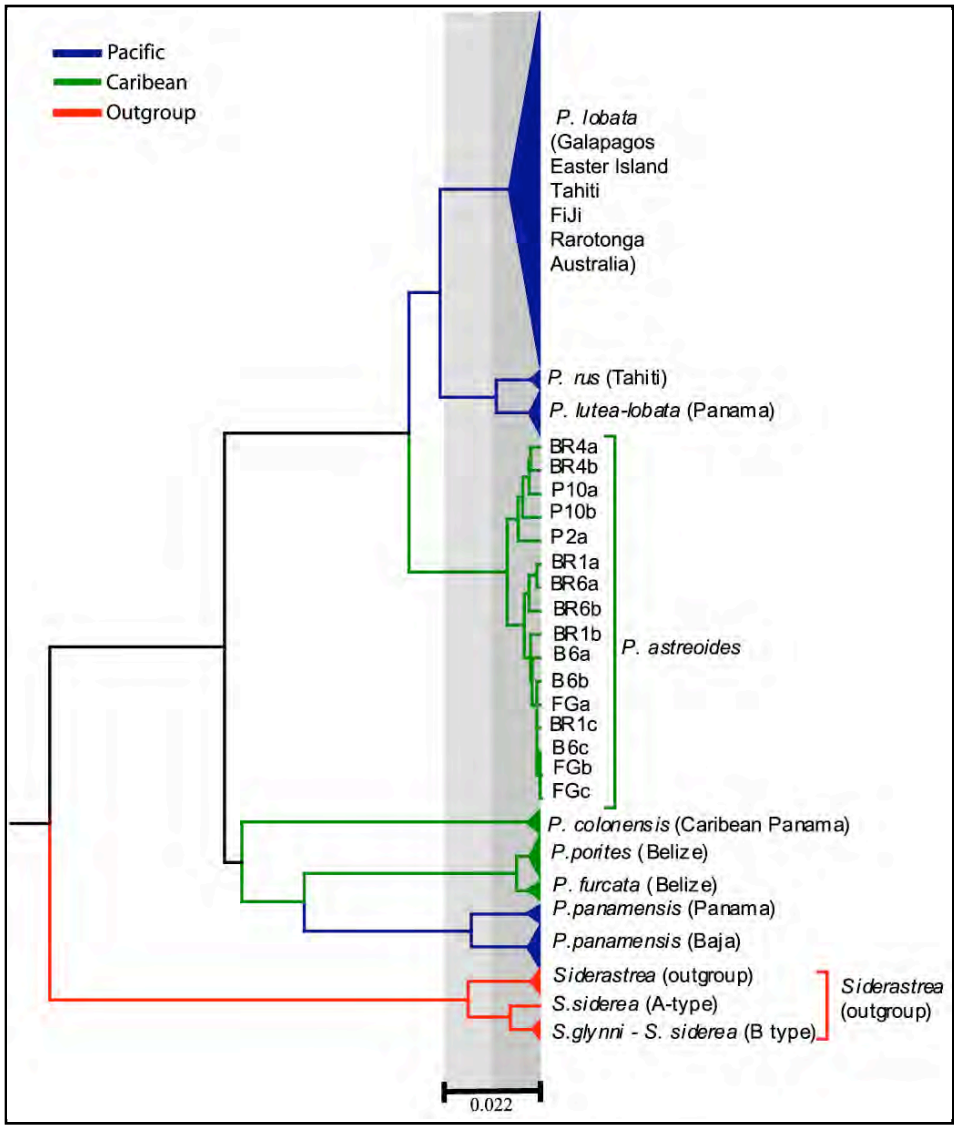

Figure 1. Uncorrected UPGMA cladogram of the ITS region of *Porites* species. Values above nodes indicate bootstrap values, triangle width is proportional to the number of taxa sampled, triangle depth is proportional to the variability within a species. BR = Brazil, P = Panama, FG = Texas Flower Gardens, B = Belize. The scale at the bottom indicates percent of nucleotide changes. Grey boxes represent expected change in about three million years (the estimated closure of the Isthmus of Panama), based on previously published rate estimates. The dark gray box is based on estimates from birch trees,[1] and the light gray box is based on estimates from the family Cucerbacea.[2]

tent with isolation by distance are also evident in *P. lobata*. Preliminary data also indicates that there are significant correlations between morphology, and genetic differences, within and among species (data not shown). These patterns indicate that the ITS region reflects differences between species and between geographic regions within species.

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Investigating the Relationship Among Water Quality Parameters in Dissolved Oxygen Impaired and Non-Oxygen Impaired Bayous

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WATER QUALITY IN THE BAYOUS OF the Houston-Galveston area is a major concern to variety of constituencies. Persons who use the bayous for recreation and fishing are concerned about the safety of the waters. Concern is generated at the State and Federal levels when bayous fail to meet the standards set forth in the federal Clean Rivers Act. Some local bayous have "impaired waters" and, thus, have been listed on the federal Clean Rivers 303 (d) list. Of the three bayous selected for this study, Halls, Armand and Double, Armand is currently on the 303 (d) list for low dissolved oxygen in the above tidal zone.

The purpose of the study was to investigate the relationships among the parameters of temperature, nutrient levels, chlorophyll-a and dissolved oxygen. Each bayou was sampled monthly from May through August for eight water quality parameters at eight sites in each bayou. The data were analyzed by examining correlations among the parameters. Interestingly, no significant, positive correlations were found among the four parameters of interest; nutrient levels, chlorophyll-a, temperature and dissolved oxygen (D.O.). Increases in nutrient levels were not accompanied by increases in chlorophyll-a levels. Thus, the traditional view of nutrient loads increasing as rainfall carries fertilizer and other land based nutrients into the bayous was not supported by the results of the study. The study also focused on the relationship between temperature and dissolved oxygen levels. The traditional view of this relationship, that as waters warm, oxygen will be lost to the atmosphere was again, not supported by the data.

The study also gathered flow rate data from each of the three bayous. Dye was placed in the water at maximum low tide and the rate of downstream movement was recorded. Average flow rates for the three bayous ranged from .176 ft/sec in Halls Bayou to .233 ft/sec in Double Bayou. Armand flow rate averaged .214 ft/sec. Further investigations are needed to determine the role that low flow rate has in water quality.

Clearly, commonly held views of the relationships among nutrient levels, chlorophyll-a, temperature and dissolved oxygen that have been generally accepted do not apply to the slow-moving waters of bayous. Bayous appear to be more complex in their behavior than commonly thought. Studies that focus on understanding the nature of bayous, rather than continued monitoring of bayous, could provide a foundation for better understanding the water quality issues of bayous.

Aspects of the Natural History of the Rio Grande Chirping Frog *Eleutherodactylus cystignathoides* (Anura: Leptodactylidae)

Dan Wells, Ph.D., Professor, and Wendy Stephenson, Graduate Student, Department of Biology and Biochemistry, University of Houston

An amphibian population can be used as a general indicator of the environmental health of an ecosystem. Amphibians inhabit both aquatic and terrestrial environments and possess a heavily vascularized skin that serves as a respiratory organ. The skin is permeable to water making amphibians particularly sensitive to desiccation and toxic substances. Amphibian egg and larval stages are particularly susceptible to chemical pollutants, which may result in developmental abnormalities.[1] A decline in amphibian populations due to deterioration in environmental quality can also affect other organisms within a community. Amphibians are both top carnivores and prey; they are intertwined in a food web with populations of invertebrates, fish, birds, mammals, and reptiles.[1,2]

The life history strategy of direct development, meaning complete development inside the egg without a tadpole stage, is common in several taxa of tropical and subtropical amphibians.[3] In the order Anura, direct development is thought to have evolved independently in several occasions. Little is known about the changes and processes that have led to the evolution of direct development.[4-11]

The Rio Grande chirping frog, *Eleutherodactylus cystignathoides*, is native to Mexico and South Texas, with two introduced populations in the Houston and San Antonio areas. This direct developing frog belongs to the family Leptodactylidae. The Rio Grande chirping frog is a completely terrestrial species, depositing its eggs on loose, humid soil. The species hatches as a small froglet and grows into an adult frog. The Rio Grande chirping frog can be found in its native range within habitats consisting of palm groves, thickets, ditches, and resacas. In urban environments, such as Houston and San Antonio, this frog appears on lawns, in flower beds, and in gutters; especially if these areas are watered frequently.[12]

Table 1. 2002 call survey for *Eleutherodactylus cystignathoides*. List of counties visited in Texas.

Texas counties with *E. cystignathoides* present		Texas counties without *E. cystignathoides* present	
Austin	Harris	Angelina	Lavaca
Bexar	Jefferson	Caldwell	Madison
Brazoria	Liberty	Calhoun	Matagorda
Colorado	Montgomery	Fayette	Newton
Comal	Orange	Gonzalas	Polk
Fort Bend	Walker	Hardin	San Jacinto
Galveston	Waller	Hays	Travis
Guadalupe		Jackson	Victoria
		Jasper	Williamson

The object of this study was to gather and record natural history attributes for this species. To investigate the expansion of the range of *E. cystignathoides* around Houston and San Antonio, a call survey was done during the summer of 2002 (see Table 1). To investigate the diet of *E. cystignathoides*, frogs were caught in the wild, sacrificed, and dissected. Stomach contents were identified to the lowest practical taxonomic level.

Call surveys were performed the months of June and July 2002. The largest urban areas in counties surrounding Harris County (Houston area) and Bexar County (San Antonio area) were visited in the nighttime hours between 10 p.m. and 2 a.m. The distinct call of the Rio Grande chirping frog was listened for in areas containing lawns and ground cover that appeared to be watered on a regular basis. If no calls were heard, a second location was visited within the area. A total of three areas within one urban area, within one county were visited.

A total of 22 frogs were captured from three locations in the city of Houston. All stomachs were dissected. The summary of stomach contents included organisms from the taxonomic classes Insecta, Arachnida, and Cheliceramorpha. More work will be done to classify these organisms to lower taxonomic levels.

There is clearly room for more study to be done on the natural history of *E. cystignathoides*. A future study may include the estimation of the Rio Grande chirping frog population in one community. This could lead to the use of the Rio Grande chirping frog as an environmental health indicator for that community.

