

# Lessons in Disaster Supply Chain Management from Waffle House Restaurants

Özlem Ergun, Jessica L. Heier Stamm\*,  
Pinar Keskinocak, and Julie L. Swann

**This teaching case is intended to document the practices of Waffle House Restaurants and to provide a basis for classroom discussion. The information presented herein does not constitute an official recommendation for particular scenarios arising in practice.**

**The authors gratefully acknowledge the Waffle House Restaurants personnel for sharing generously of their time, experience, and process documentation for the writing of this case. Support for this work was provided by the Georgia Institute of Technology Focused Research Program on Humanitarian Response, the Harold R. and Mary Anne Nash Junior Faculty Endowment Fund, National Science Foundation Grant SBE-0624269, and a National Science Foundation Graduate Research Fellowship. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.**

\*corresponding author: Jessica L. Heier Stamm; 765 Ferst Drive NW, Atlanta, GA 30332-0205;  
Email: [jheier@isye.gatech.edu](mailto:jheier@isye.gatech.edu).

# Lessons in Disaster Supply Chain Management from Waffle House Restaurants<sup>1</sup>

## 1 Introduction

Tom Forkner and Joe Rogers, Sr., opened the first Waffle House Restaurants store with a commitment to outstanding service, both to their customers and to their employees. This dedication to the community is still witnessed today, and perhaps is most evident in the company's philosophy toward hurricane response. In this case study, we detail the company philosophy and describe their preparation for hurricane season, their response process, and the lessons they have learned to improve the process through the years.

### 1.1 Company Background<sup>2</sup>

In 1955, the first Waffle House Restaurants store was opened in Avondale Estates, outside of Atlanta, GA. More than 50 years later, it has grown to approximately 1600 stores in 26 states. Of these, 650 are owned and operated by franchisees with the remainder managed by the company itself. Waffle House Restaurants has various offerings, including breakfast items, T-bone steaks, hamburgers, country ham, pork chops, and grits.

Today, employees in stores across the country contribute to serving Good Food Fast<sup>®</sup> in Waffle House Restaurants open 24 hours a day, 365 days a year. The company is headquartered in Norcross, GA, and the Southeast remains a large market. Therefore, a significant percentage of Waffle House Restaurants are subject to the effects of hurricanes. The company's hurricane preparations involve employees from all of the functional groups in the organization.

The specific roles of each group in the hurricane response process are detailed in Section 1.4. To assist in understanding the relationship between the groups, Figure 1 illustrates the organizational structure of Waffle House Restaurants. There are two major divisions of the company: operations and non-operations. The operations division runs the company- and subsidiary-owned restaurants. Three unit managers, each responsible for one restaurant, report to each district manager, and three or four district managers report to each division manager. The region/area vice presidents are each responsible for three or four divisions, for a total of approximately 30 restaurants. The region/area vice presidents report to eight senior vice presidents, who in turn are responsible to three executive vice presidents. The final roles in the managerial structure are those of the president and of the chairman and chief executive officer, who have responsibilities for both operations and non-operations.

---

<sup>1</sup> This case description is taken from Ergun, Ö., P. Keskinocak, J.L. Heier Stamm, and J.L. Swann. "Waffle House Restaurants Hurricane Response: A Case Study," *International Journal of Production Economics (Special Issue on Improving Disaster Supply Chain Management)*, <http://dx.doi.org/10.1016/j.ijpe.2009.08.018>. To appear.

<sup>2</sup> Company background was obtained through personal interviews with Waffle House Restaurants personnel and by consulting the Waffle House Restaurants media kit, available upon request at <http://www.wafflehouse.com/faq.asp>.

In the non-operations division, there are three primary areas. The chief financial officer, the vice president of close support, and the vice president of development each report to the president. The finance team is responsible for accounting, finance, franchise development and support, tax, and stock tasks. Close support manages marketing and communications, human resources and training, and operations control, which supports company operators. The development team is responsible for real estate, construction, and equipment and property management.

