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Living with Geohazards on Galveston Island: A Preliminary Report with Recommendations

Prepared for the City of Galveston

By

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July 2, 2004

Introduction

The west end of Galveston Island is undergoing development that includes excavations for creating recreational lakes, retention ponds, boat canals, beach nourishment sand, and construction fill material. This activity has recently concerned some residents and visitors to the island who fear that the island's "physical integrity" may be jeopardized. Specifically, that the holes left by the excavations may "weaken" the island and increase the possibility of a storm washing over the island, thus endangering the main road or even eroding a channel completely across the island. In light of this concern, Councilwoman Jackie Cole and the City Manager's office requested that the Bureau of Economic Geology (BEG) form a "panel of experts" to advise the City on how the island may be managed with regard to ongoing geological processes (see Resume section for panel-member backgrounds). This document reports on the preliminary findings of the panel.

Purpose, Scope, and Approach

The purpose of the panel was to consider the geologic processes and hazards affecting development on the island and how development may alter those processes. With regard to those geological processes, the panel made recommendations on how the City might mitigate negative impacts of future development. The panel was aware of and discussed specific development activities, such as the Pointe San Luis and Sunset Cove projects, but declined to comment on them in this report. The panel decided that more specific information and analyses would be required to make recommendations related to particular projects. Ongoing development activity, however, may be placed into context with the general recommendations made herein.

Galveston Island has been the focus of study by geologists since the 1950's. There is a large body of data and interpretations in the scientific literature concerning the geologic development, historical changes, and physical processes occurring on Galveston Island. The panel used their knowledge of this research and their collective experience from their own studies of the island and geologically similar barrier islands to define the processes causing changes and to make recommendations on how to live with those changes. The panel examined maps of rates of shoreline change, wetland maps, topographic maps, and aerial photography. We emphasize that existing data and knowledge exist to support the implementation of recommendations made herein. The City of Galveston is fortunate that its island has been the focus of scientific study

through the years, and it is the intent of the panel to help bring this information to the planning process.

The panel met for a total of about 8 hours on June 24 and 25, 2004. On June 24, Ms. Wendy O'Donohoe and Ms. Andrea Madison of the City of Galveston Department of Planning and Community Development met with the panel and discussed the state of current environmental zoning rules. Ms. O'Donohoe provided copies of Chapter 3 of the Galveston Comprehensive Plan, Sections 29-90 and 29-91 of zoning rules regarding excavations and the protection of sand dunes, respectively. The panel also received copies of geologic and engineering reports regarding the excavation of retention ponds within the Pointe West project. On June 25, the panel continued discussions and briefed Councilwoman Jackie Cole on its progress. The discussion was compiled into this report over the next several days.

Shoreline Change

The position of the shoreline advances seaward or retreats landward in response to changes in sea level, sediment supply, wave climate (directions and heights of waves), and storm frequency. BEG computes the rate and direction of shoreline change by comparing the positions of past shorelines and applying a linear statistical model. The current rates for Galveston are computed using a set of shorelines dating from the 1930's through 2000. These rates are expressed as average annual rates of change and are useful for predicting the position of the shoreline tens of years into the future, wherever the statistical linear model is applicable. They are not useful for predicting where the shoreline will be next year. In fact, the shoreline at a particular location whose overall statistical trend has been retreat since 1930 may have experienced periods of relative stability or even advance during that time. This is because of the variable nature of the processes causing shoreline change.

Some locations have highly dynamic shorelines, making the linear statistical model less useful for predicting future positions. Such an area exists on the southwest end of Galveston Island within about 2 miles of San Luis Pass. This is an area where the shoreline responds to processes associated with the San Luis Pass tidal delta and channels. The shoreline advanced tens of meters from 1995 through 2000, but past shoreline positions indicate that this is a temporary situation and that we are likely to see equally large amounts of retreat in the future.

Recommendations related to Gulf shoreline change:

1. Setback distances for new construction should be based on historical shoreline change rates, as determined by BEG. A setback line could be constructed by projecting the position of the dune protection line a certain number of years into the future using shoreline change rates. In places where the rate of shoreline change is stable or advancing, the setback line based on the current position of the dune protection line should remain in effect. The number of years to project the setback line should be considered by the City Council, but a minimum of 20 years (based on long-term erosion rates) is recommended.
2. Areas where historical shoreline positions are highly variable and thus unpredictable should be considered high-risk areas. These include the far western end of Galveston Island, where the shoreline responds to processes associated with the San Luis Pass tidal delta and channels. Construction should be discouraged in this area.

3. The public should be informed of why and how the setback line is determined, either in the ordinance or other literature.

Breaching and Storm Surge

Barrier-island breaching during storms is a natural process that is important in transporting sediment landward. Sediment that has been transported from the Gulf to the bay side of Galveston Island provides the platform on which environmentally valuable marshes have developed. Storm surge and high waves also deposit sediment on the island, which builds up the island, allowing it to keep pace with rising sea level.