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Photo courtesy of Gallaway Collection

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Development of Bacterial-Based Biosensors for Detection of Environmental Contaminants

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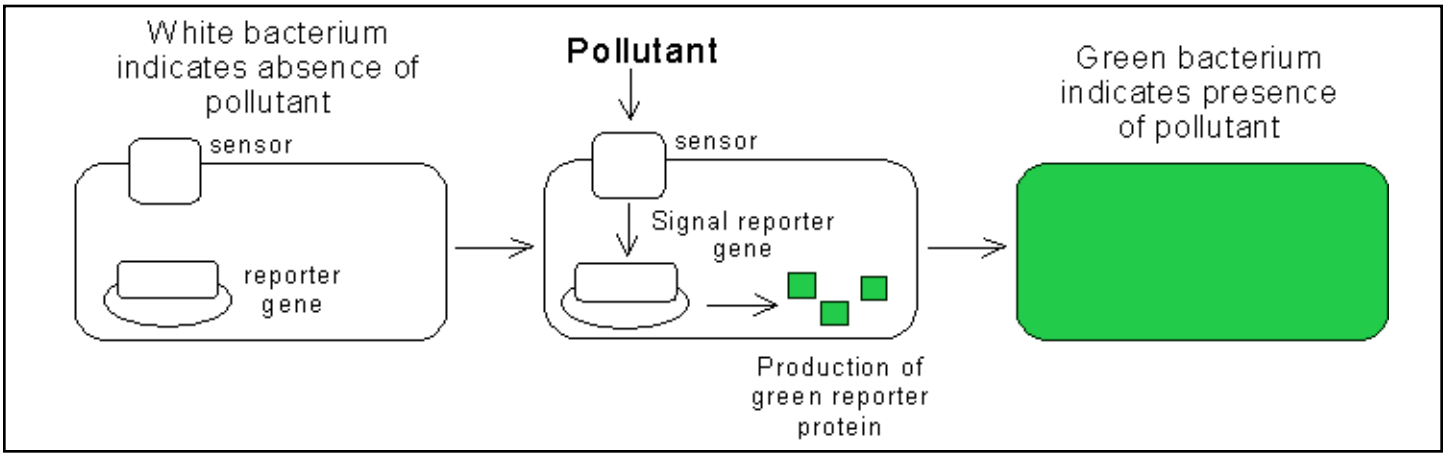

Figure 1. Schematic of bacterial-based biosensors.

Restoration of contaminated environments requires the rapid and sensitive detection of the responsible pollutant.[1-4] Detection of the source of contamination is a critical step in preventing further pollution of outlying ecosystems in close proximity to the polluted site. A very powerful approach for the detection of environmental contaminants is the development of biosensors[5,6]—bacteria that can sense and respond to the presence of specific pollutants. We have undertaken investigations to generate sensitive, renewable, and inexpensive biosensors by engineering bacteria that can biodegrade environmental pollutants.

Sensitive identification of pollutants is critical for rapid and effective decontamination of affected sites. This is especially important in cases, such as oil spills, where the prevention of pollution spread is critical for preventing damaging to nearby habitats. Often, the detection of contaminants can require special equipment, and may be a slow painstaking process. Sensors are devices that must be able to carry out two tasks (Fig. 1): (a) *detection* of a specific substance, and then, (b) *reporting* the presence of the substance.[5,6]

The overall objective of our research has been to develop biosensors for detection of environmental contaminants. We utilize existing bacterial strains that are able to "sense" and "respond" to environmental contaminants. These strains normally respond by expressing genes encoding proteins that specifically biodegrade the contaminant.

We are using a novel strategy to replace the biodegradation genes with genes encoding proteins that would turn the bacterium an easily recognizable color (green) for "reporting" the presence of the compound. All bacterial genes are regulated by genetic elements called *promoters*, which are turned "on" and "off" in response to specific environmental cues. We are working to identify specific bacterial promoters, that "turn on" gene expression in the presence of specific environmental pollutants. These promoters are being engineered to drive the expression of reporter genes that will indicate the presence of the pollutant.

To test the efficacy of this approach, we are using a bacterial species of *Pseudomonas* that is genetically tractable, and has been shown to be highly efficient at degrading pentachlorophenol (PCP) in the environment.[7] PCP is widely found in all areas of the United States, and has been designated as a toxic chemical pollutant by the priority pollutant protocol of the United States Environmental Protection Agency. While a number of bacterium and fungi have been reported to degrade PCP to some extent, *Pseudomonas* Sp. Bu34 has been found to be much more efficient at degrading high concentrations of PCP. We are using *Pseudomonas* Sp. Bu34 (Bu34) as the initial model system for identifying genes upregulated by promoters responsive to the presence of PCP.

This research is significant in that it represents a significant departure from current approaches for studying restoration of contaminated environments. Importantly, because the bacteria serve as the biosensors themselves, and are isolated from the environment, the use of cell-based biosensors presents a safe, inexpensive, and ultimately renewable strategy, with the potential to be applied for the detection of many environmental contaminants.

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"Blocking Cellular Intoxication by Bacterial Toxins." National Institutes of Health, 2002-2004, $442,500.

"Combinatorial Approaches to Probe Molecular Discrimination in Enzyme Catalysis." Welch Foundation, 1999-2002, $135,000.

"Molecular Mechanisms of the *Helicobacter pylori* Vacuolating Toxin." NIH, 2000-2005, $953,525.

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Top: St. Mary's Seminary, La Porte circa 1910—Bishop Nicholas A. Gallagher founded St. Mary's Seminary in the fall of 1901 at the site of the former Sylvan Beach Hotel, which had been heavily damaged in the 1900 hurricane. The chapel continues to serve the members of St. Mary's Parish in La Porte, Texas.

Above: Businesses such as the League City Herald and the Old Palace Livery in downtown League City, Texas, circa early 1900s, were a part of the fast growing cities along the G. H. & H. Railway.

Mathematical Analysis of Atmospheric Pollution Models

William E. Fitzgibbon, Ph.D., Professor, and Andrey Martynenko, Graduate Student, Department of Mathematics, University of Houston

Under the federal Clean Air Act of 1970 (amended in 1990) the federal government established standards (known as the National Ambient Air Quality Standards, NAAQS) for six air pollutants: ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter, and lead. Ozone is the only substance for which the greater Houston-Galveston area fails to meet NAAQS. Regretfully, the local situation regarding high levels of troposphere ozone concentrations has become recognized as the nation's worst. Although ozone has not been shown to be carcinogenic, recent epidemiological studies have suggested a statistically significant increase in mortality associated with heightened levels of ozone in the troposphere. Exposure to ozone can cause or aggravate various respiratory symptoms. It can impair the body's immune system and lead to scarring and premature aging of the respiratory system. Exposure to high levels of ozone concentration in conjunction with other air pollutants and allergens may be responsible for the recently documented increase of reported cases (and deaths from) of asthma.

We have been involved with models that describe the production and distribution of ozone. Because industrial activity and transportation can release large amounts of gases and particulate matter contributing to atmospheric pollution, the issue is important from the economic viewpoint as well as viewpoint of public health and environmental quality. Mathematical modeling of the production and dispersion of pollutants has statutory importance as well. The Clean Air Act requires computer modeling to plan air pollution reduction. The computer models rely upon simulations based upon the computation of solutions to complex systems of partial differential equations to simulate emissions, air movement, chemical reactions, and resultant ozone concentrations.

The basic mathematical equations describing the atmospheric production and distribution of ozone and other pollutants are a coupled system of reaction advection diffusion equations having the form,

$$\partial\varphi_K/\partial t + \nabla\bullet(\omega\varphi_K) = \nabla(D\nabla\varphi_K) + f_k(\varphi) + g_k. \qquad (1)$$

The state variables $\{\phi_1,\ldots,\phi_n\}$, (n can be quite large) represent time dependent concentrations of chemical species, i.e., ozone, oxygen, carbon monoxide, carbon dioxide, nitrogen dioxide, nitrous oxide, sulfur dioxide, volatile organic compounds, etc. This system incorporates a variety of processes such as chemical reactions, emission, condensation processes as well as transport and thermal and turbulent diffusion.

Both analytical and computational work has been supported by this grant. Despite the importance of the simulations, the computational methods and numerical algorithms used reflect the state of the art in the 1970s not the current state of the art. The underlying mathematical theory is yet to be understood.

We have been concerned with the mathematical analysis and approximation of models the photochemical production and atmospheric dispersion of ozone pollutants. The reaction diffusion advection systems present formidable analytic challenges. The first problem becomes that of introducing appropriate boundary conditions that will not destabilize the system. One may visualize the process as taking place in a three dimensional region with a top and a bottom. Appropriate boundary conditions for top of the region are reasonably well understood.

The first question concerned the basic wellposedness. Although mathematical modeling can produce complicated systems of differential equations to describe physical phenomena, the modeling process does not guarantee that the system of equations can indeed be solved. Computer simulations solve approximations of these equations. For example, the Navier Stokes equations were first formulated in the late 19th century. Although they have been routinely used to describe fluid flow since that time, their basic wellposedness remains an open problem. In this regard we have been able to demonstrate the fundamental mathematical wellposedness for a large class of air quality models. Resolution of questions of wellposedness can have important side consequences.

In the case at hand we have shown that quantities, which are non-negative physically such as a concentration of a chemical species, are mathematically guaranteed to be non-negative by the equations describing the process. Current state of the art computations of solutions have been known to introduce unreasonable growth in some of the state variables. In the course of our work we have been able to produce a priori estimates upon solutions. These estimates support the notion that the observed growth results from numerical artifact rather than from underlying analytical problems. Our wellposedness work required the specification of mathematically correct lateral boundary conditions. These boundary conditions are consistent with the manner in which data is measured.

We have been developing general iterative schemes that approximate strong solutions with systems of linear equations. Here we shall not only attempt to demonstrate the convergence of the schemes but to determine a priori rates of convergence. We have also been ascertaining the qualitative effects of photochemistry on model systems. These have been introduced via time dependence reflecting the diurnal cycle in the reaction rates of the kinetic terms of our equations.

Our work has and continues to involve computations. It concerned the development and implementation of implicit upwind methods for solving convection-diffusion equations in rectangular domains with three-dimensional local refinement in space. Air quality models are coupled sys-

tems of semilinear parabolic reaction diffusion convection equations. Typically such systems are solved numerically by splitting the equations into linear convection diffusion and nonlinear ODE for the chemical kinetics and solving them successively after discretization.

Efficient solvers based on splitting (ADI) methods can be used for the linear convection diffusion equations in the case of rectangular spatial domains. However, ADI methods preclude local mesh refinements. The ADI approach has low accuracy and is not applicable for nondiagonal diffusion. Non-ADI solvers need to be constructed. The nonlinear equations are a coupled system with a very high degree of stiffness needing to be solved at each point of the grid. These calculations are computationally very expensive consuming a major portion of CPU time. It is therefore important to decrease the number of computational time by reducing grid points in subregions where the concentration of pollutants is insignificant and to increase the accuracy of discretization algorithms. Local refinement techniques are well suited to air quality simulation because regional air quality models include sub domains having small concentrations of certain chemical species and other areas with sources and high concentrations. Of course local refinement methods are well known in the literature in the case of two dimensions. The challenge is to produce accurate and efficient three-dimensional results.