## **1.2 Disaster Response Philosophy**

The processes used by Waffle House Restaurants to respond to hurricanes have evolved over the course of many years, but one fundamental theme directs all the response activities. “Nothing good can come from a closed Waffle House after a hurricane – not for us, not for the community, not for the associates.” This statement from former Waffle House Restaurants president and chief operations officer, Bert Thornton, summarizes the company’s disaster response philosophy. The company is committed to getting back into the affected areas, opening stores as quickly as it is feasible and safe to do so, and helping the local economy and restaurant associates rebuild. Despite the fact that operating in these conditions presents significant economic and logistical challenges, Mr. Thornton explains, “Our position is this: those customers and those associates are there for us in the good times, so it’s our responsibility to be there when times are tough. We do not take a back seat; we don’t subscribe to the theory that you just wait until everything is easy to do and then open up the doors. We’re always the first ones in.”

Because of this commitment, the company’s reputation now precedes their arrival into an affected area. The National Guard and local authorities welcome the arrival of Waffle House Restaurants personnel, recognizing that they provide an essential service in the form of hot meals for National Guard personnel, local emergency responders, electricians, and community members alike in the aftermath of a storm. Waffle House Restaurants’ commitment and philosophy have informed the development of an integrated hurricane response process. The effectiveness of the response stems from proactive preparation and continuous improvement.

## **1.3 Hurricane Response Cycle**

Preparation for hurricane response, for which the company dedicates significant time and resources, is part of Waffle House Restaurants’ larger disaster planning. Preparation begins in the spring, prior to the beginning of the hurricane season. A major weather event triggers the response systems, and lessons learned are documented for future seasons.

Many years ago, hurricane efforts were a response *task*, but Waffle House Restaurants senior managers now consider them a response *event*. The change is reflected in the number of people and resources that are dedicated to hurricane planning. The leadership team is comprised of senior management from each of the company’s functional areas, and the team participates both in the annual preparation meeting and on-the-ground response. Many are 20- or 30-year veterans of the Waffle House Restaurants business. Though the response processes are well-documented, director of purchasing, Greg Rollings, explains, “They won’t be lost if they lose the checklist.”

### **1.3.1 Pre-season Preparation**

The Atlantic basin hurricane season officially extends from June 1 through November 30<sup>3</sup>. To make a quick and effective response possible, the Waffle House Restaurants hurricane response cycle begins with pre-season preparation. At the annual hurricane preparation meeting each May, all members of the hurricane response team gather at the corporate headquarters. Lessons learned from the prior season are reiterated, key responsibilities are confirmed, contact information and procedures are updated, and the response protocol and timeline are reviewed. In addition to the annual meeting at headquarters, communication and training occur at all levels of the organization. Associates at all restaurants receive information about how to prepare their homes and families for an imminent hurricane, as well as how to contact the company to confirm their safety and obtain information about returning to work.

Prior to the onset of hurricane season, response processes are also reviewed with Waffle House Restaurants' key vendors with whom the company interacts on a regular basis. Arrangements are also made to obtain supplies specific to hurricane response, including fuel and portable toilets. These items are critical because electricity and water are often unavailable following a storm. At this time, other key assets including generators, vehicles, and communications equipment are secured either through purchase or lease agreements.

When Waffle House Restaurants reopen following a hurricane, they serve a limited menu rather than the full normal selection. The items and prices for this hurricane menu are determined prior to the hurricane season. These are filed with the appropriate government authorities in each hurricane-prone state to document the restaurant's commitment to consumer protection practices. Prices are fixed to the current pre-season value and the lowest applicable tax rate is used. The resulting values are then rounded down to the nearest nickel to make it easier for associates to conduct transactions if cash registers are not operational. The hurricane menu is used to simplify operations in the immediate aftermath of a storm and is discussed in more detail in Section 1.4.4.

### **1.3.2 Impending Storm Preparation**

During hurricane season, weather in the region is monitored daily. If a landfall is deemed likely at Category 3 strength or above<sup>4</sup>, the hurricane response process is initiated. The first step in the process is the designation of a commander-in-control. This person, stationed at the corporate headquarters, is responsible for coordinating all of the response activities.

