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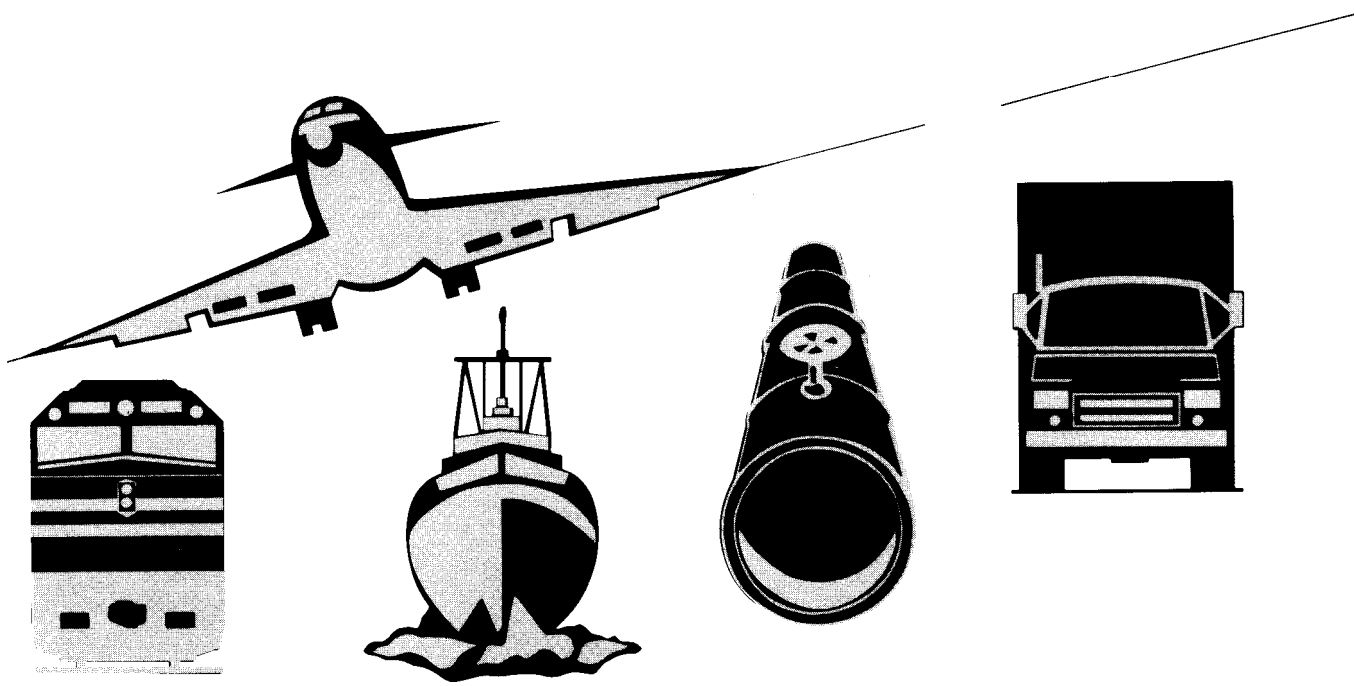
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

PIPELINE ACCIDENT REPORT

SAN JUAN GAS COMPANY, INC./ENRON CORP. PROPANE GAS EXPLOSION IN SAN JUAN, PUERTO RICO, ON NOVEMBER 21, 1996



Abstract: About 8:30 a.m. on November 21, 1996, because of a propane gas leak, a commercial building in San Juan, Puerto Rico, exploded. Thirty-three people were killed, and at least 69 were injured.

The safety issues discussed in this report are the adequacy of employee training, the need for an excavation-damage prevention program, the adequacy of maps and records of buried facilities, the adequacy of public education on what to do when the odor of gas is detected, and the adequacy of the oversight of the San Juan Gas Company, Inc., from Enron Corp., the Puerto Rico Public Service Commission, and the Office of Pipeline Safety.

As a result of its investigation, the National Transportation Safety Board issued recommendations to the Secretary of the U.S. Department of Transportation, the Research and Special Services Administration, the Puerto Rico Public Service Commission, Enron Corp., and Heath Consultants, Inc.

The National Transportation Safety Board is an independent Federal agency dedicated to promoting aviation, railroad, highway, marine, pipeline, and hazardous materials safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The Safety Board makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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Adopted: December 23, 1997
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EXECUTIVE SUMMARY

About 8:30 a.m. on November 21, 1996, because of a propane gas leak, a commercial building in San Juan, Puerto Rico, exploded. Thirty-three people were killed, and at least 69 were injured.

The building was in Rió Piedras, a shopping district in San Juan. The structure was a six-story mixture of offices and stores owned by Humberto Vidal, Inc. The company's administrative offices occupied the third, fourth, fifth, and sixth floors, and the first and second floors housed a jewelry store, a record store, and a shoe store.

The National Transportation Safety Board determines that the probable cause of the propane gas explosion, fueled by an excavation-caused gas leak, in the basement of the Humberto Vidal, Inc., office building was the failure of San Juan Gas Company, Inc., (1) to oversee its employees' actions to ensure timely identification and correction of unsafe conditions and strict adherence to operating practices and (2) to provide adequate training to employees. Also contributing to the explosion was (1) the failure of the Research and Special Programs Administration/Office of Pipeline Safety to oversee effectively the pipeline safety program in Puerto Rico, (2) the failure of the Puerto Rico Public Service Commission to require San Juan Gas Company, Inc., to correct identified safety deficiencies, and (3) the failure of Enron Corp. to oversee adequately the operation of San Juan Gas Company, Inc.

Contributing to the loss of life was the failure of San Juan Gas Company, Inc., to inform adequately citizens and businesses of the dangers of propane gas and the safety steps to take when a gas leak is suspected or detected.

In its investigation of this accident, the Safety Board addressed the following safety issues:

- Adequacy of employee training.
- Need for an excavation-damage prevention program.
- Adequacy of maps and records of buried facilities.
- Adequacy of public education on what to do when the odor of gas is detected.
- Adequacy of the oversight of the San Juan Gas Company, Inc., from Enron Corp., the Puerto Rico Public Service Commission, and the Office of Pipeline Safety.

As a result of its investigation, the Safety Board issues one safety recommendation to the Secretary of the U.S. Department of Transportation, three to the Research and Special Programs Administration, two to the Puerto Rico Public Service Commission, two to Enron Corp., and one to Heath Consultants, Inc.

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INVESTIGATION

The Accident

About 8:30 a.m. on November 21, 1996, because of a propane gas pipeline leak, a commercial building in San Juan, Puerto Rico, exploded. Thirty-three people were killed, and at least 69 were injured.

The building was in Rió Piedras, a shopping district in San Juan. (See figure 1.) The structure was a six-story mixture of offices and stores. Humberto Vidal, Inc., (Humberto Vidal) had bought the building (the HV building) in 1984, and the company's administrative offices occupied the third, fourth, fifth, and sixth floors. The first and second floors of the building housed a jewelry store, a record store, and a shoe store.

The building was on the corner of José de Diego and Camelia Soto. (See figure 2.) The San Juan Gas Company (SJGC)[1] was the local gas pipeline distribution company. The company had a 4-inch cast-iron gas main on de Diego. A 2-inch abandoned gas line, a pressurized steel service pipe, ran from the main to the HV building, about 6 to 8 inches east of the east wall. The service pipe did not enter the building, and gas had not been used in the building for more than 10 years.

The Humberto Vidal Shoe Store was on the first floor, and its front door was on de Diego. The store was owned by Humberto Vidal, which owned other shoe stores in Puerto Rico, as well.

Week Preceding Accident.--Many people later reported that they had detected the odor of gas inside buildings and along streets adjacent to the HV building for at least a week before the explosion.

Several HV employees had worked in the basement and on the first floor early in the mornings before the air conditioning was started. They had smelled a strong odor that they identified as propane gas. Those who had worked in the basement complained of dizziness, nausea, and difficulty breathing while in the basement. One HV employee stated that most of the HV employees had smelled the gas odor, as did some customers. She said the odor was strongest in the basement, where merchandise was stored. The manager of the shoe store (who later died in the explosion) told her that he had advised one of the HV officials that employees could not go into the basement because of the strong smell of propane gas.

SYMPTOMS OF PROPANE GAS EXPOSURE

According to materials safety data sheets, the effects of inhaling propane gas and either odorant, Ethyl Mercaptan or C.S. Captan, include:

Health Hazards of Propane

Symptoms following exposure: Concentrations in air greater than 10 percent cause dizziness in a few minutes. Concentration of 1 percent can cause the same effect in 10 minutes. High concentrations cause asphyxiation.

Health Hazards of Ethyl Mercaptan

Strong objectionable odor irritating to the skin, eyes, and mucus membranes. Symptoms following exposure by inhalation include: headache, nausea, vomiting, or dizziness.

Health Hazards of C.S. Captan

May cause headache, nausea, and difficulty breathing.

[1]San Juan Gas Company, Inc., is a corporation that is wholly owned by Enron Corp. Unless otherwise indicated, the use in this report of "the SJGC" refers to the current Puerto Rico Corporation or to any of its predecessor names.

Figure 1. Accident Location Map.

Some of the employees at the Chicken Kingdom had told their supervisor that they had smelled a strong odor of gas that came and went. The supervisor stated that he called the company that serviced his gas cooking equipment and had all of the equipment tested. No leaks were found. He stated that the equipment-company personnel assumed that the odor must be associated with gas work going on along Camelia Soto, since someone was constantly there checking for gas leaks.

The administrator of the Chicken Kingdom stated that he used a pay telephone to report to the SJGC that his employees had smelled gas. The SJGC employee receiving the call asked for the street name. The administrator explained to him that the smell came and went. The SJGC employee said the gas company would take care of the problem. The administrator stated that the SJGC employee did not ask for his name, for his company's name, whether the smell was inside or outside, or any other questions. The administrator also said that the SJGC employee did not tell him what actions he should take. After he made the report, the administrator said, he saw an SJGC truck and SJGC employees working in the area and assumed that they had come in response to his call. He stated that he never smelled gas in the area while he was outside his building. He also said that during the week or so before the explosion, he had been in Joyería Super Precio, Disco Fiesta, and La California stores and had not detected the odor of gas.

The owner of Pepe Ganga stated that some of his employees had commented to him before the explosion about detecting an odor in the store that they thought might be propane gas. He said that he thought that the odor might have come from the exhaust fumes of the local bus or other vehicles using the street.

Thursday, November 14.--According to the SJGC, the first report it received of the odor was on Thursday, November 14. The SJGC dispatcher on duty that morning said that the manager of the shoe store telephoned him at 8:15 a.m.[2,3] The dispatcher said the manager told him that he smelled gas when he opened the store and that when he went into the basement, he could smell gas, although the odor was not very strong. The dispatcher stated that he recorded the call and told the manager what he told anyone who reported smelling gas--leave the basement door open and try not to turn on any electrical appliances or anything that has to do with electricity.

The dispatcher sent a technician to investigate. The technician arrived at the shoe store about 9:30 a.m. and met with a store employee, probably the store manager. The two then walked down the basement stairs, which were on the east side of the building (the side next to La California). They walked to the north wall of the building (the wall along de Diego), where the manger pointed to the upper right part of the wall and said that the odor seemed to be coming from there. He told the technician that he smelled gas in the mornings when he entered the store. The technician had a gas detector with him, the kind that is not accurate unless it is turned on in an area that is free of gas. Once turned on and moved to an area that is suspected of containing gas, the detector will beep if it detects gas. The technician did not turn the detector on until he had been in the store for about 5 to 10 minutes. When he used it to test the basement air, the detector did not beep.

According to the SJGC dispatcher, the technician spoke with him from the HV building and said that he smelled a slight odor of gas out on the street, but not in the basement.

Friday, November 15.--On Friday, November 15**,** the SJGC sent a brigade to the building. The brigade, consisting of four men and a leader, arrived at 8:15 a.m. The leader had been told by his supervisor that the store manager was complaining of an odor of propane gas inside the building. When the brigade arrived, the store manager told the leader that he smelled propane gas in the store, and both men entered the basement by the stairs at the east wall. In the basement, they walked about 12 to 15 feet north from the stairs, and the manager told the leader that they had reached the spot where he had smelled gas and that the odor seemed to be coming down from the basement ceiling. According to the leader, both he and the manager agreed that they could not smell gas at that time. The leader later stated that the manager had told him that sometimes in the morning when he opened the store he could smell gas. The leader did not have an instrument with him for testing the basement atmosphere for the presence of gas, so he went outside to test the underground with a combustible gas indicator (CGI).

PROPERTIES OF PROPANE GAS

The United States Coast Guard *Hazardous Chemical Data Manual* provides the following selected properties of propane:

- Flammable limits in air are 2.1 percent to 9.5 percent.
- Vapor is heavier than air and may travel a long distance to a source of ignition and flashback.
- Ignition temperature is 842° F.
- Vapor (gas) specific gravity is 1.5.

[2]According to computer records of Telefonica de Puerto Rico, telephone calls were made to the SJGC on November 14, 1996, from the HV building phone normally used by the manager at both 7:43 and 8:22 a.m. The duration of the first call was 83 seconds; the second call lasted for 5 minutes and 17 seconds.

[3]At this time and until after the explosion, it was the dispatcher's practice to not record leak calls from the same address made after one for which a work order had already been issued. The dispatcher did not acknowledge that two calls were received from the HV shoe store on the morning of November 14, 1996.

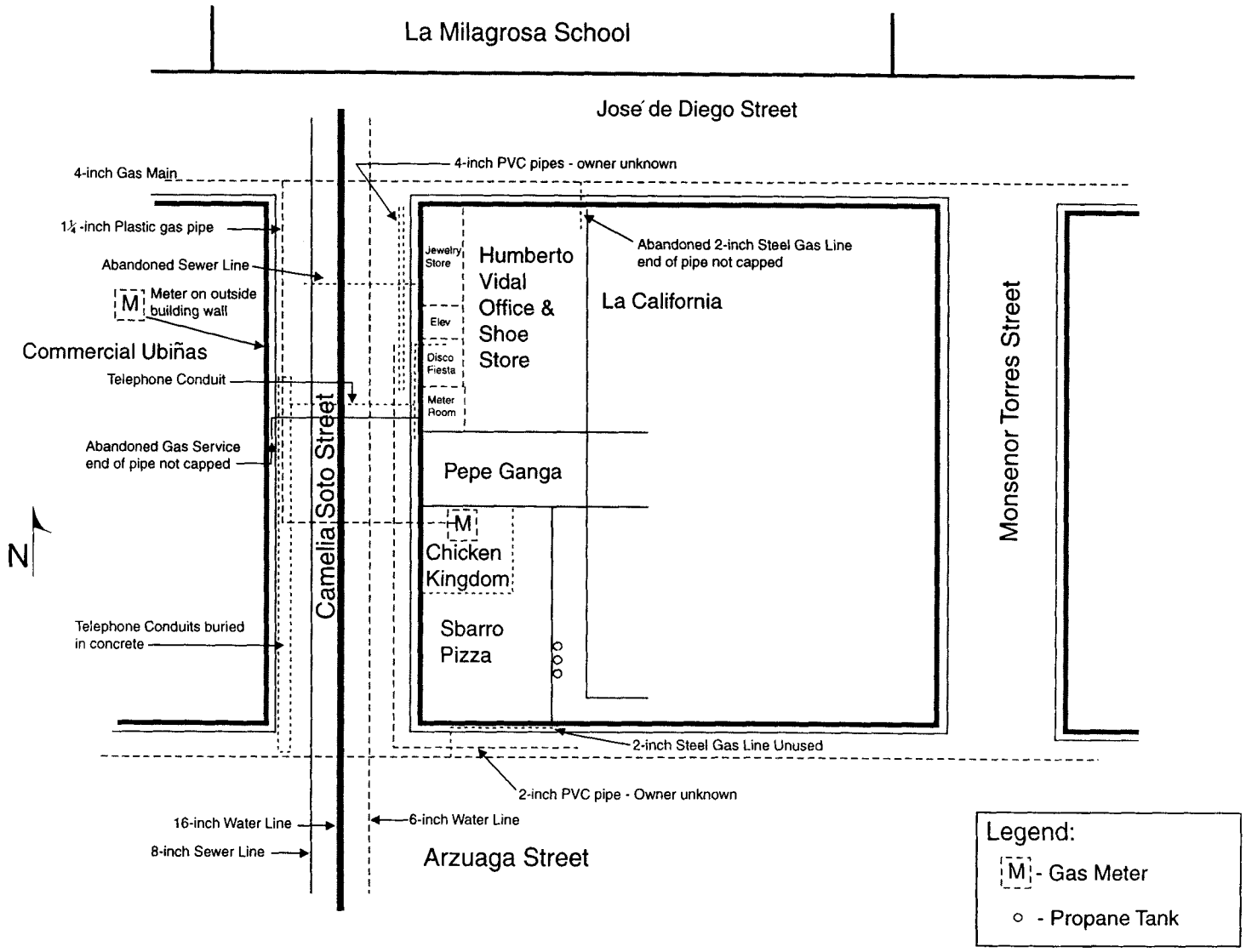

Figure 2. Sketch of Accident Area Showing Buried Conduits and Pipes.

The brigade made about 18 to 20 barholes[4] about 4 feet apart in de Diego and, according to the leader, about 18 to 20 inches deep or deeper. They began east of La California and proceeded west. The leader said that the CGI read *0* until it was about 2 to 3 feet beyond the east wall of the HV building. In a barhole about 4 feet west, the CGI indicated about 2 to 3 percent on the lower explosive limit (LEL) scale.[5] As the leader pumped the CGI to draw in more air from the barhole, the CGI reading dropped.[6] He repeated the test several times, and each time he obtained the same result.

The brigade continued its survey until it was within 20 to 30 feet of Camelia Soto, and the CGI continued to read *0*. The leader called the gas company to find out whether any gas pipes went from the main to the HV building. The company told him about the old line that ran from the main into the building. The brigade excavated the area over the old line, located it, disconnected it from the main, and plugged the opening of the main. The leader stated that a laborer plugged the open end of the old line. (Inspection after the explosion found that the gas service pipe had not been plugged.)

According to the leader, the brigade members used a soap solution to test for leaks in the part of the main they had uncovered. They detected no leaks, so they reburied the main and compacted the soil over and around it. The brigade leader stated that he told the manager to call the SJGC if he again smelled gas.

Monday, November 18.--On Monday morning, November 18, an HV employee told the manager that the odor of gas in the shoe store was very strong. The manager told her that he had already spoken with the SJGC and that the company was not paying much attention. She later stated that he asked her to go to the basement with him and that she walked from the staircase about halfway to the north wall, but could not go any farther because the odor was strong enough to make her dizzy and nauseated. She had to go back upstairs to get some air.

The following day, November 19, was a holiday, and the shoe store was closed.

Wednesday, November 20.--The employee who had gone into the basement on Monday said that on Wednesday, November 20, the odor was still present and the smell appeared to be about the same. She stated that she did not go into the basement again because she was afraid. According to the SJGC dispatcher, an unidentified person (believed to be the store manager) called from the HV building a short time before 8 a.m. and said that a slight odor of gas was detectable in the building. The dispatcher did not record the call. The dispatcher stated that he used the November 14 work order to dispatch a brigade because “they keep on calling.” He said that, as before, he advised the caller that the building should be left open.

The dispatcher said that later in the morning a woman called to report an odor of gas in the building, but he did not take her name since the company had already dispatched a brigade. (According to the SJGC’s records, the only other call the SJGC received that day from the HV building was in the early afternoon.) Later that morning, when the store manager saw an HV official who worked in the building, he told the official about the odor. The official told the manager to open the door or get some fans if the smell got worse, as he did not want customers to smell the gas. Reportedly, the manager did not follow the instructions because it would have been difficult for him to watch the merchandise if the door were open.

After the accident, the SJGC operations superintendent, the supervisor of the dispatcher, stated that he recalled the dispatcher telling him on November 20 about receiving a complaint from the store manager. The operations superintendent said that he responded to the complaint by dispatching a brigade leader and a five-person crew to investigate. He instructed them to go into the store and store basement and

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[4]A barhole is a hole that is made in the soil or paving for the specific purpose of testing the subsurface atmosphere for the existence of a combustible gas.

[5]The LEL is the lowest concentration in air of a flammable gas that can be ignited.

[6]Once a combustible gas is detected, the person operating the CGI draws additional samples from the barhole to see if the CGI reading can be reduced. A reduction in the CGI reading indicates that the combustible gas is flowing into the barhole at a rate less than the sampling rate.

to probe the street outside the store to make certain that there were no problems inside the building. He stated that he instructed the brigade leader to take all the time needed to investigate the report because the brigade leader who went to the building on November 15 had not gone all the way into the basement.

The leader of the November 20 brigade stated that he understood that he was responding to a call reporting a strong odor of gas in the store. He was aware that other SJGC employees had previously responded to a similar complaint and that they had made some barholes. He said that when he arrived at the store, he talked to the manager, who, he claimed, said that he was not sure that what they were smelling in the basement was gas, but that his employees were telling him that it was gas. The leader said that he went throughout the basement with the manager checking for any gas pipe or odor of gas; he said he found neither. He did not use an instrument to check for gas, but he smelled a strong odor, which he believed to be the odor of rubber. He said that when he smelled what he believed to be rubber, HV employees were unpacking shoes, readying them to be put on shelves.

According to two HV employees, no one worked in the basement on November 20 because the odor of gas was too strong. Merchandise arriving at the store that day was stored on the first floor instead of in the basement. One of the two employees reported entering the basement to look for merchandise requested by customers. She said that she tried holding her breath because of the odor. She estimated that she was in the basement about 5 minutes and became dizzy and nauseated. The other reported that he was unable to fully enter the basement because the “fumes” were too strong.

Another HV employee, a messenger, said that he had walked with the store manager and the leader to the stairs. The messenger said that although he did not go into the basement, he became nauseated from the gas odor, as did another employee. The messenger stated that he stayed at the top of the stairs because the gas odor was too strong, but that the leader and the manager walked about halfway down the stairs. The messenger said that the two men did not go completely into the basement and that he overheard the leader say that it smelled like gas.

Propane gas is heavier than air. The leader stated that he knew that propane gas tends to pool and not to rise when it is released underground and that it is therefore necessary to probe deeper into the soil because pockets of propane may be below the gas main. A few days after the explosion, the leader said the barholes his brigade had made were about 12 to 18 inches deep. He said that he did not verify the depth of the holes except by comparing their depth to the length of the probe for his CGI. He estimated the probe was 2 feet long.

In January 1997, the leader said that he made new barholes rather than using the old ones because he recalled being instructed never to use old holes because water might have collected in them, which could damage the CGI. He claimed that he had observed the barholes to be about 2 to 2 1/2 feet deep and was aware that the gas main was 2 feet deep. He said that, beginning at the intersection of Camelia Soto and de Diego, on the west side of the building, his brigade made barholes, first at 20-foot intervals and then at 10-foot intervals, to the east until they were about 15 to 20 feet from Monseñor Torres. He said he had had two reasons for thinking that he knew where the gas main on de Diego was: he had had previous experience with it; another brigade had marked the location of the gas main with crayon when it was repairing the service line to La Milagrosa School.

The brigade made barholes at 10-foot intervals along both sides of Camelia Soto. (The barholes on the eastern side of Camelia Soto started about 5 feet south of the Chicken Kingdom and continued to de Diego. The barholes on the western side of Camelia Soto began at the Comerical Ubiñas gas service line and continued to de Diego.) The leader said he had decided on making barholes along Camelia Soto because he thought there was a gas main on Camelia Soto and that he had thought that gas might have migrated from the main on Arzuaga or the main on Camelia Soto to de Diego. (De Diego is downhill from Arzuaga.) He said that the crew found no indications of combustible gas in any of the holes they made that morning.

The leader said that had he known there was a gas service to the Chicken Kingdom, he would have probed over that line also. He said that he knew that a service line ran to the Comerical Ubiñas building because he could see the meter, but he was not aware that a service line ran to the Chicken Kingdom. He did not call the dispatcher to learn the locations of gas pipes in the area, nor did he use a pipe locator, the maps in his truck, or other means to locate the gas lines.

The SJGC operations superintendent later testified that on November 20, the leader reported that he had found a power transformer that was leaking oil in the basement of the HV building. (The leader did not report this information when interviewed by a Safety Board investigator, nor was there a transformer in the basement.) The operations superintendent stated that the leader told him that his crew had used a soap-and-water solution to test the location where a gas service had once entered the building (the leader testified that he looked for evidence of gas lines entering the basement and found none) and at other locations, but found no areas indicating the entry of propane gas.

The leader said that his CGI had been used by others the previous day and around noon he wondered whether it was operating correctly, since he had not found any indication of combustible gas in the barholes. He and the rest of the brigade drove to the SJGC shop, where they had the CGI tested. It was found to be functioning properly.

Meanwhile, the HV messenger told the HV attorney that the gas odor was still in the basement and, at times, the odor could be detected in the stores in the building. According to the attorney, she called the SJGC after 1 p.m. and reported what the messenger had told her. On receiving her complaint, the SJGC dispatcher informed the operations superintendent. He radioed the leader, who was in the shop testing the CGI, and told him to return to the HV building to check again for gas leaks. He stated that he instructed the leader to test in all directions for leaks and to test even further from the building because he wanted to know why the HV employees were calling.

The leader and the rest of the brigade returned to the HV building and re-tested all of the holes that had been made that morning. Again, they did not detect combustible gas. About 5 p.m., the brigade returned to the SJGC shop. The brigade leader talked with the maintenance and construction coordinator (MCC) and reported that his testing had not revealed evidence of combustible gas near the HV building. He also advised that a store employee had reported detecting the odor of gas that morning when the store was first opened. The MCC stated that he did not believe that there was a gas leak at the HV building because he knew the results obtained by previous crews and because he trusted his personnel and the instruments that they used.

Thursday, November 21.--On November 21 about 6:45 a.m., air conditioning contractors (a father-and-son team) arrived to do the routine, monthly maintenance on the air conditioners that they had been doing for the past 10 years. They met the store manager and the messenger outside. According to the messenger, the manager opened the door to the store and said that he smelled gas. The messenger said his stomach became upset and he told the manager to call the SJGC because the odor was so strong. The manager turned on the lights, and the four men entered the building together. The manager and the contractors walked through the store to the elevator on the west side of the building. The son (the father died in the accident) later stated that when he entered the building, he did not detect any unusual odors but said the manager told him about detecting a strong odor of gas. The three used the elevator to go to the building receptionist area on the fourth floor, where the manager opened the office doors and left.