A breach is defined as an area in which flowing water is confined in a channel that cuts across the Gulf side beach and dune. Breaches may extend across an entire barrier island to the bay side or connect with ponds, swales, or excavations behind the foredunes. Breaches are generally temporary features but may persist and become tidal inlets or creeks. Studies have shown that breaches tend to recur in the same location or in locations that are predictable through topographic and geomorphic analysis.

Recommendations related to breaching and storm surge:

1. The island should be mapped for areas susceptible to cross-island breaching or breaching that may endanger the main highway. This mapping could proceed on the basis of historical and geological evidence of breaching within the past 2,000 years. Construction and excavation should be discouraged in these areas.
2. Topographic and geomorphic analysis should be applied to further refine the map to show specific potential breach sites that could endanger the main road. Construction and excavation should be prohibited in these areas.
3. Potential breaches that may connect ponds or swales landward of the vegetation line but may not necessarily endanger the main road should be mapped on the basis of historical evidence of past breaching and current topography and geomorphology. Construction and excavation should be prohibited in these areas.
4. Excavations that increase the likelihood of breaching by creating artificial pathways for water flow should be prohibited.
5. Setback distances for excavations should be implemented and should be based on historical shoreline change rates as determined by BEG.

Wetland Habitat Loss on the Bay Side of Galveston Island

Geologic processes provide the substrate and physical conditions necessary for developing and sustaining important wetland environments. The loss or alteration of these environments is considered hazardous in that they are important to the ecology of the barrier-island system and that they provide a physical buffer to protect the upland against storm surge, waves, and currents. Because the Army Corps of Engineers regulatory practices may not be adequate for protecting current wetlands or ensuring the viability of wetlands in the future, it is important for the City to review its own practices in this area.

Recommendations related to habitat change:

1. The City should implement an ordinance for the purpose of managing wetlands.
2. Current wetland maps should be used to define broad areas in need of protection.

3. Canal and channel dredging should be discouraged in wetland areas, even if wetlands are not directly excavated. This is because of the potential for increased erosion and deterioration of wetlands by increased exposure to currents, waves, and in some cases isolation of wetlands from the upland areas.
4. Tidal creeks and their immediate drainage areas should be protected because they supply sediment to marshes and allow space for the landward migration of wetlands during sea-level rise, which Galveston Island is experiencing.
5. Buffer areas of gently sloping topography should be preserved around wetlands to allow landward migration during rising sea level.
6. Development practices that cut off sediment supply to wetlands or create a barrier to wetland migration should be discouraged.

Creating a Geohazards Map

As mentioned earlier, we are fortunate that Galveston Island has been studied by numerous researchers and that there already exist datasets to improve the environmental planning process of the island. We suggest that the recommendations in this report be expressed as a map. This map could serve as the basis for new environmental planning, as well as for educating the public on the island's geological processes, thus enabling potential property owners to make wise decisions.

Condensed Resumes of Panel Members

Professional Summary (Condensed)

James C. Gibeaut, Ph.D., P.G.
Lead Principal Investigator, Coastal Research Group

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Academic Background

B.S. Geology and Mineralogy, Ohio State University, 1983
M.S. Geology, University of Rhode Island, 1986
Ph.D. Marine Science, University of South Florida, 1991

Areas of Expertise

A. Coastal processes and sedimentation.
B. Application of LIDAR and GPS.
C. Statistical analysis and mathematical modeling of beach and tidal inlet morphodynamics.
D. Application of synthetic aperture radar to coastal mapping.
E. Coastal oil spill damage and cleanup assessment.

Professional Work Experience

A. Present Position: Research Associate, Bureau of Economic Geology, The University of Texas at Austin, Austin, Texas (July 1992 - Present).
Researching coastal processes and sedimentation including shoreline change analysis. Developing and applying new techniques for coastal mapping, including Global Positioning System Surveys, airborne synthetic aperture radar, and airborne LIDAR.

B. Visiting Assistant Professor, Department of Geology, University of South Florida, Tampa, Florida (August 1991 - June 1992).
Supervising students, research assistants, and technicians in conducting coastal research including beach-nourishment monitoring and sand-source studies. Teaching advanced graduate course in coastal sedimentology.

C. Chief of Science and Data Management, Oil Spill Response Center, Alaska Department of Environmental Conservation, Anchorage, Alaska (November 1990 - July 1991).
Supervising employees and contractors responsible for collection and analysis of data concerning the Exxon Valdez oil spill. Representing State of Alaska to Federal Technical Advisory Group (TAG). Advising Federal On-Scene Coordinator on matters concerning survey and cleanup techniques.

