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GEOTUBES FOR TEMPORARY EROSION CONTROL AND STORM SURGE PROTECTION ALONG THE GULF OF MEXICO SHORELINE OF TEXAS

James C. Gibeaut, Tiffany L. Hepner, Rachel Waldinger, John R. Andrews, Rebecca C. Smyth, Roberto Gutierrez,
Bureau of Economic Geology
John A. and Katherine G. Jackson School of Geosciences
The University of Texas at Austin

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INTRODUCTION

In September 1998, Tropical Storm Frances caused severe beach and dune erosion along the Gulf shoreline of the southeast Texas coast. This erosion placed many beach houses in danger of being undermined or damaged during subsequent storms and gradual shoreline retreat. To help prevent such damage, shore-parallel geotextile tubes (geotubes) were installed. The geotubes are sediment-filled sleeves of geotextile fabric having an oval cross section of approximately 12 ft (Figure 1). They rest on a fabric scour apron that has sediment-filled anchor tubes along each edge. Geotubes are placed in a trench parallel to shore along the back beach or foredunes, and project designs call for sand and natural beach vegetation to cover them (Figure 2). Currently, seven geotube projects cover a total of 7.3 mi of the Gulf shoreline from Follets Island to High Island (Figure 3).

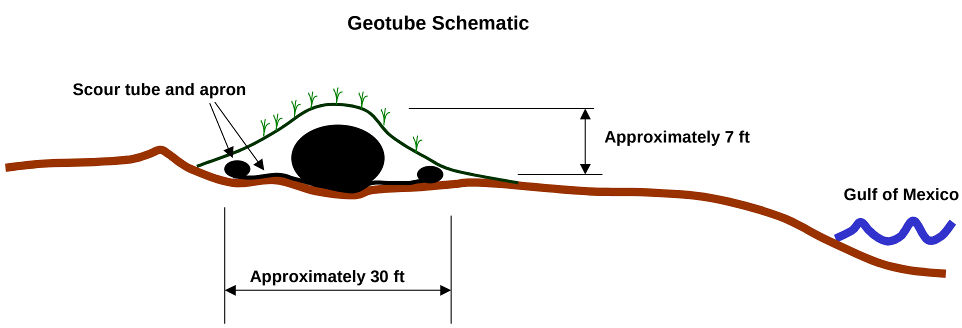

Figure 1. Cross-section schematic of a geotube installation.

METHODS

This study provides a quantitative evaluation of these projects on the basis of observations made during 2001. Three field surveys were conducted that included ground surveys (beach profiles), visual inspection of geotube exposure and damage, and an airborne topographic survey (lidar) of the projects and adjacent beaches and dunes. Wave and water-level data were also compiled. Results, data, and maps are reported on the Bureau of Economic Geology Web site (http://www.beg.utexas.edu/coastal/geotube.htm).

A primary concern with the geotube projects is that the public beach will be narrower in front of the geotubes than it would be without the geotubes present. A quantitative

Installation **Covered and vegetated**

Exposed **Maintenance**

Figure 2. Geotube stages.