According to the son, the building air conditioners usually were not turned on until 8 a.m. or later. It was usual for the store manager to turn on all the air conditioning units at their control panels; however, the son stated that when he worked on the basement air conditioner, he would turn the unit on and off as needed. To perform their work, the contractors would feel the air conditioner pipes after the air conditioner had run for a while to assess whether the machine was working properly, and

as needed, they would wash the compressor and filters.

An employee who arrived at work between about 7 and 7:10 a.m. said that as she entered the building, she smelled the odor of gas, an odor that had been present for the past week and a half. She said the odor was strong enough that it "went over the top of the regular odor [shoes] of the store." She recognized the odor as propane gas because she had a propane gas stove at home. As she did most mornings during this period, she mentioned the odor to the store manager. He told her that he would call the gas company again that morning[7] and that he was continuing to keep a log of his calls. (His call log was not found after the explosion.) The store manager's brother entered the store, and the three of them were together until 8 or 8:05 a.m., when the employee left the building to get breakfast.

The manager's brother stated that when he entered the building, he smelled propane gas. The manager complained to him about the strong odor of gas and told him that he had become dizzy and nauseated. The manager asked him to go into the basement to check on the odor. The brother walked to the bottom of the basement stairs, sniffed the air, and would go no farther because his eyes became irritated and he could not stand the smell. He ran back upstairs, advised the manager to leave the building, and soon left himself.

The son from the air conditioning contractor team said that he completed his work on the third and fourth floors about 7:50 and left the building. He stated that his father began working on the fifth floor and was to work all floors other than the third and fourth. The son said that he was aware of the odor produced by the shoes stored in the building and of the smell of propane gas from the pipe system. He stated that he did not detect the odor of gas that day in the areas he visited.

In the meantime, the MCC had decided to send a third brigade, which he dispatched at 7. The workmen arrived about 7:30 and parked their truck on de Diego, in front of the building. The MCC said he sent the brigade to make sure there was no gas in the building and to learn what the HV employees were smelling when they opened the building.

The brigade leader reported that he was given no instructions on contacts to be made at the building and that he had not been told that there had been previous complaints or what the previous SJGC crews had done. He said that because he was not told of the previous actions, he did not take with him any plans or other information about the gas piping in the area. He knew that there was suppose to be a map of the gas mains in the truck, but he did not consider the map important because he knew he could use his radio to obtain any information he needed.

The leader said that he did not smell gas on the outside of the building when he arrived and that he did not see anyone at the store door. He believed the store had not yet opened because the outside roll-up door was halfway up and the inside door was closed.[8] At no time did he or his brigade members meet with or talk to any HV employee. Without referring to the gas main map in the truck, he went to the barholes he saw in de Diego, beginning in front of the entrance to the HV building and extending west to the intersection of de Diego and Camelia Soto. He believed that the barholes had been made the previous day by another brigade. He stated that the holes were about 18 inches deep and about 6 feet north of the curb. He believed their locations to be over the gas main because he recalled the location of the gas main from an earlier time when he saw it exposed to reestablish gas service to the school across from the HV building. He inserted his CGI probe into the holes and tested in each. He detected no odor of gas, and his CGI did not register any indication of a combustible gas.

The administrator of the Chicken Kingdom stated that as he drove past the HV building on his way to work, he saw the SJGC brigade

[7]Telephone records on calls from the HV building do not show a call having been made to the SJGC that morning.

[8]The outside door was a solid metal roll-up door that was about 30 feet wide and covered the store entrance and the glass display windows. The inside door was a metal mesh roll-up door located further from de Diego than the outside door, and it was located across the approximately 6-foot wide store entrance.

working in the area. He said that about a half hour before the explosion he detected a "little" gas odor in the store when the breeze blew into the store.

The leader had three new barholes made in de Diego, between the jewelry store and the manholes in the intersection of Camelia Soto and de Diego. He said that the holes were 18 inches deep and about in line with the previously made barholes that he had already tested that morning. No combustible gas was detected in the three new holes. Next he had the crew make more barholes in the intersection of Camelia Soto and de Diego. As soon as the barholes were made, just before 8:30, he used his CGI and obtained a reading of 20 percent on the gas scale, but he detected no odor of gas. About 5 to 10 seconds afterwards, while he was standing on the manhole cover and another employee was making another barhole, the explosion occurred. The force lifted him into the air and threw him about 15 to 20 feet to the north.

People who were in the HV and adjacent buildings sustained minor to serious injuries. Those on the lower floors of the HV building received the more serious injuries. The bodies of the store manager and the air conditioning service technician were later found in the basement. Some people outside and near the HV building were severely injured or killed by debris propelled by the explosion. (See figure 3.)

Injuries

Type of Injuries	HV Building Occupants	SJGC Employees	Others	Total
FATAL	15	0	18	**33**
SERIOUS	5	4	16	**25**
MINOR	6	0	38	**44**
NONE	0	0	16	**16**
TOTAL	**26**	**4**	**88**	**118**

Title 49 *Code of Federal Regulations* (CFR) 830.2 defines a fatal injury as: any injury which results in death within 30 days of the accident. A serious injury is one that requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; results in a fracture of any bone (except simple fractures of fingers, toes, or nose); causes severe hemorrhages, nerve, muscle, or tendon damage; involves any internal organ; or involves second-or third-degree burns, or any burn affecting more than 5 percent of the body surface.

Emergency Response

Immediately after the explosion, police officers on Camelia Soto and Arzuaga ran toward the building and began helping the injured and those trapped on the upper floors. Firefighters at the Rió Piedras fire station, which was about ¼-mile from the HV building, heard the explosion and arrived in a pumper truck about a minute later. They observed cars turned upside down, injured and dead people in the street, and devastated buildings, but no fire. They radioed for assistance, and within minutes additional fire, medical, and police personnel and equipment arrived. Firefighters provided first aid, removed bodies, and evaluated the risks of entering the building. The Puerto Rico Police dispatched members of its bomb squad to investigate.

At 8:42, the police notified the trauma center at the Rió Piedras Medical Center, which initiated its disaster plan. A triage area was set up at La Milagrosa School.

Figure 3. Building after Explosion (courtesy of *The San Juan Star*).

At 8:45, a San Juan Civil Defense Department search and rescue worker, who had been trained in handling gas emergencies, was dispatched to the scene. When he arrived, he smelled a strong odor of gas, but did not see any evidence of fire or smoke. Dust was still coming from the building, and he said he saw injured and dead people all over the area. He said that people were shouting and screaming and that although he attempted to administer first aid, many victims could not be reached because the debris and objects falling from the HV building made it dangerous to approach them. The streets into the area were narrow and became congested with arriving vehicles, hampering traffic flow into and out of the area.

The Puerto Rico Secretary of Health was notified of the accident at 8:50 and dispatched medical teams and Mental Health Crisis Counseling personnel. A medivac unit was dispatched to transport patients as necessary.

The Disaster Preparedness Improvement Director of the State Civil Defense arrived about 9:00, assumed the role of incident commander, and coordinated the response efforts of participating agencies. At 9:15, the San Juan Civil Defense Department dispatched more search and rescue people.

At 10:00, rescue groups entered the HV building, and some areas of the structure began to collapse. The rescue was discontinued until the Department of Housing, which is responsible for public safety related to the damaged buildings, arranged for structural engineers to assess the stability of the building. By 12:30 p.m., the engineers had identified those areas of the building believed to be stable enough for the rescue workers to enter. The Salvation Army and the American Red Cross also responded and provided support services.

Representatives of the Federal Emergency Management Agency (FEMA) and the Puerto Rico Secretary of State, as Acting Governor,[9] worked with the incident commander to coordinate the response. At 2:30 p.m., the Acting Governor requested a Presidential Declaration that the area in which the explosion occurred was a disaster zone. The President of the United States declared a state of emergency, and a FEMA representative then activated and coordinated the U.S. Urban Search and Rescue Task Force.

A search and rescue team from Bayamon, Puerto Rico, arrived at 4:45 p.m. and joined the rescue operations. FEMA gave interim support to the local response forces by providing flatbed trucks for removing the damaged vehicles and by providing search dogs to help locate missing people. By 6:00, an advance party of the FEMA Task Force had arrived, including people from Florida, New York, and California. At 7:15, rescue teams reported a strong odor of gas in the debris of La California store.

At 9, the rescue was suspended again because of the instability of the building. By that time, 18 bodies had been found, and more than 80 people had been transported to area hospitals. The building was reinforced at various locations and supported by a crane so that the rescue could continue. Search and rescue efforts went on until December 21, when the bodies of the last four people reported missing were found, bringing the total of those who had died in the explosion to 33.

Survival Aspects

According to interviews, because most stores were not yet open, few shoppers were in the area at the time of the explosion and many employees had not yet arrived. The HV building usually held 50 or more employees, including 37 who worked in the offices, 7 who worked in the jewelry store, 12 who worked in the shoe store, and 2 who worked in the record store. Many other people worked in adjacent buildings, and hundreds of shoppers and tourists came into or passed by the building during shopping hours.

Damage

The HV building was destroyed, as was a major portion of the building that housed La California. Several other nearby buildings suffered moderate to severe damage.

[9]The Secretary of State serves as Acting Governor at times when the Governor is unavailable.

The first, second, and third floors of the HV building were shattered, and they dropped into the basement, as did portions of the fourth floor. The fifth and sixth floors remained relatively intact. The building's structural columns and beams were severely damaged, and the Puerto Rico Housing Department declared the building unsafe and arranged for it to be demolished.

The estimated property damage was approximately $5 million. Enron Corp. (Enron)[10] estimated its property damage as less than $50,000. Humberto Vidal estimated property losses to be more than $3.5 million for the building. The estimates, however, did not include the following items: Enron's loss of sales during the many months that the gas system was not in service as a result of the accident, the expenses Enron incurred during the accident investigation, and Humberto Vidal merchandise and business interruption loses.

The combined cost of the damage done to adjacent buildings was estimated to be more than $1 million, which did not include the money lost by the businesses that could not operate for several months after the accident. No estimates are available about the cost of the damage done to motor vehicles, the cost of damage done to windows in buildings on adjacent blocks, or the costs incurred by the Civil Defense, FEMA, the Bureau of Alcohol, Tobacco, and Firearms (ATF), and the Puerto Rico government agencies that responded to the emergency.

Personnel Information

Dispatcher.--The dispatcher who received the leak complaints from the HV building on November 14 and 20 had been a dispatcher for 26 years and an employee of the SJGC for about 27 years. He stated that his knowledge about his duties was gained through on-the-job experience. During 1995 and 1996, he had had training on how to complete the paperwork related to his job, and he had been given pamphlets to read about the SJGC's procedures. He stated that the bulletin board at his workstation had all the emergency-response information he needed.

Technician.--The technician who responded to the leak complaint on November 14 had worked for the SJGC for 28 years. In addition to responding to leak complaints, he installed stoves and read meters. His on-the-job training had included his being told how to use equipment to detect gas and that responding to leaks is a first priority. His primary trainer had been the assistant superintendent of operations, who, in 1996, trained the technician on the use of a gas detector. The training consisted of in-the-field training in the use of the instrument. The technician was not tested.

He described his training as consisting of the assistant superintendent of operations getting together the four people responsible for checking gas leaks and installing stoves and showing them how to use the instrument and how to check the instrument with gas.

First Brigade Leader.--The brigade leader on November 15 had worked for the SJGC for about 40 years. He stated that he did not take the leak survey training given in January and December 1996. During 1995 and 1996, he had been trained in plastic pipe fusion welding, using a gas detector, and the SJGC's emergency procedures. He had not been tested.

Second Brigade Leader.--The brigade leader on November 20 had been employed by the SJGC for about 4 years. He had previously worked for 15 years with a company that installed fire sprinklers. He stated that at the SJGC he supervised the work of laborers and was a pipe fitter. His supervisor, the assistant operations superintendent, had trained him in using the CGI. The superintendent taught him how to test the CGI for accuracy. He was not tested after his training; based on the assistant operations superintendent's observations of his work, he was allowed to perform field leak surveys using a CGI.

Third Brigade Leader.--The brigade leader on November 21 had been employed by the SJGC for 4 years. He began as a laborer, a position which he still held at the time of the explosion, but he was also being trained and used as a brigade leader. He had functioned as a

[10]Unless otherwise specified, Enron is used to refer to the Enron Corp. or to any of its predecessor names, such as InterNorth, Inc.

brigade leader on several occasions before the explosion. He stated that he had not been trained in being a brigade leader and had not been tested to determine whether he understood what the job entailed. He took field training on the use of CGIs in January 1996, but did not have to take a written test. He did not participate in the December 1996 leak survey training.

MCC.--The MCC had worked for the SJGC for about 5 years and had held his MCC position for about a year. Before that, he was a plant operator. In his present position, he visited construction sites, estimated what was needed, assigned a brigade to the work, told the brigade what equipment it would need, talked to the supervisor about the work to be performed, and answered the supervisor's questions. The projects he coordinated included repairs and leak surveys. He also tested the CGIs to ensure that they were functioning and registering correctly. He stated that he had attended the December 1996 leak survey training and was tested afterwards. He stated that in that training, he had been taught to make barholes to a depth of 18 inches and to deepen them if combustible gas was detected.

Assistant Operations Superintendent.--The assistant operations superintendent had been employed by the SJGC since 1975. He had taken his present position in September 1996 after several months of taking on-the-job training from the operations superintendent, who was also being trained for his position. He had previously been a brigade leader. The operations superintendent evaluated his work. He had a copy of the SJGC's *Operations and Maintenance Manual* (O&M Manual) at his work station, but he had never been tested about it. He stated that although the SJGC required supervisors to read the procedures completely, he had not read either the entire manual or all of the portions that pertained to his job. He and the operations superintendent were responsible for checking supervisors in the field to ensure that they were performing their work correctly. The operations superintendent evaluated the performance of the assistant operations superintendent, but he did not know whether the evaluation was written down. He participated in both the late 1995 and the December 1996 leak survey training. Written tests were not given for the 1995 training, but were for the December 1996 training.

Operations Superintendent.--The operations superintendent, who at the time of the accident was being trained for his position, had been employed by the SJGC since 1968. He began as a draftsman's helper, and most of his knowledge had been gained through on-the-job training. He had been the operations superintendent since the end of April 1996 and had overall responsibility for operating the gas system. He stated that he had attended the classroom portion of the 1995 leak survey training, but not the field portion. He had other assistants, such as his assistant operations superintendent and the MCC, there during all of the training. Since the 1995 training, he had taken more leak survey training in December 1996. During 1995 and 1996, Enron provided him with training on dealing with reporters, productivity, organizing his time, delegating authority, and developing potential in himself and others. For his training on the SJGC's practices and procedures, he said, he had been given a copy of the O&M Manual and told to study it. He kept a copy of the manual in his office. He was aware that the manual covered policies and procedures related to work he supervised, but he had never been tested and did not discuss with the employees that he supervised their knowledge of the information in the manual. He had had conversations with the general manager about what was in the manual, and he had conversations every morning when he met with his supervisors to discuss the work for the day and the relevant SJGC procedures.

Safety Manager.--Before July 1990, the safety manager had had no experience with pipeline or propane-gas operations. From July 1990 to August 1992, he had worked for the Puerto Rico Public Service Commission (PSC). During his first year with the PSC, he was given on-the-job training on inspecting companies that bottled and sold liquid gases. In his second year, he received on-the-job training from the PSC's pipeline inspector on inspecting the SJGC's operations. He stated that the training continued until he learned enough to make the inspections on his own. In the meantime, he had attended a 1-day session conducted by the Office of Pipeline Safety (OPS). He stated that while some of the session involved general discussions, more of it involved listening to

someone from the U.S. Department of Transportation (DOT) explain the application of pipeline safety regulations. Participants were not tested at the end of the session. Of his 2 years with the PSC, he said, about 60 percent of his time involved being trained in bottled-gas and pipeline operations.

In September 1992, he began working for the SJGC as the safety manager. He worked for the engineer who operated both the SJGC and Pro Gas Co. (a bottled gas company affiliated with Enron). As safety manager, he stated, he was responsible for personnel safety in both the field and the office, for gas pipeline safety, and for public safety as it related to the gas system. He was responsible for changing the emergency procedure, updating the contact list, investigating accidents, familiarizing employees with the operations manual, working with supervisors to help reinforce procedures, and administrating the Federal drug and alcohol testing. He had read most of the O&M Manual in detail, but he had never been tested or otherwise evaluated on his understanding of it.

In both January and December 1996, he took training in surveying for leaks. In October 1996, about a month before the accident, he took a course at the Florida Gas Transmission school on advanced distribution; he was tested at the end of the course. For 5 to 6 years before the accident, he had been going to college to earn a degree in industrial engineering with a major in quality and safety. He had completed his course requirements in 1995 and, at the time of the explosion, was working on his thesis.

General Manager.--Before working for Enron, the general manager had been an auditor for two consulting companies: Brown & Root and Arthur Andersen. He joined Enron in 1987 in an auditing group of an Enron affiliate company, where he became the director for commercial development.

In October 1995, he became the general manager of the SJGC, and he reported to the president of the SJGC, who also was an executive of an Enron affiliate company. He served as a corporate administrator responsible for operations, safety, human resources, and finances. He had no pipeline operating experience, and as the on-site leader of the SJGC, he viewed his role as one of allocating resources in a way that would best satisfy customers' needs. He stated that he considered SJGC operations a part of his overall responsibility, but acknowledged that he had to rely heavily on the pipeline people that Enron placed in other leadership and management positions. He stated that he allocated resources for functions to be performed but had to rely on the technical expertise of the operations superintendent and the safety manager to ensure that the functions were correctly performed.

The general manager stated that when the safety director proposed changes in the manual, he would call someone at Enron headquarters to review the proposed change and help him assess whether the change should be made. Similarly, if the operations superintendent and the safety manager differed on an issue related to their responsibilities, he, the general manager, would contact someone with Enron to assist him in making a decision. He was not aware that such a situation had occurred.

Concerning the hiring of consultants for the SJGC, the general manager stated that he did not award contracts, that contractors were paid by Enron, and that after paying them, Enron billed the SJGC.

Fatigue.--The members of the brigade who responded on November 21 had had a normal amount of rest (approximately 8 hours) the night before. The crew work schedules for the 2 weeks before the explosion showed normal daytime work hours, a 40-hour work week, and no changes in work shift.

Training

SJGC Training.--Federal and PSC regulations did not require training for many jobs and tasks for gas pipeline employees. Employees were trained at the discretion of the SJGC's management. According to the general manager and the operations superintendent, employees were selected for training in operations according to what their regular duties were or whether they might have to back up operating personnel. Some supervisors were included in operations training. The SJGC did not have general or individual training plans for its employees.

The general manager acknowledged that he was responsible for employee training, but believed that his role was primarily logistic. That is, he was responsible for making sure that when an employee was being trained, the tasks that the employee normally did were done by someone else. The general manager stated that he sometimes recommended training for particular employees, distributed training catalogs, and discussed with the operations superintendent who should take what training, but that he relied on the operations superintendent as having the primary responsibility for recommending training. He also stated that he relied on consultants, such as Heath Consultants, Inc., (Heath), for recommending the type of training a given employee might need. He said that he did some evaluating of the quality and adequacy of training given to the SJGC employees, but had to rely on other Enron resources to evaluate the technical adequacy of the training.

The general manager stated that in his time with the SJGC, the company had not had a professional assess the company's training needs or decide on the most effective means of developing training for its employees.

He said that when consultants who did not speak Spanish trained employees, he made sure the consultants had adequate translation resources. During the Heath training, three bilingual employees helped provide a consensus translation of the material being taught and helped convey the information to Spanish speaking employees. The general manager acknowledged that the process was far from perfect.

Enron had a documented skill-based pay program for its employees, but the program was not available to the SJGC employees because of their union contract. Enron also had a computer-based training program, which was not used by the SJGC employees, and it had access to classroom training on gas distribution through the Florida Gas Transmission School, which some the SJGC employees had attended. (See also appendix D.)

Leak Survey Training.--At Enron's request, on November 28, 1995, Heath proposed that it provide specialized expertise and function as an advisor and trainer for SJGC personnel in order to improve the leakage control program. The proposal called for a ½-day classroom session in gas leak surveying and gas pinpointing and 12 days of hands-on training in leak survey techniques, including barhole testing, leak indication, leak classification, and leak reporting. A January 8, 1996, letter from Heath to Enron broadened the original proposal so that specialized training and assistance in various aspects of the leakage control program would be provided. The project team would consist of a technical manager as the on-site supervisor, a leak pinpointing instructor, and a leak survey technician, who would be assigned primarily to leak surveying but would advise SJGC personnel on other issues concerning leakage control. Heath would conduct hands-on training for a minimum of 3 months. Heath's proposal was revised later to include 1 day of classroom training in leak pinpointing and 8 days of hands-on pinpointing training. All work was proposed to begin on January 15, 1996.

At Enron's request, Heath began in December 1995. Heath's technical manager met in San Juan with SJGC management. They discussed the goals of the proposed project, reviewed the procedures and guidelines for surveying leaks, and established the organization, rotation, and responsibilities for each of the trainees. The technical manager then conducted a ½-day informal classroom review with the employees who were to be trained. The instructional material given to the employees said, "When conducting tests for leakage on buried petroleum gas systems, it is essential that samples be taken at or near the pipe, in the bottom of the ditch lines and at low points of substructure."[11] The technical manager also gave hands-on leak survey training. At the end of the session, he and the SJGC's general manager reviewed the field activities conducted between December 5 and 19.

The technical manager said that the brigade leaders knew the properties of propane gas, understood how to lay out barholes, and understood that barholes had to be drilled to the depth of the gas lines. He said:

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[11] *GPTC Guide for Gas Transmission and Distribution Systems,* Appendix G-192-11A, "Gas Leakage Control Guidelines for Petroleum Gas Systems."

> They needed to understand, you know, the procedures to go through to do the survey, and what they were trying to accomplish in doing it [the survey]. It's a labor-intensive type of survey, and you need people who have a keen interest in wanting to be out there doing it. They all knew what to do, but not all of them had the interest. Well, some of them would rather be digging ditches.

He also said that even though the brigade leaders knew what to do, only one showed any interest in leakage surveys. The technical manager stated that some of the SJGC laborers did not make the barholes to the depth of the gas main and had to be re-instructed. Some, he said, were reluctant to follow instructions and had to been re-instructed repeatedly about the depth to which the barholes had to be made.

During January 1996, the technical manager conducted a ½-day training session on pinpointing gas leaks and spent most of the month with three of the SJGC crews working in the Old San Juan area. The crews received hands-on training in pinpointing and surveying leaks. Heath continued to provide the SJGC employees with hands-on training during the surveys they conducted between January and April.

Gas Company Operations

Gas Distribution and Ownership.--The first gas pipeline system in Puerto Rico was installed in 1912. The gas system was initially owned by the Puerto Rico Gas Company, and it distributed gas manufactured from coke or coal. Eventually it converted to a propane/air system. The system was composed of cast-iron pipe with steel service lines and was not coated or otherwise protected against corrosion. Later, plastic coated steel pipe was installed. The newer pipes were made of plastic, and the SJGC has been replacing some of the older mains and services with plastic.

Enron owns the SJGC, and the SJGC's stock is wholly owned by Enron; its headquarters are in Houston, Texas. Enron was incorporated as Northern Natural Gas Company on April 25, 1930, in Delaware. In 1980, the corporate name was changed to InterNorth, Inc.; and in 1986, it was changed to Enron Corp. On or about January 3, 1985, Petrolane Incorporated sold all outstanding stock of the SJGC, then a Delaware corporation, to The Protane Corporation; and it, in turn, on the same date transferred the assets to InterNorth, Inc. The SJGC continues to be managed and operated by its own slate of directors and officers, and its chairman is the CEO of an Enron affiliate operation.[12]

The SJGC distributed a 60-percent propane/40-percent air mix to customers in the greater San Juan area through about 220 miles of gas mains, both low-pressure (1/4 psig) and high-pressure (20 psig) piping systems. The low-pressure system that served Rió Piedras consisted primarily of about 6 miles of 4-inch diameter cast-iron gas mains and 3.2 miles of mostly 1 ¼ inch diameter galvanized steel service lines and served approximately 500 customers. The 1 ¼ inch inactive bare steel service lines to the Sbarro on Arzuaga and to the HV building were connected to 4-inch cast-iron mains and not protected from corrosion. Additionally, the steel tee section connecting the plastic gas main on Camelia Soto to the service lines for the Chicken Kingdom and for Comercial Ubiñas was not protected against corrosion.

Pipes and Ducts Installed on Camelia Soto.--More than 20 pipes and conduits were beneath Camelia Soto, some meant for future use, some being used, and others that had been abandoned. The conduits meant for future use included 4-inch and 2-inch polyvinyl chloride (PVC) plastic pipes of undetermined ownership and purpose. The pipes and conduits that were in use included the two water mains, a sewer main, a plastic gas line, telephone conduits, and electric conduits. The abandoned pipes and conduits included a gas main, electric conduits, sewer laterals, and water service lines. Many of the abandoned pipes and conduits had not been plugged or otherwise sealed, which would have prevented them from being paths for gases that might have entered the soil. At least five of the

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[12]Enron has numerous organizations, many of which use Enron in their name and which can or do provide various services to other Enron affiliates. For simplicity, such organizations are often referred to as Enron affiliate companies.

conduits and pipes beneath Camelia Soto entered the HV building beneath the floor of the meter room at the southwest corner of the building. The meter room floor was raised about 2 feet above the first floor of the HV building, and the space beneath was filled with gravel. From the gravel-filled space, electrical conduits entered the HV basement.

According to the SJGC's records, in February 1985, the SJGC installed a 1 ¼-inch diameter polyethylene (PE) plastic pipe along the west side of Camelia Soto. It ran about 2 to 3 feet east of the west curb. Some time later, the line was extended south by using PE plastic pipe with PE socket fusion fittings. The extended line crossed Camelia Soto to provide service to the business that had occupied the space that the Chicken Kingdom occupied at the time of the explosion. To cross Camelia Soto, the line had to change direction, which was accomplished by using a 90-degree plastic "ell" socket fusion fitting.

