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# NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

# RAILROAD-MARINE ACCIDENT REPORT

DERAILMENT OF AMTRAK TRAIN NO. 2
ON THE CSXT BIG BAYOU CANOT BRIDGE
NEAR MOBILE, ALABAMA
SEPTEMBER 22, 1993

**Abstract:** On September 22, 1993, barges, being pushed by the towboat MAUVILLA in dense fog, struck and displaced the Big Bayou Canot railroad bridge near Mobile, Alabama. Shortly after, the Amtrak Sunset Limited struck the displaced bridge and derailed. Forty-two passengers and 5 train crewmembers were killed; 103 passengers were injured. The towboat crew was uninjured.

The major safety issues discussed in this report include towboat operator training and evaluation, bridge risk assessment, bridge identification, emergency response and evacuation procedures, and event recorder crashworthiness.

As a result of its investigation, the Safety Board issued safety recommendations to the U.S. Department of Transportation; the U.S. Army Corps of Engineers; the U.S. Coast Guard; the National Railroad Passenger Corporation; the Federal Emergency Management Agency; The American Waterways Operators, Inc.; the Warrior & Gulf Navigation Company; the Association of American Railroads; and the American Short Line Railroad Association.

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# DERAILMENT OF AMTRAK TRAIN NO. 2 ON THE CSXT BIG BAYOU CANOT BRIDGE NEAR MOBILE, ALABAMA SEPTEMBER 22, 1993

## RAILROAD-MARINE ACCIDENT REPORT

Adopted: September 19, 1994
Notation 6167B

NATIONAL
TRANSPORTATION
SAFETY BOARD

WASHINGTON, D.C. 20594

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## EXECUTIVE SUMMARY

On September 22, 1993, about 2:45 a.m., barges that were being pushed by the towboat MAUVILLA in dense fog struck and displaced the Big Bayou Canot railroad bridge near Mobile, Alabama. About 2:53 a.m., National Railroad Passenger Corporation (Amtrak) train 2, the Sunset Limited, en route from Los Angeles, California, to Miami, Florida, with 220 persons on board, struck the displaced bridge and derailed. The three locomotive units, the baggage and dormitory cars, and two of the six passenger cars fell into the water. The fuel tanks on the locomotive units ruptured, and the locomotive units and the baggage and dormitory cars caught fire. Forty-two passengers and 5 crewmembers were killed; 103 passengers were injured. The towboat's four crewmembers were not injured.

The National Transportation Safety Board determines that the probable causes of Amtrak train 2's derailment were the displacement of the Big Bayou Canot railroad bridge when it was struck by the MAUVILLA and tow as a result of the MAUVILLA's pilot becoming lost and disoriented in the dense fog because of (1) the pilot's lack of radar navigation competency; (2) Warrior & Gulf Navigation Company's failure to ensure that its pilot was competent to use radar to navigate his tow during periods of reduced visibility; and (3) the U.S. Coast Guard's failure to establish higher standards for inland towing vessel operator licensing. Contributing to the accident was the lack of a national risk assessment program to determine bridge vulnerability to marine vessel collision.

Safety issues discussed in the accident report include towboat operator training and evaluation, bridge risk assessment, bridge identification, emergency response and evacuation procedures, and event recorder crashworthiness.

The Safety Board makes recommendations addressing these issues to the U.S. Department of Transportation; the U.S. Army Corps of Engineers; the U.S. Coast Guard; Amtrak; the Federal Emergency Management Agency; The American Waterways Operators, Inc.; the Warrior & Gulf Navigation Company; the Association of American Railroads; and the American Short Line Railroad Association.