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Photoionization of Tetraphenylporphyrin in Mesoporous *Si*MCM-48, *Al*MCM-48, and *Ti*MCM-48 Molecular Sieves

Larry Kevan, Ph.D., Professor (deceased), and Zhixiang Chang, Graduate Student, Department of Chemistry, University of Houston

THE IMPORTANCE OF PHOTOINDUCED electron transfer reactions in nature have lead many researchers to look for ways to study these processes. A significant part of this effort has been devoted to the study of photoinduced charge separation reactions as a means of capturing and storing solar energy. The goal of this research is to design artificial systems for the conversion of solar energy into chemical potential energy. A vital part of this research is the design and synthesis of complex molecular systems which are comprised of electron donors and acceptors that mimic the charge separation function of photosynthetic proteins. Porphyrin derivatives have been used as photosensitive electron donors due to their structural and functional similarities to chlorophylls and their absorption of visible light.

Many different host systems have been studied to improve the efficiency of energy storage by preventing rapid back electron transfer. The net photoionization efficiency in organic assemblies is typically higher than that in homogeneous solution, but the photoinduced radicals are not typically stable at room temperature. However, photoionization studies in porous inorganic materials such as molecular sieves and silica gels have shown that their pores and channels provide an appropriate microenvironment to retard back electron transfer and increase the lifetime of the photogenerated radical ions, which can even be stable at room temperature.

Amorphous silica gel has an irregular pore structure with no long-range order and a wide pore size distribution compared to molecular sieves. Therefore, the development of ordered mesoporous silica molecular sieves (M41S) materials containing some transition metal ions in the pore walls has opened new possibilities for the use of mesoporous materials in the fields of photochemical solar energy conversion and of catalysis. M41S materials have large channels with regular pores which can be varied from 2 to 10 nm or more and which are ordered in hexagonal (MCM-41), cubic (MCM-48), or lamellar (MCM-50) arrays. These materials are characterized by quite narrow pore size distributions in the mesoporous region, long range order, high surface area, and thermal stability after removal of the organic template typically used in synthesis. Less research has been carried out on MCM-48, probably due to the difficulty of its reliable synthesis compared with the extensively studied MCM-41.

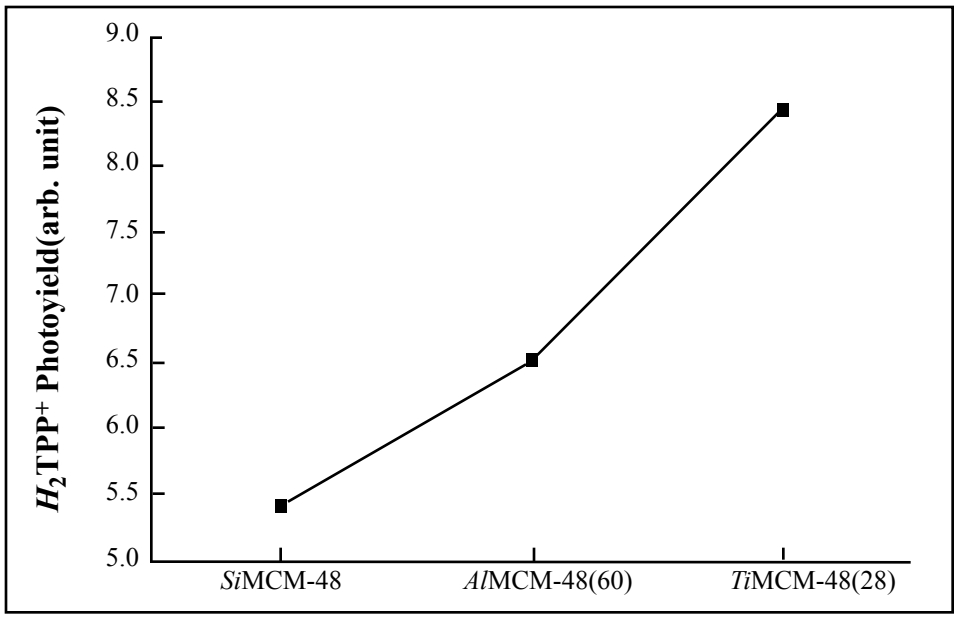

Figure 1. Increase of ESR intensities of H_2TPP^+ radical at room temperature vs 350 nm irradiation for *Si*MCM-48, *Al*MCM-48(60), and *Ti*MCM-48(28).

In this research, a series of mesoporous *Si*MCM-48, *Al*MCM-48 and *Ti*MCM-48 molecular sieves have been synthesized and used as heterogeneous hosts for photoinduced electron transfer from bulky meso-tetraphenylporphyrin (H_2TPP). The photoionization of H_2TPP in these mesoporous materials is achieved with photoirradiation at 350 nm at room temperature, and photoinduced H_2TPP^+ cation radical is characterized by electron spin resonance (ESR). The associated photoproduced electron is presumably trapped in the framework of siliceous MCM-48 but is not separately detectable by ESR. Incorporation of *Ti*(lV) and *Al*(III) into the MCM-48 framework enhances the electron-accepting ability of the framework.

The photoionization of bulky H_2TPP in MCM-48 mesoporous molecular sieves at room temperature increases in the order *Ti*MCM-48 > *Al*MCM-48 > *Si*MCM-48, indicating that the photoionization efficiency via electron transfer depends on the type of metal ion (Fig. 1). *Al*MCM-48 has a higher H_2TPP^+ photoyield than does *Si*MCM48 probably because the negatively charged *Al*MCM-48 framework enhances the reactivity of H_2TPP and acidic sites in *Al*MCM-48 are better electron acceptors than the terminal *Si-OH* hydroxyl groups in *Si*MCM-48. It seems that the *Ti*(IV) sites in *Ti*MCM48 framework most enhance the electron-accepting

ability of the framework probably by reduction to *Ti*(III). Mesoporous MCM-48 molecular sieves are shown to be promising heterogeneous hosts for long-lived photoinduced charge separation of incorporated meso-tetraphenylporphyrin.

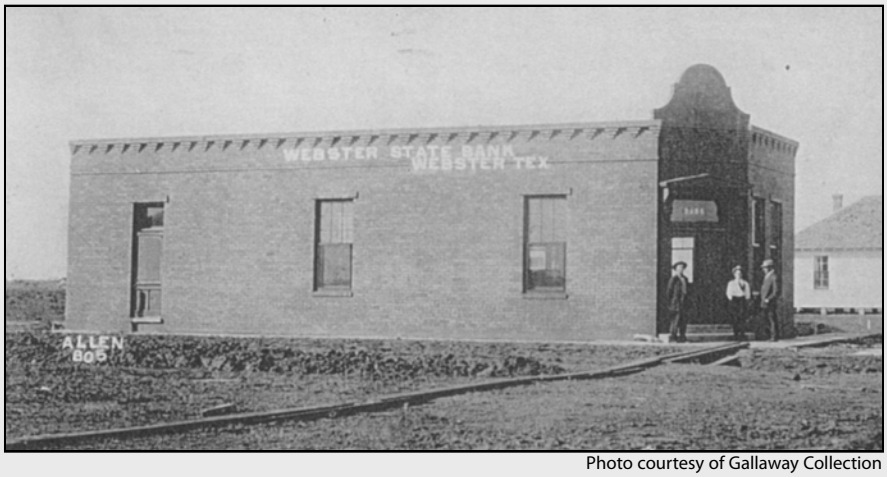

Photo courtesy of Gallaway Collection

Webster State Bank, Webster, Texas circa 1908

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New Open-Framework Metal-Organic Polymers For Pollution Control and Prevention

Jack Y. Lu, Ph.D., Assistant Professor, and Vaughn Schauss, Research Assistant, Department of Chemistry, University of Houston-Clear Lake

RESEARCH ACTIVITIES IN OUR LABORATORY produced numerous new porous materials for potential environmental applications. Further research on their applications is in progress.

$\{[Cu_2(IN)_3]\cdot I_5^{-\cdot 5/6}I_2\cdot H_2O\}_\infty$ (IN: isonicotinato) is an unusual polyiodide inclusion metal-organic polymer with a novel 3-D nano hollow-channel open-framework (Fig. 1) synthesized via an oxidation reaction route under hydrothermal conditions. The diameter of the channel is about 1.15 nm, slightly smaller than that of carbon nanotubes (~1.4 nm). While the hollow-channel metal-organic open-framework is unique and unprecedented, the open metal-organic framework structure may have potential applications after the removal of the polyiodide template.

$[(Cu_2I)(NC_6H_4O_2)_2]$ is a fascinating open-framework (see Fig. 2) mutual-face insertion layered polymer with mixed *Cu*(I)-*Cu*(II) oxidation states. This mutual-face-insertion double-layer arrangement results in a large amount of empty space in the van der Waals gap between adjacent double layers (Fig. 3) and it displays attractive intercalation properties. This material has black lustrous surface and is stable up to 300°C.

$[(H_2O)_2M(N_2C_{10}H_8)(N_2C_{12}H_{10})_2]\cdot 1.6(N_2C_{12}H_{10})\cdot 0.4(N_2C_{10}H_8)\cdot 2NO_3\cdot xH_2O$ (M = *Ni*, *Co*; x = 2.65, 2.40) has a novel mixed-ligand network structure with large channels filled by solvents and anions. This material is acentric and represents the first mixed-ligand and mixed bonding guest-containing rectangular grid open-framework. The *Ni*-*Ni* separation in the rectangular grid is about 11.20 × 12.80.

$[CuI(C_5H_3NI_2)\cdot 1/2I_2]$ is a novel inclusion 3-D metal-organic open-framework compound (Fig. 4) synthesized from a simultaneous reduction, substitution and self-assembly chemical process under hydrothermal conditions.

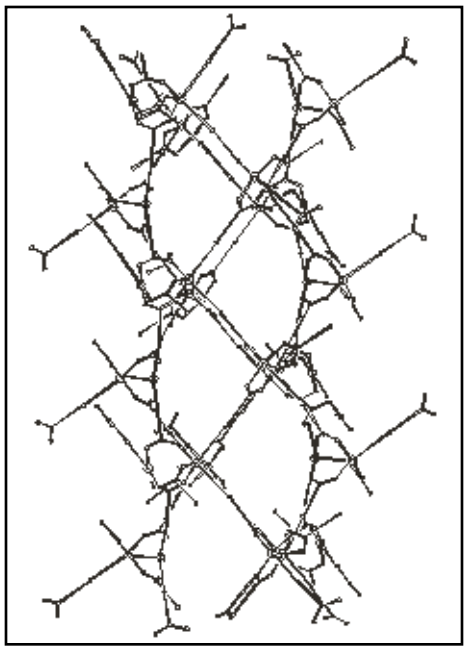

Figure 1. View of the open-channel network. Isonicotinato units are represented by lines for clarity.