In 1991, the Puerto Rico Aqueducts and Sewer Authority (PRASA) installed a 16-inch diameter water transmission pipeline under Camelia Soto. The PRASA's records indicated that the PRASA had given the SJGC advance notice that it would be working in the area of gas pipelines. The SJGC's maps in the PRASA's files for this project showed that a 4-inch diameter gas main under Camelia Soto was about 2 feet east of the west curb and ran parallel to the proposed water line. The PRASA's files had no information about the PE plastic line that the SJGC had installed in 1985.

In 1992, the Puerto Rico Telephone Company modified its facilities under Camelia Soto west of the HV building. The company hired a contractor to install PVC ducts parallel to the west curb. The contractor's project supervisor said that before the work was begun, the telephone company conducted at least three pre-construction meetings to inform government agencies and utilities about the planned work to ensure that the work was coordinated. He stated that at one of these meetings, the SJGC distributed copies of its pipeline maps for the area and provided telephone numbers to call should there be any problem. He said the SJGC said that the maps showed the locations of its pipes, but, based on his recollections, the maps did not show all pipe locations accurately. (See also *Tests and Research*.) He did not recall the SJGC representative providing information on how to work safely around the pipeline, nor did the gas company mark the locations of its pipes in advance of the excavation work.

The project supervisor said he first learned that there were gas pipes in the path of his project when he found a gas line in an excavation near the south side of the HV building. He called the SJGC and was told that the pipe was an old, unused one. When working on Camelia Soto, he first learned of the existence of a small plastic pipe when his backhoe operator severed it. He stated that he notified the SJGC and that the gas company responded very quickly to repair the damaged pipe. He recalled that the SJGC crew supervisor stated that the company probably would abandon that section of gas line in the future. The project supervisor recalled that due to the existence of the gas line, he had to alter his construction procedures by placing some ducts side by side, rather than on top of one another. During the project, he said, he called the SJGC about five times, and the SJGC had to repair about three leaks. He said that he often had to use his own excavation equipment to help the SJGC, as its employees did not bring a backhoe.

Public Education.--The SJGC O&M Manual did not explain how the company would inform its customers and the public about the hazards of propane gas. The manual did not explain how readers could recognize hazardous conditions or how they could report problems to the gas company. About 8 months before the accident, in January, the SJGC had started a campaign to educate the public about what to do when the odor of gas is detected. The SJGC began making announcements in local newspapers, distributing flyers, including inserts with customers' bills, and making presentations to community groups. The SJGC explained in a pamphlet that odorants are added to gas to make its presence detectable. The pamphlet was in Spanish and was distributed to all customers.

The flyers that the SJGC distributed to the public before the accident explained that when a person smelled a strong gas odor, he should:

- Evacuate the area immediately;

- Not use any electrical appliance;
- Not smoke or use matches;
- Not connect or disconnect any appliance or electrical plugs, or any other source of ignition or flame;
- Not try to repair or stop the gas leak himself;
- Move to a safe place against the wind and wait for the arrival of the gas company personnel; and
- Inform others in the area about the possibility of a gas leak.

The pipeline safety regulations, 49 *Code of Federal Regulations* (CFR) 192.615, require that operators establish a continuing education program to enable customers, the public, appropriate government organizations, and people engaged in excavation-related activities to recognize a gas pipeline emergency for the purpose of reporting it to the operator or appropriate public officials. The regulations require that the education program reach all areas in which the operator transports gas and that it be conducted in English and in the other languages commonly understood by the population in the operator's area. The operator must establish and maintain liaison with appropriate fire, police, and other public officials for the purposes of (1) learning the responsibility and resources of each organization that may respond to a gas pipeline emergency; (2) acquainting the officials with the operator's ability to respond to a gas pipeline emergency; (3) identifying the types of gas pipeline emergencies about which the operator will notify the officials; (4) and planning how the operator and officials can engage in mutual assistance to minimize hazards to life or property.

Emergency Procedures.--Section 7.02 of the SJGC's O&M Manual listed the names and telephone numbers of employees and agencies to contact in case of an emergency. The list had not been updated since 1993. In front of the English version of the manual's index was a collection of memos. The memos were not indexed to sections of the manual, and they covered such subjects as safety, payroll, maintenance, emergency procedures, operations, estimating, suspension of service, and parking. Some of the memos were not dated; the dates on the other memos varied from about 1985 to 1993. One of the longer memos was undated and explained the procedure to be followed in emergencies. It included a telephone list similar to the list in Section 7.02.

The O&M Manual told employees to take immediate and effective action in all emergencies, such as when gas was detected inside or near buildings, when there was a fire or explosion in or near gas lines, or when there was a natural disaster. It said that in an emergency, the field supervisor was responsible for determining which of the following kinds of action were appropriate: evacuating, eliminating all sources of ignition, ventilating the area, locating the gas leak, repairing the gas leak, coordinating the work with firemen, police, civil defense, etc., and helping control traffic and crowds in the area.

According to the manual, "As soon as a dispatcher or shift guard receives the call or report he/she should prepare a job order, indicating the name of the person who called, his/her address, and the time and date of the call." The receiver was to record, in as much detail as possible, the matter that was reported, determine the risks that were involved, and decide whether immediate action was necessary. If an investigation was necessary, it was to be done by the shift mechanic. If the shift mechanic investigated and could not fix the problem, he was to tell either the dispatcher or the guard, who was then responsible for telling the shift supervisor.

According to the dispatcher and the customer-service representatives, callers were asked about the location and intensity of the gas odor. The receivers did not rely on a checklist of questions to gather the information. The dispatcher stated that he gave safety tips from memory and usually gave callers more information than was provided on the safety information sheets that were given to the dispatchers and customer-service representatives. The safety tips provided included:

- If you perceive a strong gas odor, evacuate the area immediately.
- Do not use electrical appliances.
- Do not disconnect any appliance or electrical plugs.
- Do not use any other source of ignition or flame.

The dispatcher said that callers were not told to evacuate a building because the SJGC did not want to cause unnecessary panic until a brigade determined whether there was a gas leak. Also, customers were not informed under what conditions they should notify local emergency-response agencies before the brigades arrived on scene.

Leak Surveys.--The O&M Manual called for a leak survey each year in high-density or commercial locations. All other areas of the distribution system were to be inspected for leaks at least every 5 years. An annual report of the survey, indicating the miles of pipe inspected and the cost, was to be sent to the SJGC's general manager.

According to the SJGC management, no part of Rió Piedras had been surveyed for leaks between 1994 and 1996. In 1996, the SJGC surveyed the area with a portable flame ionization detection unit that sampled the air from barholes in the pavement. The survey uncovered 55 leaks, which were then repaired. Thirteen of the 55 leaks were in the 12-block area around the HV building. None of the leaks were adjacent to the HV building.

Previously, in a December 9, 1993, letter, the OPS encouraged the PSC to use its civil penalty authority for violations discovered at the SJGC, an example being the SJGC's failure to survey Rió Piedras for leaks. The PSC fined the SJGC $500.

During the October 1996 inspection of the SJGC, the PSC noted "unsatisfactory performance about the SJGC's surveillance and patrolling of its gas system. The PSC marked the SJGC's leak survey program satisfactory; however, the PSC gave the SJGC unsatisfactory for its program of surveying business areas, such as Rió Piedras, each year for leaks.

The pipeline safety regulations, 49 CFR 192.723, require gas operators to survey business districts each year for leaks and to survey other areas as often as necessary but at least every 5 years. In doing the surveys, the operators must use leak detection equipment.

Odorization.---Section 5 of the O&M Manual stated that because of the variety of odorants available, only the engineering department had authority to buy odorant. According to the SJGC's organization chart, the company did not have an engineering department. Records show that the propane the SJGC received from its supplier contained Ethyl Mercaptan as an odorant, but do not indicate how much odorant the propane contained. The SJGC added C.S. Captan odorant; the SJGC's procedure did not specify the use of C.S. Captan, nor was the company able to produce a document that authorized the use of C.S. Captan.

The SJGC's procedures required that odorant intensity be tested monthly. The SJGC recorded the amount of odorant and number of cubic feet of gas/air entering the system daily; but it did not calculate the injection rate to determine the amount of odorant added to the gas. Records indicate that the SJGC began conducting weekly odor intensity tests in January 1996.

The O&M Manual did not specify acceptable minimum and maximum rates of odorization, establish the acceptable characteristics of the odorant injected, or establish an acceptable range for odor intensity readings obtained during tests. A review of the odorant sniff test records for the 3 weeks before the explosion showed four system locations being monitored, including one for the Rió Piedras area. Records indicate that the gas odor was detectable when the propane gas level was at 1/5 the LEL of propane gas.

The pipeline safety regulations, 49 CFR 192.625, required that gas in distribution lines be odorized so that the gas could be detected readily by a person with a normal sense of smell when the concentration of gas in air was 1/5 of

the LEL. The regulations also required operators to ensure the proper concentration of odorant by sampling the gas periodically. The PSC inspected the SJGC's odorization practices in 1996 and determined that they were consistent with the requirements.

Excavation-Damage Prevention Program.--In March 1983, the SJGC added Section 8.14, "Program for the Prevention of Damages to Gas Lines by Contractors," to its O&M Manual. The program required the SJGC to:

- Maintain an updated list of excavation companies;
- Communicate with the contractor about the existence of the SJGC facilities immediately upon learning of an excavation project;
- Provide, if necessary, at no cost to the contractor, plans, sketches, and information to help him locate the buried gas facilities; as well as mark the location of the buried facilities;
- Request that companies planning excavations call the SJGC;
- Inspect the project so the integrity of the gas conduits can be verified;
- Survey for leaks to verify that there are no gas leaks in the project area.

Copies of this section of the O&M Manual were to be sent to the PSC; 20 contractors; the San Juan Regional Office of the Department of Transportation and Public Works; the Department of Public Works in San Juan, Guaynabo, Carolina, and Bayamon; the Electric Energy Authority; the Aqueducts and Drainage Systems Authority; the Puerto Rico Telephone Company; and the Fire Services of Puerto Rico.

On August 8, 1996, a senior safety representative of an Enron affiliate company wrote to the SJGC's general manager that the O&M Manual should be revised so as to better protect the SJGC pipelines from being damaged by contractors and other buried-facility operators. The letter recommended that the SJGC:

1. Give the local planning commissions an O&M Manual and a map of the system, and have the commissions require companies to contact the gas company before beginning work;
2. Try to find out about construction before it begins;
3. Present procedures and maps to the Contractors Association membership and make a presentation, if possible, at a meeting;
4. Work with upper management at the utility companies to address the excavation problem;
5. Buy more pipeline markers;
6. Develop a public education program and initiate training classes for the public.

The pipeline safety regulations, 49 CFR 192.614, required pipeline operators to have a written program for preventing damage to pipelines from excavation activities, including excavation, blasting, boring, tunneling, backfilling, removing aboveground structures by either explosive or mechanical means, and other earth moving operations. The 1996 PSC inspection report on the SJGC operations noted that the SJGC had a satisfactory program.

Gas Maps and Records.--The SJGC maintained drawings showing the locations of gas mains, valves, and equipment related to the gas mains. It kept information related to gas service lines on cards filed at its San Juan office. For the most part, the cards had such information as the gas meter's size and serial number, the customer's name and address, and a sketch showing the service line size, materials used, and location. The records of some gas service lines did not contain sufficient measurements and references to identify the gas service lines as they currently existed.

The maps that the SJGC provided after the explosion showed the gas line on Camelia Soto being constructed of 4-inch cast-iron pipe. The map had not been updated to show that the line had been replaced with plastic pipe. The SJGC could not locate the service line card for the

Chicken Kingdom until several days after the explosion; the card did have detailed information about the service line and its location.

The pipeline safety regulations did not require operators to have maps or records that show the locations all major pipeline system components. Operators were required to have and maintain maps and records only on some specific gas system facilities, such as corrosion control systems.

Corrosion Protection.—Section 4.0, "Cathodic Protection Policy and Practices," of the O&M Manual was dated August 1979. The section required that the supervisor in charge of cathodic protection systems supervise the design and installation of the systems. The SJGC's organization chart did not show such a supervisor, nor did a revised organization chart that was made available 2 days after the explosion.

According to the manual, each pipeline was supposed to be protected by anodes and tested each calendar year. The manual said that if annual testing was not practical, protected mains and services could be tested in sections of not more than 100 feet. If the section method of testing was used, at least 10 percent of the total protected lines had to be tested each year so that the total protected system would be tested in a 10-year period.

The SJGC had no records of the corrosion leak history in Rió Piedras or of having done an electrical survey in the area. According to the SJGC, it used its leak survey and repair records in lieu of an electrical survey to identify the effects of corrosion on its lines. However, the SJGC did not perform the leak surveys as often as required by gas pipeline safety regulations, nor was there any documentation of repair records being correlated to leak survey findings.

A consultant reported in 1984 to Enron, before Enron acquired the SJGC, that the corrosion control system needed to be upgraded. In 1985, Enron retained another consultant, who proposed a cathodic protection system. The consultant recommended electrically insulating portions of the piping system, performing electrical surveys of the system, and setting up a cathodic protection monitoring procedure and an employee training program. A cathodic protection survey and master plan were prepared. The plan included taking such steps as insulating the system, increasing the electrical output at rectifiers, installing corrosion test stations and anodes, and training employees in cathodic protection. The gas company could produce few records of tests or additional corrective action taken after 1986 related to achievement of the consultant's recommendations.

The pipeline regulations, 49 CFR 192.453, required that the design, installation, operation, and maintenance of cathodic protection systems be carried out by, or under the direction of, a person qualified by experience and training in pipeline corrosion control methods. The PSC's 1996 inspections of the SJGC noted numerous unsatisfactory conditions relative to corrosion control procedures, practices, testing, records, and levels of cathodic protection.

Plastic Pipe.--Section 2 of the O&M Manual listed the following requirements for the safe installation of plastic pipe.

- Pipes should be laid on ground free of rocks that could damage the pipes; the ground should be firm and provide good continuous support;
- Pipes should be surrounded by 4 inches of sand or loose dirt without rocks when laid in trenches; care should be taken not to damage the pipe when compacting soil;
- Pipes should be covered by 30 inches of soil whenever possible and in no case by less than 24 inches;
- Pipes should have a minimum vertical distance of 12 inches and a minimum horizontal distance of 24 inches from any other buried facility, unless approved by the inspector; and
- Pipe sections should be cut with proper tools only and should always be cut straight.

Under the SJGC's procedures, if steel and plastic were being connected by a compression fitting, the steel pipe was to be cleaned and a special nipple for rigidity (stiffener) was to be

inserted into the plastic pipe. The pipes being joined had to be aligned and inserted at least 1/3 of the way into the fitting. The fitting had to be tightened, checked for leaks, and wrapped with special wrapping tape to protect it from corrosion.

Postaccident inspections revealed that lengths of plastic pipe in the gas service line to the Chicken Kingdom were connected by a compression coupling. After the explosion, investigators examined the coupling: it was bare, it was not protected from corrosion, the ends of the pipe were not evenly cut, stiffeners were not inserted into the ends of the pipes, rocks, pavement pieces, and other debris were near the west side of the pipe, the cover over the pipe varied in depth between 1 1/2 and 3 feet, and sand was beneath and adjacent to the part of the pipe that was in the area that had not been excavated to install a 16-inch water main under Camelia Soto.

Abandoned Services.--Section 6.02 of the O&M Manual was about discontinuing and abandoning gas lines. It said:

> As a general rule, the SJGC procedures call for service lines that are out of service for more than 1 year to be abandoned. They are to be physically separated from the main and the open ends of services are to be closed using plugs.

The SJGC operations superintendent stated that technicians were told that when they were investigating leaks, they were to check for inactive gas services. Any such services were to be abandoned. Generally, crews closed an abandoned service by using a mechanical coupling that had a cap; sometimes they closed the service with a flexible plastic material that is used to coat pipe.

The assistant operations superintendent said that he did not know that the SJGC had a policy about abandoning inactive service lines. However, he stated, when a customer said that gas was no longer to be used at a given location, the company normally cut the service at the gas main and plugged the main.

During the investigation, two gas service lines, one on Camelia Soto and one on Arzuaga, were found that were inactive and still connected to the gas mains. A third inactive service line, on de Diego, had been disconnected a week before the explosion, but the end of the service line had not been sealed. The inactive service on Arzuaga was leaking gas in the area where it had been damaged by excavation. The inactive service at Comercial Ubiñas was connected to the main pipe, which had a compression fitting that was leaking gas. The inactive service for the HV building had been inactive for at least 6 years before it was disconnected, on November 15, 1996. The SJGC's records for 1983 through 1995 showed that of its 12,000 service lines, 4,000 were probably inactive but had not been abandoned.

Unaccounted for Gas.--Unaccounted for gas is the difference between the quantity of gas that enters the gas system and the quantity that is delivered to customers or used for other known purposes. The SJGC reported to the OPS that it was unable to account for 5.0, 4.7, and 3.5 percent of the gas that had entered its system in 1993, 1994, and 1995, respectively. The chairman of the SJGC's board of directors testified that in 1995 the SJGC had set a goal of reducing its unaccounted for gas to 5 percent or less in 1996. In 1995, the unaccounted for gas was about 25 percent, and the SJGC chairman attributed about 7 percent to billing and metering problems and the remaining 18 percent to theft.

Meteorological Information

Between November 14 and 21, the temperature ranged from 72 to 85 degrees F. Except for November 17 and 18, little rainfall was recorded during the period. About 0.2 inch of rain was recorded on November 17, and about 0.8 inch was recorded on November 18.

Medical and Pathological Information

Injuries consisted of abrasions, contusions, lacerations, fractures, sprains, dust and gas inhalation, friction burns, and multiple body trauma. Survivors were triaged at the scene. Of the people triaged, 85 were treated at area hospitals. Sixty-nine people sustained injuries; 25 injuries were classified as serious. An

undocumented number of injured people were treated by private physicians and not seen at local hospitals.

The 33 fatalities were autopsied at the Institute of Forensic Sciences in San Juan between November 21 and December 20. According to the autopsy reports, the deaths were caused by traumatic injuries and traumatic suffocation.

The Caribbean Medical Testing Center collected urine samples from each of the six people in the November 21 brigade. Because no laboratory in Puerto Rico is approved to perform all required tests, the samples were sent to Corning Nichols Institute of San Diego, California, to be tested for drugs. On November 27, all tests were reported negative for drugs.

According to the SJGC, it complied with 49 CFR 199, which requires testing of employees within 8 hours of an accident or providing a written explanation of why the employees were not tested. The SJGC explained that five of the six employees were injured and seeking medical treatment. The sixth employee was in the custody of one of the agencies investigating the explosion.

Tests and Research

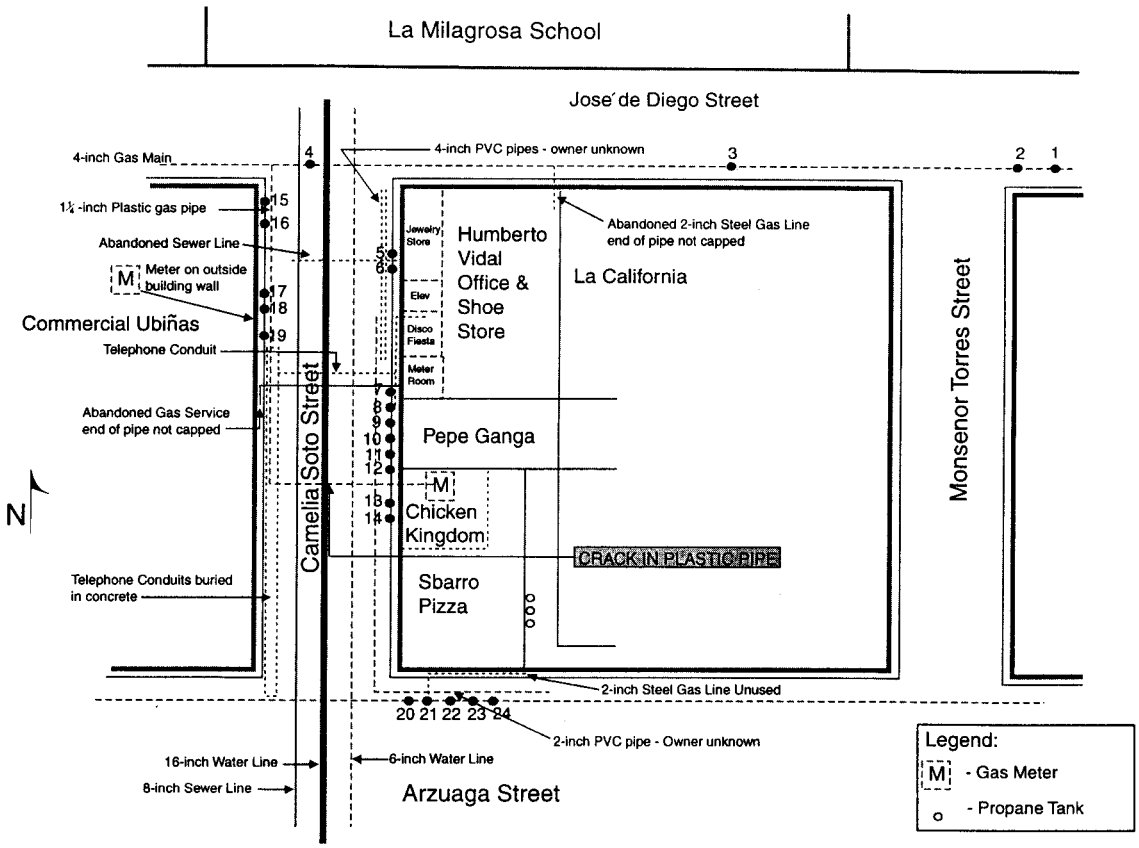
SJGC Pipelines.--After the explosion, investigators tested the subsurface of the streets in the area of the HV building in various ways. They sank barholes as deep as the approximate depth of the main (2 to 3 feet according to the SJGC's records) at intervals of approximately 10 feet along the gas main and positioned them between the gas main and the nearest street curb along de Diego, Monseñor Torres, and Arzuaga. Because the investigating team did not yet know that Camelia Soto had a gas line that was near the HV building, barholes were made at 10-foot intervals along the east curb of Camelia Soto between de Diego and Arzugua and then along the west curb from the Comercial Ubiñas service line northward to de Diego. (See figure 4.)

To determine during the early stages of the investigation whether propane was present in the subsurface adjacent to the HV building, the investigators collected two samples from each of the three barholes in which the CGI reading was 100 percent LEL or greater for propane gas. One set of samples was subjected to comparative gas chromatography at a local laboratory, and the results confirmed the presence of propane in the sample taken from a barhole at the intersection of Camelia Soto and de Diego. The second set of samples was subjected to analytical gas chromatography, and the results confirmed that propane was present in all three barholes and was the major combustible gas constituent in two of the three.

After finishing the CGI tests, under the direction of Safety Board investigators, nitrogen[13] was introduced into the gas pipes on de Diego, Camelia Soto, and Arzuaga. (The nitrogen was under the approximate pressure that the gas system had been at the time of the explosion: 7 inches water column.) Those pipe sections that did not hold pressure underwent further tests designed to identify possible leak areas and determine the leak rate. Nitrogen was generally used to measure the rate of release from the pipe section, and helium was used to pinpoint leak locations. Based on the helium test results, pipe sections were excavated for examination. If a pipe section was damaged, the section was removed, the pipe ends were closed, and the remaining pipe was re-tested until it held pressure, another release point could be identified, or sufficient information was obtained to decide that the remaining leaks probably had had no effect on the explosion in the HV building.

When the investigators excavated the service line to Comercial Ubiñas, they learned that a steel T-shaped pipe section had been left in place when the SJGC installed a plastic line. Compression couplings had been used to connect the T-shaped section to the plastic line and the Comercial Ubiñas service line. The investigators injected nitrogen into the gas main at the compression coupling south of the Comercial Ubiñas service line and found that it took a flow of 1.76 cubic feet per minute (105.6 cubic feet per hour) into the pipe section to maintain pressure.

[13]Nitrogen flow properties are much closer to those of propane than to those of helium.



Indication Location[5]	CGI Reading %(LEL)	Indication Location[5]	CGI Reading %(LEL)
1	12	13	20[3]
2	2	14	2
3	1	15	4
4	100[1]	16	5
5	100[2]	17	30
6	2[2]	18	4
7	100	19	50[4]
8	8	20	30
9	30	21	100
10	5	22	100
11	25	23	5
12	20[3]	24	5

[1]When switching to gas scale, a 25% gas in air reading was indicated

[2]Around temporary steel piles

[3]Near Chicken Kingdom service line

[4]Near Commercial Ubiñas service tap

[5]Numbered locations where combustible gas indications (CGI) were found after the explosion.

Figure 4. Locations of Combustible Gas Indications and CGI Readings.

When the investigators excavated the pipe section, they found that the test medium was escaping from a crack in the plastic pipe in front of the Chicken Kingdom. The pipe segment with the crack was removed for later laboratory testing, and the remaining segments were re-tested. Nitrogen was then used to determine the leak rates of various portions of the gas line between the service to Comercial Ubiñas and the Chicken Kingdom. (See figure 5.) The compression fitting at the Comercial Ubiñas service was determined to leak at 0.04 cubic feet per minute, and the steel T-section connecting the plastic leaked 0.02 cubic feet per minute. No additional leaks were found south of the Comerical Ubiñas service line to the area of the crack. Therefore, the undisturbed crack in the plastic pipe in front of the Chicken Kingdom was found to have been leaking at a rate 1.70 cubic feet per minute (102 cubic feet per hour).