## INVESTIGATION

### The Accident

*The bridge collision sequence.*--About 12:55 a.m. on September 22, 1993, the towboat MAUVILLA, pushing six barges in a two-row, three-column combination (see p. 6), departed the National Marine Fleet (mile 5) on the Mobile River.[1] The crew comprised a captain,[2] a pilot, and two deckhands. The pilot, who had assumed the watch from the captain at 11:30 p.m. on September 21, 1993, said that before departing northbound, he had allowed a faster tow, the THOMAS B. McCABE, to pass. (See figure 1 for a synopsis of times relevant to this accident.)

**SEQUENCE OF EVENTS**

| *Sunset Limited* | | *MAUVILLA* | |
|---|---|---|---|
| **9/21/93** | | | |
| 9:30 p.m. | Crew on duty, New Orleans | | |
| | | 11:30 p.m. | Pilot on watch |
| 11:34 p.m. | Train 2 departed New Orleans | | |
| **9/22/93** | | | |
| | | 12:55 a.m. | Departed National Marine Fleet, mile 5, Mobile River |
| | | 2:15 a.m. | Radioed THOMAS B. McCABE |
| 2:30 a.m. | Arrived Mobile | | |
| 2:33 a.m. | Departed Mobile | | |
| | | 2:45 a.m. | Hit bridge |
| 2:53 a.m. | Derailment | | |
| 2:56 a.m. | Assistant conductor radioed "MAY DAY" | | |
| 2:57 a.m. | CSX dispatcher notified | | |
| 3:00 a.m. | CSX called 911 | | |
| | | 3:05 a.m. | Radioed "MAY DAY" -- lost tow, need help |
| | | 3:07 a.m. | Reported fire via radio |
| | | 3:08 a.m. | Coast Guard advised captain of accident |

**Figure 1.--Times relevant to accident.**

[1]On U.S. Army Corps of Engineers (USACE) river charts, river miles along the Black Warrior/Tombigbee/Mobile River system are measured northbound in miles beginning at the Bankhead Tunnel (mile 0), Mobile, Alabama.

[2]In accordance with standard marine terminology for river towboats, the terms "captain" and "pilot" are used to differentiate between the MAUVILLA's two operators. The captain is the senior licensed operator and is in charge of the vessel; he stands the 0600-1200 and 1800-2400 watches. The pilot stands the 0000-0600 and 1200-1800 watches. Each is required to have a Coast Guard license as operator of uninspected towing vessels (OUTV) (see **Licensing Requirements**, pp. 32-34).

He stated that visibility was good[3] and recalled learning from marine radio conversations shortly before he departed that conditions were foggy north of his position. He could see the THOMAS B. McCABE's stern lights until that vessel rounded a bend in the Mobile River at Bayou Sara (about mile 8.2). The MAUVILLA's position at the time, according to the pilot, was near the south end of Twelve Mile Island (mile 7), and he recalled visibility beginning to become "hazy" there (see figure 2).

The pilot testified that as he passed Catfish Bayou at mile 8.6, "it started getting foggier and foggier on me." Between Catfish Bayou and the north end of Twelve Mile Island (mile 9.6), the pilot contacted the operator of the THOMAS B. McCABE and asked about the fog; the reply was, "it's shut out" (zero visibility). The THOMAS B. McCABE's operator said he was going to continue, and the MAUVILLA's pilot stated that he "was going to try to get me a line," that is, moor his tow by securing it with a line to a tree or other structure on the riverbank. The two vessels were about three-quarters of a mile apart at this point, according to the THOMAS B. McCABE's operator, who said he could still see the glow of the MAUVILLA's lights.

As the MAUVILLA approached the north end of Twelve Mile Island, the "fog shut in," according to the pilot. The fog was dense enough that the pilot could not see the head of the tow, and he began to look for a place to tie to the bank. The pilot said he thought he was between Thirteen Mile Marsh, which is between miles 10 and 12, and the CSXT Fourteen Mile railroad bridge,[4] which crosses the Mobile River at mile 13.3. He ordered the on-duty deckhand onto the lead barge on the starboard side to try to snag a tree so that a mooring line could be placed around it to secure the tow.