When a storm is imminent, the purchasing group executes a number of actions to prepare for store closure and reopening. In particular, the timing, destination, and quantity of food deliveries must be managed with suppliers. In addition to coordinating the food supplies in the days leading up to landfall, the purchasing department also secures recreational vehicles (RVs) and a refrigerator truck, as deemed necessary. The RVs are used to transport and house Waffle House

---

<sup>3</sup> National Oceanic and Atmospheric Administration's Hurricane Research Division, 2007. "Frequently Asked Questions, version 4.2." Accessed online June 2, 2008. <http://www.aoml.noaa.gov/hrd/tcfaq/G1.html>.

<sup>4</sup> National Oceanic and Atmospheric Administration's Hurricane Research Division, 2007. "Frequently Asked Questions, version 4.2." Accessed online July 15, 2009. <http://www.aoml.noaa.gov/hrd/tcfaq/D1.html>.

Restaurants personnel who will enter the affected area immediately after the storm passes, while the truck is used to transport supplies from stores that cannot or will not reopen immediately to those that will. These vehicles are dispatched to staging locations closer to the storm area in the day before landfall. Along with the dispatch of the RVs and the refrigerator truck, the response teams from each of the functional areas are mobilized in the days leading up to the storm.

### **1.3.3 Post-storm Action**

Smaller hurricanes and tropical storms are handled on a case-by-case basis and may be addressed by a smaller team or through the company's standard crisis procedures. However, for storms that are large Category 2 hurricanes or above and thus affect a significant number of restaurants, the Waffle House Restaurants hurricane team aims to have personnel in the affected area 12 hours after the storm has passed. These responders travel from their staging locations and immediately begin assessing damage and implementing a recovery plan. Each functional group within the company has specific responsibilities during the recovery, which are detailed in Section 3.4. The recovery plan draws on the documented hurricane response procedures.

### **1.3.4 Return to Normalcy**

Waffle House Restaurants is committed to speeding the return to normal operations for the sake of its employees and the communities in which it operates. Depending on the scope of the hurricane impact, this process may take less than a week or more than a year. The company is able to reopen stores more quickly than many other businesses because of their proactive approach developed over time. Lessons learned in each storm are used to improve future preparedness. Many of the processes outlined in the remainder of this case study are the result of experience in responding to hurricanes throughout the years. The company responds more quickly, has more resources dedicated to the response, and has identified what supplies and tasks are critical to a successful recovery operation.

## **1.4 Functional Area Responsibilities**

In this section we describe the responsibilities of each functional group in the days immediately preceding and following a hurricane that affects company-managed stores. The primary areas of responsibility include the purchasing, construction and equipment, operations, people and information technology, and control functions. The response efforts are coordinated by a commander-in-control stationed at corporate headquarters in Norcross, GA. Senior managers are involved in every step of the response process and are among those that are on the ground immediately following a storm. In the case of franchisees, corporate leaders make available any resources requested, but the franchisees lead the response process.

### **1.4.1 Commander-in-Control**

Stationed at corporate headquarters, the commander-in-control communicates across all functional groups and mobilizes corporate resources to meet the needs of the personnel in the affected areas. This is a very intense responsibility, often requiring 18-hour work days. The company has identified a number of people with experience in filling this position, and the

person initially appointed to this role typically passes the responsibility to another after the first several days of the recovery effort.

#### **1.4.2 Purchasing**

The purchasing group has developed a timeline to assist with the many tasks necessary to prepare for and respond to a hurricane. Five days before the anticipated landfall, communications with suppliers are critical to ensure that the suppliers have adequate inventory of the emergency items (which are not part of typical orders) Waffle House Restaurants will need. Items such as to-go supplies, paper towels, cleaning materials, hand sanitizer, ice, bottled water, and canned drinks are all needed in much greater quantities following a hurricane than under normal circumstances. Communicating with suppliers is also critical so that they can begin planning for drivers and deliveries of supplies immediately after the hurricane.