Further excavation of the Chicken Kingdom gas service line showed that PVC plastic telephone conduits had been installed about 15 feet west of the leaking plastic coupling. The conduits were directly over and in contact with the gas line, and both the conduits and portions of the gas line had been buried in concrete. (See figure 6.) According to SJGC records, the gas line had originally been installed along the west side of Camelia Soto to a point where it was across from the Chicken Kingdom. At that point, the plastic line was shown to make a 90-degree turn, crossing under Camelia Soto and entering the Chicken Kingdom. Excavation revealed that the service line did not contain a 90-degree tee. Instead of making a 90-degree turn, the plastic pipe changed direction to enter the Chicken Kingdom by making a long sweeping curve, and the two segments were joined by a compression coupling. The supervisor for the contractor who had installed the telephone conduits confirmed during his interview that he was unaware of any gas line beneath Camelia Soto because none was shown on the drawings he had obtained from the SJGC. He stated that while excavating with a backhoe to install the telephone conduits, his crew cut the gas line. He said that he had reported the incident to the SJGC, which repaired the gas line. He said that the plastic pipe ran down the trench in which the telephone conduits were being installed and that SJGC employees had told him that the gas line would probably be abandoned. (See also *Pipes and Ducts Installed on Camelia Soto.)*

The 4-inch diameter gas main on Arzuaga, from a point east of Camelia Soto to a point about 1 ½ blocks east of Monseñor Torres, and a short segment of main on Camelia Soto south of Arzuaga were tested with helium to find out whether the pipes leaked. The pipes could not hold pressure with no flow. The pressure was raised to 7 inches water column, and the flow rate was measured to be about 4 cubic feet per hour. Testing the barholes for helium identified a helium release point in front of the Sbarro restaurant near the northeast corner of Camelia Soto and Arzuaga. Excavation in front of Sbarro revealed a damaged and leaking inactive service line to the restaurant; the service line leaked at a rate of 2.06 cubic feet per hour, and the main east of that point leaked at a rate of 2.83 cubic feet per hour. (See figure 7.) The main to the west had a leak rate of less than 0.1 cubic foot per hour.

Sbarro Restaurant Propane Fuel Lines.-- Sbarro Restaurant used propane gas from cylinders stored outside the building's east wall. The propane flowed into an underground fuel line and then into the building. While the line was under test pressure, the outside exposed portion was checked for leakage using a soap/water solution. The line leaked at the above-ground shut-off valve. The valve was lubricated, and a subsequent test showed no loss of pressure. Those tests indicated no leaks underground.

Smoke Migration Tests.--On November 30, investigators tried to find out whether there were any direct, underground paths beneath Camelia Soto from the area of the cracked plastic pipe into the HV building that might have survived the explosion. The hole that had been excavated to remove the cracked plastic pipe was covered, and a smoke generator and a blower were used to introduce smoke under pressure into the adjacent soil. Observers stationed around the destroyed buildings saw no smoke exiting buildings or other structures.

On December 1, a second hole, just west of the southwest corner of the HV building, was used in smoke migration tests. Similar procedures as described above were employed,

Figure 5. Location of Crack in Plastic Gas Line to Chicken Kingdom.

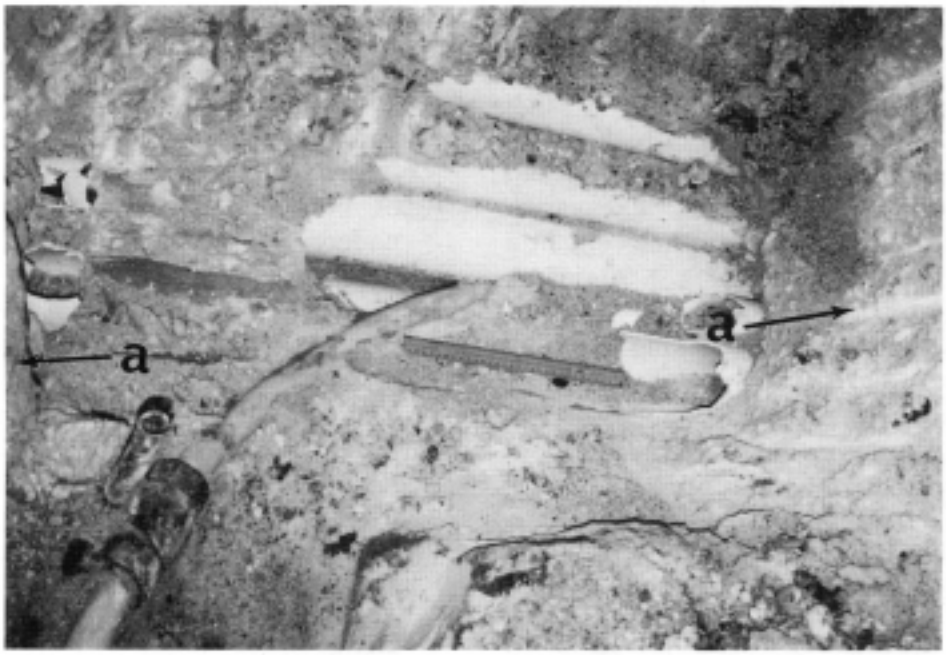


Figure 6. Plastic Gas Line Entering Telephone Conduit Bundle in Concrete under Camelia Soto. (Arrows point to the concrete walls on each side of the excavation.)

and again no observer saw smoke exiting buildings or other structures.

Examination of Debris and Retrieved Damaged Materials.--The day after the explosion, a team from the ATF examined the building and its debris for evidence of explosives. Samples of debris (concrete, plaster, and a paint can) were sent to the ATF's Forensic Science Laboratory, where they were examined for "any and all explosive residue." The ATF also examined the building, using dogs trained to find explosives. The ATF did not find any evidence of explosives. Based on those tests, the use of dogs to detect any explosives in the debris, and the physical evidence examined in the HV building, the ATF team determined that no explosives were used and that damage to the HV building was the result of a fuel-based explosion.

Figure 7. Location of Gas Leak from Inactive Gas Service Line under Arzuaga.

In January 1997, Safety Board staff documented the damage inflicted on the HV building and recorded the directions of forces, the damages to structural components, and the locations where heat had apparently had an effect. (See figure 8.) There was no evidence of fire in the building, and the failure direction of the building's columns was consistent with that resulting from overpressure. The building column and connected beams nearest the east wall just west of the east stairway, column D-1, (see appendix E) was the area identified as most affected by heat. Blackened web-like residue was on the north and west faces of the basement column and on some faces of the north and connected west beams between the basement and the first floor.

An air conditioner exchange unit that was in the building when Humberto Vidal bought the building had been mounted on the west face of column D-1 before the explosion. The unit had been mounted 20 inches above the floor, and the electric fan motor was about 41 inches above the floor. The thermostat was mounted on a rectangular piece of plywood on the south face of this column. The exchange unit was torn from its mounts by the explosion, and its thermostat and control wiring showed effects of heat damage. The plywood surface was

Figure 8. Major Crack in West Wall of Basement of HV Building.

scorched, and the thermostat plastic base plate was deformed.

Also collected were small pieces of cardboard and insulation material taken from the southwest juncture of column C-1, north of D-1, where the first-floor concrete slab once had joined the connecting beams. Both items exhibited slight surface scorching. Additionally, the west half of the surface underneath the basement beam between columns E-1 and E-2 was noted as having numerous black patterns typical of shoe soles that were stored in the basement. (See figure 9.)

In February 1997, while building debris and damaged merchandise were being removed from the basement, various synthetic and wood products items that exhibited heat exposure damage were removed for further examination. The items included polyethylene shrink-wrap, fiberglass, vinyl, nylon stockings, paper, cardboard, and plywood. The most severe heat damage to the synthetic materials indicated exposure to a temperature sufficient to melt some portions of them. The highest melt temperature for the synthetics that were damaged is approximately 220° F. According to witness observations, the paper, cardboard, and fiberglass recovered from the debris probably were damaged in fires accidentally set during the rescue and demolition operations. Visual examination of the heat-affected synthetic items removed from the basement showed that the heat had been high enough to melt small portions of the items but not to ignite them.

Laboratory Examination of Failed Pipes.-- The damaged 1 ¼ inch diameter plastic pipe section from Camelia Soto was examined under Safety Board supervision at the Washington Gas Materials Testing Laboratory and at the Safety Board's laboratory. The exterior surface of the section had a ¼-inch long circumferential crack at the interface of a fused socket coupling. Portions of the socket-to-pipe fusion joint did not contain the melt roll-out plastic bead that plastic-pipe manufacturers recommend as a visual indication of a quality fusion joint. It was determined that the crack, which went through the wall of the pipe, had started on the outside of the pipe and slowly progressed inward. The

slow growth of the crack was the result of excessive bending stress. (See figure 10.)

The wall of the 1 ¼ inch diameter steel service pipe removed from Arzuaga had two holes; the holes were caused by corrosion. The pipe had a lateral deflection with an indentation typical of one caused by excavation activities, and the part of the pipe that had been damaged by excavation was corroded.

Oversight and Regulation

Enron.--Several times Enron sent consultants to examine the SJGC and report on its condition. Brief summaries of some of the reports follow.

Figure 9. Shoe Sole Imprints on Bottom of Beam in Basement of HV Building.

Before deciding to buy the SJGC, Enron sent a consultant to evaluate the system and the company's compliance with the DOT pipeline safety requirements. The consultant's report discussed the PSC's special concerns about gas volume accountability and system corrosion protection and the DOT's concerns about corrosion and general system operations. The report also addressed concerns about the corrosion protection system, gas volume accountability, metering accuracy, regulatory compliance, system safety, and the adequacy of system pressure control. Among the improvements the consultant recommended to Enron were:

1. Eliminate casing and underground electrical shorts to improve its corrosion protection;
2. Insert plastic pipe into old, leaking, and corroded pipelines;
3. Abandon all unused service lines that are still under gas pressure to lessen the chances of electrical shorts to the corrosion protection system;
4. Give all employees the training on the basic fundamentals and corrosion protection that was earlier given to system management;
5. Develop closer communication with other buried-facility operators to assist in protecting buried facilities; and

6. In coordination with other buried-facility operators, establish a one-call excavation notification system.

During the week of March 11, 1985, the same consultant and the SJGC representatives inspected maps, records, and buried piping to assess the system's corrosion protection needs, and the consultant developed a master corrosion protection plan. In June 1985, he did a corrosion protection survey, developed a corrosion protection video training program, developed recommendations on re-testing protected system segments, and again recommended using plastic pipe to replace steel pipe where the steel was excessively corroded. He also noted that a corrosion control map should be prepared to show the locations of corrosion test stations, insulated fittings, corrosion protected areas, anodes, and other pertinent information.

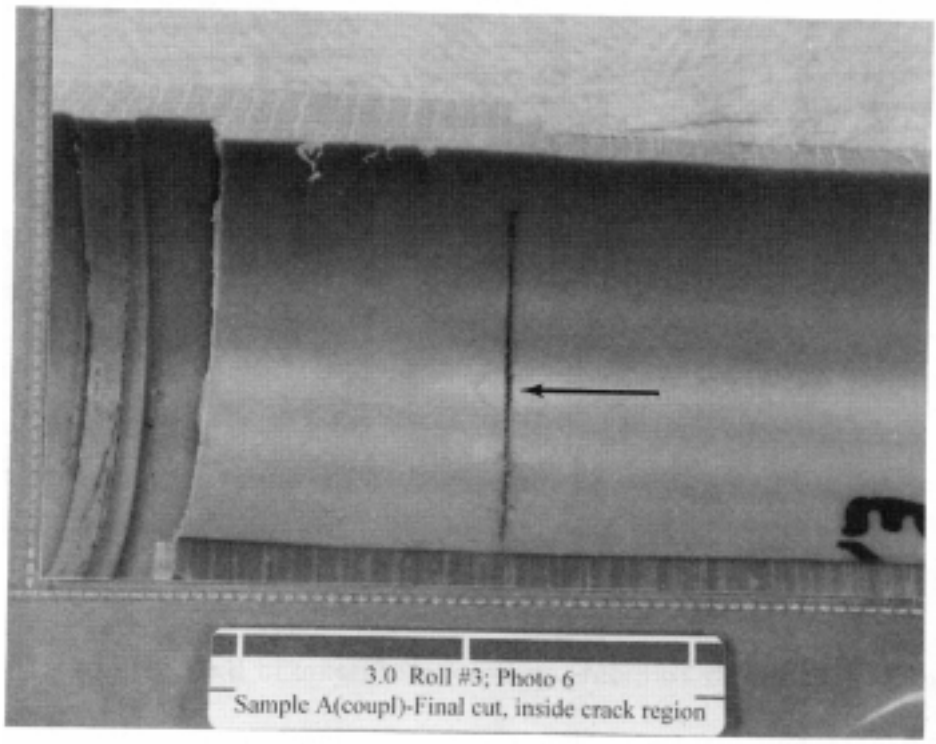


Figure 10. Crack in 1 ¼ Inch Plastic Gas Service Pipe to Chicken Kingdom.

In 1986, Enron contracted with Interamerican Technical Services to perform a safety audit of the SJGC system and operations. The contractor reported that the audit had not uncovered any major safety problems. The representative wrote that all of the work then underway was a step toward complying with DOT regulations and that the SJGC should have made real progress by the end of the year. The contractor concluded the report by pointing out that the general corporate knowledge of the experienced workers was being lost by attrition and that little knowledge was being recorded for future use. The contractor noted that the lack of training manuals, emergency procedures, and drawings might prove to be a problem in the future. The report included the following comments and recommendations:

> All activities should be documented so as to support the training of others.
>
> The operations manual is too general to be effective, as it does not provide the necessary details, such as who is to take an action, with what frequency, in what

manner, etc. Greater specificity is needed to guide employees as to when a safety action should be taken, how to take the action, and under what circumstances the action should be taken. [He summarized his assessment stating that the existing operation manual is acceptable, but only in general terms.] To make the manual useful, it needs to be complete through references to other books, industry manuals, written job descriptions, company organizational charts, and other documents.

It is difficult for a supervisor to be responsible for the safety actions of others if neither has received complete training that includes a detailed description of the job to be done.

The company cannot expect a worker to do a job safely unless there is a standard to follow that includes the use of proper tools and protection equipment. Step-by-step procedures need to be specified in writing and used as a training tool; otherwise the trainee cannot be considered properly trained.

There were no records of accident investigations for the previous few years. [He theorized that accidents had occurred, but no records were being maintained.]

Protection of anode leads during back fill operations.

Improved compaction of sand bedding used to protect plastic pipe installations.

Improved procedures on heat fusing plastic pipe joints.

Protection of plastic pipe from damage during insertion.

Job site protection to warn traffic when work is being performed and to warn against smoking near job sites.

On-the-job training by supervisors or fellow workers is not the safest nor most proper way to train personnel. Such training methods often will result in some essential procedures not being related during training.

There needs to be an emergency plan as required by DOT.

There needs to be a program for educating the public on the hazards of propane gas when released and on what actions should be taken for safety.

Using a flame ionization leak detector, survey the business districts, high pressure pipelines and, by the end of 1986, survey all residential areas.

According to Enron, in September 1995, the president of Enron Liquid Services began to evaluate the SJGC and other Latin America operations. In October 1995, he visited Puerto Rico, where he reviewed the SJGC's operations and met with its general manager (his vice president of operations). Afterwards, Enron decided to have a lawyer and an experienced outside consultant evaluate the SJGC's compliance with regulations. Enron also decided to have an outside consultant assist with a gas leak survey and leak repairs. Enron selected Gillispie Ventures, Inc., (Gillispie) as its outside consultant and Heath as its leak survey consultant. According to Enron, the construction engineering manager of the Enron Engineering & Construction Company was called on to assist the SJGC with the project.

Around November 1995, in an undated note, Gillispie told Enron that approximately 40 percent of the service lines were inactive and that the inactive lines might be the reason for a significant amount of the unaccounted for gas. Gillispie suggested that reviewing odorization records, inspection and maintenance plans, and incident reports might be useful in "finding" the unaccounted for gas.

In a November 29, 1995, facsimile, Gillispie contacted the construction engineering manager to discuss a proposed unaccounted-for-gas control program. The proposal described a three-phase program: (1) a search-and-verify phase consisting of an above-ground electronic leak survey to confirm that there were leaks, (2)

a leak-pinpointing phase to locate the leaks and classify them according to severity and repair priority, and (3) a repair-leaks phase, which would provide an opportunity to assess the condition of the pipeline system.

In November 1995, Enron also contracted with Heath to help with a leak survey, with determining the location of leaks, and with repairing the leaks. Heath was also retained to train the SJGC employees to perform leak survey work.

Gillispie prepared a report, dated December 27, 1995, on the SJGC's compliance with regulations. Enron refused to give a copy to the Safety Board, claiming that the information was privileged.

Enron International's manager of environmental safety, who was responsible for safety and health matters in six affiliated Enron companies, including the SJGC, audited the safety of the SJGC's operations shortly before the accident. Enron contended that the audit was done at the request of an Enron attorney, thus also privileged; Enron refused to provide a copy. At the June 1997 Safety Board Public Inquiry, an OPS representative was asked whether the OPS expected pipeline operators to perform safety audits as a normal operating function. He replied that operators are expected to conduct safety audits, and that it is not usual for an operator to claim privilege for such work.

PSC.--The PSC was established to regulate public service companies, such as the SJGC. Its procedures were established in the Puerto Rico Public Service Act of June 28, 1962, as amended, and in the Commonwealth of Puerto Rico Uniform Administrative Procedures Act of August 12, 1988, as amended,. Under those acts, the PSC can seek administrative remedies in the enforcement of the pipeline safety requirements. To enforce compliance with its pipeline safety regulations, the PSC may chose to:

1. Perform a follow-up inspection;

2. Issue an Order to Show Cause as to why the company should not be penalized for violations;

3. File in the Court of First Instance of Puerto Rico a special procedure seeking professional relief when life, health, safety, or public welfare needs to be protected.

In 1974, the PSC adopted 49 CFR 192 as the pipeline safety requirements in Puerto Rico. The OPS designated the PSC as the agency in Puerto Rico responsible for the pipeline safety program. The PSC certified to the OPS that it would monitor gas company operations through comprehensive daily on-site examinations or evaluations.

Comprehensive inspections consisted of on-site examinations of the SJGC's plans, procedures, programs, records, physical plant, and work in progress. Comprehensive inspections were done throughout the year, and the results were combined in an annual inspection report. An SJGC representative accompanied the PSC inspector during all inspections and could record the findings for the SJGC management. The PSC did specialized inspections as necessary to ensure that identified problems were corrected; to investigate failures; and to evaluate the adequacy of designs, operator training, facility tests, and construction activity.

The PSC's certification to the OPS noted that it would continue revising the gas company's documents about its inspection and maintenance, operating and maintenance, emergency plan, and damage prevention programs. The certification also noted that the PSC periodically inspected the operator's maintenance records about leak surveys, leak repairs, valve maintenance, pressure-limiting and regulating stations, telemetering and recording gauges, relief device tests, odorization, and corrosion control.

PSC Inspections of SJGC.--The PSC's records of its inspections of the SJGC in 1992 through 1996 identified numerous probable violations. The 1992 inspection uncovered 16 probable violations; and at least 5 of the 16 were noted in 1993. Probable violation subjects included: (See appendix B.)

1. Records on telephonic leak notifications;

2. Records on written leak reports;

3. Welding procedures and welder qualification tests;

4. Inspection of welds;

5. Qualifying plastic pipe joining procedures and persons who join plastic pipe;

6. Inspection of gas main construction;

7. Testing of cathodically protected systems;

8. Records on required gas line leak and strength tests;

9. Performance of leak survey; and

10. Records on leak tests of reactivated gas service lines.

In early 1992, the PSC inspector who was the SJGC's safety manager at the time of the accident audited the SJGC and noted 16 deficiencies. He told the SJGC general manager in writing that the SJGC had not scheduled or executed during the last year the cathodic protection required by 49 CFR 192.465 and that the SJGC had not monitored the distribution system valves as required by 49 CFR 192.747. He said the SJGC was probably in violation of the requirement that the adequacy of corrosion protection be tested. The inspector also told the general manager that gas system valves had to be checked and serviced each year and that the interval between servicing was not to exceed 15 months.

1992 Probable Violations

Title 49 CFR	Subject of Probable Violation
191.5	record of all telephonic notices of leak reports to DOT
191.9	record of written leak reports
192.225	welding procedure in detail and results of the qualifying tests
192.227	welder qualifications, including follow-up checks on welder
192.241	inspection of test welds
192.283	qualifying plastic pipe joining procedures
192.285	qualifying persons to make plastic pipe joints
192.305	inspection of transmission line or main construction
192.465	testing of cathodically protected system
192.501 through .517	a record of each test performed under sections 192.505 and 192.507
192.723	periodic leak surveys
192.627	hot taps performed by qualified crews
192.725	record of test on reactivation of previously disconnected service lines

On April 16, 1993, the SJGC's safety manager reported to the PSC on the progress made in correcting the probable violations that he had cited in 1992 while he was a PSC inspector. After reporting the SJGC's position on the noted sections, he said that the SJGC had repeatedly stated its position of compliance with the regulations; and he thanked the PSC for making the SJGC aware of a few misconceptions.

On January 27, 1994, the PSC's director wrote to an attorney in the Puerto Rico Office of Public Interest (the office that initiates legal action), advising that the September 15, 1993, inspection of the SJGC had identified three deficiencies in the area of maintenance:

1. Lack of records of leak survey tests during the year.

2. Lack of records to show that appropriate pressure tests had been done on plastic pipe before the pipe was placed in service.

3. Lack of records about corrosion control.

He wrote that two OPS Southern Region Office inspectors had been present during the inspection and that he was submitting the information so that action could be taken to cause compliance.

In a February 24, 1994, letter, the SJGC safety manager responded to the PSC with the following statements: The CFR did not refer to the use of any detection equipment. The SJGC had done leak surveys, and the results would be available to the PSC. Every plastic pipe that the SJGC had used complied with requirements. The physical condition of each pipe was checked before it was stored and checked again before it was installed. The SJGC had always maintained records about its external corrosion control system, and the records had been available to the PSC upon request.

The SJGC was fined $500 on August 31, 1994, for its failure to comply with safety requirements.

The PSC and OPS representatives testified at the Safety Board's June 1997 Public Inquiry that the PSC had inspected the SJGC in 1994, but that records of the inspection could not be located. In 1995 and 1996, PSC reports showed, respectively, more than 80 and more than 50 probable violations. More than 30 of the probable violations listed on the 1995 report were listed on the 1996 report, and more than 20 of the probable violations on the 1995 and 1996 reports were on or related to probable violations that were on the 1992 and 1993 reports. (See appendix B.) The probable violations listed on both the 1995 and 1996 reports had to do with the following subjects: inspection of plastic pipe installations; protection against corrosion; monitoring of corrosion control systems; maintenance of required operating records; written operations and maintenance procedures; emergency procedures; investigation of failures; patrolling of gas system; abandonment of gas facilities; and protection of cast-iron pipe.

The PSC inspector testified that he could not understand why he was unable to explain to the SJGC's management what the SJGC had to do in order to comply with the regulations. He commented that while the SJGC's employees needed extensive training in many areas of the pipeline safety requirements, Enron had competent personnel who could help the SJGC.

PSC Annual Program Certification.--The PSC reported the following information about the SJGC to the OPS in its annual 5(a) Certification.

PSC Annual Program Certification Summary

Certification Year	No. of Incidents Reported	No. of Probable Violations Found	No. of Probable Violations Corrected	No. of Compliance Actions Taken	No. of Civil Penalties or Assessments
1994	0	3	4	0	0
1995	0	2	2	0	2/500
1996	0	2	2	0	0
1997	3	69	0	0	0

OPS.--In Puerto Rico, the PSC has the primary jurisdiction over the SJGC pipeline system, while other pipeline operations, such as the intrastate liquid lines, are subject to OPS jurisdiction. The pipeline safety regulations applicable to systems in Puerto Rico are the Federal pipeline safety regulations since the PSC has adopted them.

States participate with the OPS in administering pipeline safety programs in one of two ways. A State may certify to the OPS that its pipeline safety and enforcement provisions comply with or exceed Federal minimums, that it inspects specific pipeline operations in the State, and that it enforces its requirements. The OPS then views the State as having the primary responsibility for pipeline safety, and the OPS monitors the State's activities annually.

The second manner in which the OPS and a State can cooperate is for the State to enter into an agreement with the OPS under which the State inspects gas operations and the OPS enforces the correction of the deficiencies the State identifies. Except for Hawaii, Alaska, Idaho, and Maine, all States, as well as Puerto Rico, and Washington, D.C., participate in the Federal pipeline safety program. About 95 percent of the pipelines in the United States are under the oversight of State pipeline safety programs.

The Safety Board gathered from the OPS and the PSC their records and correspondence related to the PSC's compliance monitoring of the SJGC. The activities were traced back to 1983 and show that an OPS representative visited Puerto Rico each year. During the OPS oversight reviews, its representative reviewed the PSC operations and performed some on-site reviews of the SJGC's facilities and operations. (See appendix C). In the early 1980s, the OPS told the PSC it was concerned that the SJGC had a variety of problems: its gas leak repair activities; the adequacy of its operations, maintenance, and emergency plans; the lack of an excavation-damage prevention program; the adequacy of its pressure regulation and overpressure protection; its corrosion control; and its treatment of discontinued service lines. The OPS also told the PSC that the PSC needed to do a better job of training its inspector, of documenting inspection results and keeping records, and of developing administrative procedures for processing cases of non-compliance. In correspondence, the OPS recognized that the PSC had improved its inspector training, that the SJGC's compliance with safety regulations was better, and that the PSC's pipeline safety program performance was significantly improved.

OPS correspondence during the 1990s continued to note deficiencies, both in the SJGC's operations and in the PSC's pipeline safety program. The SJGC activities noted as being deficient from 1990 to 1993 involved corrosion control, excavation-damage prevention, leakage surveys, testing of pipe before being placed in service, installing plastic pipe, replacing cast-iron pipe, and testing employees for drugs and alcohol. In 1993, the OPS recommended that the PSC assess a civil penalty[14] against the SJGC for not surveying leaks in all principal business districts as required. The OPS told the PSC to improve its documentation of inspections, promote the development of an excavation-damage prevention program, and monitor the SJGC to ensure that it complied with its written procedures on installing plastic pipe.

In 1994, the OPS advised the PSC that it needed to make major improvements to comply with pipeline safety requirements. In 1995, after the PSC documented over 80 probable violations in the SJGC's operations, the OPS advised the PSC that it needed to promote the development of a damage prevention program and that the PSC needed a vehicle permanently assigned to the pipeline staff, but it made no recommendations for obtaining compliance with pipeline safety requirements.

In 1996, the OPS arranged for 12 representatives of Puerto Rico government agencies, including the PSC, to tour two one-call excavation notification systems to learn about implementing excavation-damage prevention programs.

In February 1997, the OPS told the PSC that in 1996 its program was "generally complying with the pipeline safety requirements" and that a

[14]The PSC imposed a $500 fine in 1994 on the SJGC for not surveying leaks.

vehicle needed to be assigned to the pipeline safety program to allow quicker response to pipeline emergencies and to allow the staff to work more efficiently.