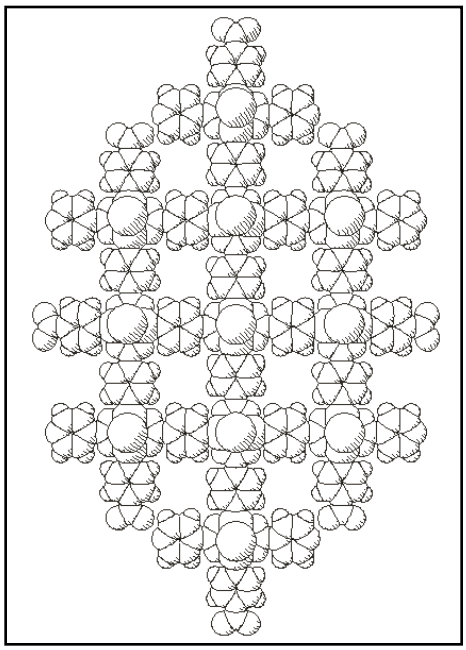

Figure 2. Space-filling view of the open-framework of a single layer with iodine atoms shown as large spheres.

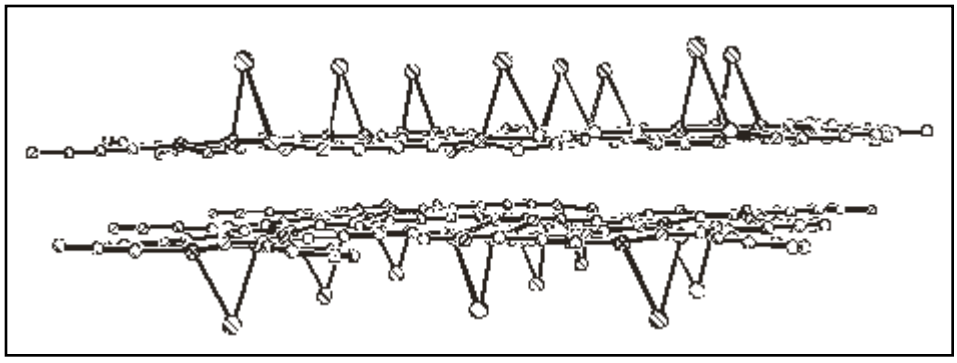

Figure 3. View of back-to-back stacking of the layers in the structure.

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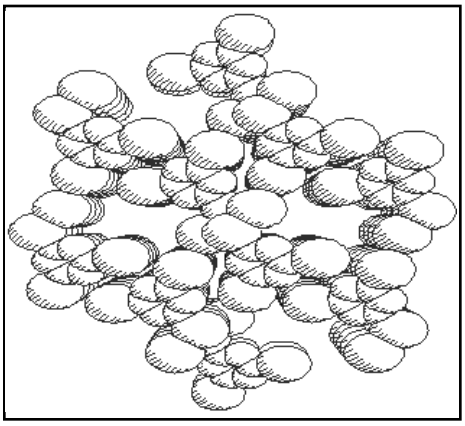

Figure 4. A space-filling view of the 3-D structure with open channels down to the a axis.

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Photo courtesy of Gallaway Collection

Oleander Country Club and Golf Course on Dickinson Bayou circa 1902

NO_x Destruction in a Reverse Flow Reactor

Dan Luss, Ph.D., Professor, and Y. O. Jeong, Research Associate, Department of Chemical Engineering, University of Houston

The destruction of NO_x is accomplished by Selective Catalytic Reduction (SCR). In that process the NO_x is destroyed by a catalytic reaction with ammonia. The regulated restriction on the emission of ammonia are more restrictive than those on NO_x. Thus, to minimize ammonia emission it is desirable to use a catalyst which strongly adsorbs ammonia and traps it within the bed and to operate with a slight deficiency of ammonia over that need for total conversion. This "chromatographic" operation minimizes the ammonia emission and provides an efficient and rapid response to any perturbation in the NO_x feed rate or concentration.[1-3]

We conducted a study on the use of a reverse-flow chromatographic reactor (RFCR) for the destruction of NO_x, which is a packed reactor in which the flow direction is reversed periodically. We found that the RFCR operation enables a reduction of the NO_x and ammonia emissions well below the minimum attainable under a steady-state operation of the same packed-bed reactor. We have conducted also a parametric study which determined the impact of the use of ammonia deficiency and of the ratio between the regulated maximum emission of ammonia and NO_x on the operation. In addition, we developed a methodology for determining the optimal operation conditions for a specific feed and levels of regulated maximal allowable emissions.

We have studied the influence of a non-uniform rate of introducing the ammonia to the bed. We found that the most efficient method was to feed ammonia at a constant rate to the bed. If a non-constant mode of operation is used, then it is advantageous to introduce the ammonia before the reversal in the flow direction rather than right after the reversal in the flow direction.

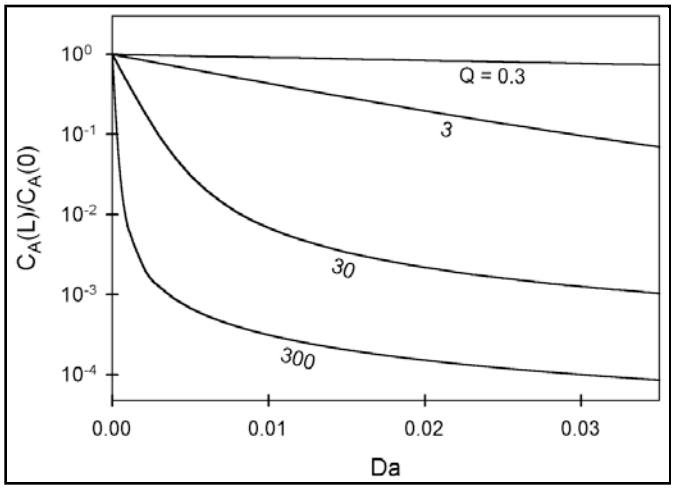

Figure 1. Influence of the catalyst adsorption capacity (Q) and the Damkohler number (linear function of the reactor length) on the reduction in the NO_x effluent concentration from a packed bed reactor.

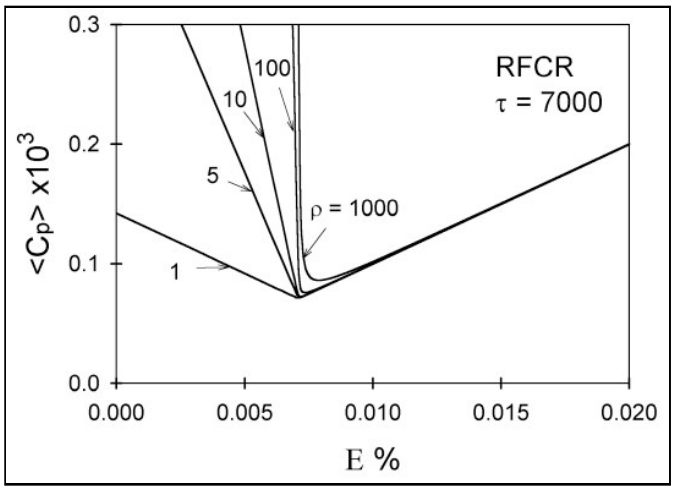

Figure 2. Dependence of the time average weighted effluent concentration (<Cp> = <NO_x + rNH_3>) on the deficiency in the feed rate of ammonia E and the ratio r between the allowable emission of NO_x to that of NH_3.

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Automated Wastewater Flow Control Using Neural Networks

Nicolaos B. Karayiannis, Ph.D., Associate Professor, Department of Electrical and Computer Engineering; Heidar A. Malki, Ph.D., Associate Professor; Shayan Mirabi, Research Assistant, Department of Engineering Technology; and N. K. Murthy, Research Assistant, Department of Electrical and Computer Engineering, University of Houston

IN THIS PILOT PROJECT WE DEVELOPED an automated system to control and regulate wastewater flow into the Clinton Drive Wastewater Treatment Plant, which is maintained and operated by the City of Houston. A key feature of the system is its capacity to make decisions regarding pump openings and closings by relying on past data, which include the wastewater level, the pump status, date and time. The proposed approach relied on an artificial neural network, which was trained using past data to determine the status of the pumps for the Clinton Lift Station.

The Clinton Plant controls the incoming wastewater flow through 14 pumps with different capacities. The pumps are typically controlled by operators, who make decisions based on their past experience regarding the water level in the receiving tank and the corresponding pump(s) necessary to keep the water level at preset thresholds according to the weather and rain patterns. The operators typically activate/deactivate a series of pumps based on his/her experience by taking into account the weather conditions, the time of year, and protocols established by the plant's operational procedures. The overall objective of this project is to provide the operators with information on which pumps need to be on or off based on the water level in the receiving tank.

Figure 1 shows a feed-forward neural network with one hidden layer, which was used in this project. There are sixteen inputs: two of them represent the average wastewater level over an hour and two hours and the remaining fourteen inputs represent the status of the pumps (0: pump off and 1: pump on). The output layer has fourteen neurons representing the desired status of each fourteen pumps. The output can be converted to command-signals through hardware interface that direct the operation of the pumps. Alternatively, the output can be used to assist the operators by providing recommendations as to which pumps should be active/inactive. The data were provided by the Department of Public Works and Engineering of the City of Houston and span a period from June 2001 to August 2002 (the most recent data were received three weeks ago). The data from June 2001 to November 2001 were used to train the neural network while the data from January 2002 to April 2002 were used to test the trained neural network.