As landfall nears and the areas likely to be affected are more clearly identified, suppliers are notified to suspend delivery to areas that are being evacuated. The company's primary supplier has ready access to hurricane-affected areas because it also provides food for hospitals. However, other suppliers are often unable to mobilize quickly following a storm. To remedy this, purchasing personnel alert other suppliers in advance of an oncoming storm and stage extra product in restaurants that are outside the storm path but near the affected markets. This enables Waffle House Restaurants personnel to draw from these stocks to supply affected stores, transporting the goods themselves until normal shipments from these suppliers can resume. For example, two days prior to expected landfall, the company's bread supplier makes its last deliveries to the affected area. In addition to the standard delivery, the bread supplier delivers safety stock to stores that are out of the storm's path but nearby. This bread supplies the reopened stores in the days immediately following the hurricane.

When a storm is imminent, purchasing personnel secure recreational vehicles to provide sleeping quarters for the teams arriving on the scene first. These teams are staged in locations that will ensure their safety while still allowing quick access to affected areas. For example, during a Gulf Coast hurricane, response teams are staged to the east and west of the predicted storm path. This enables them to enter the affected area as the storm pushes north. The RVs also serve as mobile command centers during the response. In addition to the RVs, the purchasing group secures a refrigerator truck that will be used to transport food from nearby restaurants to those that are selected to open first.

Two days prior to projected landfall, the purchasing group also places an order for the first truck containing "first-wave supplies": ice, bottled water, canned soft drinks, to-go supplies, and cleaning supplies. The contents of the first-wave truck have been standardized based on experience in past hurricanes. This truck is staged and ready to deliver supplies on the day after landfall as soon as the operations group has determined which units will open first.

The first restaurants that are opened are able to operate with the supplies from the first-wave truck, their remaining food, and items recovered from surrounding restaurants. As additional restaurants are identified for opening, the second wave of supplies is ordered. Until recently, when a store was identified for reopening immediately following a hurricane, each restaurant

manager was responsible for determining the food and supplies that were necessary. In the chaos, this frequently led to a mismatch between orders and requirements. After Hurricane Ivan in 2004, purchasing personnel developed a hurricane inventory sheet with a par level for each item. This tool enables managers to assess their current inventory levels and order up to the par level for each item. Standardizing this process has improved Waffle House Restaurants' ability to effectively open and operate stores quickly after a storm.

### **1.4.3 Construction and Equipment**

The construction group has two primary responsibilities in the immediate aftermath of a hurricane: assess damage to all affected restaurants and manage refueling for all on-location responders. To execute these tasks, this group interfaces with several other functional areas before and after the storm. Prior to hurricane season, the construction and purchasing groups ensure that RVs are available to serve as sleeping quarters for response personnel and as command centers for the response. Following a storm, construction leaders work with operations managers to determine which stores can be reopened and in what order. These decisions are based on the physical condition of the restaurants; the availability of staff, food, and supplies; proximity to other restaurants; and proximity to major transportation routes. The equipment group is closely involved in these tasks, as well, arranging for generators and other equipment necessary to reopen restaurants.

Supplies of fuel are scarce and demand is high following a major hurricane. Frequently, Waffle House Restaurants must rely on generators to operate restaurants until electricity is restored. In addition, the response teams must travel between all the restaurants in the affected area so fuel for vehicles is a necessity. The company has developed processes to obtain fuel by establishing relationships with suppliers in the pre-season and making arrangements when storms are imminent. This is a joint responsibility of the construction and purchasing teams.

### **1.4.4 Operations**

On a day-to-day basis, the operations group is responsible for running the restaurants. Following a hurricane, operations personnel work with the construction group to identify which restaurants to reopen and in what order. They are also responsible for the on-site tasks that are necessary for operating the stores, such as food preparation, customer service, and cleaning.

