ABSTRACT
Management of debris produced by a storm event is an adjunct function of the Solid Waste Authority of Palm Beach County (SWA) in its role as a support agency to Palm Beach County Engineering and Public Works Emergency Support Function Three (ESF-3) responsible for the restoration of public infrastructure following a disaster. In a post-storm environment the primary goals of the SWA are to manage the removal of storm debris and resume normal garbage collection as quickly as possible. The SWA has utilized the power of GIS as an additional tool for debris management. The Solid Waste Authority along with Dewberry and Davis, LLC have developed a debris prediction model using GIS technology, Disaster Assistance Response and Recovery Technology (DARRT).

GIS OVERVIEW
GIS (Geographic Information Systems) is a powerful software technology that allows a virtually unlimited amount of information to be linked to a geographic location. Coupled with a digital map, GIS allows a user to see regions, counties, neighborhoods, and the people who live in them with unprecedented clarity, showing layer upon layer of information—such as demographic trends, soil types, income levels, voting tendencies, poverty rates, pollution levels, epidemics, cereal brand preferences, high school drop-out rates, college scholarship rates, television watching preferences, and Internet accessibility—the list is limited only by the imagination GIS also incorporates powerful tools to analyze the relationships among all these kinds of data (Greene, 2000).

DEBRIS PREDICTION
DARRT is a stand alone GIS application that provides the SWA the ability to estimate the amount of debris a storm event could generate. Storm events include hurricanes, tornados or floods. Palm Beach County has been divided into 9 SWA Service Areas for our routine garbage collection (Figure 1). These 9 Service Areas also double as our debris zones. Using DARRT, the SWA can input the swath of a storm to obtain debris estimates. Users can map the swath by selecting debris zones, municipalities or drawing a polygon. DARRT then lists the number of single family homes, condos and mobile homes in the selected area that will be used as a base for calculating debris estimates. The forecasted debris quantities are based on the USACOE (United States Army Corp of Engineers) debris prediction model (Figure 2). Adjustments are made to the model for mobile homes and condo units.

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Q = H (C) (V) (B) (S)
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- \(H\) = number of households, or population/3
- \(C\) = 2cy (cat1), 8cy (cat2), 26cy (cat3), 50cy (cat 4), 80cy (cat5)
- \(V\) = 1.1 (light), 1.3 (medium), 1.5 (heavy)
- \(B\) = 1.0 (light), 1.2 (medium), 1.3 (heavy)
- \(S\) = 1.0 (none to light), 1.3 (medium to heavy)
- Note: The predicted accuracy of the model is ± 30%

The result is an estimate of cubic yards of debris generated; acres needed to manage it, and estimates dollar amounts of the structure and land damages. The results also break down the types of debris by type and estimated percentage generated (Figure 3). The types of debris include construction and demolition and clean woody waste.

Along with debris estimates, DARRT is able to display designated areas for debris management, while identifying the locations of emergency management agencies (Fire, Police and Hospitals), equipment staging areas, and shelters.

DEBRIS MANAGEMENT
In the post-storm phase, Temporary Debris Sites (TDS) will have debris monitors located at the entrance in towers.
To gain access to the debris site, the debris hauler will have to present a load ticket to the monitor. Monitors are used as funneling points to fill out and distribute tickets. Load tickets are used to track the amount of debris being delivered to a debris management site for the purposes of FEMA reimbursement.

Maps of Palm Beach County are created using GIS to display all open debris sites and what debris materials they are accepting, as well as what debris zone they are located in (Figure 4). These maps are distributed to the debris contractors, SWA Customer Service Field Representative and our debris consultants. Detailed maps of each debris zone are also created to better assist debris contractors, who may be unfamiliar with the area navigate their zone (Figure 5).

Utilizing GIS the SWA is able to track and monitor the progress of the debris cleanup. This is done using a “sweeps” process. The sweeps process involves having debris removal trucks make scheduled and coordinated passes to remove debris from impacted areas. SWA Customer Service Field Representatives monitor the progress of these “sweeps” and highlight roads as contactors continue their sweeps. Using GIS, maps are produced and updated showing the status of the sweeps through affected areas by color coding the roads until they have returned to normal. During the 2004 hurricane season, the SWA used red to signify the first pass had been completed and blue to signify the completion of the second pass. Green represented the final pass for that area and that it would soon be returned to it franchise hauler. Other colors were used to display a different situation in certain areas. For example, pink was used to signify an area with no homes, orange was used to show areas that required a rear loader or typical garbage truck, and purple was used to show areas where Home Owner Associations (HOA) performed their own cleanup activities (Figure 6). Tracking this information played a vital role in the debris clean up efforts in the aftermath of Hurricanes Frances and Jeanne, which struck 3 weeks apart.

Utilizing DARRT, and GIS the SWA will be able to better manage the debris in the aftermath of a future storm event.
FIGURE 1

DARRT Debris Model Program and Debris Zones
FIGURE 3

DARRT Performing Hurricane Debris Predictions
Open Debris Sites in Palm Beach County after Hurricanes Frances and Jeanne
FIGURE 5

Detailed Map of a Debris Zone
Debris Collection Status after Storm