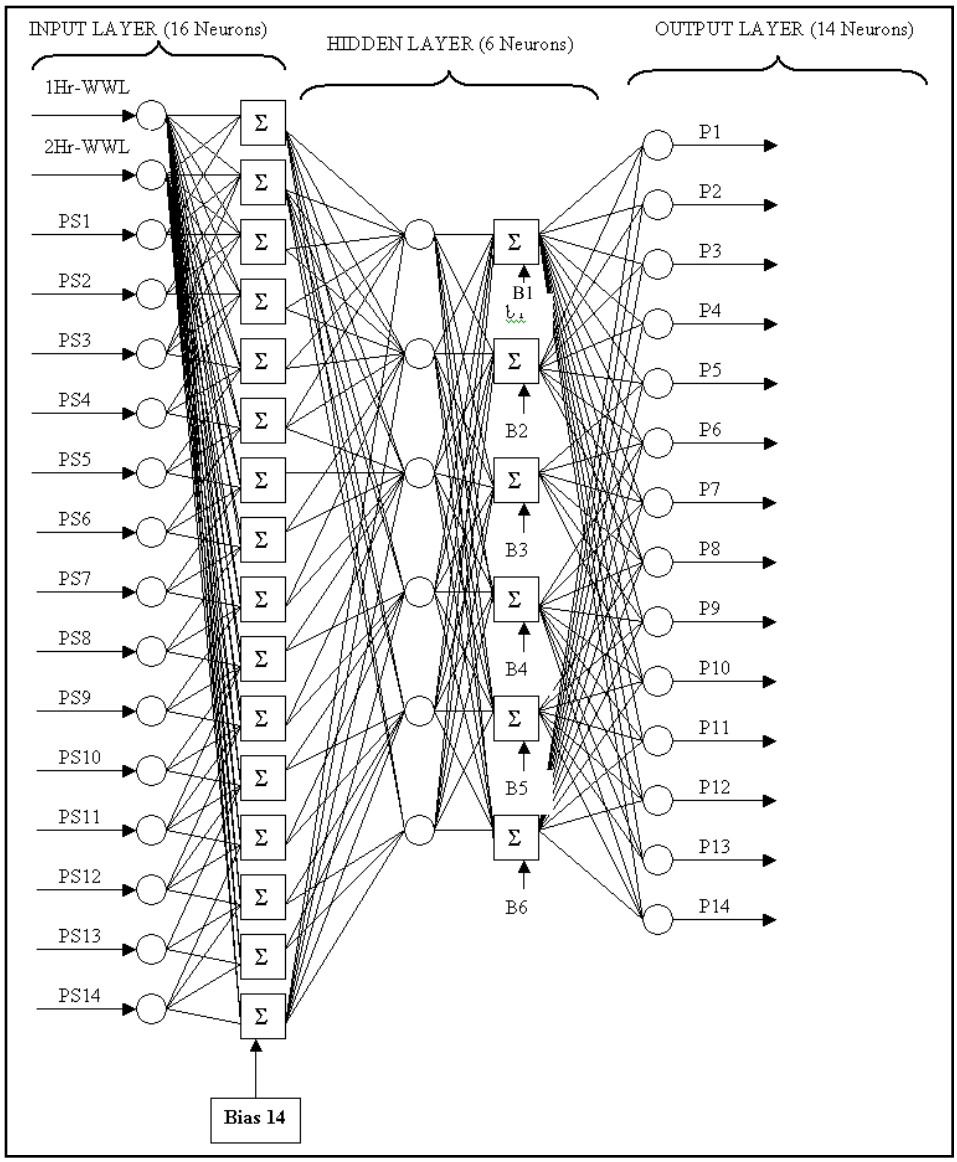

Figure 1. Architecture of the feed-forward neural network trained in this project. PS1-PS14 represent the status of the pumps and P1-P14 represent the desired status of the pumps.

According to our preliminary results, the system developed in this project can provide a valuable tool for determining the status of the pumps at the Clinton Lift Station. Figure 2 shows the results obtained for the status of one of the 14 pumps for the first 120 samples of operation. Figure 2(a) shows the actual pump status, Fig. 2(b) shows the pump status produced by the trained neural network, and Fig. 2(c) shows the error between the actual pump status and that produced by the neural network. It is apparent from Fig. 2 that it is feasible to train a neural network to mimic the performance of a human operator. Even more importantly, the neural network can be trained to perform decision-making based on past data and not on explicit decision-making rules. Therefore, this approach can be employed toward the automation of decision-making, which will be critical for the City of Houston in cases of emergencies.

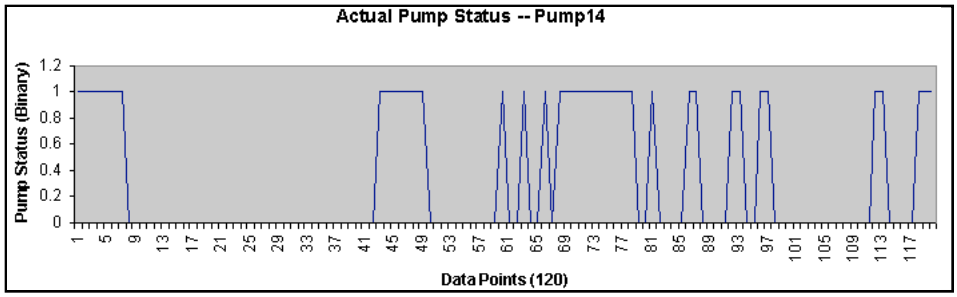

Figure 2(a). Actual pump status for pump 14.

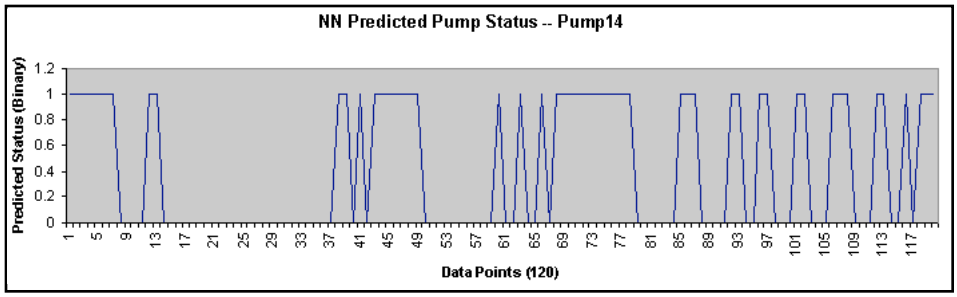

Figure 2(b). Status of pump #14 produced by the trained neural network. Note that 0 corresponds to an output value below 0.5 and 1 corresponds to an output value above 0.5.

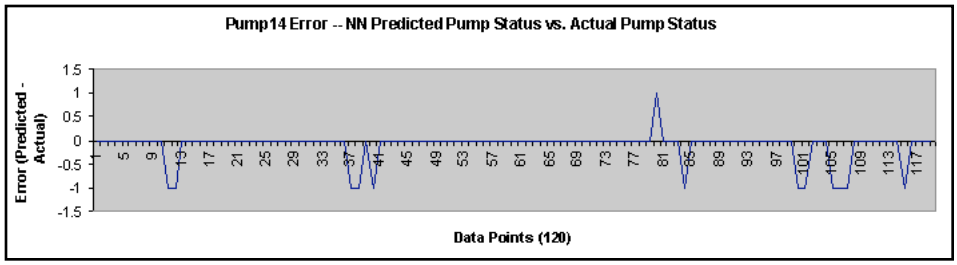

Figure 2(c). The error between the actual pump status and that produced by the trained neural network.

Acknowledgment

The principal investigators would like to thank the Department of Public Works and Engineering of the City of Houston for providing the data and their valuable expertise.

Publications

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Presentations

Karayiannis, N. B. and H. A. Malki. "Application of Neural Networks for Wastewater Treatment," Department of Public Works and Engineering of the City of Houston, Univ. of Houston, Houston, TX, March 12, 2002.

Photo courtesy of Gallaway Collection

Morgans Point, settled in 1835 as New Washington by Colonel James Morgan (1786-1866), became a popular summer haven for wealthy Houstonians who sought refuge from the heat and humidity of the city. The photograph shows visitors enjoying boating and bathing at Cupola Inn circa 1910.

Designing Synthetic Base Fluids to Meet New Environmental Standards Regulating Their Discharge During Oil Drilling Activities in the Gulf of Mexico

Deborah J. Roberts, Ph.D., Associate Professor, David C. Herman, Research Assistant Professor, and Jimena Santalla, Undergraduate Student, Department of Civil and Environmental Engineering, University of Houston

ESTER-BASED ORGANIC COMPOUNDS are one type of synthetic base fluid (SBF) added to drilling mud used during off-shore oil-drilling operations in the Gulf of Mexico. SBF are needed to cool and lubricate the drill bit, and to help bring rock cuttings to the surface. Concern over the environmental impact of SBF-contaminated rock cuttings discharged into the Gulf of Mexico has prompted EPA regulations requiring that all SBF are tested for biodegradability in marine sediment (Federal Registry Vol. 66, No. 111, Friday, June 8, 2001/Rules and Regulations/30807). The EPA has approved the use of the Closed Bottle Test system (Modified ISO 11734) for use in evaluating the destruction of SBF by microorganisms indigenous to marine sediment under anaerobic conditions.

Ester-based compounds are composed of a fatty acid moiety bonded by an ester linkage to an alcohol moiety. Ester-based SBF can vary in terms of composition and size. This study shows that the chemical structure of esters can affect their rate of anaerobic biodegradation, and could possibly affect their ability to be certified for use as a SBF in the Gulf of Mexico. A variety of ester compounds have been tested using the Closed Bottle System to reveal the effect of five structural characteristics on the relative anaerobic biodegradation of ester compounds. The structural characteristics tested are as follows.

1. Increasing the chain length of the acid moiety. Ethyl esters from ethyl octanoate (C8 acidic moiety) to ethyl octadecanoate (C18 acidic moiety) were tested.
2. Increasing the chain length of the alcohol moiety. Esters of octanoate were tested from methyl ester (C1 alcohol moiety) to octyl ester (C8 alcohol moiety).
3. Alternating the relative size of the alcohol and acid moieties. A comparison was made between C12 ester containing a ten carbon alcohol or acidic moiety (ethyl decanoate vs. decyl acetate), and between C20 esters containing an 18 carbon alcohol or acidic moiety (ethyl octadecanoate vs. octadecyl acetate).
4. Branching in the alcohol moiety. C10 esters containing either a branched alcohol moeity (2-ethylhexyl acetate) or an unbranched alcohol moiety (octyl acetate) were compared.
5. The presence of an unsaturated bond in the acidic moiety. Ethyl octadecanoate (C18 saturated acidic moiety) was compared to ethyl oleate (C18 unsaturated acidic moiety).

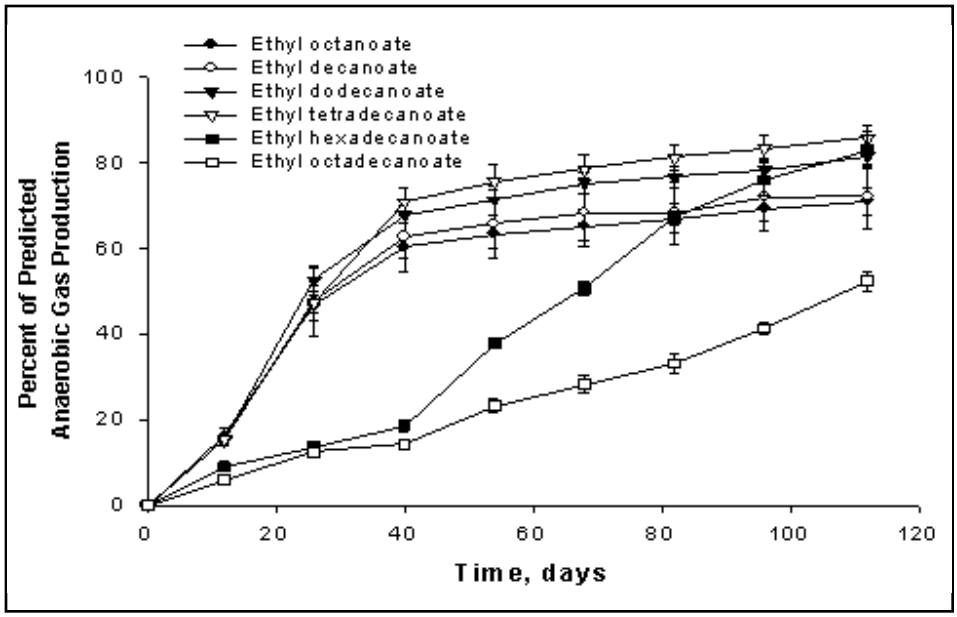

Figure 1. Anaerobic gas production from Galveston Bay sediment spiked with ethyl esters (1000 mg carbon/kg dry sediment) which vary in the length of the acidic moiety. Anaerobic gas production is expressed as the percent of expected gas production calculated using the equations of Symons and Buswell.[1] Each point is the mean anaerobic gas production (± standard deviation) from quadruplicate sediment samples. Anaerobic gas production from ester-spiked sediments are corrected for the gas production from the controls which were not spiked with ester compounds.