Until Hurricane Hugo in 1989, Waffle House Restaurants that were reopened in the aftermath of a hurricane offered the same menu as they did under normal operations. But this poses a challenge in post-hurricane conditions, especially for made-to-order breakfast items. Former Waffle House Restaurants president and chief operations officer, Bert Thornton, explains the advent of the hurricane menu:

I was standing in the middle of it and listening to people call out orders like, "Let me have an order over-medium plate scattered, smothered, covered, chunked, diced, topped, peppered, and capped," and our people were going nuts. So I actually got up on a chair and I said, "Ladies and gentlemen, I've got good news and bad news for you. The good news is everybody's gonna get fed. The bad news is --," because I had hand-written on

several pieces of paper for each salesperson – I said, “Your salesperson will show you what you can order. [...] it’s a limited menu. You can have anything you want; now here’s the list of things that you’re gonna want.”

Since then, the hurricane menu has changed as Waffle House Restaurants personnel observed what worked well and what did not. For example, bacon is not available in a post-hurricane situation because it takes up a lot of valuable grill space and requires long cooking times. However, ham was added because it is fast. The decision about what to offer on the hurricane menu requires a consideration of the space and time available for cooking, both of which are at a premium in the aftermath of a storm. Waffle House Restaurants are typically the first, and often remain the only, restaurants open for some time after a major hurricane. Law enforcement, emergency responders, and local citizens are anxious for a hot meal. While they are grateful for any food, customers do have preferences and menu diversity is important. Choosing the menu items becomes a balance between resource availability and customer utility. The hurricane menu does not differ significantly from the normal menu, but it is a combination of what people want most and what is easiest to prepare.

#### **1.4.5 People and Information Technology**

The people group has a number of important tasks following a hurricane. First and foremost, all employees must be accounted for. Prior to hurricane season, all associates are provided with a key chain attachment that is printed with a phone number to call to confirm their own location and the status of their restaurant. Working with operations and construction personnel, the people group helps redeploy associates to the stores that will be reopened first. If an employee is available, but his or her home restaurant has not yet reopened, that associate often works in a nearby restaurant until the home restaurant comes back online. The people group also works with the control group to manage payroll processes in the days following a hurricane.

At the onset of a response, at least one person in the people group must also secure hotel rooms for the response personnel and displaced associates. This is a difficult task given the high demand for rooms. To help address this issue, Waffle House Restaurants purchased a recreational vehicle following the 2005 hurricane season. The RV is outfitted with satellite capability to support internet and phone communications. This helps alleviate another challenge that arises in large-scale hurricane response – communications among people in the affected area as well as with the corporate headquarters. Because cellular and landline phone service are frequently unavailable in the aftermath of a storm, satellite capabilities greatly simplify communications.

Information technology personnel are tasked with addressing hardware issues and securing any necessary replacement parts. They also assist with the shutdown and restart processes for restaurant computer systems. Finally, a corporate psychologist plays a vital role in response efforts and is available both to local associates and to responders.

### **1.4.6 Control**

The control function has two primary challenges in the aftermath of a hurricane. The first is accounting for food that was already in restaurants prior to the storm. As part of the closing process, most food at each restaurant is stored in the freezer, where it stays frozen for a short period even if electricity is lost. If a store is chosen for immediate reopening, this food is still available for use. However, if the store cannot be reopened, the food may be transferred via refrigerator truck to another restaurant. The control group is tasked with tracking this movement of food to help maintain inventory accuracy for each store. The second challenge faced by the control group is administering payroll. Waffle House Restaurants pays hourly associates every Sunday and wages are paid in cash. Following a hurricane, banks are often closed, so cash must be brought in from outside the affected area.

### **1.5 Conclusions**

Waffle House Restaurants' hurricane response processes have developed over decades of experience. The company's commitment to its associates and to the communities in which they operate has driven the continuous improvement in these processes. Each functional area of the organization has clear responsibilities and plays a key role in enabling quick recovery following even a major event such as Hurricane Katrina. As a result, Waffle House Restaurants has earned recognition as a leader in disaster relief. The lessons learned continue to shape the future of Waffle House Restaurants and provide insight for other organizations to further develop their own response capabilities.