The pilot used his searchlights to locate a tree. After at least two unsuccessful attempts to snag a tree, according to the pilot, he ordered the on-duty deckhand, whom he could not see from the wheelhouse, back to the towboat, fearing the deckhand might injure himself in the dense fog or fall overboard. He said he had reduced the vessel's speed at this point but was unable to estimate how fast he was moving. While trying to locate a tree, the pilot stated that he noticed his swing meter[5] indicate a turn to port and he observed two banks on the radar screen as the tow and barges straightened. The last navigation aid that the pilot recalled seeing before the accident was a red navigation dayboard on his starboard side before he reached the north end of Twelve Mile Island (probably the dayboard at mile 9.2).

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[3]According to the National Weather Service, fog, which can form very quickly in this area, was not forecast for the area near Mobile on September 22, 1993. At 2:56 a.m. on the night of the accident, the National Weather Service weather report for the area was clear below 12,000 feet, 4 miles visibility, and 72 degrees Fahrenheit.

[4]Although mariners know it as the Fourteen Mile railroad bridge, its official name is the Mobile River bridge. It is one of three railroad swing bridges in the area; the Bayou Sara at mile post (MP) 658.3 and Tensas River (MP 651.6) are the other two. The Mobile River bridge (MP 653.5) is manned at all times by a bridge tender, who has radio communications with trains and marine traffic on the river.

[5]A gyroscopic device that indicates a rate of turn of the tow's head, often before visual cues of the turn are apparent. It does not indicate the amount of heading change.