Relative biodegradation of ester compounds is determined by comparing the amount of anaerobic gases produced from sediment spiked with the test compound. Typical results are shown in Fig. 1. There was a longer lag period in anaerobic gas production when the acid moiety of the ethyl esters was greater than ethyl tetradecanoate (C14 acidic moiety). Ethyl esters containing a C16 or C18 acidic moiety, namely ethyl hexadecanoate and ethyl octadecanoate, are solids at room temperature, and showed a slower increase in anaerobic gas production compared to the

smaller esters which are liquid at room temperature. Possibly the smaller surface area of crystalline esters limit their bioavailability compared to esters that are liquid at room temperature. GC-FID analysis of sediment extracts revealed that more than 97 percent of each of these esters had been removed from the sediment. Therefore, an incubation period of 120 days or less was required for the complete biodegradation of these ester compounds. An early plateau in anaerobic gas production would indicate that esters from ethyl octanoate to ethyl tetradecanoate may be biodegraded after 60 days, while the larger esters, ethyl hexadecanoate and ethyl octadecanoate required an incubation period closer to 120 days.

Relative biodegradability of esters can also be compared using the rate of anaerobic gas production, which was based on linear regression analysis for the time period with the greatest increased in anaerobic gas production (Table 1). The design features of ester compounds which were found to enhance the rate of anaerobic biodegradation are 1) an acidic moiety chain length less than 14 carbons, 2) an alcohol moiety greater than a methyl group, 3) increasing the length of the alcohol moiety relative to the acidic moiety (for C20 esters), 4) the absence of branching in the alcohol moiety, and 5) the presence of an unsaturated bond in the acid moiety.

Table 1. Summary of results comparing the rate of anaerobic gas production from ester compounds spiked into Galveston Bay sediment.

Objective of Comparison	Ester Compound	Linear Regression Analysis			ANOVA Analysis[3]
		Slope[1]	Stnd Error[2]	r-squared	
Increasing chain length of acidic moiety	Ethyl decanoate	1.70	0.20	0.88	
	Ethyl dodecanoate	1.91	0.16	0.94	
	Ethyl tetradecanoate	1.98	0.09	0.97	
	Ethyl hexadecanoate	0.66	0.07	0.87	Signif[4]
	Ethyl octadecanoate	0.45	0.01	0.97	Signif
	Methyl octanoate	0.90	0.09	0.90	Signif
Increasing chain length of alcohol moiety	Ethyl octanoate	1.58	0.13	0.94	
	Butyl octanoate	2.19	0.20	0.93	
	Hexyl octanoate	1.96	0.15	0.95	
	Octyl octanoate	1.59	0.07	0.98	
Changing the relative size of the alcohol or acidic moiety	Ethyl decanoate	1.70	0.20	0.88	
	Decyl acetate	1.74	0.05	0.99	
	Ethyl octadecanoate	0.42	0.02	0.97	Signif
	Octadecyl acetate	0.70	0.06	0.86	
Branching in alcohol moiety	2-ethylhexyl acetate	-[5]	-	-	Signif
	Octyl acetate	1.50	0.20	0.85	
Unsaturated acidic moiety	Ethyl octadecanoate	0.45	0.01	0.97	Signif
	Ethyl oleate	1.62	0.26	0.80	

[1]Maximum rate of anaerobic gas production, expressed as the percent of expected gas production per day of incubation.
[2]Standard error of the slope.
[3]Statistical analysis of anaerobic gas production using a two way analysis of variance (ANOVA) followed by Tukey's method for multiple comparisons of treatment means.
[4]Significant ($P < 0.05$) lower anaerobic gas production compared to other esters in the test group.
[5]No significant anaerobic gas production detected.

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Funding and proposals

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—. "Degradation of Synthetic-Based Drilling Mud Base Fluids by Gulf of Mexico Sediments." Mineral Management Service, 2002-2004, $291,166.

A Batch Study on the Potential PAH Release from Contaminated Sediment in Houston Ship Channel

Chunlong Zhang, Ph.D., Assistant Professor, Gabriel Zheng, Research Assistant, Gregory Holston, and George Lambert, Department of Environmental Science, University of Houston-Clear Lake

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) represent a group of compounds with two or more fused aromatic rings that are mutagenic, carcinogenic, and teratogenic and are included in the U.S. EPA priority pollutants list. PAHs from various sources are ultimately deposited in sediments, the potential release from contaminated sediment is of concern and important to the remediation, risk assessment, pollution prevention and water quality management. Of particular interest to this study is the sediment in Houston Ship Channel where various sources of PAHs are likely to be profound and frequent waterborne transport may result in secondary pollution of overlying water due to sediment re-suspension and enhanced sediment-to-water mass transfer processes such as diffusion, dissolution, and desorption. Year 1 study of this project focused on the batch test on the adsorption/desorption behaviors in three of the six sediment samples acquired from the Houston-Galveston area (Table 1).

A method for PAH extraction and analysis has been developed based on EPA SW846. Aqueous PAHs were extracted using 3 mL methylene chloride in 10 mL sample, while sediment bound PAHs were extracted using a mixture of hexane and acetone (50:50) with an ultrasonic extractor (three minutes at 15 seconds on/off; 1 g sediment in 5 mL mixed solvent). Samples were analyzed on 5890 GC coupled with 6972 MS detector with a 30 m × 0.32 mm × 1 μm HP-5 capillary column. The oven was held at 35°C for 10 minutes and ramped to 280°C at 12°/min. The MSD was run in SIM mode using 128, 178, and 202 as the quantifier ions for naphthalene, phenanthrene and pyrene in that order. Three minor ions for each compound were used for qualifier ions.

Sediment adsorption isotherms were found to be linear in the range of concentration tested. A typical result is shown in Fig. 1 for phenanthrene. The sediment-water partitioning coefficient K_d (L/kg) can be described as: $K_d = C_S/C_W$, where C_S and C_W are the aqueous phase concentration (mg/L) and sediment phase concentration (mg/kg), respectively. K_d values of phenanthrene for Clear Lake, Galveston Bay, and Horsepen Bayou are 757, 303, and 46 L/kg respectively. It is evident that the K_d value attributes to the organic contents of the sediment samples. The Horsepen Bayou is a clayed sediment with low organic content, while two others are silt with Clear Lake sediment being the most heavily contaminated.

Several important factors that may contribute to elevated PAH concentrations in the aqueous phase were also tested at various simulated conditions: synthetic seawater, actual water at the same location, and DI water at pH 3, pH 5, pH 7 (static vs. mixing), and pH 9. Results to date have shown that mixing significantly enhanced the mass transfer and, therefore, the sorption rate, especially for a low organic Horsepen Bayou sediment (Fig 2). The effects of pH and composition of overlying water were minimal presumably due to the nonionic/hydrophobic adsorption of PAH compounds. Under most conditions, the PAHs appeared to irreversibly bind to sediment in a three-week period. PAH des-

Table 1. Sampling Location

Location	GPS Reading	Water Depth (feet)
Horsepen Bayou near UHCL (HPB)	29°34.789N/95°05.542W	4
Clear Lake near Hilton Hotel (CLK)	29°19.256N/94°55.229W	6
Galveston Bay near Kemah Post 4-6 (BAY)	29°33.096N/95°02.181W	8
Houston Ship Channel, Barge Holding Area (HSC1)	29°47.251N/95°03.932W	27
Houston Ship Channel, Lynchberg Ferry (HSC2)	29°45.840 N/95°04.833W	50
Houston Ship Channel, New Fed Hartman Bridge (HSC3)	29°42.253 N/95°01.059W	51

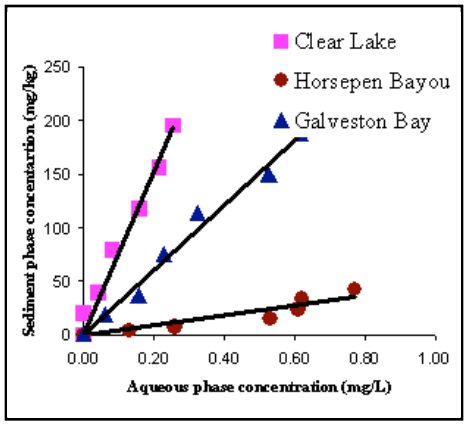

Figure 1. Adsorption isotherm of phenanthrene in various sediments

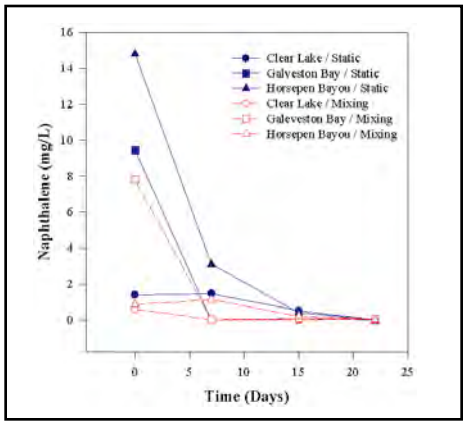

Figure 2. Sorption/desorption of naphthalene in various sediments: Static vs. mixing conditions (Sediments were spiked with 15 ppm naphthalene).

Photo courtesy of Gallaway Collection

Photo courtesy of Gallaway Collection

Top: Clear Creek County Ferry between Seabrook and Kemah circa 1908

Above: Landing of the Clear Creek County Ferry between Seabrook and Kemah circa 1910

orption was noted at low pHs and for a treatment with seawater. Further studies are under way to fully characterize the PAHs in the obtained sediments, to examine the controlling factor(s) and to quantify the rate of release from sediments.