## **2 Case Discussion Questions**

1. Four companies were cited for their effective response to the 2005 hurricanes: Lowe's, The Home Depot, Waffle House Restaurants, and Wal-Mart. Based on the processes described in this case study, what advantages and disadvantages might Waffle House Restaurants have in their hurricane response in comparison to these other companies? To competitors in the restaurant business?
2. Based on the material in the case description, what similarities do you see between the day-to-day operation of Waffle House Restaurants' supply chain and the hurricane response operations? Differences?
3. What opportunities exist for the application of operations research or supply chain management techniques to the challenges faced by Waffle House Restaurants in planning for and responding to hurricanes?
4. Several logistics challenges faced by Waffle House Restaurants were identified in the case study. Discuss other logistics challenges that may not have been explicitly mentioned but that could arise in hurricane response. How might operations research or supply chain management methods be used to address these challenges?
5. How might the processes developed by Waffle House Restaurants be used to help other organizations improve their disaster response preparedness?
6. How might the decisions made in the humanitarian sector be similar to those faced in the business sector? How might they be different?

### **3 Disaster Response Decision Making: Pre-event Equipment Purchase**

One important decision made by Waffle House Restaurants during pre-season planning is the purchase or lease of equipment such as generators or portable toilets. The demand for such items is highly uncertain, and both item costs and storage costs can be high. However, if advance arrangements are not made, it can be more expensive or even impossible to obtain such items immediately before or after a storm due to high demand. Answer the following questions to explore factors affecting the decision to purchase or lease and in what quantities.

1. Suppose you are responsible for determining the generator procurement plan for Waffle House Restaurants' hurricane response. What information and data would you need to make a decision about how many generators to purchase?
2. How would you estimate the cost of purchasing a generator?
3. How would you estimate the cost of generator shortages?
4. What are the impacts of over- or under-estimating the need for generators?
5. Using the estimates from the previous questions, how would you determine the number of generators to procure? Explain the factors that affect your decision and the process that you follow to reach it.

### **4 Technical Analysis: Advance-Purchase Decisions for Recovery Equipment**

Table 1 provides the cumulative distribution function for the number of major U.S. landfalling hurricanes and is generated from historical data for the number of such storms that occurred each year from 1956 to 2005. Here,  $y$  is a random variable representing the number of major U.S. landfalling hurricanes for a year. According to the historical data, the probability that  $y$  is less than or equal to four storms, for example, is one. Similarly, there is a 52 percent chance that there will be no major U.S. landfalling hurricanes in a given year. This information can be used for disaster planning purposes to help anticipate the resources required.

One way this data may be used is to help predict the number of generators Waffle House Restaurants should purchase or lease for a given season. Suppose management has determined that four generators are necessary per response effort and that generators cannot be reused for multiple storms in the same season. (This may be determined based on other factors and could be a subject of further analysis. For example, if maintenance is necessary between storms or it is desirable to hedge against the risk of concurrent storms, this approach is appropriate.) Based on Table 1, we can construct Table 2 with the cumulative distribution function for the number of generators needed, where  $x$  is the random variable indicating the number of required generators.

1. Tables 3 and 4 give estimates for the cost of a procuring a generator and for the lost profit experienced in the event of a shortage of generators. Based on these scenarios, construct a newsvendor model for the problem of selecting the number of generators that will minimize expected cost by completing each table.
2. Based on the data from the tables in Problem 1, answer the following questions:
  - a. Suppose that experience indicates that the region will be without electricity for three days following a major hurricane and that lost profits are estimated at \$5,000 per day. How many generators should be purchased to minimize the expected cost?