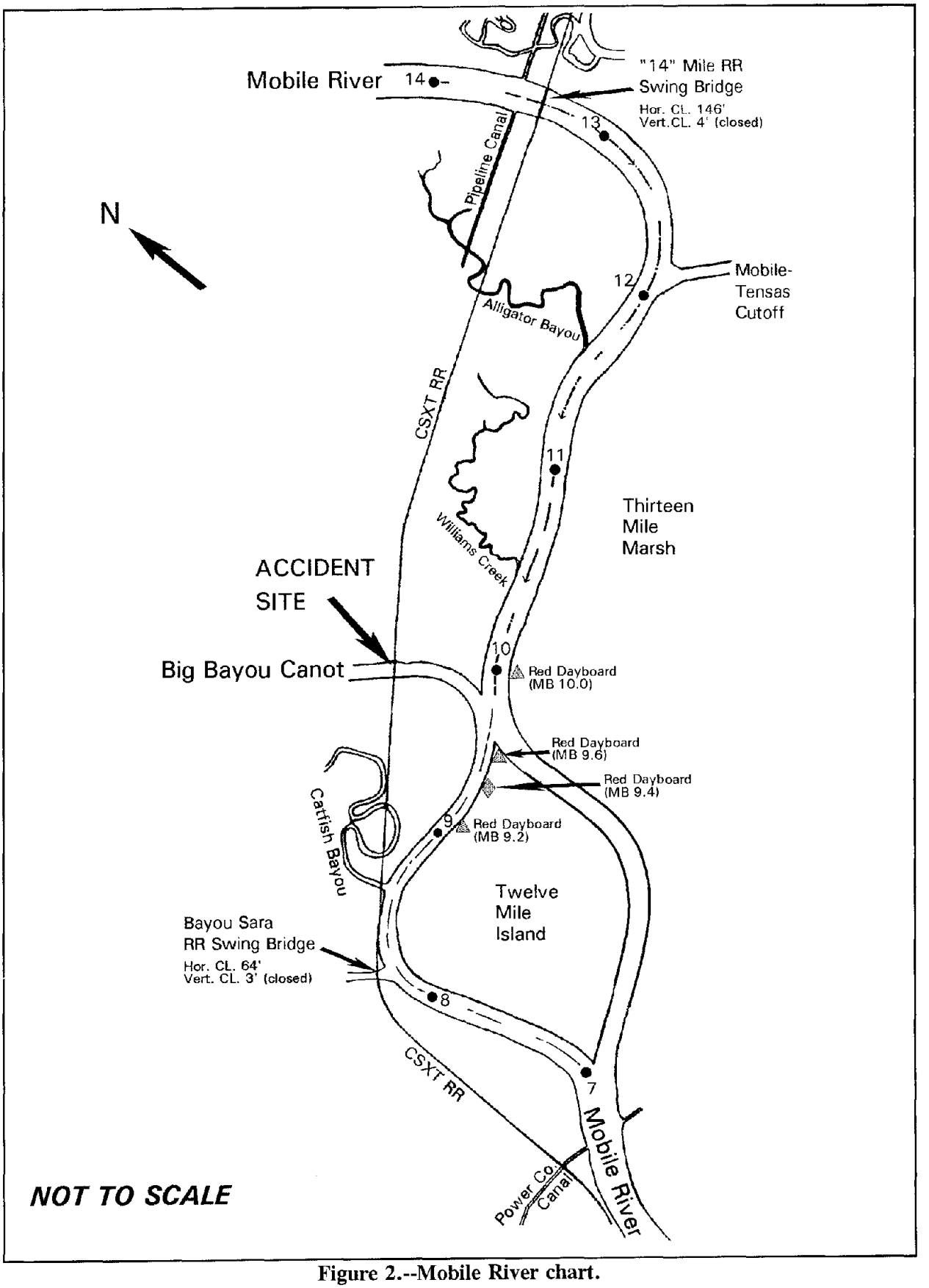


**Figure 2.--Mobile River chart.**

The pilot explicitly stated that at no time did he see the intersection formed by the Mobile River and Big Bayou Canot either visually or by radar. He also said that he never considered "pushing in," that is, placing his barges into the bank and using engine maneuvers to hold the tow in place. According to testimony, he thought he was in the Mobile River and was proceeding to the Mobile-Tensas cutoff to tie to a tree he knew to be there; in fact, he had entered the Big Bayou Canot, a waterway not usually used by commercial traffic. He could not recall how long the on-duty deckhand remained on the barges or how far the MAUVILLA traveled while he attempted to snag a tree.[6] After returning to the towboat, the deckhand stood by in the galley while the pilot maneuvered the tow and barges back into the waterway.

The pilot stated that as he maneuvered slowly upstream, he saw an object on his radar that appeared to be lying across the waterway. No river charts were on board the towboat, nor were they required to be.[7] He recalled contacting the THOMAS B. McCABE to ask whether that vessel's operator had seen a towboat tied along the bank as he proceeded up the Mobile River. The THOMAS B. McCABE's operator replied that he had not. The MAUVILLA's pilot said he never considered the object might have been something other than another towboat and barges that had swung out from the bank. In fact, the object was the single-track Big Bayou Canot railroad bridge, which has a vertical clearance of about 7 feet and is part of the CSXT system.

The MAUVILLA continued moving toward the bridge. The pilot continued to glance at his radar even though, as he later testified, he did not know what scale it was on and had made no adjustments to it after coming on watch. He said he was "idling along at 1 or 2 knots" and twice tried to make radio contact with the presumed tow operator and also shined his lights at the object, to which he intended to tie alongside. He did not order the on-duty deckhand to move to the head of the tow so that he could advise him how close the tow was to the object. Although he observed his approach to it and saw what he believed were the banks of the Mobile River on radar, he stated he could not judge the distance from the object to the head of his tow.