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Task Force for Ozone Reduction Strategies—TFORS

Alex Cuclis, Air Quality Specialist, Environmental Institute of Houston, University of Houston-Clear Lake

In the past year, Jim Lester, Pris Weeks, and Alex Cuclis of the Environmental Institute of Houston have coordinated five meetings that brought together a diverse group of stakeholders interested in air quality issues in the Houston-Galveston eight county area. The Task Force for Ozone Reduction Strategies (TFORS) includes representatives of industry, local governments, environmental groups, academics, and regulatory agencies committed to designing control strategies using the best available science with assistance from the Air Quality Modeling Group (AQM) at the University of Houston's main campus. TFORS intends to submit a set of recommendations to the Texas Natural Resource Conservation Commission (the Texas state regulatory agency), now called the Texas Commission on Environmental Quality (TCEQ), based on scientific analysis and consensus by the stakeholders.

When TFORS formed last year the group was focused on solving the problem of the nitrogen dioxide or NOx gap in the Houston-Galveston Area State Implementation Plan (SIP). According to the SIP at that time the state needed to identify and eliminate an additional 56 tons/day of nitrogen oxides from various sources to achieve attainment with the one-hour ozone standard. The one-hour standard is 125 ppb ozone. Nitrogen oxides (NOx) react with volatile organic compounds (VOCs) and sunlight to form ozone. As the year progressed, it became evident that a major flaw in the Houston-Galveston SIP was that VOCs, particularly highly reactive VOCs like ethylene, propylene and 1,3-butadiene, were significantly undercounted in the inventory. As a result the TCEQ has shifted its focus from NOx to VOCs.

Thus far, TFORS has identified over 20 possible scenarios to help identify the best control strategy for solving the ozone problem in the Houston area. The scenarios include reductions in both NOx and VOCs. Unfortunately, due to the lengthy and complex set up time for the modelers to run these proposed scenarios, only four or five scenarios will be chosen for modeling. Also, because the emissions inventory is uncertain, much of the modeling work has been delayed. It is part of the old garbage in-garbage out problem. If researchers do not have the correct amount of NOx and VOCs emitted from various sources to input to the model, there is no way that the model can provide an accurate output. The TCEQ is working feverishly to improve the emissions inventory, in order to have an acceptable plan to reduce ozone in our area.

Despite the slow start in producing modeling results, TFORS has provided a forum where various stakeholders have had the opportunity to learn about the issues regarding the emissions inventories, the atmospheric chemistry of ozone formation, and some of the complexity of ozone modeling. The TFORS meetings have also been a place for environmental non-governmental organizations to voice their concerns about air quality in the presence of industry representatives and regulators. In addition, TFORS has had the benefit of members who are doctors from the University of Texas Medical Branch at Galveston who have provided information about air pollution and its impacts on health.

For more information, visit the following websites:

Task Force for Ozone Reduction Strategies (TFORS):
www.eih.uhcl.edu/outreach/tfors/

Air Quality Modeling Group (AQM):
www.uh.edu/aqm/

Texas Commission on Environmental Quality (TCEQ):
www.tceq.state.tx.us/

Social and Natural History, The Butler Museum and Heritage Park

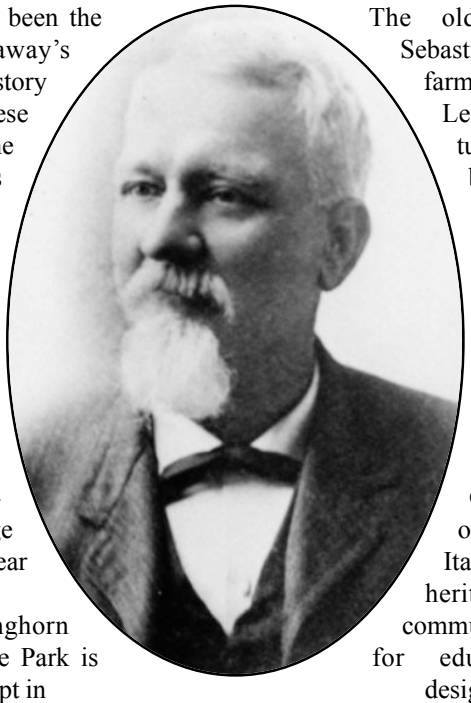
Alecya Gallaway, Historian, Environmental Institute of Houston, University of Houston-Clear Lake

The Environmental Institute of Houston Public Participation and Outreach Program continues in the quest to preserve the social and natural history and to increase awareness of Galveston Bay. Historian Alecya Gallaway has worked in the history program for six years and has used a combination of archival research and oral interviews to document the place, culture, and ecology of the region. This information is being accessed and used by civic leaders, educators, agency personnel, researchers, and the public. Several natural resource history issues have been the basis of investigation including: the history of bay shrimping and the scientific management of the resource, the changing landscape of the bay as agricultural development gives way to industrial growth, the history of the terrapin fishery in Galveston Bay, and the history of shipping canals dredged through the bay system. The current topic of investigation is the historical use of saltgrass marshes as cattle range and how prairie management techniques changed from agricultural use to industrial use.

Included in the study of the Galveston Bay saltgrass prairies and marshes are the histories of the first European-American settlers who migrated to these vast grasslands, the reasons they came, and the land use traditions they brought with them.

The resources that brought the first wave of settlers to the coast were the vast grasslands and the herds of wild cattle, horses, and burros that were free for the taking. The transition of land use from cattle range to industrial development came slowly to the coastal region of Texas and the cattlemen reigned the coastal prairies for the first one hundred years.

In order to facilitate a greater understanding of the history of Galveston Bay area land use and its impact to social groups not usually involved in formal stakeholder groups, EIH, for the first time, entered into in-kind partnerships with local government entities whose projects involve cultural heritage and historical resource use that has been the focus of Ms. Gallaway's social and natural history of the area. One of these partnerships is with the League City Parks Department in their two new Clear Creek corridor projects—The Butler Longhorn Museum and Heritage Park and The League City Environmental Park. Both of these projects include the historical cultural heritage and land use of the Clear Creek area.

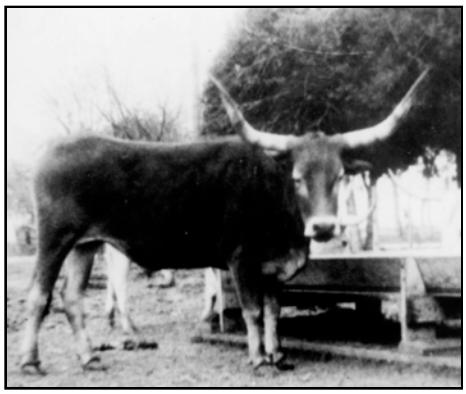


George Washington Butler

The Butler Longhorn Museum and Heritage Park is an exciting new concept in museums for this region. It grew from Ms. Gallaway's research on the saltgrass cattlemen and the transition of land use from ranching to farming in the early 1900s. The museum spotlights the Butler Family who owned and operated the first ranch and railroad cattle station in 1872 where the town of League City was later platted and the development of the Butler Longhorn bloodline, one of the original bloodlines that saved the Texas longhorn from extinction. The bloodline was developed by Milby Butler and his son Henry in the years between the 1920s and the 1970s and originated in League City. The museum is housed in the Clear Creek home of the late Walter and Helen Hall, one of League City's leading families. Walter Hall was known to all as a benefactor to League City's efforts to save the history of their area and was the first to recognize the importance of the cattlemen of the area. For decades patrons and visitors alike enjoyed the local brand display he had constructed for the Citizen's State Bank community room in League City. This display was the first donation to the museum. The old farm house of Sebastian Ghirardi, a truck farmer who immigrated to League City near the turn of the century, has been donated by the family to be moved onto the ten acres adjoining the Hall house. This will become a house museum restored to the original era of early coastal prairie agriculture and the Ghirardi family and other local pioneer Italian farmers. Cultural heritage, land use, and community will be the basis for educational programs designed for this facility. Alecya Gallaway has worked with the Butler family since 1994 to document their history as pioneer saltgrass cattlemen and has assisted League City in the acquisition of collections of Butler Ranch paperwork that dates back to 1868.

George Washington Butler

In 1854 George Washington Butler was nine years old when he moved to Clear Creek from Calcasieu Parish Louisiana



An early Longhorn used to develop the Butler Longhorn bloodline.

along with brothers Richard, the oldest child, Green, who was eleven, and sisters Margaret, seven, Rebecca, five, and Vianna, who was an infant nearing one year, and their parents, Willis and Hepsibah Perkins Butler. The Butlers were part of a large group of related families who were engaged in raising cattle on the open coastal prairies of Louisiana and Jefferson County Texas. The group was composed of older couples and their extended families and their slaves. From Jefferson County they traveled the Atascosita Trail around Galveston Bay by fording creeks, bayous and wet prairies. They traveled in wagons and oxcarts to land that Allen and Margaret Perkins Coward, a childless couple with 23 slaves, had put under survey in the late 1840s.

The families who came together in 1854 included Richard and Harriet Perkins Coward with seven children and eleven slaves, Willis and Hepsy Butler with six children, Hepsy's mother Martha Perkins and twelve slaves, Needham and Eliza Coward with six children and eight slaves, Austin and Sarah Coward, Samuel and Rebecca Coward Perkins with six children and twenty-one slaves. These families comprised one hundred and two individuals in total. The area that they settled included lands in modern day League City and Friendswood and that territory extended from Galveston County into Brazoria County. They built their residences near good fresh water streams above the tide headwaters of Clear Creek. The Cowards built on Coward Creek, the Perkins on Magnolia Creek, and the Butlers on Chigger (Chigoe) Creek. While in Louisiana these families had raised crops of cotton, sugar cane, and cattle on their plantations, but when they moved to Texas they became primarily cattlemen and only farmed for their own community in this isolated area of upper coastal prairie. Richard Butler, Willis and Hepsy's oldest son, married and moved on to Madison County. Green and George Washington stayed at home and worked their father's herd and worked for pay on Allen Coward's ranch. Allen was an uncle by marriage to Hepsy's sister.

In 1861, men living on the Clear Creek watershed formed a Texas militia regiment called The Magnolia Rangers and young Green and George Washington were mustered in. In 1862, the Texas militiamen

George W. Butler became the first postmaster for the area known as Clear Creek and later changed to League City.