- b. What is the impact of your decision about the number of generators to purchase if electricity is actually out for four days?
  - c. What are the advantages and disadvantages of using a model that minimizes expected cost in determining how many generators to procure?
3. Now suppose the realized demand for generators is  $D$  and the total quantity of generators purchased is  $Q$ . Estimates indicate that electricity will be out for three days in the event of a major hurricane and lost profit at stores unable to open is projected to be \$5,000. Generators cost \$1,000. Complete the following steps to analyze the generator procurement problem using an alternative objective, namely to minimize the maximum regret experienced.
  - a. Express the realized cost of a decision to purchase  $Q$  generators, including procurement cost for generators and the cost of lost sales, in terms of  $Q$  and  $D$ .
  - b. If a planner knew *a priori* what the total demand for generators would be, what is the optimal cost the planner would incur? Express this cost in terms of  $Q$  and  $D$ .
  - c. Regret is defined as the difference between the realized cost of a procurement decision and the cost of an optimal decision that would have been made with *a priori* knowledge of the demand for generators. Express the regret incurred as a result of a decision to purchase  $Q$  generators when  $D$  are actually needed in terms of these two variables.
  - d. Using the expressions you developed, complete Table 5, which summarizes the realized costs and the regret of procurement decisions. In this scenario, assume that the maximum number of generators that could possibly be needed in a season is 16.
4. Based on your analysis in Problem 3, answer the following questions:
  - a. Suppose once again that your operations management team estimates from experience that the region is likely to be without electricity for three days following a storm and that lost profits are \$5,000 per day. How many generators should be purchased to minimize the maximum regret?
  - b. What is the impact of your decision about the number of generators to purchase if electricity is actually out for four days?
  - c. What are the advantages and disadvantages of using a model that minimizes maximum regret in determining how many generators to procure?
5. In Problems 1 – 4, the decision about the number of generators to purchase was made based on estimates for the number of days without electricity and the lost profits that result from the inability to open stores. Historical data and management expertise can help improve these estimates, but uncertainty still exists. In this question, we will examine the effects of this uncertainty on the procurement decisions made under the two objectives.
  - a. Using the approach from Problem 3, calculate the value of  $Q$  that minimizes maximum regret if daily profit loss is \$3,000 and electricity is out for 2, 3, or 4 days. Do the same if daily profit loss is \$5,000 and electricity is out for 2, 4, or 5 days.
  - b. How do these values compare to those from Problem 1 for each scenario, where the objective was to minimize expected cost? How do the  $Q$  values change under each objective as the number of days without electricity and the anticipated profit loss increase?
  - c. What implications do these trends have for supply chain managers and their decisions about procuring emergency equipment in the face of uncertain scenarios?
6. Based on your findings from the previous problems, how many generators will you purchase? Explain your reasoning for this recommendation.