At some point as he continued toward the bridge, the pilot placed the throttles of the MAUVILLA in reverse. He testified that he was "still trying to figure out what was in front of me. And I never could." He said he felt a "bump" and thought he had run aground. The deckhand on duty testified that he also felt the "bump" while sitting in the galley and noted the time as 2:45 a.m. In fact, the lead port and starboard barges of the MAUVILLA had struck the south and center piers of the bridge's through-girder span (the other two sections of the bridge were a truss section and a timber trestle; see figures 3 and 4). The forward center barge, which protruded about 5 feet ahead of the port and starboard barges, struck the east girder between these two piers, displacing the south end of the girder span 38 inches to the west. Following the displacement, the east girder obtruded into the space traversed by trains. The port string of

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[6]The THOMAS B. McCABE's operator recalled a conversation about 2:15 a.m. during which the MAUVILLA's pilot stated that he almost "had a line caught."

[7]Charts for the area that are typically carried aboard inland river towing vessels include the USACE "Photographic Charts for the Black Warrior-Tombigbee Rivers" and a graphic charts booklet, "Lower Black Warrior-Tombigbee Waterway-Waterway Charts." These charts show the Big Bayou Canot bridge as a trackline over the waterway but do not state its name, clearances, or the fact that it is a fixed bridge.

barges broke free from the tow, and the pilot ordered the on-duty deckhand on deck.

When the captain, awakened by the "bump" at 2:45 a.m., arrived in the wheelhouse, the pilot described his location as "between Twelve Mile Island and Thirteen Mile Marsh, somewhere in that neighborhood." The pilot, who had been in the mouth of the Big Bayou Canot at least once before, still thought he was on the Mobile River. None of the MAUVILLA crew was aware at this point that the tow had struck a bridge. In the process of trying to retrieve the loose barges, the MAUVILLA backed into the east bank of the Big Bayou Canot, where it remained pinned for about 8 minutes, until about 2:53 a.m.