The OPS began rating State pipeline safety programs in 1989 to reflect its evaluation of State pipeline programs. Each program aspect, such as adequacy of inspections or compliance enforcement, was assigned a maximum number of points that the evaluator could award based on his findings. The State program rating was determined by dividing the total points awarded by the total possible points and then expressed as a percentage. The PSC program ratings from the OPS regional office were 96 for 1989, 92 for 1990, 91 for 1991, 87 for 1992, 84.2 for 1993, 95 for 1994, 97 for 1995, and 97 for 1996.

Other Information

Humberto Vidal.--Humberto Vidal is a retail merchandise company that sells shoes, socks, handbags, and related items. The company owns more than 30 stores in Puerto Rico, and its headquarters were on the upper floors of the HV building.

Emergency-Response Procedures.--The HV vice president stated that the store manager had the authority to evacuate the building. He said that he believed that the manager had been aware of his authority through verbal communications, but that the manager had not received any specific training on the issue. Humberto Vidal officials stated that they were not fully aware of the dangers of gas and that they had not received, either by mail or through the media, any information from the SJGC or the local authorities about the dangers of gas.

HV Building.--The HV building had six stories and a basement. The basement was 12 feet, 11 inches, high, 74 feet long, and 53 feet, 10 inches, wide. It had a plaster drop ceiling that was 16 inches deep. The south end of the basement was used to store open boxes of shoes on shelves for the shoe store above, and the north end was used to store sealed cardboard boxes of shoes for other Humberto Vidal shoe stores. After deducting the space occupied by beams, columns, and stairs, the basement contained about 50,000 cubic feet of air space. HV officials estimated that about 10,800 cubic feet of space in the basement was used for storage at the time of the explosion: 7,200 in the north portion and 3,600 cubic feet in the south portion.

A 5-ton air conditioner exchange unit was mounted on the west face of a column just north of the east stairs, and its thermostat control was mounted on the south face of the same column. The unit pulled air from the basement floor, cooled the air, and sent it through ducts in the ceiling, to be returned to and re-distributed throughout the basement. The unit reportedly was used only 2 to 3 hours a day and when employees were working in the basement.

The building had a meter room, which was on the first floor at the southwest corner. The floor of the meter room was about 2 feet above the level of the first floor, and the space between the level of the first floor and the floor of the meter room was filled with gravel. Many pipes and other conduits for electric, telephone, water, and sewer services to the building penetrated the building's west wall at the meter room. Some of the pipes, including one for gas, were for discontinued utility services. Pipes and conduits also entered the meter room from the gravel-filled space below the floor, and electric lines conduits penetrated the basement wall. The wall separating the space beneath the meter room floor from the rest of the building was made of concrete block. Also, there was a joint at each basement wall and building column juncture. The basement floor had two small drains into the soil, one beneath the exchange unit and one in the southeast corner.

Excavation-Damage Prevention.--During the investigation, representatives of telephone, electric, sewer, water, and gas operations discussed with Safety Board investigators their methods of notifying other operators of underground facilities before they started excavating. They said that the excavation contractor or utility brigade leader would visit the gas company and obtain a map showing the buried facilities in the area of the planned excavation. The SJGC did not customarily visit the excavation site, which is necessary if the gas company intends to mark the locations of buried gas lines. The SJGC also did not normally inspect the excavation work as it progressed.

During the investigation, there were several instances in which maps and records of buried facilities were nonexistent, outdated, incomplete, or not readily available. For instance, the Puerto Rico Aqueduct and Sewer Authority map, initially used on scene to locate its facilities, did not show the 16-inch diameter high-pressure water main under Camelia Soto. The investigators found several other 2- and 4-inch diameter plastic pipes beneath Arzuaga and Camelia Soto and could not find out who owned them or what their purposes were.

Puerto Rico does not have a one-call system. (A one-call system allows an excavator to make one telephone call and know that all companies that have underground facilities in the area the excavator is planning to work on will be notified. The companies that are notified can locate and mark the location of their facilities and take other steps to ensure that the excavator will not accidentally damage their facilities in the process of digging.) The OPS had been supporting underground-damage prevention legislation in Puerto Rico for many years, at least since 1983; and the PSC had worked since 1991 to prepare one-call legislation. However, the proposed legislation had not been enacted by the government of Puerto Rico.

ANALYSIS

Exclusions

The Safety Board considered two potential sources for the explosion within the HV building: an explosive device and combustible gas. The ATF's on-site and laboratory examinations and the Safety Board's investigation found no evidence of an explosive device. The ATF's examination of the HV building debris found the explosion to be consistent with a fuel-based explosion.

The Safety Board identified three possible sources of combustible gas that could have fueled the explosion: propane gas from storage tanks, naturally generated gases from the sewer system or from deteriorating vegetation, and propane from the SJGC's propane/air distribution pipeline system. The Board excluded propane from storage tanks because the only tanks in the area were at the Sbarro Restaurant and pressure tests confirmed the integrity of the underground portion of the fuel line from the tanks. The Safety Board also excluded naturally occurring gas from the sewer system or from deteriorating vegetation because no damage to the sewer system was reported and because such gases would have had an odor distinctly different from the odor of the odorant added to propane that several witnesses reported smelling in the building before the explosion. Therefore, the Safety Board concludes that the explosion was fueled by propane from the SJGC's gas distribution pipeline.

The Safety Board also excluded employee fatigue and employee use of drugs or alcohol as factors that might have contributed to the accident. The investigation found no evidence in support of either issue. The work schedules for the November 21 brigade for the 2 weeks before the accident and the interviews with the crew did not indicate that fatigue was a problem. Three different crews and one technician separately made calls at the Río Piedras area. None of the brigade crew worked extensive hours, and although temperatures and humidity in Puerto Rico were comparatively high, crewmembers were adapted to the environment.

The SJGC did not take urine, blood, or breath specimens from the incident brigade until about 8 hours after the explosion. The SJGC documented two causes of the delay: injured employees needed time for medical treatment and uninjured employees needed time to help with the emergency response. Because of the delay, the tests for alcohol were not useful. The body usually eliminates alcohol at a rate of about 0.015 percent to 0.018 percent per hour.[15] Thus, after 8 hours, as much as 0.12 percent to 0.14 percent can be eliminated from the blood stream. Without a timely alcohol test, neither the SJGC nor the Safety Board could positively rule out alcohol as a factor in the accident.

Drugs were not a factor in the accident; the urine samples tested negative for drugs. Urine samples for the purposes of drug testing are not as time sensitive as blood or breath samples for alcohol testing because the body eliminates most drugs much more slowly than it does alcohol. The Safety Board concludes that neither employee fatigue nor the use of drugs was a factor in the accident.

In August 1997, the SJGC notified the Safety Board that "in an effort to expedite the postaccident drug and alcohol testing procedures of SJGC, a review of current procedures had been initiated." The letter said that the SJGC manager of human resources was responsible for the review and that he would also meet with representatives of the local hospitals to discuss procedures that would allow postaccident alcohol and drug testing to be more timely. According to the letter, the SJGC's employees would be trained to understand the importance of drug and alcohol testing and to know what was expected of them.

[15] O'Neill, B.A., Williams, A., and Dubowski, K., "Variability in Blood Alcohol Concentrations," *Journal of Studies on Alcohol*, vol. 44, no. 2 (1983), pp. 222-230.

The Accident

This section discusses how propane entered the HV building and the most likely source of ignition.

Propane Release Points.--Postaccident tests identified indications of combustible gas in the subsurface of both Camelia Soto and de Diego, and an analysis of gas samples taken from barholes in those streets showed that propane was the primary combustible gas. Postaccident testing also revealed that the gas system in the area of the HV building leaked, and subsequent testing revealed piping failures on Camelia Soto and Arzuaga. On Arzuaga, in front of the Sbarro Restaurant, an inactive gas service line that had once serviced the restaurant leaked through a corrosion hole caused by excavation damage. According to flow tests, the line leaked about 2 cubic feet of propane/air an hour. According to postaccident combustible-gas-indicator and helium tests, the released propane traveled only a few feet both east and west of the corrosion hole and along the path of the 2-inch PVC conduit that had been installed above and in contact with the inactive service line.

A compression coupling that connected the gas main and the inactive service line to Commercial Ubiñas also leaked. The coupling leaked about 1 cubic foot of propane/air an hour, and according to postaccident combustible-gas-indicator tests, most of the propane flowed primarily downhill, along the west side of Camelia Soto, to de Diego.

The plastic gas line between the Commercial Ubiñas service line and the gas meter for the Chicken Kingdom was cracked. Postaccident flow tests using nitrogen established the rate of release as 1.70 cubic feet a minute (102 cubic feet an hour). The crack was right above a 16-inch-diameter water line that had been installed in 1982 after the plastic service line was. The crack was at a plastic coupling that had been used to join two pieces of plastic pipe.

Migration Paths into HV Basement.-- Smoke tests did not reveal a direct path, such as gas flowing through a conduit, that the propane could have followed into the HV building. However, an analysis of the postaccident combustible-gas-indicator tests shows that propane escaping from this crack flowed downhill beyond the HV building. The migration probably followed pipes under Camelia Soto and the voids and pipes beneath the east Camelia Soto sidewalk, at least as far as the meter room at the southwest corner of the HV building. The propane probably flowed along one or more of the active and abandoned pipes and conduits that entered the HV building beneath the floor of the meter room. Once under the meter-room floor, the gas could have flowed into the basement, following the path of electrical conduits into the basement. The propane could have also entered the basement through joints at columns and wall intersections, which may not have been effectively sealed. Although the investigation was unable to determine the precise path the propane followed into the HV building basement, the presence of the odor of propane in the basement is confirmed by several HV employees.

Fueling the Explosion.--Merchandise and other combustibles in the vicinity of the exchange unit were damaged by heat but showed no signs of having been touched directly by flame or fire. Consequently, it is likely that the fuel/air mixture in the basement at the time of ignition was optimum, about 5 to 6 percent gas in air, which would have provided a maximum-force explosion; thus there would have been little flame or soot. Soot is the result of incomplete combustion. The volume of the basement was about 35,000 cubic feet, excluding space taken up by beams, columns, storage and shelving, and other solid objects.

Assuming the reported propane/air mix of the gas transported in the SJGC's pipeline (60 percent propane gas/40 percent air), the plastic service line in front of the Chicken Kingdom was releasing 36.7 cubic feet[16] of propane an hour (0.6 times 61.2 cubic feet per hour). Assuming that only the propane released from the crack in the plastic pipe entered the basement, it would have taken about 57 hours for enough propane (2,100 cubic feet) to enter to

[16]The test medium (nitrogen) measured flow was not converted to an equivalent flow rate for propane as there are many other uncertainties, such as when the leak first occurred and the rate at which propane entered the building, that would have had much greater effects on the calculations.

raise the gas-in-air level to 6 percent. It is not likely that all of the propane released from the crack entered the basement, but there is no evidence from which the rate of propane entering the basement can be determined. Furthermore, there is no evidence about how long propane was escaping before the odor was first detected. Nevertheless, the Safety Board concludes that the 7 days between the time the SJGC was first informed of the gas odor and the explosion was more than enough time for that leak to have produced enough gas to fuel the explosion. Therefore, the Safety Board concludes that the propane/air being released from the cracked plastic pipe under Camelia Soto entered the HV basement and was the fuel source for the explosion.

Location of Explosion in HV Building.-- The explosion cracked the columns of the building and the basement walls about 4 feet below the top of the basement walls, indicating that the columns were subjected to severe bending as the building expanded outward in response to the expanding internal pressure. The fracturing of the concrete floor above the basement, the destruction of the basement stairs due to an upward force, and the imprints of shoe soles on the bottom beam face in the basement indicate that the explosion occurred in the basement. Heat damage to items in the basement indicates that the origin of the explosion was at or near the exchange unit in the basement, which was near the east wall of the building.

The exchange-unit motor was the only source of ignition in the area where the explosion originated. The store manager or the air conditioner maintenance man had probably operated the thermostat for the unit about the time of the explosion. The electric spark generated when the fan motor was activated would have been sufficient to have ignited the propane/air mixture in the basement. Therefore, the Safety Board concludes that the explosion was initiated in the basement when the exchange unit was started in preparation for routine inspection and maintenance.

Gas Leak Investigation Procedures

The SJGC employees who checked for combustible gas outside the HV building did not follow the practices included in the leak-survey materials provided during their training and in industry guidance because they did not sink the barholes to at least the depth of the gas lines. The November 15 brigade leader did not probe and test at greater depths, as he should have when he obtained a combustible gas reading, and none of the brigade leaders had the barholes probed to the depth of the gas lines being surveyed. The failure of the brigade leaders to follow standard procedures was critical because the gas system was a low-pressure one; the pressure in the area of the HV building was about 7 inches water column. Such pressure is not enough to drive escaping gas upward from the point of release. As a heavier-than-air gas, propane released from the pipe system would migrate downhill, flowing through voids along buried pipes and conduits or flowing through voids in the subsurface. Laboratory tests confirm that propane was present in the underground at three subsurface locations in the vicinity of the HV building. Tests show also that there were high levels of combustible gas in the subsurface of the de Diego and Camelia Soto intersection, both before and after the explosion. The Safety Board concludes that the SJGC employees did not detect the underground migration of propane because they did not follow the procedures that were included in their training and in industry guidance on how to survey for leaks in a low-pressure, heavier-than-air gas system.

Had the SJGC employees who tested the subsurface on November 15 and 20 tested the areas adjacent to the HV building at the depth of the gas lines, as was done in the postaccident testing, they would have found indications of combustible gas along the east side of Camelia Soto, where gas was migrating underground. Further tests would have identified the crack in the plastic gas service from which the propane was escaping, and the service could have been repaired.

Excavation-Damage Prevention

Postaccident testing showed that excavation work had damaged the pipeline system in three areas: under Camelia Soto in front of the Chicken Kingdom, under the east side of Camelia Soto at the telephone conduits, and under Arzuaga in front of the Sbarro Restaurant.

The only known event that could account for the deformation of the plastic service line to the Chicken Kingdom was the construction of the 16-inch water main in 1992. The main passed directly beneath the plastic line, and there was no sand bedding beneath that segment of the plastic line, as there was beneath other line segments. The plastic line appeared to have been deformed by the backfilling or compacting of soil after it was backfilled over the water main. Once the plastic line was deformed, its wall was under stress, initiating a slow-growth crack in the wall of the pipe. The Safety Board concludes that the manner in which the water line was installed imposed excessive stresses on the plastic gas service pipe, which resulted in the pipe's later failure.

The damage to the steel service line on Arzuaga, which accelerated the on-going corrosion, was initiated when mechanical damage, similar to that caused by a backhoe bucket while excavating, was inflicted on the pipe. The damage probably occurred when the 2-inch PVC conduit of unknown ownership was installed.

The plastic pipe near the telephone conduits had been cut by a contractor in 1992 while he was excavating in order to install the conduits. The gas system maps that the SJGC gave the contractor did not show the plastic pipe, and the SJGC did not mark the location of the pipe before the contractor excavated. When notified of the damage, the SJGC repaired the pipe, but allowed a major portion of the gas service line to be intermingled with the telephone conduits that were being installed and were later encased in concrete. The SJGC did not disentangle the gas line from the telephone conduits, ignoring its own construction practices and gas industry guidance[17] and thus making the gas line inaccessible for maintenance, leak surveying, and emergency repair.

Accurate maps are an asset for identifying the location of buried facilities before excavation; however, during the investigation, investigators found several buried facilities for which the maps and related records were nonexistent, out of date, or incomplete. The Puerto Rico Aqueduct and Sewer Authority maps did not show the 16-inch-diameter high-pressure water main under Camelia Soto. For 2 days, the SJGC was unable to find its drawings of the plastic gas line under Camelia Soto, and some records it produced of gas service lines in the area were not fully descriptive. Additionally, no one was able to locate any records that showed the purpose or ownership of the 2-inch-diameter plastic conduit found in contact with the gas service line under Arzuaga.

Based on the above observations and investigators' discussions with representatives of the telephone, electric, sewer, water, and gas operations, the Safety Board determined that excavators in Puerto Rico do not necessarily notify operators of underground facilities before they excavate. Some excavators may give notice, but if they do, the action is voluntary and does not follow uniform procedures. For example, a company or person intending to excavate near SJGC facilities usually notified the gas company by informally dropping in to get a map of the facilities in the area of excavation. The SJGC did not always respond by marking the location of its buried facilities in areas of planned excavation, informing the excavator about the precautions he should observe, or periodically inspecting the excavation site. The responses from the operators of buried facilities made it clear that most of them do their own excavating without notifying the operators of other buried facilities in the same area. Moreover, the excavation-caused damage to the gas lines under Arzuaga and Camelia Soto indicate that excavators most often do not report damage to facility owners; thus, the owners are not aware of the need to make repairs.

The Safety Board addressed the need for an effective excavation-damage prevention program in Puerto Rico in a 1980 Safety Board report.[18] In the report, the Safety Board identified the need for the government of Puerto Rico to minimize damage to pipelines and other buried

[17]Gas Piping Technology Committee's "Guide for Gas Transmission and Distribution Piping Systems."

[18]National Transportation Safety Board Pipeline Accident Report--*The Pipelines of Puerto Rico, Inc., Petroleum Products Rupture and Fire, Bayamon, Puerto Rico, January 30, 1980* (NTSB/PAR-80/06).

facilities. The Safety Board recommended on January 30, 1980, that the Governor of Puerto Rico:

P-80-87:

Direct the appropriate utilities and agencies of Puerto Rico to establish an island-wide one-call excavation notification system.

The Safety Board also made safety recommendations to The Pipelines of Puerto Rico, Inc., the PSC, and the Puerto Rico Telephone Company (Safety Recommendations P-80-79, -83, and -88, respectively), calling on them to cooperate with operators of all buried facilities in establishing an island-wide one-call[19] excavation notification system. Although attempts to initiate the recommended one-call notification system were made, the attempts were ultimately unsuccessful, primarily because of insufficient cooperation among the various operators of buried facilities and because the PSC lacked the authority and resources to sponsor such a system. Safety Recommendations P-80-79 and -87 were classified "Closed—Unacceptable Action" on April 13, 1988. Safety Recommendations P-80-83 and -88 were classified "Closed—No Longer Applicable" on July 25, 1988, and May 20, 1984, respectively. The pipeline company involved in the accident discontinued operations, and the telephone company, although willing to participate in a one-call notification system, stated that it was not able to undertake the management responsibility for such an operation.

The Safety Board reviewed the correspondence between the OPS and the PSC about the need for an excavation-damage prevention program. Since at least 1990, the OPS has been encouraging the PSC to work with the SJGC and other buried-facility operators to establish an excavation-damage prevention program, including a one-call notification system. The correspondence confirmed that the PSC had drafted legislation requiring excavators to give advance notice of excavation to operators of buried facilities, but further action had not been taken. The OPS had periodically given the PSC information on the excavation-damage prevention efforts of several States and had encouraged the PSC to take similar actions. To encourage Puerto Rico to implement an excavation-damage prevention program, the OPS gave the PSC and operators of buried facilities chances to review State programs. The OPS also provided grants.

On December 16, 1996, as a result of the explosion in San Juan, the Safety Board issued the following safety recommendations to the Governor of Puerto Rico:

P-96-27

Immediately require that no excavation (except during emergency conditions) be made in areas where buried facilities are likely to exist unless the operators of those facilities have clearly identified and marked the facility locations.

P-96-28

Immediately instruct buried-facility operators to review their maps and facility records to identify errors and omissions, to update their system maps, and to keep their maps up to date.

P-96-29

Immediately require excavators to promptly notify facility operators of any damage to a buried facility or its support caused by excavation operations.

P-96-30

Expedite the implementation of an excavation-damage prevention program that (1) requires full participation from all organizations that excavate or that operate buried facilities, (2) has an island-wide one-call notification center that accepts emergency notifications 24 hours a day, (3) has effective damage-prevention requirements that include

[19] In most States, individuals or organizations are required to notify a one-call notice center before beginning any excavations. The center disseminates information about the planned excavations to buried-facility operators, who then have an opportunity to mark the location of any underground facilities in the excavation area.

government-performed compliance monitoring and enforcement, (4) incorporates comprehensive education programs for buried-facility operators, excavators, and the public that explain how to use the damage prevention program, and (5) establishes penalties for failing to use the program properly.

On January 31, 1997, the Puerto Rico Secretary of State responded for the Governor, saying that a task force had been established to develop a plan for implementing the Safety Board's recommendations and that the task force had already made progress. On March 7, 1997, the Safety Board classified the recommendations "Open—Acceptable Response." The Secretary of State testified at the Safety Board's June 1997 Public Inquiry about the development of a computerized Graphical Information System (GIS) for mapping all buried utilities in Puerto Rico. The mapping system includes both government-owned and private systems, and system operators are required to keep the GIS current. On October 8, 1997, the Secretary of State reported that the Governor had required through Executive Order that all agencies consult the GIS maps before excavating so as to minimize the opportunity of damaging underground facilities. The Safety Board acknowledges the mapping improvements made by Puerto Rico and classifies Safety Recommendation P-96-28 "Closed—Acceptable Action."

The October 8, 1997, letter from the Secretary of State said that the Governor's Executive Order had also established within the PSC an Office for the Coordination of Excavation Works. The office is responsible for developing procedures on receiving and disseminating excavation notifications and on identifying and marking the locations of government-owned buried facilities in advance of excavation work. Government agencies must comply with the procedures the office establishes. Further, the office is to motivate private interests to comply with its procedures. The PSC has established a notification center, which began receiving excavator notifications on October 27, 1997. While awaiting the start of the notification center, the PSC worked with the government agencies, cable companies, and the SJGC on coordinating their excavation work so as to minimize the potential of excavation-caused damage.

The October 1997 letter also said that legislation has been drafted. If the legislation is enacted, private interests will be brought under the same excavation-damage prevention program as government agencies are under the Executive Order. The Safety Board expressed its appreciation of the Governor's active participation in resolving the safety issues identified during the investigation of the Río Piedras explosion. Safety Recommendations P-96-27, -29, and -30 remain classified "Open—Acceptable Response," pending implementation of the anticipated island-wide excavation-damage prevention program.

The Safety Board and the DOT agree that excavation-caused damage is the major cause of pipeline accidents. To emphasize the need to improve State programs, the Safety Board and the DOT jointly sponsored in 1994 a workshop to define ways of improving excavation-damage prevention nationwide and to define the elements that are essential to an effective program. The proceedings[20] of the workshop, which were provided to all States and to Puerto Rico, said that to be effective, an excavation-damage prevention program must:

- Have full participation from all organizations that excavate or that operate buried facilities.
- Have one-call notification centers that accept emergency notification 24 hours a day.
- Have effective State damage prevention requirements that include compliance monitoring and enforcement.
- Have comprehensive education programs for buried-facility operators, excavators, and the public that explain how to use the damage prevention program and the penalties for improper use or nonuse.

[20]National Transportation Safety Board, *Proceeding of the September 8-9, 1994, Excavation Damage Prevention Workshop* (NTSB/RP-95/01).

The Safety Board encourages the Governor of Puerto Rico to expedite the activities now in progress so as to implement an effective, island-wide excavation-damage prevention program as soon as possible.

Emergency Response

Fire department personnel in Río Piedras heard the explosion about 8:30 a.m. and immediately responded. Police officers who were on scene at the time of the explosion reacted promptly to help survivors. Additional police officers, rescue workers, and medical personnel arrived on scene within minutes of the explosion, and Puerto Rico's emergency plan was quickly and effectively implemented, including the use of the incident-command management system.

The government of Puerto Rico quickly recognized the need for longer-term search and rescue support. The President of the United States issued an emergency declaration within hours of the explosion, which made Federal disaster support funds and resources available to aid continuing search and rescue efforts. The several hours needed to bring search and rescue personnel and equipment from Florida did not, in this accident, delay operations, as rescue workers could not enter the building because it was not stable. Under other conditions, however, the time needed to bring search and rescue support from remote locations could have interfered substantially with saving lives.

Even though the rescue was hampered by rain and the instability of the building, workers diligently searched through rubble and debris until December 21. They were able to help survivors and find the bodies of the 33 fatalities. The Safety Board concludes that the emergency response was timely and appropriate, considering the instability of the building.

Survival Aspects

The number of casualties was significantly influenced by the time of day. When the explosion occurred, Río Piedras had not become crowded with shoppers, and employees were just beginning to arrive for work; most were still en route or had not yet left their homes.

The location of people influenced the severity of the injuries they sustained. Of those within buildings, those on the lower floors of the HV building were more seriously hurt because they fell to lower areas when the floors they were on shattered. Employees on the fourth, fifth, and sixth floors had a better chance of surviving than did people on the first, second, and third floors because the upper floor structures remained basically intact. People outside, but in the vicinity of, the HV building were injured or killed because the force of the explosion either caused people to strike objects or to be struck by debris.

The SJGC's written procedures do not require dispatchers to gather enough information from callers to evaluate risks. The dispatcher who spoke with HV employees about the gas odor did not obtain information sufficient to caution them on actions that should be taken while awaiting the arrival of SJGC response personnel. He stated that he routinely gave safety precautions to callers, advising that they not use electrical appliances, but that had he been told that the odor was strong, he would have considered the situation more serious and would have suggested more precautions. The Safety Board believes that callers reporting a gas leak should be instructed, as appropriate, on immediate response actions to take, regardless of the perceived strength of the odor, so that they can evaluate their situation and take appropriate actions for their safety. Further, the Safety Board does not believe it reasonable for a gas system operator to use a caller's perception of the strength of the odor as a basis for determining the urgency of the situation. The ability of a person to detect an odor varies according to many variables, including his perception of "strength," his innate ability to detect odors, the effect of being in an environment that may limit his ability to detect odors, the quantity of odorant injected into the gas stream, and the leeching effect of soils on odorants. Consequently, the dispatcher should have asked whether people were experiencing such side effects as nausea and whether the odor was detected in a confined area. The dispatcher should have asked for all the information that he needed to assess whether the building should be evacuated and whether the help of an emergency-response agency was necessary.

Despite the dispatcher's claim that he had given advice, the only surviving HV employee who had called the SJGC said that the employee to whom she had spoken gave no advice. The administrator of the Chicken Kingdom also said that when he called, the dispatcher gave him no advice. HV employees who talked with the store manager after he had complained to the SJGC said that he had not mentioned receiving any advice about safety. Instead, the employees said, the store manager had complained that the SJGC did not seem to be taking him seriously.