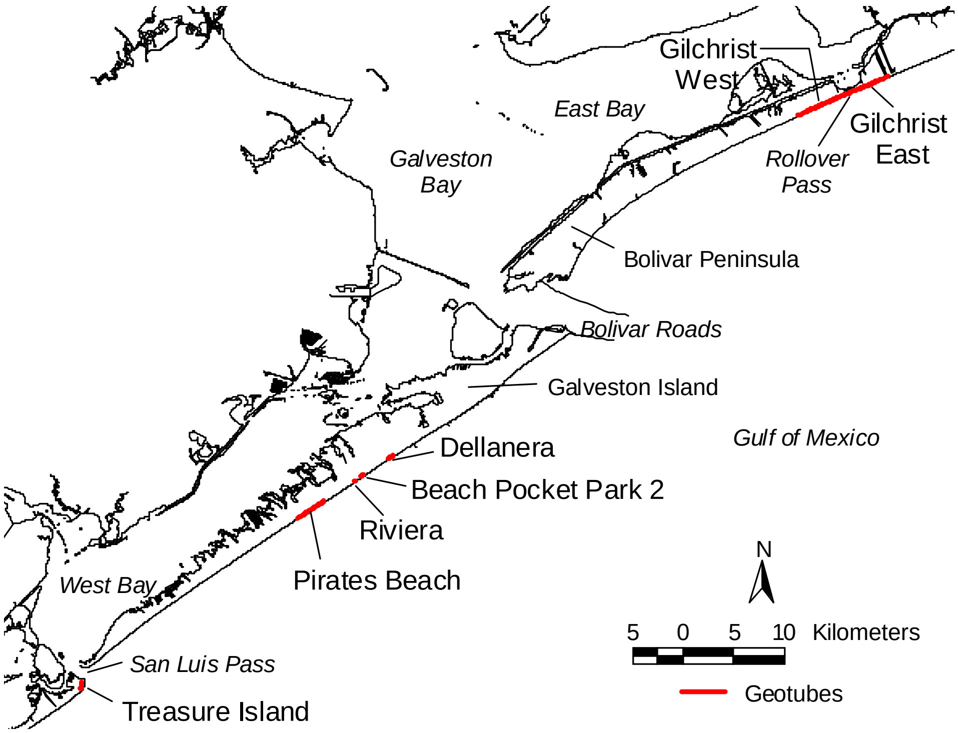

Figure 3. Map of geotubes along the upper Texas Gulf of Mexico shoreline.

technique to compare beach widths, therefore, is required. For this purpose, segments of beaches adjacent to each geotube project on Bolivar Peninsula and Galveston Island were selected for comparison. Beach segments contiguous with the geotube projects and with similar processes and sand supply were selected to represent what the beach width would be if the geotubes and houses seaward of the natural line of vegetation were removed. Beach segments used for comparison were selected to have long-term shoreline change rates within ±2 ft/yr (±0.61 m/yr) of the beaches in front of the tubes. Locations within the adjacent comparison beach segments where houses have caused artificial narrowing of the beach and areas where beach access roads have caused artificial widening of the beach are not included. The comparison segments include both vehicular and non-vehicular beaches.

The seaward boundary for computing the beach width is the 1.97 ft (0.6 m) above mean sea level (MSL) contour line. This level corresponds to the boundary of wet and dry sand as shown in the beach profiles. If the beach is lower than 1.97 ft (0.6 m) MSL, passage and public use will be hindered. The landward boundary for computing beach width is the seaward edge of the geotube projects including the sediment cover if present. In the comparison segments, the landward boundary is the seaward toe of the foredune ridge or the base of a scarp/bluff if a foredune ridge is not present. The foredune ridge is the geomorphic feature the geotubes are emulating. Furthermore, the seaward toe of the foredune ridge commonly coincides with the “line of vegetation” defined in the Texas Open Beaches Act. The “line of vegetation” is the landward boundary of the public’s easement on Texas beaches. Figure 4 is a segment of the lidar digital elevation model used to map the beach boundaries and determine beach width.

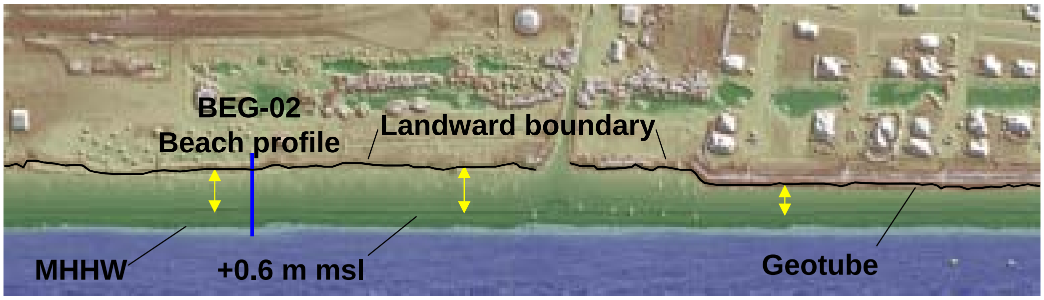

Figure 4. Lidar topographic image of the southwest end of the Pirates Beach geotube project and the northeast end of Galveston Island State Park. Double-ended arrows demonstrate beach width measurement.

RESULTS

Table 1 shows snapshots of the conditions of the geotubes during each field visit. Lengths of sections of geotubes where at least the seaward face was fully exposed and sections with little or no vegetation cover are tabulated. The June survey was conducted seven days after Tropical Storm Allison when the seaward faces of the geotubes were exposed along 44% of their length. Except for the Treasure Island project, maintenance activity was able to recover most of the exposed geotubes and by November only 15% of the total length of all projects was exposed (Table 1). The Treasure Island middle project was destroyed by waves and slightly elevated water levels in November.

Table 1: Exposed and sparsely vegetated geotubes.