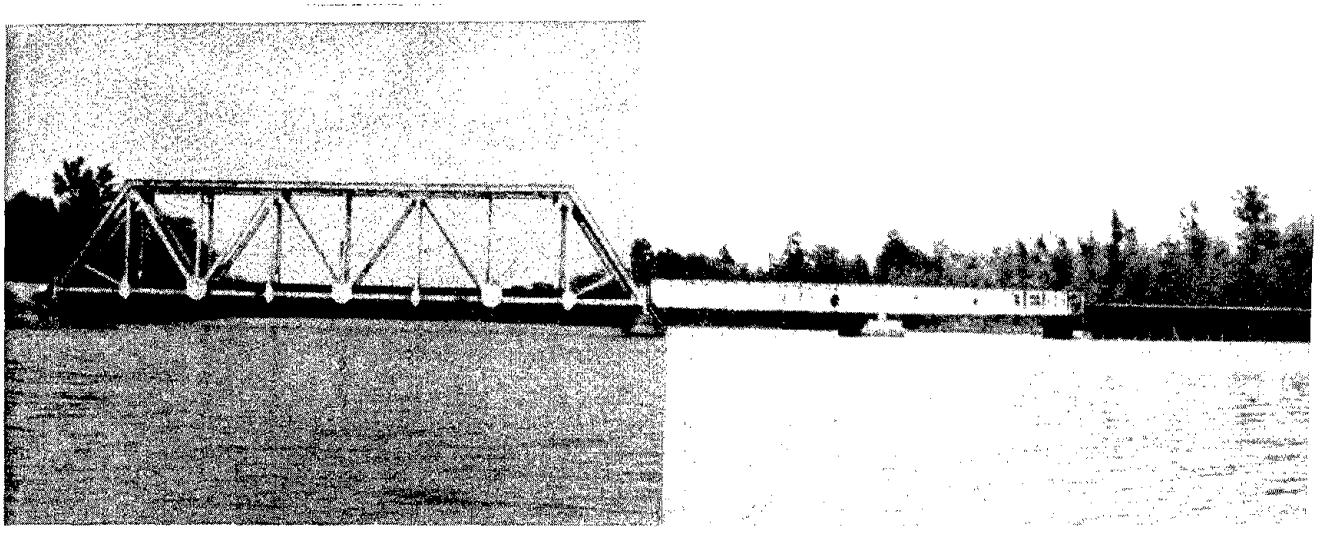

**Figure 3.--Last inspection photograph of Big Bayou Canot railroad bridge before accident.**

*The derailment sequence.*--At 10 p.m. on September 21, 1993, Amtrak train 2, the Sunset Limited, arrived in New Orleans, Louisiana, where it was delayed 34 minutes for repairs to an air conditioner and a toilet on two cars. The five-person operating crew included an engineer, two assistant engineers, a conductor, and an assistant conductor. A mechanical department rider was also on board to make minor repairs to passenger equipment en route. The operating crew had reported for duty in New Orleans at 9:30 p.m. Train 2 departed New Orleans, en route to Miami, Florida, at 11:34 p.m. Twelve on-board service (OBS) crewmembers, including an OBS supervisor, were also on board.

The train arrived in Mobile, Alabama, about 2:30 a.m. on September 22, 1993, and the conductor helped passengers in Mobile detrain and board. According to the conductor's delay report, the train departed Mobile at 2:33 a.m., 33 minutes behind schedule, with 202 passengers on board. After departure, the assistant conductor and a train attendant walked through the train collecting tickets. They met the conductor at the upper level of the dining car, where they planned to do paperwork.