Butler constructed a series of loading chutes that permitted the simultaneous loading, or unloading, of four cattle cars on the adjacent railroad siding.

became soldiers in the Confederate Army. George Washington became part of the coastal defense under Captain R. L. Fulton in DeBray's Regiment. After the war, G. W. Butler went into a cattle partnership with his uncle, Allen Coward. By 1870, George Washington Butler began buying out his uncle's part of their cattle partnership to start his own cattle business. In 1872 he moved his ranch headquarters and cattle business to the Galveston, Houston & Henderson (G. H. & H.) Railroad near Clear Creek where the League City historic downtown is today. His "Oh-Tee" brand could be found on cattle to the east from Galveston Bay at San Leon, and Dickinson Bayou to Kemah and ranging west from Hitchcock to Halls Bayou up to Alvin on approximately 55,000 acres. He became the first postmaster for the area, originally called Clear Creek and later changed to League City. He was a Galveston County Commissioner representing the Mainland Precinct in Commissioners Court from 1884 until 1892. In the early 1890s he helped Mr. J. C. League acquire title to the lands north and east of his ranch headquarters to plat the city of League City.

George Washington Butler established the Butler Ranch in 1872 with the purchase of a thirty-acre tract of land from Mr. Andrews, one of the G. H. & H. Railway investors. This land was located adjacent to and east of the Galveston, Houston & Henderson Railroad right-of-way approximately one mile south of Clear Creek in Galveston County, Texas. A small frame building existed on this property about 300 feet east of the railroad. Butler doubled the size of the structure by adding a hallway and rooms to the rear of the building. A three-foot wide walkway constructed of clamshells and beach sand was installed between the front porch steps and the stile over the railroad's fence. He constructed a large three-storied wooden building a few hundred feet from the existing building. The first floor of the three level structure housed a "chuck house" for feeding the cowboys, a carriage house for the buggies, and stables for the horses and milking stock. The second story contained the bunkhouse and hay storage. The third level was G. W.'s office and observation room where he used a telescope to check his cattle while they grazed on the flat, treeless, tall-grass cattle range. In the southwest corner of this thirty-acre tract he constructed a series of livestock pens that connected to four livestock loading chutes that permitted the simultaneous loading, or unloading, of four cattle cars on the adjacent railroad siding.

The Butler Ranch became a passenger and mail pickup and drop-off point on the G. H. & H. Railroad. Mail was simply addressed to Butler's Ranch and the building's porch became the "depot." The ranch

Brahma bull imported from India, 1873

Seaborn Lyons was a nine year-old slave in 1854.

was used so much as a depot that G. W. had the railroad company place an old section car in his ranch yard adjoining the railroad for a temporary depot until one was built.

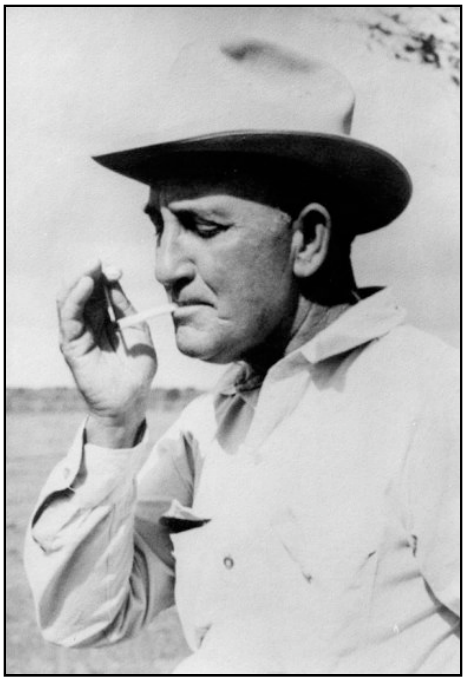
In 1873, George Washington Butler imported Brahma cattle from India and had them shipped to Louisiana. He and his cowboys met the ship in New Orleans and drove the cattle overland from New Orleans to his ranch on Clear Creek along the same Atascosita Trail that his father had driven his cattle herds to market before the Civil War.

When the Butler, Coward, and Perkins families migrated to Texas and settled on Clear Creek in 1854, it is estimated from census records that the family groups were composed of 27 white men, women, and children and 75 African American slave men, women, and children. The slave census in 1860 showed that 19 living children increased the number of slaves to 94. They came from South Carolina, Kentucky, Mississippi, Louisiana, and Texas depending on the time frame of the migration of the families. These families stayed to become the largest group of founding African American families on the Galveston County mainland.

Ambrose Lyons Hargrove and family

Milby Butler, the youngest son of George Washington and Mary M. Butler of League City, was born in 1889. He was a third generation Texas cattleman and the son of one of the finest Brahma cattle and Norman horse breeders in Texas.

George Washington Butler wanted his sons to go into businesses other than cattle breeding so he sent Milby Butler to Massey's Business College in Houston where he received his diploma in 1907. Milby had lived and breathed cattle since birth. When his father put him in charge of the confectionary in the drugstore of



Milby Butler

Milby Butler and Zebu calf

Bevo, a Milby Butler Longhorn Bloodline Bull

the Butler Building, he only lasted a couple of years before he left League City and went back to the old ranch on Chigger Creek west of town. Milby became a successful young cattleman in his own right and soon won the respect of his father and the other ranchers. At a very early age, Milby became interested in cattle breeding and bloodlines and became well known for his own Zebu breeding techniques.

In 1921, George Washington Butler died and Milby moved his ranch headquarters back to League City so he could be near and care for his mother, Mary M. Butler. Milby built his ranch headquarters on Calder Road and began increasing his lands in the area. Milby and his son Henry soon became interested in the diminishing big-horned cattle known as Texas Longhorns. He was intrigued because this was the breed of cattle that his grandfather had raised in Louisiana, and both his grandfather and father had captured wild on the coastal prairies of Texas in the early 1800s. Longhorns were disappearing from the prairies and only a few old big-horned cows would come through from the bottoms of Liberty and Jefferson counties as they were shipped to the stockyards. Together Milby and Henry started pulling the largest horned cows from the herds that came through League City. Milby began to use the breeding experience he had with Zebu bloodlines to carefully pick and choose cows and sires to bring back the genetic traits that he remembered best from his childhood. The traits that will always be associated with Milby's longhorns are the big corkscrew twisted horns and red and white speckled color. It is only appropriate that Milby brought back the Longhorn to Galveston County because it was his father G. W. Butler who a century before began breeding the longhorn off of the prairies by improving the range cattle with Brahman cattle to better withstand the humidity, heat, and mosquitoes of the saltgrass marshes.

Environmental Capacity Building in an Inner City Community: The MDI Superfund Site and the Fifth Ward

Pris Weeks, Ph.D., Public Participation and Outreach Manager, and Andrea Dunn, Community Outreach Associate, Environmental Institute of Houston, University of Houston-Clear Lake

Photo by Winifred Hamilton

Drums of spent catalysts.

The goal of this project was to assist the Fifth Ward Chapter of Mothers for Clean Air (MfCA) educate members of the Fifth Ward community about the Many Diversified Interests (MDI) Superfund site. MDI sits on a 36-acre tract in a residential area, a quarter mile south of Interstate Highway 10 and two miles east of downtown Houston. Approximately 100 families live near the site and Bruce Elementary School is located across the street on its west side.

Operations at the MDI site began in 1926 under Texas Electric Steel Casting Company (TESCO). In the 1980s, TESCO leased some of its land to Can-Am who used it to store about 5,300 drums of spent chemicals. By 1988, the stored drums were abandoned.

The drums were removed in 1999 and most of the buildings have been torn down. A chain-link fence with warning signs surrounds the debris-strewn land.

Elevated levels of lead have been found in the soil of adjacent residential properties and soil in the yards had to be removed. The community has concerns about how and when the area will be cleaned up.

The Fifth Ward Chapter of MfCA received a Technical Assistance Grant from the Environmental Protection Agency (EPA) to keep the community informed about the clean-up process. The Environmental Institute of Houston is helping to manage the grant, serving as a liaison between the local MfCA chapter and the EPA. Staff has been assisting the chapter by providing technical information related to environmental risk. The project provided a GIS map that can be used at community events depicting sources of environmental risk in the Fifth Ward. EIH also organized an Environmental Expo at a local community center that focused on cumulative risks in the community. Educational materials about various environmental hazards in the community have been gathered and the chapter now has a booth display focusing on the Fifth Ward that it takes to community events.

Principal Investigators

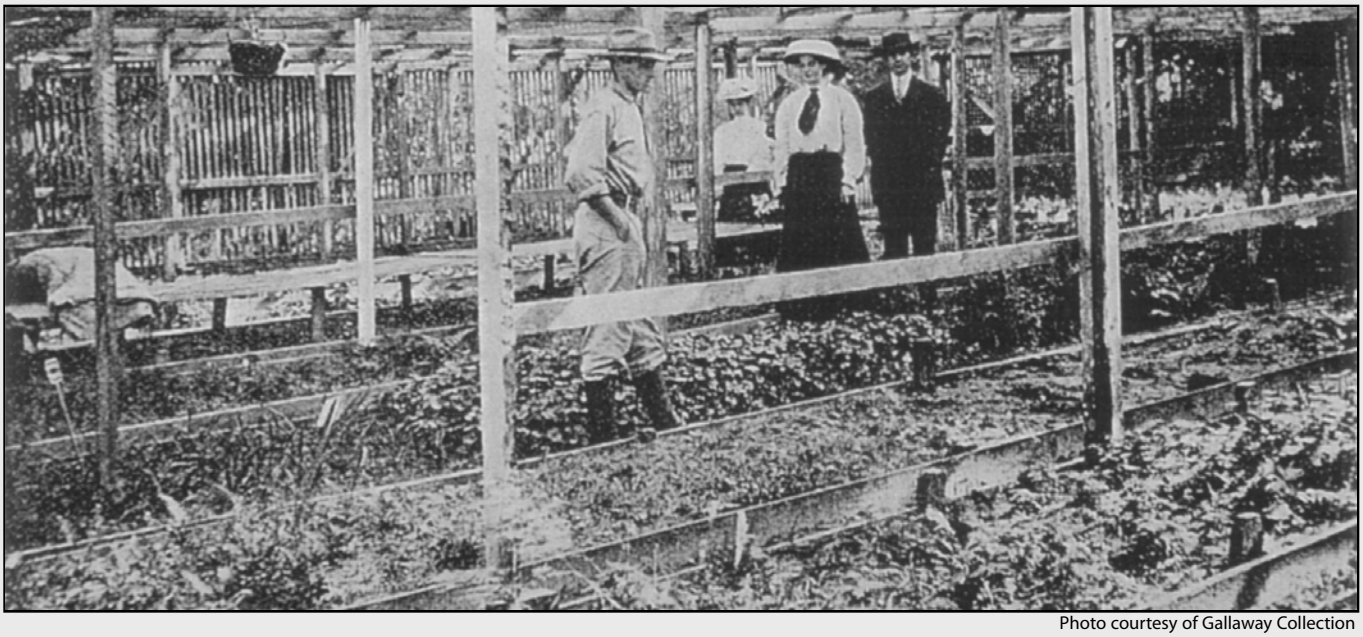


Photo courtesy of Gallaway Collection

Fernery or Shade House at nursery in Dickinson circa 1905

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