Professional Societies

Sigma Xi, The Scientific Research Society

Awards and Honorary Societies

Third Place GCAGS/GCSSEPM Grover E. Murray Best Published Paper Award, GCAGS Transactions, 2002

Best of Session Poster, "Airborne Laser Swath Mapping of Galveston Island and Bolivar Peninsula, Texas," 5th International Conference on Remote Sensing for Marine and Coastal Environments, 1998

Honorable Mention Poster, "Mapping Barrier Islands Using AIRSAR," 4th International Conference on Remote Sensing for Marine and Coastal Environments, 1997

Graduate Council Fellowship, University of South Florida, 1987 - 1988

Phi Kappa Phi Honor Society, 1987

Eugene J. Tynan Memorial Prize for Graduate Research, University of Rhode Island, 1986

Speiker-Toivonen Scholarship for Summer Field Work, Ohio State University, 1982

Committee Responsibilities and Professional Activities

Member, Technical Program Committee, Coastal Sediments Conference, , 2003

Chairman, Poster Session, Gulf Coast Association of Geological Societies Convention, Austin, Texas, 2002

Co-Chair, Annual Meeting Poster Session, "Techniques for Analyzing Modern Environmental Processes and Change and Impacts", American Association of Petroleum Geologists, 1999

Co-organizer/convener, Lidar Workshop, Bureau of Economic Geology, 1999

Member, Mapping Advisory Committee, Bureau of Economic Geology representative, State of Texas, 1998 - 2002

Member, Coastal Hazards Theme Team formed to help NASA develop research plan, NASA, 1998

Representative of the Bureau of Economic Geology, Geographic Information Council, Texas , 1997 - 2001

Member, Topography and Surface Change Program Investigators Working Group, NASA, 1995 - 1998

Publications (Articles)

Gibeaut, J. C., White, W. A., Smyth, R. C., Andrews, J. R., Tremblay, T. A., Gutiérrez, Roberto, Hepner, T. L., and Neuenschwander, Amy, 2003, Topographic variation of barrier island subenvironments and associated habitats, *in* Coastal Sediments '03: Crossing disciplinary boundaries: Proceedings, Fifth International Symposium on Coastal Engineering and Science of Coastal Sediment Processes, Clearwater Beach, Florida, May 18–23, 10 p., CD-ROM.

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CURRICULUM VITAE

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Maurice Ewing Professor of Oceanography
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Education

B.S. 1968 (Geology)	University of South Alabama, Mobile, Alabama
M.S. 1970 (Geology)	University of New Mexico, Albuquerque, New Mexico
Ph.D. 1972 (Geology)	Florida State University, Tallahassee, Florida

Teaching Experience

1972-75 Assistant Professor of Geology, Hope College, Holland, Michigan
1975-80 Associate Professor, Rice University
1980-85 Professor, Rice University, Houston, Texas
1992-98 Chairman, Department of Geology and Geophysics, Rice Univ.
2002-Present Maurice Ewing Professor of Oceanography, Rice University

Awards and Honors

GCAGS Outstanding Educator Award, 1992
Voted Teacher of the Year by the Graduate Students of Rice University, May 1995
Councilor for Research-Society of Sedimentary Research (2000-2002)
AAPG Distinguished Lecture Series-Haas-Pratt Distinguished Lecturer
President-Society of Sedimentary Research (2003-2004)
Rice University Presidential Mentoring Award-2004

Professional Societies

Geological Society of America (Fellow)
American Geophysical Union
American Association of Petroleum Geologists
Society of Sedimentary Research

BOOKS

Anderson, J.B., and Molnia, B.F., 1989, Glacial-Marine Sedimentation: Short Course Notes, American Geophysical Union, Washington, D.C., 127 pp.

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Rodriguez, A.B., Anderson, J.B., Siringan, F.P., and Taviani, M., Holocene evolution of the east Texas coast and inner continental shelf: along-strike variability in coastal retreat rates, Journal of Sedimentary Reseach, v. 74, p. 406-422..

Biographical Sketch

Timothy M. Dellapenna
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Professional Preparation

Michigan State University	Geology	BS 1986
Western Michigan University	Geology	MS 1991
Western Michigan University	Hydrogeology	MS 1993
College of William and Mary	Marine Science	Ph.D. 1999
Texas A&M University	Oceanography	Post-doc 1999-2000

Appointments

Sept. 2000	Assistant Professor, Texas A&M University at Galveston-Dept. of Marine Science
Sept. 2000	Assistant Professor, Texas A&M University- Dept. Oceanography- joint appointment
1999-2000	Texas Institute of Oceanography Postdoctoral Fellow- Texas A&M University

Awards and Fellowships:

1999 TIO Post-doctoral Fellowship, TAMU/TAMUG
1998 VIMS Matthew Fontaine Maury Award for Outstanding Marine Science Research
1996 Best Ph.D. Student Paper Award, Atlantic Estuarine Research Society Meeting, Hampton, VA

Related Publications

Dellapenna, T.M., Kuehl, S.A., and Schaffner L.C., 1998. Seabed mixing and particle residence times in biologically and physically dominated estuarine systems: a comparison of lower Chesapeake Bay and the York River subestuary. Estuarine, Coastal and Shelf Science, **4**:777-795.

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