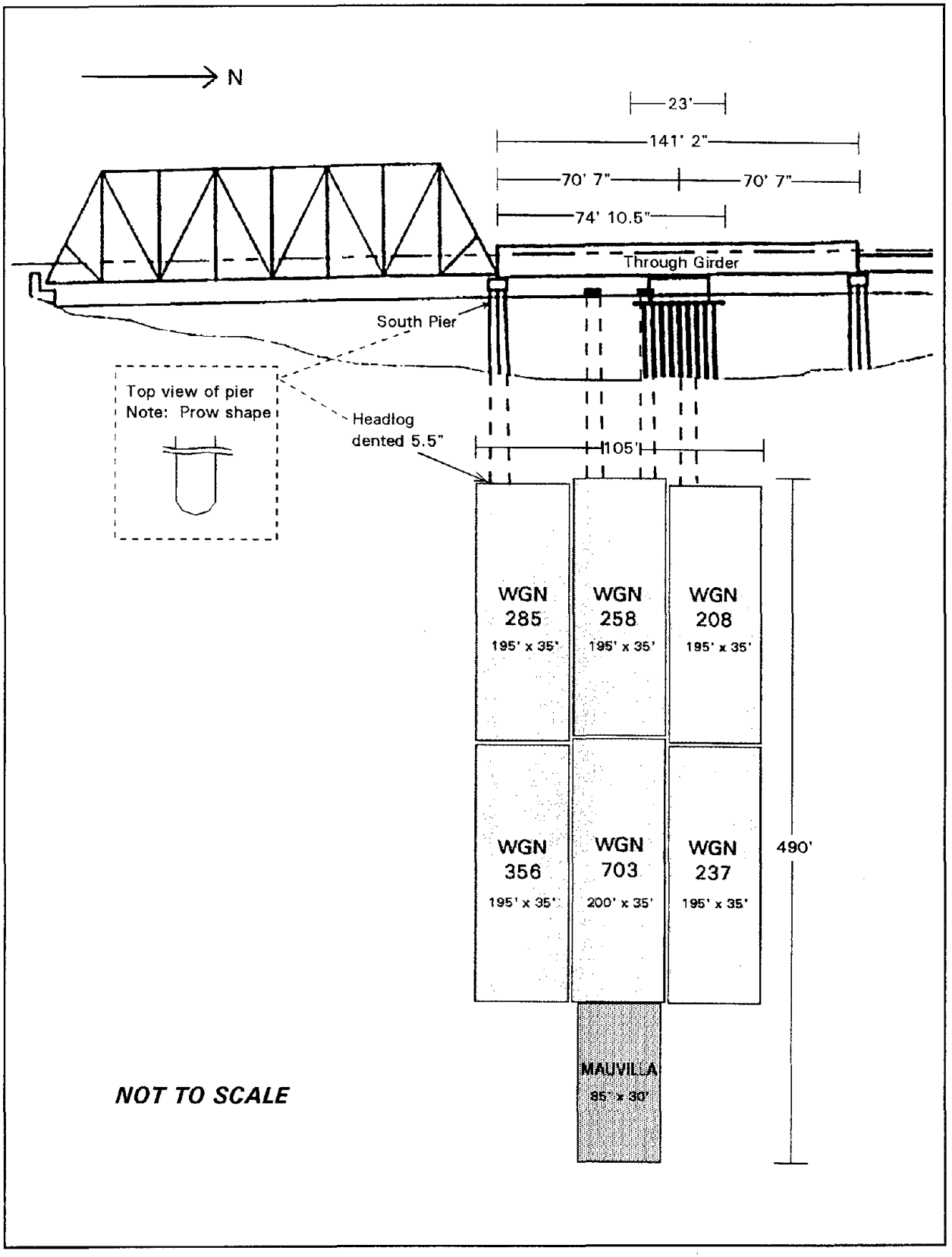


**Figure 4.--MAUVILLA tow configuration and Big Bayou Canot bridge.**

The conductor described the trip from Mobile to the accident site as uneventful. He said the locomotive crew called all signal indications over the radio, and he repeated them over his portable radio.[8] According to the assistant conductor, he last talked with the locomotive crew before the accident when the engineer called to thank him for bringing coffee at Mobile. The assistant conductor last remembered the locomotive crew calling the signal at Bayou Sara, mile post (MP) 658.4; the call was "clear" and the conductor repeated it to them shortly before the derailment. The train accelerated toward the Big Bayou Canot bridge and, traveling about 72 mph (authorized speed was 70 mph), struck the displaced bridge girder and derailed at MP 656.7 about 2:53 a.m. (see figure 5).