The flyers that the SJGC produced and distributed did tell readers what to do if they detected a strong odor of gas. The SJGC dispatchers and other employees who answered calls had checklists that listed safety tips and explained the procedures to follow, including evacuating buildings. However, the SJGC employees did not routinely follow the procedures when they were telling callers the precautions to take until the site could be inspected.

The Safety Board concludes that the SJGC dispatcher did not gather enough information from the HV employees and consequently could not assess the severity of the situation or tell the callers what they should do immediately. An SJGC employee cannot give reasonable interim safety advice unless he gathers basic information from each caller. SJGC employees must be trained to understand that the caller usually will not be aware of the seriousness of the situation or of the precautions that should be taken. The SJGC employees must form the vital first line of defense for callers so that the public will not be harmed by the product the SJGC supplies.

On February 25, 1997, the Safety Board recommended that Enron:

P-97-4

Require the SJGC to modify its procedures so that an employee who receives a call about a gas odor collects enough information to be able to assess the danger, advise the caller appropriately, and determine whether to notify local emergency-response agencies.

Enron's May 2, 1997, letter responding to the recommendation said that all employees responsible for receiving complaints had completed a refresher course on responding to such calls and had completed training on the use of a revised form. At the June 1997 Safety Board Public Inquiry, an Enron representative testified that the checklist had been revised to encourage dispatchers to take more information from callers. The Safety Board reviewed the checklist and noted that it now includes additional precautionary recommendations, such as when to call local authorities and the possible need to evacuate the premises. The Safety Board classifies Safety Recommendation P-97-4 "Closed—Acceptable Response."

The store manager demonstrated his concern about the propane odor by complaining to the SJGC and to others. However, he apparently did not fully understand the enormity of the threat since he took no action to evacuate the store. His failure to evacuate the store was no doubt influenced by the SJGC employees who visited the building during the week before the explosion and repeatedly told him that there was no gas in the basement.

The HV employees detected the stronger gas odors in the basement during the mornings before the basement air conditioner had been turned on. Apparently during the first several days, operating the air conditioner reduced the odor to the point that it was no longer detectable. However, according to witness statements, the odor level and the effects of the gas concentration on employees increased over time to the extent that employees who entered the basement became sick. The store manager then directed that no employee was to enter the basement.

No SJGC employees entered the basement before the air conditioner had been turned on; but the statement of at least one HV employee indicates that a brigade leader detected the odor while he was in the basement. Given that the SJGC employees knew that people in the shoe store had complained of gas odors in the basement, the SJGC employees should have erred on the side of safety and evacuated the building until the source of the odor had been established and the conditions proven safe.

According to the SJGC's emergency plan, if a gas leak is confirmed, the building should be evacuated or other actions should be taken. In the case of the Río Piedras explosion, more than a week passed before SJGC employees confirmed the existence of a significant level of combustible gas in the soil; and at the time of the explosion, they had not confirmed that the CGI indication was due to propane gas. HV employees stated to SJGC employees that the odor dissipated when the basement air conditioner was on; yet no SJGC employee tested the basement atmosphere before the air conditioner was turned on. The first SJGC employee to investigate the complaint was the only one who had an instrument capable of testing the basement atmosphere. He did not start and adjust the instrument when he was outside the building to ensure that it would be accurate inside the building. Starting and adjusting the instrument inside the building meant that it would show only concentrations greater than those in the shoe store. SJGC employees who later entered the basement did not have instruments capable of detecting gas in such large areas as the basement and thus relied only on their senses of smell to detect the presence of gas.

SJGC management, because of the repeated complaints and because the SJGC employees failed to identify the cause of the odor, should have questioned the appropriateness and thoroughness of the SJGC's responses and should have required additional testing of the basement with appropriate instruments and before the basement air conditioner was turned on. SJGC management should also have made certain that the HV management was aware of the potential danger and of the symptoms people may have when they work in environments containing propane. The gas company's management should have told the HV management about the emergency actions, including evacuation, that should be taken when gas odors continue.

The SJGC's practice of not deciding whether a building should be evacuated until a gas leak has been confirmed is not appropriate: the decision may be made too late, as demonstrated by the Río Piedras explosion. SJGC employees need to consider many factors, with the risk to public safety being paramount, when evaluating the on-site information to assess whether an area should be evacuated before or even during testing. The Safety Board concludes that Enron needs to require the SJGC to revise its emergency plan to include procedures adequate for protecting public safety any time a gas leak is suspected, including the need for building evacuations during leak investigations.

Public Education

Most people interviewed after the accident who had recognized the odor as being that of propane indicated that they did not fully understand that the odor was intended to warn them of danger and that they did not know what to do to protect themselves, especially when the odor was detected inside a building. The SJGC's public education program told people what to do if they smelled gas. A pamphlet explained that an odorant is used to aid them in detecting gas leaks and told them how to report problems to the SJGC. However, the program was not sufficient because it did not tell people how to know when emergency responders should be called.

The HV managers stated that they were not aware of the substantial threat presented by propane gas and that the SJGC had not told them of the danger. The majority of employees and residents in the area of the explosion interviewed after the explosion were not fully aware of the threat posed by a propane gas leak, and they did not recall receiving information from any source about what to do if they smelled gas. The HV managers also stated that they did not consider evacuating the building because SJGC employees had not told them of the danger. The HV managers believed that the SJGC's employees would recognize and warn them of any threats to public or employee safety, a belief that was reasonable.

Even though the HV building did not have gas service, the occupants should have known more about gas emergencies because pipeline safety regulations required the SJGC to tell the public, as well as its customers, how to recognize and respond to the odor of gas. Yet the SJGC's customers and non-customers alike were unaware of the content or existence of the SJGC's program. Therefore, the Safety Board

concludes that the SJGC's public education program did not effectively transmit information about the dangers of propane gas and about the steps to take when gas is detected.

As a result of its investigation into this accident, on December 16, 1996, the Safety Board recommended that the Governor of Puerto Rico:

P-96-26

Require information be disseminated to educate members of the public about the potential hazards of propane gas and about actions they should immediately take to protect themselves and others when a gas odor is detected.

At the Safety Board's Public Inquiry, the Secretary of State for Puerto Rico testified about the programs that had been initiated in response to Safety Recommendation P-96-26, and the PSC also provided information on actions it had taken. In an October 8, 1997, letter, the Secretary of State reported on the full array of actions taken by Puerto Rico. Since the accident, the Puerto Rico government has taken various steps to educate the public about recognizing and coping with a gas leak. The government has acquired and will distribute hundreds of thousands of education pamphlets. It has trained people in government agencies and municipalities to reach and educate such emergency first-responders as police, bomb squads, fire, civil defense, environmental, and employee-safety personnel. It has given courses to school children. The local and regional news media have presented public service messages and educational articles about detecting and coping with gas leaks. The Puerto Rico government has made effective use of the available media to provide essential safety information to the public, has conferenced with all potentially affected government agencies, and has incorporated on a continuing basis the teaching of safety information into school programs. The Safety Board classifies Safety Recommendation P-96-26 "Closed—Acceptable Action."

On February 25, 1997, the Safety Board recommended that Enron:

P-97-3

Revise the SJGC's public education program so that members of the public understand the danger posed by a release of propane gas, can tell when such a release has occurred, and know when steps, such as evacuating the area or notifying the local emergency-response agencies, are appropriate; incorporate in the program a means of measuring its effectiveness.

In a May 2, 1997, letter, Enron stated that it was employing a public relations firm to develop a community outreach campaign to inform the public about the safe use, handling, and management of propane gas, to establish an on-going public education program to keep the community informed about the efforts undertaken by the SJGC, and to measure the effectiveness of the program. At the June 1997 Public Inquiry, an Enron official testified that the SJGC would contribute to an island-wide public education program if all other petroleum gas companies also contributed. On July 2, 1997, the Safety Board classified Safety Recommendation P-97-3 "Open—Acceptable Response." On September 30, 1997, Enron advised the Safety Board that the PSC had approved its plan to reduce the SJGC's pipeline system from a 220-mile one to a 20-mile system that would serve only commercial customers. In light of its significantly smaller gas system, it had modified its public education program. It now mails customers information twice a year about the safe use, handling, and management of propane gas. Once a year, the company sends its customers a telephone rolodex card that describes the steps to take should a gas leak be suspected and a list of emergency telephone numbers. The company also sends its customers a "Scratch and Sniff" brochure to remind them of the smell of the odorant added to the propane gas. The company sends its customers a flyer containing safety information in a bullet point format. Once a year, the company gives the above-referenced materials to residential and commercial locations that are near the pipeline system. Finally, the company contributes to an island-wide public education program coordinated by the PSC for educating the public on the safe use of propane.

According to the May 2 letter, Enron has also distributed more than 25,000 "Scratch and Sniff" brochures to customers and the general public. The Safety Board notes the above improvements in the SJGC's education program; however, it is not clear whether Enron will assess whether the program has reached all people who may be exposed to the risks posed by the smaller gas system. The Safety Board agrees that the island-wide education program can achieve the results called for by the safety regulations; however, Enron must monitor the results of the program to ensure that the objectives in the regulations are achieved. On November 4, 1997, the Safety Board advised Enron that Safety Recommendation P-97-3 would remain classified "Open—Acceptable Response" and requested Enron to define the actions it would take to measure the effectiveness of the island-wide public education program.

After the Río Piedras accident, Humberto Vidal put into writing the procedures it had verbally given its store managers on preventing injury and illness for employees and the public. Those procedures provide for:

- Early detection of any hazardous condition in Humberto Vidal stores.
- Immediate reporting to management of unsafe conditions.
- Safety and health training to employees, including drills on what to do in case of an emergency.
- Specific evacuation procedures to be developed for each Humberto Vidal building.

The Humberto Vidal management stated in a November 7, 1997, letter that it was formalizing in these procedures the instructions verbally conveyed to its managers before the accident on actions they were to take in the event of an emergency. Tragically, it opined, even had these written instructions been in place before the accident, they would have been of little use in preventing an unexpected explosion in a building that did not have gas service, did not store any hazardous materials, and had been checked several times by the SJGC and found to be safe.

The Safety Board has addressed in several reports about accidents the need for better public education programs, and in a 1990 pipeline accident report[21] it recommended that the Research and Special Programs Administration (RSPA):

P-90-21

Assess existing gas industry programs for educating the public on the dangers of gas leaks and on reporting gas leaks to determine the appropriateness of information provided, the effectiveness of educational techniques used, and those techniques used in other public education programs, and based on its findings, amend the public education provisions of the Federal regulations.

At a 1992 meeting of Safety Board and RSPA staffs, the Safety Board noted that gas-industry public education programs appear to receive less than half the public recognition that other public safety programs do, such as those about seat belt restraint and child seat restraints. Safety Board staff urged RSPA to identify the techniques that make other public education programs more effective, determine which of the techniques would improve gas-industry programs, and then incorporate them into the Federal requirements. On April 5, 1993, RSPA published Advisory Bulletin ADB-93-02, which directed "gas pipeline facility owners and operators to review and assess their continuing education programs as applied to customers and the public." The Safety Board did not consider that action responsive and classified Safety Recommendation P-90-21 "Open—Unacceptable Action."

The Safety Board asked RSPA to address the status of Safety Recommendation P-90-21 at the June 1997 Public Inquiry. The director of the Enforcement, Compliance and State

[21]National Transportation Safety Board Pipeline Accident Report, *Kansas Power and Light Company Natural Gas Pipeline Accidents, September 16, 1988, to March 29, 1989* (NTSB/PAR-90/03).

Operations Division of RSPA stated that RSPA had recently received $800,000 in funding to develop a national public education format to be used by pipeline operators. RSPA planned to work closely with industry to determine the most effective way to educate the public about handling gas. Although RSPA's past actions on this issue have not been timely, the Safety Board is pleased that the OPS now has on its agenda the development of a national public education format and encourages the OPS to expedite work on this project. Because of the OPS's renewed activity, the Safety Board classifies Safety Recommendation P-90-21 "Open—Acceptable Response."

Employee Training

The inadequacy of the training of the SJGC's employees contributed substantially to causing the explosion. Employees cannot do a proper leak survey or pinpoint a gas leak without knowing the lateral location of the gas pipes, the depth of the gas lines, and the depth at which the barholes should be made. For low-pressure propane/air systems, it is imperative that a crew first know the depth of the pipeline and then ensure that the barhole depths reach the pipe depth. The SJGC employees did not know the depth of the gas line and did not sink the barholes deeply enough.

The SJGC's training was inadequate in other ways. The company did not assess the performance of its trainees after they had been trained or document its training. The personnel files for the incident crewmembers did include certificates for various training courses, but the files did not indicate the content of the courses or whether the courses were part of a training plan.

Because the SJGC did not have a written training plan, the Safety Board could not determine whether its employees had completed a prescribed set of courses for their particular jobs. The certificates in the files did not indicate whether personnel in certain jobs were all to receive the same training, as not all individuals had the same certificates in their files. Test scores on some training courses for some people were documented, but not every certificate had test scores. Interviews with management indicated that there had been periodic safety briefings, but the personnel files did not indicate whether the brigade members had attended the briefings. The files did not include periodic reviews of employees' performance. In all, the Safety Board found that the employee training program before the accident was poorly and inconsistently documented and that no overall training plan had been established.

The Safety Board assessed the development, conduct, and evaluation of training for the SJGC's employees as inadequate, particularly for the people who surveyed, located, and repaired leaks. The major deficiency was the lack of a front-end analysis of the training needed. A front-end analysis of a job is necessary in order to identify the tasks[22] that the holder of the job must be able to do. Once a task is identified, it can be converted to a learning objective,[23] or a goal that the trainee will achieve by taking training. Learning objectives can be used to measure the effectiveness of the training. If the trainee, after training, can meet the learning objectives, that is, successfully perform the tasks that have been identified as necessary to do the job, the training has been successful and the trainee is prepared for the job. Not only does the use of learning objectives provide a way of assessing the effectiveness of training, it keeps the training focused on the tasks that the trainee actually has to be able to do in order to perform the job. Thus, a good front-end analysis of a trainee's job can save both time and money.

The SJGC had the same problems with the training for which it had contracted. The company should have, but did not, require that Heath assess the performance of the employees it trained. Heath, having had years of experience in employee training, should have assessed the SJGC trainees to determine the knowledge they already had in the areas being proposed for training. Had Heath done so, its trainers would have known whether the SJGC employees needed advanced training or training on the

[22] A task is an action or function performed as part of a job. Tasks are usually readily observable and should be measurable for determining adequacy of performance.

[23] A statement describes what knowledge the students will have or what they will be able to do upon completion of training.

fundamentals. Doing a job analysis[24] would have identified the individual tasks related to the job, the number of people needed to perform the job, the tools and equipment necessary for performing the work, and any manuals, references, regulations, or company procedures the trainees were required to follow.

Heath should have performed a front-end analysis. The analysis is typically accomplished using occupational surveys and in-depth interviews of experienced subject-matter experts and management personnel. After fully describing the learning objectives, the course designer determines the appropriate course presentation options. Options can include computer-based training, on-the-job training, interactive video, slides, and other media, as well as the standard platform or lecture format. During this design phase, written testing and/or ways to assess student performance can be designed to reflect the agreed upon learning objectives. In this way, assurance is provided that all critical job tasks are identified and can be taught and tested.

Assessing Effectiveness of Training on Barhole Depth.--When an employee fails to perform a particular procedure or task correctly, it is usually an indication the he has not been trained or that the training was deficient. Poor performance can also be the result of human error. In this accident, the crews were not following the correct leak detection procedure, which called for making barholes to the depth of the pipeline.[25] The depth of the main line under de Diego was generally 2 to 3 feet, and some parts of it were deeper. The depth of the gas line under Camelia Soto varied from 1 1/2 feet to 3 feet. The brigade leaders indicated that the barholes they made around the HV building were about 18 inches deep. The November 15 brigade leader and members stated that the holes they dug were “18, 20, [and] 19 inches and sometimes deeper.” Although one brigade leader stated in January 1997 that his crew probed barholes 2 feet and deeper and that the gas main was about 2 feet deep, days after the explosion he told a Safety Board investigator that the barholes were 18 inches deep. Additionally, the brigade leader who tested for gas in the barholes the following day stated that they, like the ones his crew made, were about 18 inches deep.

The concept that 18 inches is the proper depth for a barhole appears to be information that had been internalized by the work crews, but the Safety Board was unable to determine the source. A reference (the earliest found) to barhole depth is included in Heath’s November 1995 work proposal to the SJGC:

> Barholes are a minimum of 18 inches deep, except when the main is less than 18 inches deep, but may need to be to the depth of the pipe depending on the soil type and condition as well as the condition of the pipe, the operating pressure and the instrument being used.

The brigade workers would not have seen a copy of this proposal, and Heath’s training materials[26] called for the barholes to be at or below the depth of the gas main. The materials do not direct an 18-inch barhole depth. A Heath consultant maintains that he taught the crews to penetrate to the depth of the pipe. He also stated that SJGC employees showed little interest in performing leak surveys.

After the accident, the SJGC general manager and Enron’s operations manager asked Heath to hold training in December 1996 for designated employees on surveying and pinpointing gas leaks. Heath trained SJGC employees in investigating odor complaints, surveying for gas leaks, pinpointing gas leaks, and using the SJGC’s newly acquired GMI Gas Surveyor 434. After each course, Heath gave the trainees a written examination, which consisted

[24]Job Analysis: The basic method used to obtain a detailed listing of duties, tasks, and elements necessary to perform a clearly defined, specific job, involving observations of workers and conversations with those who know the job, in order to describe in detail the work involved, including conditions and standards.

[25]Appendix G-192-11A “Gas Leakage Control Guidelines for Petroleum Gas Systems,” GPTC *Guide for Gas Transmission and Distribution Systems*.

[26]A copy of Appendix G-192-11A, “Gas Leakage Control Guidelines for Petroleum Gas Systems,” from the 1990-9 GPTC *Guide for Gas Transmission and Distribution System* was provided as part of the training materials.

of multiple-choice and fill-in questions, and awarded certificates to those who passed.

However, in January 1997, when Safety Board investigators interviewed SJGC employees, the brigade leaders still did not know that barholes should be dug to the depth of the pipe. On February 25, 1997, the Safety Board recommended that Enron:

P-97-1

Immediately retrain all SJGC employees who perform leak detection tasks, instructing them how to determine whether propane gas has leaked from the pipeline system, where and at what depth to test the subsurface, and how to define the likely extent of gas migration; in addition, implement a means of measuring the effectiveness of the training provided.

P-97-2

Promptly develop and implement for SJGC employees who perform operational and safety-sensitive responsibilities a training program that is based on an evaluation of tasks assigned, so that it imparts the technical and procedural information needed to correctly perform their duties, and that incorporates a means of measuring the effectiveness of the training provided.

In its May 2, 1997, response, Enron said that SJGC employees had had formal classroom and on-the-job instruction on gas-leak detection and repair. In its July 2, 1997, letter to Enron, the Safety Board classified the recommendations "Open—Acceptable Response." At the June 1997 Public Inquiry, Enron said that it had required the SJGC employees to pass tests on the training they had taken and that employees who failed were retrained and retested. Therefore, Safety Recommendation P-97-1 is classified "Closed--Acceptable Response."

At the June 1997 Public Inquiry, an Enron official testified that the company would soon complete a comprehensive training and verification program. Later that month, the SJGC gave the Safety Board a master training plan, outlining how the company intended to develop and conduct training. The program is to consist of four phases:

Phase One: orientation and mandatory safety and health training,

Phase Two: fundamentals training,

Phase Three: company overview,

Phase Four: job-specific training.

The plan shows that Enron is systematically developing a program that includes the use of front-end analysis and identifies job-specific tasks, but the plan fails to fully identify job tasks for some SJGC positions. The plan needs further clarification and refinement. The plan shows that the company intends to evaluate employee performance through written tests, field-skills verification, and periodic review.

Since the explosion, Enron has demonstrated its understanding of the importance of developing and documenting training for SJGC employees, as evidenced by the company's acceptance of and fast response to the Safety Board's emergency recommendations about training. That Enron offers its own employees skill-based pay and computer-based training also shows the company understands the need for proper training development, as the skill-based pay and computer-based training were developed to help improve employee performance. The skill-based pay program was developed using proper front-end analysis and by involving education specialists, instructional design specialists, and subject matter experts. (The program, however, was not available to SJGC workers.) Having computer-based training showed that Enron understood the value of individualized training plans. Further, the programs demonstrate that Enron had the knowledge to build effective employee training programs and, as suggested by its response to Safety Recommendation P-97-2, could have earlier extended this philosophy to its affiliate organization, the SJGC.

The Safety Board recognizes that through Enron's extensive work the SJGC program has progressed rapidly from one having virtually no documented employee training and qualifica-

tions to one that is being systematically planned and documented. The Safety Board encourages the developers of the training program to continue refining their identification of employee tasks, duties, and responsibilities, as such identification is the foundation of the program. Pending completion and implementation of the training program, Safety Recommendation P-97-2 has been classified "Open--Acceptable Response."

Federal Employee Training Requirements.--In a February 18, 1987, report,[27] the Safety Board recommended that RSPA:

> **P-87-2**
>
> Amend 49 CFR Parts 192 and 195 to require that operators of pipelines develop and conduct selection, training, and testing programs to annually qualify employees for correctly carrying out each assigned responsibility which is necessary for complying with 49 CFR Parts 192 or 195 as appropriate.

In March 1987, RSPA published an Advance Notice of Proposed Rule Making, *Pipeline Operator Qualifications* (Docket No. PS-94, Notice 1), which said:

> This notice, issued in advance of a proposed rule, invites public comment on the need for additional regulations or a certification program regarding the qualification of personnel who design, construct, operate, or maintain gas or hazardous liquid pipelines.

The Board responded in May, saying that it had issued 110 recommendations about the training of pipeline workers. The Board had issued the recommendations as the result of various pipeline accidents between 1975 and 1986, and the recommendations covered a wide variety of training deficiencies that applied to a broad segment of pipeline activities. The Safety Board advised that it had found training deficiencies that were either contributing or directly causal to pipeline accidents in nearly every facet of activity investigated, including operations, construction, and emergency response. It noted that training and performance criteria for the pipeline operating community needed to be developed and implemented so that the effectiveness of the training and the performance of the operator could be measured. The Board said that without such measures it would be hard to determine objectively whether training had improved an employee's performance and whether the objectives of the training had been met.

In its comments to the Advance Notice of Proposed Rule Making and directly bearing on the SJGC investigation, the Safety Board told RSPA that it needed to require pipeline operators to:

- Identify each employee whose successful accomplishment of assigned responsibilities or tasks was a necessary part of an operator's actions to comply with the Federal pipeline safety regulations;
- Perform analyses to identify the tasks, jobs, and responsibilities each employee had that related to Federal pipeline safety regulations;
- Identify specific training methods to be employed to provide each employee with enough knowledge to effectively carry out applicable jobs, tasks, and responsibilities identified in the analyses;
- Identify methods to be used in evaluating the effectiveness of the training, including the identification of standards for acceptance; and
- Document the training provided for each employee and training evaluations.

On May 11, 1993, the Safety Board reminded RSPA that it had been more than 5 years since the Board had recommended establishing employee qualification standards and that implementing the recommendation should have been one of RSPA's top priorities. The Board affirmed that it remained firmly convinced that the recommended training,

[27] National Transportation Safety Board Pipeline Accident Report, *Texas Eastern Gas Pipeline Company Ruptures and Fires at Beaumont, Kentucky on April 27, 1985, and Lancaster, Kentucky, on February 21, 1986* (NTSB/PAR-87/01).

qualification, and testing requirements and standards were essential. As a result of RSPA's inaction, Safety Recommendation P-87-2 was classified "Open—Unacceptable Response."

On July 27, 1994, RSPA issued a Notice of Proposed Rulemaking (NPRM) proposing the qualification standards for pipeline employees. On November 9, 1994, the Safety Board responded to the NPRM, commenting on the proposal and urging RSPA to expedite completion of the rulemaking. RSPA received 131 comments on its proposal; and almost 2 years later, on June 25, 1996, it withdrew the proposal in favor of conducting a procedure known as "Negotiated Rulemaking."[28] In its June 26, 1996, Notice of Intent, RSPA stated that "Commenters to the NPRM stated that the proposal was too prescriptive and that many references to training requirements should be modified to place the focus of the NPRM on actual qualifications, not the methods of achieving it." RSPA selected a committee to represent the "interests" affected by actions that it may take on employee qualification requirements. In April 1997, the committee began drafting a new rule proposal, but has not completed its task.

The committee has addressed provisions for employee performance assessment and recordkeeping. By requiring the evaluation of employees' performance, the committee addressed the Safety Board's concern that the qualifications of employees of pipeline facilities be judged on the basis of objective, demonstrable forms of evaluation. The committee will also recommend that an evaluation of an employee's performance be required if the employee is involved in a reportable incident to which his actions may have contributed. In August 1997, the committee had its fourth meeting. The goal was to obtain consensus among committee members on a draft regulation concerning operator qualifications and to review and revise the outline for the rulemaking preamble.

If employee qualification requirements are established, an operator will be able to access documentation about the training and qualifications of any employee he is considering hiring. In an era of downsizing and reductions in force, the industry should benefit from being able to know about an employee's training and qualifications. The employees will have credentials that are accessible. In support of the current employee training and qualification efforts, a manager of pipeline training[29] stated that having a properly trained workforce adds tremendous value to a company by reducing the expense of maintenance, equipment damage, and personal injuries. Moreover, he added, well-trained employees are usually much more productive. Needless to say, the public's safety would be significantly enhanced if RSPA ensures that the pipeline workforce is qualified and trained to carry out its assigned tasks safely. The Safety Board continues to urge RSPA to expedite the completion of rulemaking action to achieve this essential safety objective.

Pipeline Safety Oversight

At the time of the accident, SJGC management did not provide a working environment that encouraged its employees to adhere to operating policies and practices; management did not adequately train its employees, and management did not oversee the employees enough to identify and correct unsafe practices. Of the three top managers, only the operations superintendent had extensive knowledge of the gas system, and he had limited management experience. That environment created by management contributed significantly to the cause of the accident.

Even though the SJGC management failed to prepare and motivate its employees, other entities had chances to correct the deficiencies before the accident. Enron, the PSC, and the

[28] "The negotiated rule process assists in the development of the NPRM, allowing all affected parties to present their views to reach a consensus, thus avoiding litigation and disagreement once the rule is finalized. By using this process the OPS has agreed to publish the committee's consensus. Also, the overall contents of the regulation are the responsibility of the committee. However, by participating in this process, the OPS does not give up its responsibility to promulgate the final rule." Taken from the draft summary minutes of the April23, 24, 1997, advisory committee meeting.