## Exhibits

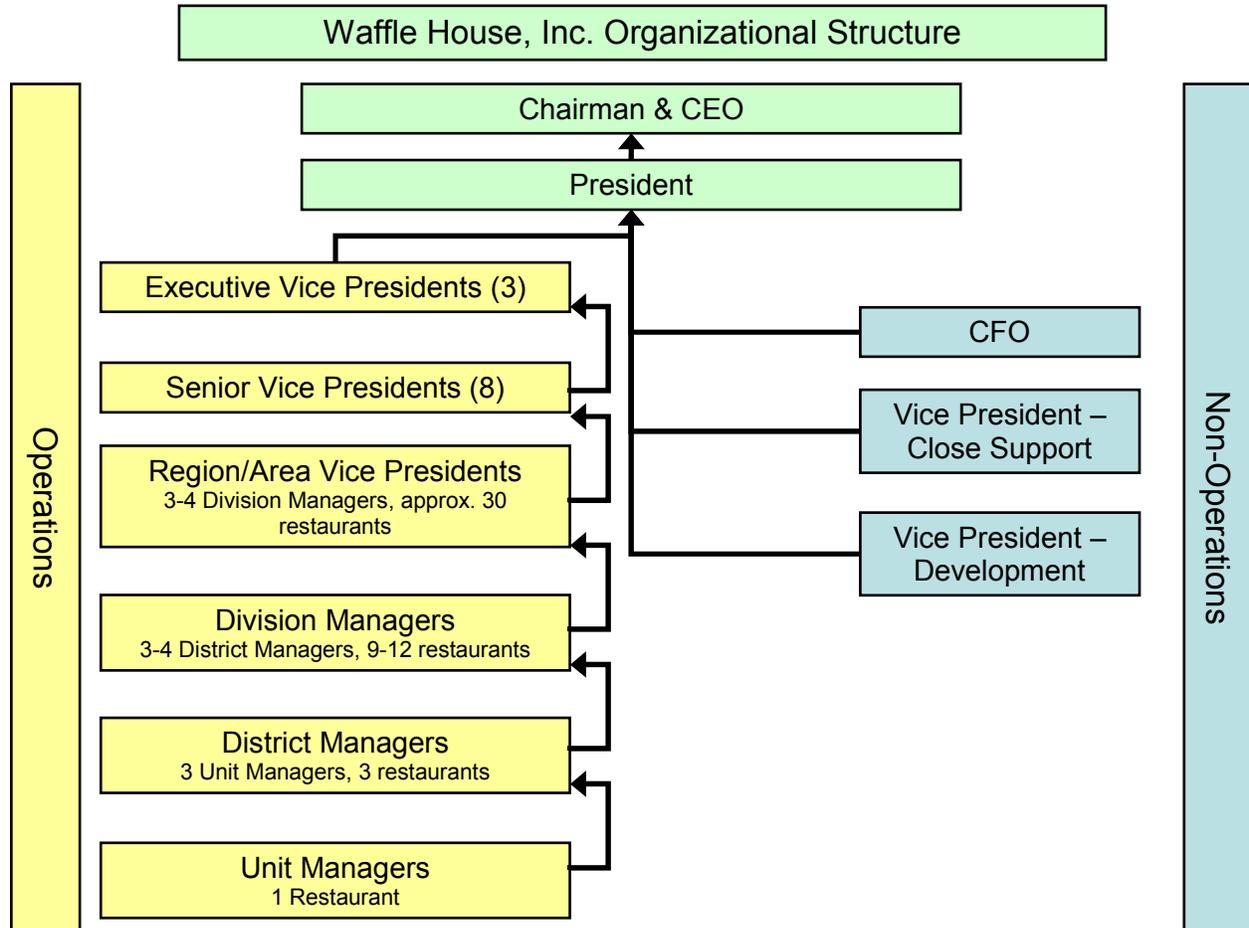


Figure 1: Waffle House, Inc., Organizational Structure

<b>Table 1: Cumulative Distribution Function for Number of Major US Landfalling Hurricanes (from NOAA)</b>	
Y	$\Pr\{y \leq Y\}$
4	1.000
3	0.980
2	0.960
1	0.940
0	0.520

<b>Table 2: Cumulative Distribution Function for Number of Generators Needed</b>	
X	$\Pr\{x \leq X\}$
16	1.000
12	0.980
8	0.960
4	0.940
0	0.520

**Table 3: Scenario 1 – Generator Shortage Costs \$5,000 per day in lost profit.**

Days without Electricity	2 days	3 days	4 days	5 days
Overage Cost (Cost per Generator)	1,000	1,000	1,000	1,000
Underage Cost (Lost Profit)				
Newsvendor Critical Ratio				
Q* (Cost-minimizing number of generators to purchase)				

**Table 4: Scenario 2 – Generator Shortage Costs \$3,000 per day in lost profit.**

Days without Electricity	2 days	3 days	4 days	5 days
Overage Cost (Cost per Generator)	1,000	1,000	1,000	1,000
Underage Cost (Lost Profit)				
Newsvendor Critical Ratio				
Q* (Cost-minimizing number of generators to purchase)				

<b>Table 5: Realized Costs and Maximum Regret</b> <b>Electricity Out 3 Days</b> <b>\$5,000 lost profit/day</b> <b>Generator Cost = \$1,000</b>			
<b>Q</b>	<b>Realized Cost if D=0</b>	<b>Realized Cost if D=16</b>	<b>Max Regret</b>
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			