	June 2001		July 2001		November 2001	
Project	**Exposed ft/%**	**< 25% veg. ft/%**	**Exposed Ft/%**	**< 25% veg. ft/%**	**Exposed ft/%**	**< 25% veg. ft/%**
Gilchrist East	1,670/27	5,079/82	0/0	4,403/52	702/6	7,011/62
Gilchrist West	10,382/73	12,421/87	6,142/43	13,438/95	3,967/28	10,968/77
Dellanera	392/26	761/50	545/36	695/46	207/14	574/38
Pocket Park 2	0/0	499/100	0/0	0/0	0/0	0/0
Riviera	0/0	479/100	0/0	0/0	0/0	0/0
Pirates Beach	791/10	791/10	791/10	791/10	108/1.3	971/12
Treasure Isl. Middle	417/100	417/100	417/100	417/100	destroyed	destroyed
Treasure Isl. North	285/29	282/29	305/31	305/31	538/55	974/100
Treasure Isl. South	256/100	256/100	256/100	256/100	256/100	256/100
Total	**14,193/44**	**20,985/65**	**8,456/26**	**20,305/59**	**5,778/15**	**20,754/56**

Table 2 gives the minimum and average beach widths. Average beach widths are narrower in front of the geotubes than adjacent to them by 21 to 83 ft (6.4 to 25.3 m). Except for the Riviera and Pocket Park II projects, the beaches in front of the geotubes have minimum beach widths narrow enough to prevent passage during water levels of 1 to 2 ft (0.30 to 0.61 m) above mean higher high water.

Table 2: Comparisons of beach width in front of and adjacent to geotubes July 17, 2001.

	Minimum Width (ft)		Average Width (ft)		
Project	**In front**	**Adjacent**	**In front**	**Adjacent**	**Difference front – adj.**
Dellanera	14	28	40	61	-21
Gilchrist east	21	73	93	132	-39
Gilchrist west	22	95	62	117	-55
Pirates Beach	14	101	67	150	-83
Pocket Park II	87	70	92	114	-22
Riviera	50	67	55	110	-55

CONCLUSIONS

The geotubes are intended to serve as temporary storm-surge protection and erosion-control structures. Their effectiveness in protecting against storm surge had not been tested by the end of 2001. Tropical Storm Allison struck the coast in June, but the storm was not a significant event with regard to storm surge and beach erosion. Pre- and post-Allison beach profiles at the Galveston Island State Park where there are no geotubes show that Allison did not cause significant erosion. However, in places where geotubes were in the swash zone because of ongoing erosion, they were destroyed or damaged. To prevent failure it is critical to (1) keep the geotubes covered with sand, (2) maintain a beach in front of them through beach nourishment, and (3) quickly repair holes in the fabric.

Although Allison did not test the storm-surge-protection function of the geotubes, the storm was largely responsible for eroding much of the sand cover. Fair weather and transportation of sand from borrow sites allowed most of the geotubes to be recovered by November. Because the geotubes cannot be recovered through natural processes, covering them requires a significant effort. Furthermore, maintaining even a sparse vegetation cover on at least half of the project lengths has been impossible.

There has been concern that the geotubes, by preventing erosion and release of landward sand to adjacent beaches, may eventually cause adjacent shorelines to retreat at a higher rate than they otherwise would. As of 2001, however, adjacent shorelines had not been affected by the projects. Furthermore, if beaches are nourished in front of the projects, the nourishment sand will erode and supply adjacent beaches. If beaches are not maintained, the geotubes will be destroyed before adjacent beaches are significantly affected. Even a short-term increase of erosion rate on adjacent beaches, however, could cause problems, and monitoring is required.

The geotubes alter the geomorphology and sedimentary environment of the beach/dune system. Even when covered by vegetated sand they rise abruptly from the back beach and appear more like earthen dikes than natural dunes or bluffs. Along natural beaches, a coppice mound subenvironment, consisting of sparsely vegetated wind-blown sand, forms on the back beach seaward of the foredune. This subenvironment is not well developed or does not exist in front of the geotubes because the beaches are not wide enough to provide dry sand for wind transport and to prevent waves and salt spray from inundating the back beach. The beaches in front of the geotubes are significantly narrower than they would be if the geotubes and houses seaward of the natural line of vegetation were not there; thus the public's use of the beach may be diminished.

In summary, the geotube projects may be effective for short-term erosion control, but their storm-surge-protection function has yet to be tested. They are significant engineering structures that have changed and are changing the geomorphic and sedimentary environments of the beach/dune system. Continued maintenance and beach-nourishment projects will be required to maintain the geotubes and to mitigate adverse effects on public beaches.

James C. Gibeaut
University Station Box X
Austin, Texas 78713
Phone: (512) 471-0344
E-mail: *jim.gibeaut@beg.utexas.edu*