[29] Gas Industries, *U.S. DOT Qualification Ruling*, Timothy Lilly, Manager of Compliance and Technical Training, CNG Transmission Corporation, January 1997.

OPS each had responsibilities for ensuring that the operations of the SJGC were conducted so that public safety was not endangered. The Safety Board concludes that the accident might have been prevented had Enron, the PSC, or the OPS been timely in requiring the gas company to adequately train its employees in leak survey procedures.

Enron.--Enron, as the owner of the SJGC, had the corporate and primary responsibility for ensuring that its affiliate company's operations were safe. It had the opportunity and capability to identify the SJGC's needs and to make improvements, either by using SJGC employees or by calling on specialized or technical resources, such as legal, regulatory compliance, and safety, available in corporate groups and affiliate companies. The SJGC managers did not know about the older audit findings. They were heavily dependent on Enron for assistance in technical and safety matters. However, Enron affiliate company personnel also did not know about the previous studies and audits.

Before buying the SJGC in 1985, Enron management learned of deficiencies in SJGC operations through a consultant's audit. After acquiring the SJGC, Enron used consultants and Enron affiliate personnel to audit the SJGC's operations. Enron affiliate management often visited the SJGC and met with the SJGC general manager. Because the Enron affiliate management reported to Enron management, the visits allowed Enron to learn about operating problems, including the results of the PSC's inspections. Consequently, it was possible for Enron management to be aware of the status of SJGC operations.

The problems that the SJGC had with its operations before it was acquired by Enron were not resolved, as they were repeatedly identified in subsequent audits contracted by Enron affiliates and in PSC letters to the SJGC. Corrosion, employee training, construction, and operation deficiencies continued to be identified as areas requiring improvement. Even so, Enron did not act expeditiously to ensure effective corrections. Toward the end of 1995, Enron began to improve the SJGC's compliance with the safety requirements. Enron management brought in Enron affiliate and contract resources to plan and direct the improvement. Enron wanted to reduce the amount of unaccounted for gas by improving the accuracy of measurements and by finding and repairing gas leaks. Enron also wanted to reduce the amount of damage that excavation was doing to the pipelines. While the improvements were needed, they constituted only a small portion of the improvements necessary to bring the SJGC's operations into compliance with accepted industry standards and with Puerto Rico's safety requirements on employee training, public education, etc.

Since the explosion, Enron has dedicated considerable resources to correcting the deficiencies at the SJGC. Enron, through SJGC filings to the PSC, requested that it be allowed to shut down about 200 miles of its 220-mile distribution system. Enron's request stated that the gas system was unable to compete economically with other energy options available in Puerto Rico. The PSC has approved Enron's plan. The smaller 20-mile gas system network will provide service only to its commercial gas customers; however, the hazards to public safety in the vicinity of the system will remain. Enron needs to establish a permanent method of effectively overseeing the SJGC so as to ensure that its actions are consistent with public safety requirements and pipeline safety regulations.

PSC.--Before 1990, the PSC had only one inspector, and he had many other responsibilities, including overseeing all bottled propane operations in Puerto Rico. During that time, the OPS, through its annual audits, appeared to be doing most of the oversight of the SJGC, and its representative pointed out several areas that needed improving. In the early 1990s, the PSC's oversight of the SJGC improved: the inspector had taken extensive training at DOT's Transportation Safety Institute and a second employee was being trained as an inspector. The PSC did not have written procedures to guide its inspectors on documenting probable violations, notifying SJGC management of violations, following up violations, and telling the PSC commissioners when formal action was needed to enforce compliance. Even so, the PSC inspectors did identify, document, and formally notify the SJGC of probable violations. While the SJGC did not totally ignore the notices, its responses indicate that it saw little urgency about

making corrections. The PSC's 1992 and 1993 inspections documented 16 and 20 probable violations, respectively; 5 violations were the same for both years.

At the OPS's urging in 1993, the PSC levied a small monetary penalty against the SJGC in 1994. In 1995, PSC inspectors documented more than 80 probable violations. A PSC inspector testified at the June 1997 Public Inquiry that he had discussed the 1995 inspection results with SJGC management; however, the PSC could produce no documents proving that it had either notified the SJGC or told the PSC commissioners of any need to take formal action against the SJGC. The PSC did not take any formal action against the SJGC for failing to correct the probable violations; and in 1996, PSC inspectors documented almost 60 probable violations. More than 30 were the same as those documented in 1995. Again, the PSC was unable to produce written documentation showing that the SJGC had been notified; however, a PSC inspector testified that an SJGC representative accompanied the PSC inspectors on all inspections and was informed about all probable violations. Therefore, it would appear that in both 1995 and 1996, SJGC management had the opportunity to learn about the PSC's findings.

On March 13, 1997, the PSC issued an administrative order to the SJGC about the 1996 inspection. The order noted that the SJGC had been told about the areas of non-compliance on the day of the inspection and that the problems included corrosion control, operation and maintenance plans, public education, investigation of failures, maximum operating pressure, patrolling, required tests before restoring gas service, abandoning facilities, deactivating facilities, protecting metal pipe, remedial steps, required notifications, and revision of records. The order stated that the SJGC was required to eliminate the deficiencies.

The PSC order referred to the Río Piedras explosion and the Safety Board's February 25, 1997, recommendation letter to Enron. The PSC adopted the Safety Board's recommendations as part of the administrative order. Using the order of presentation in the Safety Board's letter, the PSC identified the recommendations as items 'A' through 'D.' Under each item, the PSC added to, clarified, and emphasized the individual actions that the SJGC would have to take to fulfill the intent of the recommendations. Within 30 days of the order, the SJGC was to send the PSC a copy of its plans for complying; thus the PSC could evaluate the SJGC's progress.

On April 3, 1997, an attorney for the SJGC asked the PSC to reconsider its administrative order on the following grounds: (1) the SJGC objects to and disputes the contention that it lacks programs, systems, and appropriate means to reasonably conduct operations; (2) the SJGC had informed the PSC that it had fulfilled and was ready to comply with assignments when and where required; (3) the SJGC is determined to certify fulfillment of assignment 'C' during or before April 18, 1997; (4) the SJGC proposes to coordinate a program comparable to assignment 'D.' The SJGC stated that it believed the PSC should consider these alternatives and meet with the SJGC to reconsider and revise the order. On April 30, 1997, after reconsidering, the PSC ordered the SJGC to comply with the administrative order.

The PSC's most recent inspections demonstrate that it has recognized the need to inspect SJGC operations more thoroughly; however, until the explosion, the PSC did not enforce its safety requirements aggressively. After the explosion, the PSC ordered the SJGC to comply with the Safety Board's recommendations, but the PSC did nothing to make the SJGC resolve the probable violations the PSC had identified in 1995. On May 27, 1996, the SJGC responded to the March 12 administrative order about the 1996 inspection. The PSC has not yet determined whether the SJGC has corrected the probable violations or whether further enforcement action is required. The Safety Board concludes that the lack of written guidance for PSC inspectors on documenting probable violations, on formally notifying the SJGC, on doing timely followups to determine whether violations have been corrected, and on telling the PSC commissioners when there is a need for formal action to enforce compliance contributed to poor communications among PSC staff, its commissioners, and SJGC management. The lack of effective program management likely contributed to the ineffective use of PSC enforcement capabilities and may

have contributed to the failure of Enron and the SJGC to correct deficiencies. The Safety Board believes that the PSC must develop written procedures to guide its staff's actions if it is to ensure that monitoring will be effective, that the SJGC will be notified of its probable violations, and that the commissioners will take prompt, aggressive enforcement steps if the SJGC fails to make timely corrections in its operations.

OPS Oversight of State Pipeline Safety Program.--The OPS is responsible for evaluating the PSC's pipeline safety program. At the June 1997 Public Inquiry, the OPS southern region director, whose responsibilities include overseeing Puerto Rico, advised that it is essential to the success of a program, as well as a requirement of the certification, that the agency be able to enforce the regulations by levying civil penalties as appropriate. He also said that if a State finds violations but does not notify the operator and follow up to make sure the violations are corrected, the OPS will call the deficiency to the attention of the PSC.

The region director said that the PSC's program has improved steadily since 1992. "Today, there is more support from the PSC commissioners for the pipeline safety program, and this is especially true for the past couple of years since one commissioner pledged his cooperation to the OPS and his support for the pipeline safety staff." Based on his review of the correspondence between the PSC and the SJGC about the probable violations, the region director said, the SJGC needs to improve its technical knowledge significantly in order to understand the pipeline safety regulations.

The director of OPS's Safety Enforcement Compliance and State Operations Office stated at the Public Inquiry that the OPS has less than 40 inspectors with which to cover the entire country. If a State does not certify to perform intrastate inspections of gas pipeline operators and enforce pipeline safety requirements, the OPS is required to do it. Consequently, the OPS will work with a State program until the State almost turns it back to the OPS. He added that that does not mean the OPS will let things go on that should not. Rather, the OPS works with the State to improve the program to get its support. The OPS does everything it can to keep from decertifying a program. He stated that one reason the OPS works hard to keep the program with the States is that the OPS believes that operator response is better and that a State usually has much greater resources than the OPS does.

Each year, the OPS evaluates the PSC's performance during the previous year. During the 1970s and 1980s, the OPS sent letters to the PSC specifying the deficiencies in SJGC operations and followed up with the PSC to ensure that corrective action had been taken. Based on the OPS's letters to the PSC in the 1990s, the OPS concentrated, almost to the exclusion of all other needs, on obtaining equipment to enable PSC staff to better perform its inspections and on establishing an excavation-damage prevention program for Puerto Rico.

Although the OPS has been trying to improve the PSC's pipeline safety program, since 1993, the OPS has given the PSC's pipeline safety program high scores despite significant deficiencies. The problem was compounded by the OPS's letters to the PSC's president; the letters gave no indication the program needed significant improvements, such as the development of a written procedures to guide its staff on documenting and notifying an operator of probable violations or the development of an effective enforcement program.

The OPS did notify the PSC in 1993 of its concern about the PSC's 1992 inspection findings of 16 probable violations, and it advised the PSC that it should seriously consider using civil penalties to force the SJGC to make corrections. As a result, the PSC did levy a monetary penalty. Since then however, the OPS has not recommended that the PSC take any enforcement actions, even after the Río Piedras explosion. Based on its latest evaluation, the 1996 evaluation, the OPS awarded the PSC a rating of 97 for its pipeline safety program, including giving it the highest possible rating for its compliance program. The OPS awarded these ratings even though the PCS in 1996 had told the SJGC that it had more than 50 probable violations, of which more than 30 had been identified in 1995, and the PSC had not taken any formal action to force the SJGC to make corrections.

The Safety Board agrees with the OPS that the States do provide more resources than the OPS does for monitoring pipeline operations and that when possible, the responsibility for monitoring should remain with the State. However, the OPS retains overall responsibility; and through its monitoring of State programs, it must ensure that pipelines are operated in a manner that provides adequate public safety. The Safety Board also agrees that the OPS should work with the States to help them maintain and improve their programs. However at no time should the OPS's objective of keeping States in the pipeline safety program take precedence over its responsibility for ensuring that pipeline systems are safely operated and maintained to preserve public safety.

Each year, after the OPS had evaluated the PSC's pipeline safety program, it scored the program's effectiveness and gave the PSC president a numerical grade. The PSC's enforcement program received the maximum allowable points in each of the 3 years. For the past 3 years, the PSC's pipeline safety program received overall scores of 95, 97, and 97, respectively. The scores would indicate little, if any, need for improvement. The Safety Board concludes that the OPS's evaluation scores for the PSC before the Río Piedras explosion misled the PSC commissioners about the need to bring enforcement action against the SJGC.

The OPS may have given the PSC program high ratings because the questions on the OPS's evaluation form were poorly designed and because the OPS's evaluators lacked written guidance on how to rate various aspects of a State program. The evaluation questions that the Safety Board reviewed were loosely framed, and the evaluators' assessments of the answers seemed to be subjective rather than based on specific, uniform criteria.

When a State program is not functioning, the OPS must fill the gaps; any time public safety is being compromised, the OPS must act. The Safety Board believes that in view of the events preceding the Río Piedras explosion, the OPS must improve its State pipeline safety certification program. The OPS must develop written guidance and criteria that its personnel can use to evaluate State programs objectively, and the OPS must require States to be prompt in correcting identified program deficiencies.

The Safety Board concludes that the OPS failed to effectively monitor Puerto Rico's pipeline safety program. The Safety Board is concerned that the deficiencies in the PSC's pipeline safety program were allowed to exist for so long without the OPS recognizing them and notifying the PSC commissioners about the need for corrective actions. The Safety Board concludes that the Río Piedras accident might have been prevented had the OPS been timely in notifying the PSC commissioners that the ineffectiveness of the PSC's enforcement was endangering public safety and had it insisted that the PSC require the SJGC to promptly correct all deficiencies. Had the PSC's oversight been effective, the SJGC brigade leaders might have been properly trained in detecting subsurface gas leaks, and thus able to locate and repair the gas leaks on Camelia Soto before the explosion. Therefore, the Safety Board believes that the OPS needs to reassess the effectiveness of its State monitoring program.

CONCLUSIONS

Findings

1. Neither employee fatigue nor the use of drugs was a factor in this accident.
2. The explosion was fuel based; it originated in the basement of the Humberto Vidal building and was probably initiated when the basement air conditioner unit was operated.
3. The source of fuel for the explosion was the mixture of propane and air that leaked from the failed plastic gas service pipe to the Chicken Kingdom Restaurant and probably migrated underground into the meter room of the Humberto Vidal building and then into the basement.
4. The 1992 backfilling and compacting of soil over the 16-inch water line imposed excessive stresses on the plastic gas service pipe to the Chicken Kingdom Restaurant, stresses that later caused the service pipe to fail.
5. The gas company's employees were not properly trained in testing for leaks; they did not test correctly, and they did not find and repair the leak.
6. The gas company employee who received telephoned reports of gas odors failed to provide effective instruction to callers on the dangers of propane and the steps to take to protect themselves because neither employee training nor supervision was adequate.
7. The gas company dispatcher who talked to callers reporting gas odors did not give adequate advice to callers partly because he did not gather enough information from the callers to evaluate the seriousness of the situation.
8. The gas company's public education program was not effective in warning people who had reported a gas odor about the dangers of propane gas and about the steps to take when gas is detected.
9. The response from local, Puerto Rico, and Federal emergency responders was timely and appropriate, given the building's instability and the weather. The time required for Federal emergency responders to arrive on scene did not hamper the search and rescue efforts in this instance.
10. The gas company's employees were not adequately trained in surveying and pinpointing leaks.
11. The leak detection training given to the gas company's employees was inadequate partly because neither the company nor Heath Consultants, Inc., identified the tasks for which the employees needed to be trained or tested the employees to make sure the training had been effective.
12. Enron Corp. did not provide a working environment that encouraged the employees of the gas company to follow its operating policies and practices strictly, and it did not oversee employees' actions enough to identify and correct unsafe practices.
13. Although Enron Corp. had known since 1985 that the gas company's operations did not comply with pipeline safety requirements and recommended industry practices, it failed to require the gas company to comply.
14. Enron Corp. had begun before the explosion to correct some deficiencies in the gas company's operations, but its attempt was neither timely nor sufficient.
15. In 1995 and 1996, the Puerto Rico Public Service Commission found numerous probable violations in the gas company's compliance with pipeline safety requirements, but the Commission did not require timely, effective corrections.
16. The Puerto Rico Public Service Commission's inspectors did not have written guidance on documenting probable violations, on formally notifying the gas company of violations, on doing timely followups to determine whether violations

had been corrected, and on telling the commissioners when formal action was needed to enforce compliance; the lack of written guidance contributed to poor communications among the staff and commissioners of the Puerto Rico Public Service Commission and the management of the gas company.

17. The Research and Special Programs Administration/Office of Pipeline Safety failed to effectively monitor Puerto Rico's pipeline safety program.

18. The evaluation scores that the Research and Special Programs Administration/Office of Pipeline Safety gave the Puerto Rico Public Service Commission mislead the commissioners about the adequacy of its pipeline safety program and about the need to take enforcement action against the gas company.

19. The accident might have been prevented had the Research and Special Programs Administration/Office of Pipeline Safety been timely in notifying the Puerto Rico Public Service Commission that the ineffectiveness of its enforcement was endangering public safety and had the Research and Special Programs Administration/Office of Pipeline Safety insisted that the Puerto Rico Public Service Commission require the gas company to promptly correct all deficiencies.

20. The accident might have been prevented had Enron Corp., the Puerto Rico Public Service Commission, or the Research and Special Programs Administration/Office of Pipeline Safety been timely in requiring the gas company to adequately train its employees in leak survey procedures.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the propane gas explosion, fueled by an excavation-caused gas leak, in the basement of the Humberto Vidal, Inc., office building was the failure of San Juan Gas Company, Inc., (1) to oversee its employees' actions to ensure timely identification and correction of unsafe conditions and strict adherence to operating practices and (2) to provide adequate training to employees. Also contributing to the explosion was (1) the failure of the Research and Special Programs Administration/Office of Pipeline Safety to oversee effectively the pipeline safety program in Puerto Rico, (2) the failure of the Puerto Rico Public Service Commission to require San Juan Gas Company, Inc., to correct identified safety deficiencies, and (3) the failure of Enron Corp. to oversee adequately the operation of San Juan Gas Company, Inc.

Contributing to the loss of life was the failure of San Juan Gas Company, Inc., to inform adequately citizens and businesses of the dangers of propane gas and the safety steps to take when a gas leak is suspected or detected.

RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board makes the following recommendations:

--to the U.S. Secretary of Transportation:

Improve the Department of Transportation's State pipeline safety evaluation program by developing written guidance and evaluation criteria to assist the Research and Special Programs Administration/Office of Pipeline Safety personnel in objectively evaluating State programs and in requiring States to promptly correct identified program deficiencies. (P-97-5)

--to the Research and Special Programs Administration:

Modify your monitoring of State pipeline safety programs to ensure that the States are timely in monitoring the correction of identified safety deficiencies and to ensure that they implement enforcement action as necessary. (P-97-6)

Complete a final rule on employee qualification, training, and testing standards within one year. Require operators to test employees on the safety procedures they are expected to follow and to demonstrate that they can correctly perform the work. (P-97-7)

Require that San Juan Gas Company, Inc., take action necessary to ensure that abandoned pipelines are properly disconnected, purged of propane, and adequately secured to prevent the transmission of flammable vapors and gases, and to ensure that abandoned pipelines are properly identified on maps. (P-97-8)

--to the Puerto Rico Public Service Commission:

Develop written procedures to guide pipeline inspectors in assessing the compliance of gas pipeline operators with pipeline safety requirements, in documenting probable violations, in notifying gas pipeline operators of probable violations, and in recommending to the commissioners any formal action that may be required to obtain prompt compliance. (P-97-9).

Require that San Juan Gas Company, Inc., take action necessary to ensure that abandoned pipelines are properly disconnected, purged of propane, and adequately secured to prevent the transmission of flammable vapors and gases, and to ensure that abandoned pipelines are properly identified on maps. (P-97-10)

--to Enron Corp.:

Require San Juan Gas Company, Inc., to include procedures in its emergency plan that its employees can use in determining whether a building or area should be evacuated when a gas leak is suspected. (P-97-11).

Require San Juan Gas Company, Inc., when soliciting a training proposal, to require that the proposal include plans for identifying the tasks for which the trainees must be trained and for assessing the job performance of the trainees and the effectiveness of the training. (P-97-12).

--to Heath Consultants, Inc.:

Identify, when developing contracted training, the tasks for which the trainees must be trained and develop measures for assessing the job performance of the trainees and the effectiveness of the training. (P-97-13)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

ROBERT T. FRANCIS II
Vice Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

GEORGE W. BLACK, JR.
Member

December 23, 1997

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APPENDIX A

Investigation and Hearing

Investigation

The National Transportation Safety Board was notified on November 21, 1996, by the Office of Pipeline Safety's Southern Region Office of an explosion damaging a six-story building in the Rió Piedras shopping district of San Juan, Puerto Rico. The Safety Board dispatched an investigative team from Washington, D.C., comprising investigative groups for pipeline operations, survival factors, and human performance.

Hearing and Depositions

The Safety Board conducted a public hearing in conjunction with the investigation on June 2-5, 1997. A staff-conducted deposition was also conducted on July 1, 1997.

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APPENDIX B

Summary of PSC Compliance Inspections of SJGC 1992-1996[1]

49CFR Section	1992	1993	1994	1995	1996
191.5	X	X			
191.9	X	X			
191.11		X			
191.13				X	
191.23		X		X	X
191.25		X		X	X
191.5	X				
191.9	X				
192.13(c)				X	
192.16					X
192.53(c)				X	
192.105				X	
192.117				X	
192.181					
192.121				X	
192.152-.161				X	
192.223	X				
192.223(a)				X	
192.223(b)				X	
192.225	X			X	
192.227	X			X	
192.229				X	
192.241	X			X	
192.273				X	
192.273(b)				X	
192.283	X	X		X	
192.285	X	X		X	
192.287				X	X
192.303				X	
192.305	X			X	
192.359(a)				X	
192.453				X	X
49CFR Section	**1992**	**1993**	**1994**	**1995**	**1996**

[1] The PSC is unable to produce records for its 1994 annual inspection of SJGC.

192.455				X	X
192.455(b)				X	X
192.457				X	X
192.457(a)		X		X	
192.457(b)		X		X	
192.459				X	
192.463(a)	X			X	X
192.465	X			X	X
192.465(a)		X		X	X
192.456(b)				X	X
192.465(c)		X			X
192.465(d)				X	X
192.465(e)				X	X
192.467(a)				X	X
192.469				X	X
192.471					X
192.473					X
192.475(a)		X			
192.475(b)					X
192.477		X		X	X
192.479				X	X
192.481				X	X
192.487				X	
192.489					X
192.491				X	X
192.501-.517	X			X	
192.551-.557				X	
192.603				X	X
192.603(b)				X	X
192.603 (c)					X
192.605					X
192.605(a)				X	X
192.605(b)					X
192.605(b)(2)					X
192.605(b)(5)					X
192.605(e)					X
192.605(f)				X	
49CFR Section	**1992**	**1993**	**1994**	**1995**	**1996**

192.613				X	X
192.613(a)					X
192.613(b)					X
192.614		X		X	
192.615				X	
192.615(a)(4)					X
192.615(a)(6)				X	
192.615(a)(7)				X	
192.615(a)(9)				X	
192.615(a)(10)				X	
192.615(b)(2)				X	X
192.615(b)(3)				X	X
192.615(c)				X	X
192.615(d)				X	
192.616					X
192.617				X	X
192.619				X	X
192.621					X
192.623					X
192.625		X			
192.627	X	X			X
192.629				X	
192.705(a)				X	
192.705(b)				X	
192.707(a)				X	
192.707(c)				X	X
192.707(d)				X	X
192.721				X	X
192.723	X			X	
192.723(b)		X			X
192.725	X			X	
192.725(a)		X			X
192.727				X	
192.727(a)				X	
192.727(b)				X	X
192.727(c)					X
192.727(d)				X	X
49CFR Section	**1992**	**1993**	**1994**	**1995**	**1996**

192.743				X	X
192.743(a)				X	
192.743(d)				X	
192.747	X			X	
192.749				X	
192.751				X	
192.753				X	
192.753(b)				X	
192.755				X	X
199.9		X			
199.21		X			

APPENDIX C

Summary of OPS Oversight Actions Relative to Puerto Rico PSC

Date of Evaluation Letter	OPS Correspondence	OPS Rating of PSC	OPS Field Inspection Findings
2/6/97	The Southeast Regional Director advised the PSC President that all was OK. PSC needs vehicle permanently assigned to pipeline safety staff.	97	10/15/96 - Four-day inspection results. There were no inspections concerning drug & alcohol requirements and inadequate action on noncompliance with federal safety requirements. The last TSI seminar was in 1993, but there is only one jurisdictional operator in PR SJGC replaces all bad pipe, regardless of cause, with plastic pipe. Lab examination of bad pipe required by SJGC. OPS inspector checked and determined that SJGC was not following its written procedures on cathodic protection, bare pipe replacement, and plastic fusion.
3/15/96	PSC Chairman applied to OPS for $37,000 grant for improving excavation damage prevention efforts in PR		
2/20-23/96	OPS hosted 12 reps. Of PR government agencies and buried facility operators touring GA and AL one-call centers and to learn of ways to implement excavation damage prevention program in PR		
12/13/95	The Southern Regional Director advised the PSC President that the PSC needs to promote damage prevention program, including one-call notice system. Also advised that PSC needs vehicle permanently assigned to pipeline safety staff.		
12/13/95	OPS State Liaison advised the PSC Rep. that the PSC needs to promote damage prevention program, including one-call notice system. Also advised that PSC needs vehicle permanently assigned to pipeline safety staff.	97	9/25/95 - Five-day inspection results. PSC did not promote excavation damage prevention program. 5(a) certification documents not received at OPS by 3/1/95. Cast iron replacement requirements found to be more stringent that AGA guidance.

12/30/94 The Southern Regional Director advised the PSC President that the PSC needs to promote damage prevention program, including one-call notice system. Excavation damage continues to be major cause of pipeline incidents. Need vehicle permanently assigned to pipeline safety staff. PSC inspection effort for CY 1994 was behind schedule which could result in inadequate program performance. PSC should obtain computer equipment compatible with OPS equipment to facilitate communications and provide access to pipeline safety data.

1/21/94	PSC President acknowledged to OPS Southern Regional Director comments about compliance, pledged to study and carry them out as soon as possible. Also pledged to perform closer observation of SJGC to ensure that all violations are corrected.	95	9/26/94 Five-day inspection results. PSC program needs major improvement in state compliance actions, for employees directly involved with pipeline safety program, and on compliance with federal requirements (Areas not specifically identified). PSC did not promote damage prevention program. SJGC is using leak history studies to determine when a replacement is needed and when needed is inserting plastic pipe. SJGC has procedure for continuing surveillance with lab. Examinations to determine cause. SJGC has merged with Pro Gas and are combining offices.

12/9/93 The Southern Regional Director advised the PSC President that the PSC needs to promote excavation damage prevention program. Need vehicle permanently assigned to pipeline safety staff. Need response to address suggested improvements - no response last year. Some probable violations of PL safety regulations discovered during field inspection of SJGC. They were of serious nature and recommend that PSC exercise its' civil penalty authority. States are being encouraged to obtain computer equipment compatible with OPS' to improved communications and provide better access to PL safety data.

On the same date (12/9/93) the OPS State Liaison wrote a letter to the PSC Pipeline Safety Office Director advising that the PSC needs to become more involved in promoting excavation damage prevention, that the PSC needs to provide written updates on actions taken to address program improvements noted in OPS letters, that the PSC needs to improve the tracking of time devoted to the pipeline safety program, that the PSC needs to devote more field days per person year to the pipeline safety program, and that there were several deficiencies in SJGC operations noted during the last inspection. Those included the failure to perform a leakage survey in the business district, the failure to timely perform some cathodic protection monitoring , and the failure to pressure test, before being placed in gas service, plastic pipe being inserted into old gas piping.

2/11/93	OPS Southern Regional Director provided the SJGC General Manager with a copy of a state damage prevention law to guide action in PR for enacting excavation damage prevention measures, advised of similar guidance being prepared by the OPS, and encouraged his participation in working with other buried facility owners to establish a similar program. He advised that he had talked with the PSC and that the PSC Chairman had expressed interest in working with SJGC and others to establish such a program. He stated that the PSC needed to motivate the development of a damage prevention program for it to receive the full amount of grant moneys available to its pipeline safety program.	84.2	9/14/93 - Needs better documentation of PSC inspection activity. Needs improvement in promoting excavation damage prevention program. On site verbal training was provided to PSC as inspector conducted the inspection. SJGC noted as using leak history studies to determine when pipe replacement was needed. SJGC noted as not following AGA guidelines on replacing CI pipe, but they patrol the system daily as the principal business area is entirely CI pipe. PSC needs 91.8 inspection days instead of 80. Civil penalty for SJGC is recommended as it did not conduct annual leak survey of all principal business districts. PSC needs improvement on checking SJGC to ensure that it follows written procedures for installing plastic pipe. SJGC did not pressure test inserted 1 ¼" PE-2306 pipe after insertion rather it relied on manufacturers pressure test certification.
12/28/92	The Southern Regional Director advised the PSC President that to prevent the loss of evaluation points, the PSC needs to be more involved in the promotion of damage prevention , to be represented at the annual NAPSR meeting, and to provide in 30 days of letter receipt a written update on actions taken to address needed improvements.		
4/30/91	The OPS Eastern Region Chief expressed to PSC Rep. Concern about REP not attending the NAPSR meeting last year, the need for the PSC to enter into the liquid inspection program., and the need for the PSC to include a hydrogen PL into the inspection program. The OPS Chief advised that TSI was planning to schedule a Seminar in PR, enclosed current inspection forms of drug testing, included current version of compliance inspection form, returned	87	10/27/92 -Four-day inspection results. PSC did not use an inspection form or checklist during its inspections. PSC did not SJGC's Safety-Related Condition Reports procedures. Mr. Santos was scheduled to attend TSI courses in 1992, but has left the PSC. The PSC now has only one inspector. OPS inspector advised that SJGC uses field-wrapped galvanized pipe to replace CI. He expressed concern about whether SJGC always insulates that pipe from the rest of the system

	a draft of excavation damage prevention legislation along with comments and advised that PSC Reps inspection of SJGC was well done, thorough, and professional.		
7/19/91	The OPS Director iterated to PSC Chairman many of the comments in 4/30/91 letter and added that there was a need for the PSC to obtain a digital type voltmeter with matching copper-copper sulfate half cell and a combustible gas indicator, that the PSC should complete the development of written enforcement procedures by the end of the year, and urged the PSC to attend NAPSR meetings, urged that the PSC extended jurisdiction to liquid pipelines.	91	2/26/91 - Two-day inspection results. PSC Rep reviewed the 10 Arizona video tapes with SJGC and it plans to use them for training its people, OPS Chief noted that while the PSC had not responded to the last OPS letter, it was sent to the Director rather than the Chairman and that it took OPS almost 5 months after the inspection to get the letter out.. SJGC uses leak report and repair records, leak survey records and continuing review to identify areas of active corrosion. SJGC does not receive from the PSC a written notice of all probable violations. PSC has not held any TSI training seminars in the past 3 years. PR has law requiring excavators to contact all utilities before excavating. Enforcement is through Public Streets and Highways Departments. Even so, PSC drafted proposed legislation to strengthen requirements and the PSC Chairman is favorable to proposal
8/9/90	OPS Director advised PSC Director that PSC Rep's inspection of SJGC was thorough and professionally performed, that OPS was pleased that a person was assigned to perform both inspection and enforcement responsibilities and that that person had made a commendable contribution to the success of the program. OPS suggested that the title of the PSC Rep be changed to "Gas Pipeline Safety Inspector." Two pieces of equipment - voltmeter and CGI - were suggested for purchase by the PSC to assist the PSC Rep. The PSC should complete the development of written enforcement procedures by the end of the year, the PSC should promote excavation damage prevention legislation, should attend the annual NAPSR meetings, and extend its safety jurisdiction to liquid pipelines.*		
7/12/90	OPS Chief advised that PSC Rep's inspection was well performed and in professional manner, and that he was pleased with PSC attendance at NAPSR. Also, it was noted that	92	3/5/90 - Three-day inspection results. PR has no master meter operators. PR has a law requiring excavators to contact all utilities before excavating. Enforcement is by the public streets

inspection found SJGC's deficient in that it had not been revised to add requirements for safety-related condition reporting. He noted that PR had not required a one-call notification system and that Federal require was tied to grant funding.

and highway department. PSC works with that department concerning violations. PSC has no responded to the requests made in letters to the Chairman from the OPS director about OPS monitoring results. Specialized inspections made of SJGC's corrosion control actions. PSC has not reviewed SJGC's O&M Manual to ensure that safety-related condition report procedures are included. SJGC procedures for determining areas of active corrosion is basically a review of leak report and leak repair records, leakage surveys, and ongoing review to determine active corrosion areas. PSC pipeline safety finances are not being audited and no audit reports have been provided.

9./1/89 OPS Director pointed out to PSC Chairman OPS's drug use requirements and the PSC's need to incorporate them

8/14/89 OPS Drug Program Manager provided information materials on anti-drug program to PSC Rep..

7/21/89 OPS Director advised the PSC Chairman that PSC performance was very good and that PSC Rep handled inspection of SJGC in thorough and professional manner. He expressed pleasure that PSC was represented at annual OPS meeting and advised that PSC needed to purchase for its Reps use a voltmeter and a CGI. He urged PSC to complete work on the development of written administrative enforcement procedures, advised of the increased civil penalty limit, of the need to adopt a drug-use rule, urged the PSC to seek jurisdiction over master meter operations, emphasized again the importance of implementing a excavation damage prevent law, and again urged that the salary level of the PSC Rep be reviewed.

3/20/89 OPS Eastern Regional Chief advised PSC Rep that his inspection of SJGC was thorough and professionally performed. He expressed disappointment the SJGC had failed to complete the rebuilding of regulator stations and urged that this important work be finished without further delay. He urged that SJGC be made to understand what is required by the safety-related condition requirements and that appropriate procedures be incorporated into its O&M Manual.

9/8/88	OPS Eastern Region. Advised the PSC Rep. that based on his last inspection on SJGC's overpressure protection that he identified one station where there was no protection, stations where the protection was questionable and required confirmation, and a station where protection appeared adequate.	96	2/20/89 Four-day inspection results. PSC has jurisdiction over all gas systems except master meters, PSC is studying Part 199 requirements in preparation for notifying SJGC of requirements, PSC needs to encourage and promote excavation damage prevention legislation, PSC needs improvement on receiving safety-related condition reports and ensuring that SJGC O&M Manual includes procedures for making these reports

6/21/88 OPS Chief provided a news item about an explosion "near the corner of Wilson Street and José de Diego Avenue in Santurce" and questioned if it related to explosions that occurred on "Tuesday," if SJGC planned to submit to OPS a written report, if SJGC investigated the mentioned leak complaints and if so he questions what were the results of those investigations. He noted also that the news item mentioned "six or seven …leaks or explosions …the last five months." And questioned if those incidents were reported. He asked for a response to his questions.

6/2/88 OPS Director advised PSC Chairman that the PSC's pipeline safety program performance was very good and that meaningful progress had been made to bring SJGC into compliance with safety code provisions, particularly in regard to regulator stations, overpressure protection equipment, and the general regulatory requirements. He expressed pleasure that PSC Rep had completed 11 of the 12 TSI courses and had attended the annual OPS meeting and he encouraged periodically repeating those courses. He emphasized the importance of using forms to record inspection findings, the use of a checklist to ensure that all items had been covered during inspections, and the need to have written administrative enforcement procedures. The importance of excavation damage prevention programs was noted and the range of salaries paid to other southeastern inspectors was provided along with a suggestion to review the salary level of the PSC Rep.

4/22/88 OPS Chief advised PSC Rep that he was pleased that Rep attended NAPSR meeting, advised that commendable progress had been made for bringing SJGC into compliance relative to regulator stations, cathodic protection, and developing its O&M Manual. He advised that the PSC's inspection forms were good and commended Rep on their development. He urged continued effort to help implement excavation damage prevention laws.

5/29/87 OPS Director expressed his appreciation to the PSC Chairman for allowing the PSC Rep to attend upcoming OPS meeting and for the PSC committing funds for PSC Rep to complete TSI training.

3/16/87 OPS Director advised that PSC Rep had become substantially more knowledgeable about pipeline safety requirements and that the assignment of only one inspector to the pipeline program had raised the performance level of the PSC program. He noted that the PSC had not yet adopted administrative enforcement procedures for handling violations and that this deficiency had been noted previously, that the SJGC was not in compliance with overpressure protection requirements which the PSC should act to correct, that the PSC should reserve travel funds sufficient to allow PSC Rep to attend a national pipeline safety meeting in August 1987, that the PSC Rep needed some basic equipment (voltmeter, CGI, and camera) to carry out field inspection obligations, and that PR had not enacted legislation on excavation damage prevention. He encourage action to encourage and promote damage prevention as that remains as the leading cause of pipeline accidents and as the PSC certification requires such actions.

3/3/87 OPS Chief advised the PSC Rep. That inspection record keeping system was an improvement and that SJGC did not have adequate overpressure protection at district regulator stations and that it had not performed required testing of the devices in place. He provided information on an upcoming damage prevention symposium and he requested information on a couple of accidents experienced by SJGC which he did not find as being reported by SJGC.

2/27/86 OPS Director advised the PSC Chairman that program performance was below the national average and was not acceptable since no violations of requirements were identified during 1984 and 1985. He noted that the PSC Rep had no previous pipeline safety experience, but that he had received some TSI training and he encourage continuation of such training. He noted that the PSC needed to obtain basic equipment (CGI, voltmeter and camera) for PSC Rep to fulfill his inspection obligations. He advised that during the inspection he found a propane system serving 30 to 60 customers from a single buried LPG tank and that the system was subject to pipeline safety rules, that no PSC inspection had been made, and that PSC needed to perform safety evaluation. He noted also that PSC had developed draft excavation damage prevention legislation, but it had not developed detailed written administrative procedures for handling pipeline safety violations

1/31/86 OPS Eastern Region Chief advised PSC Rep that he understood that it was planned for the Rep to begin using a check list to aid in his inspections and he enclosed some forms being used by other states. He noted that SJGC's 1984 reporting of leaks repaired on mains and services differed from the national average in that significantly more leaks were reported as being caused by material defects. The PSC Rep was asked to review SJGC's understanding of DOT leak reporting instructions. He confirmed that he had discussed with the Rep the need to develop administrative procedures for handling

pipeline safety violations.

5/8/84 OPS Associate Director advised the PSC Chairman that each PSC employee used as a pipeline inspector must be qualified and he urged training since the PSC employees did not have adequate knowledge of the pipeline safety requirements. He advised of TSI training and the capability of TSI to arrange for onsite training using trainers who speak fluent Spanish. He also noted the PSC need to implement effective excavation damage prevention measures.

4/17/84 OPS Eastern Region Chief advised the PSC Director that as a result of his 3/19-21/84 evaluation, that he noted that SJGC had no locking device for some types of gas service shut-off valves, that it probably would purchase a means to lock those valves when necessary, and had not locked closed some service line valves; that PSC needs to develop more detailed inspection forms on which to better document the results of inspections and to ensure that all items had been covered record the results of inspections; and he informed the PSC that TSI could perform onsite training for both gas employees and PSC inspectors and urged the PSC to request such by inviting the OPS/TSI to conduct a seminar in PR

4/19/83 OPS Associate Director advised the PSC Chairman that records show that PSC adopted Federal pipeline safety requirements on 7/24/74, but was unable to show that it had adopted later versions. He noted that 6 different PSC inspectors were shown as performing pipeline safety inspection and charging part of their time to the pipeline program. For the program to be considered acceptable, each inspector must be qualified and to do this TSI provided training for state inspectors. He encouraged that one of the PSC inspectors be trained at TSI and that the PSC assign only one or two persons as pipeline inspectors so that training efforts could concentrate on qualifying them. The PSC was informed that it had inadequate written administrative procedures for processing noncompliance items and he urged development of adequate procedures. The PSC was advised that it had not enacted legislation on excavation damage prevention and it was urged to do so.

3/14/83 The OPS Chief advised the PSC Director that it needed to examine SJGC leak repair records using greater scrutiny to ensure that hazardous leaks were promptly repaired, that the PSC needed to review SJGC's O&M and Emergency Plans on a more frequent basis to ensure that they are adequate and up-to-date, that it needed to enact damage prevention legislation, that it should develop inspection forms for completion when conducting inspections, and that it should closely monitor SJGC's corrosion control programs since leaks from the system most often are the result of corrosion.

APPENDIX D

Employee Training and Qualifications.

Florida Gas Transmission Training

The Florida Gas Transmission Company Training Center in Sanford, Florida conducts fundamental courses in servicing and installation of commercial appliances, heating, electricity, corrosion control, and propane gas principles and practices to name a few. The center serves as a primary source of training for the San Juan Gas Company. Information about several San Juan Gas employees who attended courses at the training center is summarized below:

Employee Name	Training Courses Taken	Date
Roberto Rios	Electricity	June 3-5, 1996
	CETP Principles and Practices	June 6-7, 1996
Carlos Medina	Regional Measurement School	June, 1996
	Basic Distribution	Sept. 16-20, 1996
William J. Santiago	Basic Service and Installation	June 10-14, 1996
	Advanced Service	Nov. 11-15, 1996
Holvin H. Ortiz	Commercial Appliances	Aug. 26-29, 1996
Jesus Rodriguez	Advanced Distribution	Oct. 14-18, 1996
Ricardo Santos	Advanced Corrosion Control	Nov. 4-8, 1996
	Advanced Distribution	Oct. 14-18, 1996
Jose Figueroa Sierra	Advanced Corrosion Control	Nov. 4-8, 1996

Enron Operations Corp. Skill Based Pay Training Program

As described by the company: " Skill Based Pay (SBA) a competency/knowledge based compensation program that rewards employees for acquiring, demonstrating and maintaining work skills through a hands on verification and written test qualification process."

Developed in 1993, Enron Corporation utilized an extensive curriculum development process to make certain that all critical knowledge and skills to perform a particular job were captured. Represented employees who sought increases in salary or promotion, were required to demonstrate skills and pass knowledge tests before increases in salary or promotions occurred. During the development process, behavioral scientists and professional education

specialists were used in conjunction with subject matter experts to analyze the jobs and create teaching and testing materials. Items that appear on knowledge tests are easily traceable to critical knowledge about performance of particular jobs. Skills that must be demonstrated are easily traceable to critical tasks that must be performed to a certain standard before a particular job is considered complete.

In October, 1996, through an interoffice memorandum to Oscar Gutierrez, General Manager at San Juan Gas, the technical training department of Enron Operating Company provided a listing of training resources available. The list includes classroom sessions, videotapes, manuals, standards, CD-ROM's and other training media. However the SBP program would not have been available to employees of SJGC as they are paid pursuant to a union contract.

Enron Computer-Based Training Program

"The Enron Computer Based Training (ECBT) Program is designed to teach fundamentals and advanced topics of Enron operations in a uniform, consistent and efficient manner. This ECBT program is designed to supplement and enhance location-specific and on-the-job training. The program is generally limited to Environmental and OSHA issues and is not location specific.

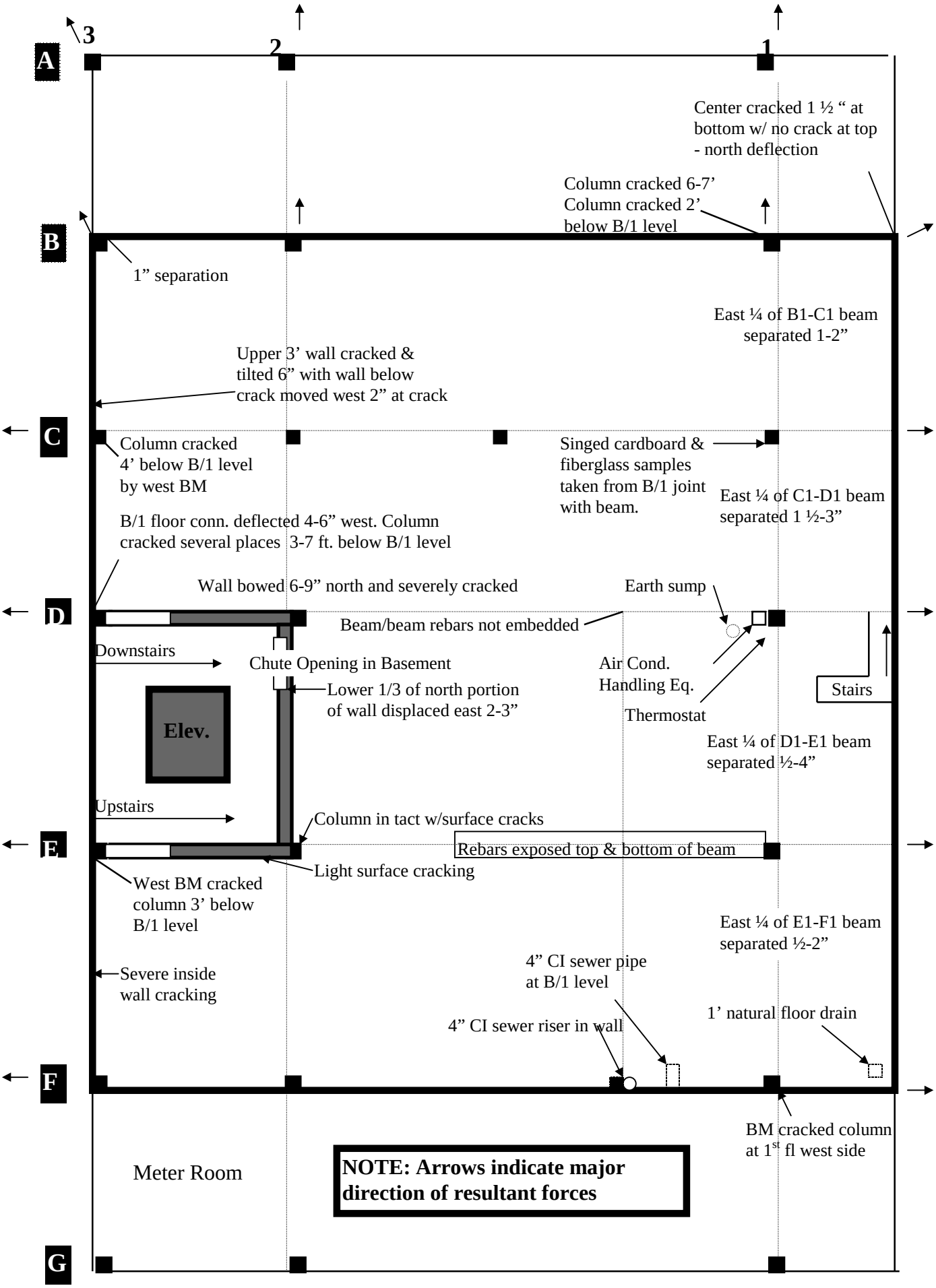
Training Plans

An individual training plan is required for employees engaged in activities covered by regulation. It is important to include in the training plan, the training module that satisfies those regulations. Training requirements specifically for Enron America-Puerto Rico are listed in program documentation. The Safety Board has obtained no individual training plans for San Juan Gas employees prior to November 21, 1996.

APPENDIX E

Sketch of Basement Showing Direction of Forces on Columns

January/February 1997


3
2
1
A
B
C
D
E
F
G
Center cracked 1 ½ " at bottom w/ no crack at top - north deflection
Column cracked 6-7' Column cracked 2' below B/1 level
1" separation
East ¼ of B1-C1 beam separated 1-2"
Upper 3' wall cracked & tilted 6" with wall below crack moved west 2" at crack
Column cracked 4' below B/1 level by west BM
Singed cardboard & fiberglass samples taken from B/1 joint with beam.
East ¼ of C1-D1 beam separated 1 ½-3"
B/1 floor conn. deflected 4-6" west. Column cracked several places 3-7 ft. below B/1 level
Wall bowed 6-9" north and severely cracked
Earth sump
Beam/beam rebars not embedded
Downstairs
Chute Opening in Basement
Air Cond. Handling Eq.
Stairs
Lower 1/3 of north portion of wall displaced east 2-3"
Thermostat
Elev.
East ¼ of D1-E1 beam separated ½-4"
Upstairs
Column in tact w/surface cracks
Rebars exposed top & bottom of beam
Light surface cracking
West BM cracked column 3' below B/1 level
East ¼ of E1-F1 beam separated ½-2"
Severe inside wall cracking
4" CI sewer pipe at B/1 level
4" CI sewer riser in wall
1' natural floor drain
BM cracked column at 1st fl west side
Meter Room
NOTE: Arrows indicate major direction of resultant forces

Column/ Beam	Observations
E3	shear crack in basement due to west bending moment
F3	basement wall pushed west from columns - heavy surface cracking on basement wall.
E2	surface cracks on basement wall, surface cracks on south elevator/stairwell enclosure wall
E2/E1;½ Fl	Beam displaced north and severely up sufficient to crack beam
F-1	Bending moment east deflection - west side cracked at 1st fl. Two sewer pipes (4" CI) 4 ft west and 7" west of column at 1st fl level. Third fl wall blown south. ½ fl behind Disco Fiesta displaced south. West wall, 1st fl, column displaced east over La California with west side collapsed down. Wall between HV and La California blown east.
B-3	NW corner basement column deflected slightly, about 1", both north and west.
B2	Column cracked in northern direction in basement 2-3 ft below 1st fl. North wall, B3 to B2 cracked northward about 2-3 feet below is fl. Beam B1-B2,½ fl, deflected north about 1 ft. at center span. Beam C1-C2, ½ fl, deflected both up and north about 1 ft. Beam C1-C2, 2/3/ fl, deflected north about ½ to ¾ ft.
D3	b/1 floor connection displaced west 4-6". Bottom 1/3 of north basement wall for elevator/stairwell enclosure displaced north with severe cracking at bottom and above chute to basement. (likely overload from above when adjacent column broke allowing weight of bldg to impact wall). Lower part of east elevator/stairwell enclosure wall displaced east 2-3". Upper 1/3 of west wall deflected west 6-8".
C3	Deflected west in basement and cracked about 4' down from top of basement wall.
B-1	Deflected east and cracked in basement about 6-7 ft below top of basement wall.
B1-C1,	East ¼ cracked and separated ½-4".
C1-D1,	East ¼ cracked and separated ½-4".
D1-E1	East ¼ cracked and separated ½-4".
C1	East ¼ cracked 1st fl, east ¼ broken away 2nd fl.
D1	East ¼ cracked to east 1st fl; separated and missing 2nd fl. North face has light sooting 2-3" fr top, west face has light sooting 4-5" from top-mounts for air conditioner exchange unit on west face. East face no sooting. South face light sooting top to bottom. Thermostat and connected signal wire as well as plastic and plywood mounting removed from south face.
B1-C1	Hairline cracks b/1 fl.
D1-D2 at b/1 fl	Heavy sooting (scorched dust) north face going to light sooting about 12 ft west of D1. Sooting in floor to beam connection areas.
C1	Cardboard and fiberglass samples taken from SW corner C1 joint between b/1 fl and beams. Shoes in plastic wrap having heat damage were taken from an area about 6' SW of D1 in basement.

C2-C1	**¾ fl concrete coating missing, beam deflected up and north likely when steel stairway fell on connecting beam.; 4/5 fl, beam deflected up. 20' skylight above.**
D1-D2	**Concrete coating missing 2/3 fl; concrete coating missing ¾ fl.**
E1-E2	**Concrete reinforcing rods exposed top and bottom ½ fl; concrete coating missing south side at ¾ fl; There is a skylight between D and E beams beginning at elevator east wall and extending 10-12 feet east and covering full north to south span width.**
Air Handler at D1	**Unit that before the explosion was mounted on the west face measured 29" wide (n-s), 22 ½" deep (e-w) and 58" tall. The electric fan motor was located about 41" above the floor and the bottom of the unit measured 20 inches above floor level. The air intake was at the bottom of the unit and it exhausted upward from the top. This unit was a Trane blower unit that was in the building when purchased by the Vidal company 15-20 years ago. It was a direct drive, 5 ton unit serving only the basement and with no outside air intake or exhaust.**

ABBREVIATIONS

ATF--Bureau of Alcohol, Tobacco and Firearms

CFR--*Code of Federal Regulations*

CGI--combustible gas indicator

DOT--U.S. Department of Transportation

Enron--Enron Corp.

FEMA--Federal Emergency Management Agency

GIS--Graphical Information System

Heath--Heath Consultants, Inc.

Humberto Vidal--Humberto Vidal, Inc.

LEL--lower explosive limit

MCC--maintenance and construction coordinator

NPRM--Notice of Proposed Rulemaking

O&M Manual--*Operations and Maintenance Manual*

OPS--Office of Pipeline Safety

PE--polyethylene

PRASA--Puerto Rico Aqueducts and Sewer Authority

PSC--Public Service Commission

PVC--polyvinyl chloride

RSPA--Research and Special Programs Administration

SJGC--San Juan Gas Company