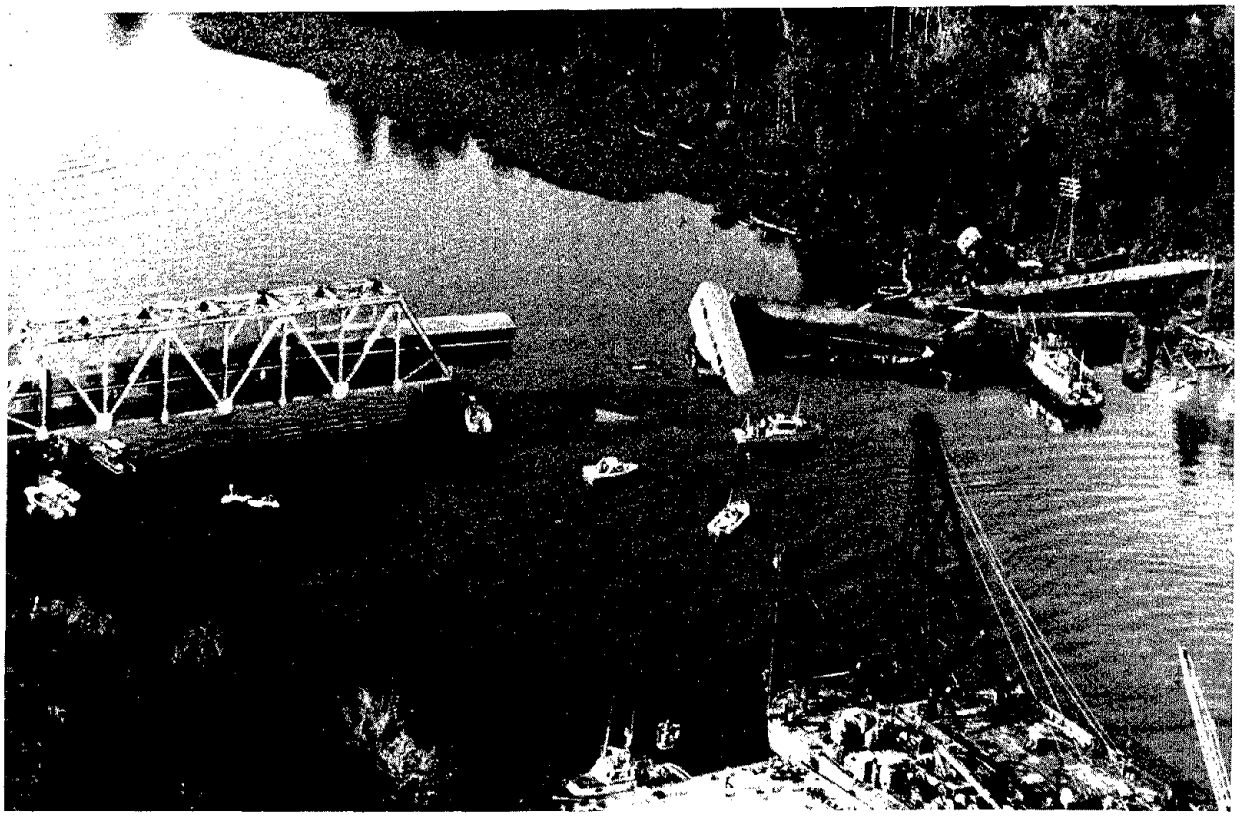

**Figure 5.--Photograph of accident site.**

Following the derailment, the three locomotive units came to rest on the east side of the bayou. Part of the lead unit, 819, was buried in about 46 feet of mud, and the part protruding above the embankment burned. The second unit, 262, also burned. The fuel tank of the third unit, 312, separated from it, and all equipment along the bottom of the unit below the frame was sheared off.

[8]A crewmember at the front of the train must announce all track side signals, which govern the train's movement, over railroad radio to a crewmember on the train, and the latter must repeat them over the radio to the former.

Baggage car 1139 and dorm-coach 39908, also on the east side of the bayou, were gutted by fire, and parts of both cars sustained major structural damage. About half of coach 34083, which rested against the bridge after the accident, was submerged, and coach 34068 was almost totally submerged. The next four cars, coach 34040, lounge 39973, diner 38030, and sleeper 32067, remained on the bridge. All passenger cars were double-decker cars. (See figure 6.)

Both the conductor and the assistant conductor were in diner 38030, the next-to-the-last car. The latter said the accident took place without warning--no setting up of the brakes, no horn blast, and no communication from the locomotive crew. He was thrown onto the table in front of him and then into the middle of the car. The conductor was thrown over him. When the train stopped, the conductor attempted to contact the engineers on the lead locomotive unit using his portable radio but received no reply.

*Postaccident events.*--After the derailment, the pilot of the MAUVILLA heard a "swishing noise" and saw a fire. He directed the on-duty deckhand to awaken the rest of the crew, and while the deckhand was doing so, the pilot maneuvered the tow to reestablish control of the port string of barges. As a result of these maneuvers, the tow was pushed against the northeast bank of the bayou, trapping the MAUVILLA between the port string of barges, which had been stripped and moved aft, and the bank. The pilot radioed the Mobile River bridge tender on VHF/FM channel 13 and asked whether anyone had reported a fire; the tender replied, "No."

When the on-duty deckhand went on deck (following the bridge collision), he saw the port string of barges slipping aft and also noticed that the starboard winch wire, which secured the starboard side of the towboat to the aft barge on the starboard string, was broken. He subsequently saw flames and said he heard "a hiss like a roar but not a boom or nothing like that." The on-duty deckhand estimated that the fire started 5 to 10 minutes after he felt the "bump." He stated that the port string of barges slipped about 80 feet aft, boxing in the MAUVILLA next to the bank.

Meanwhile, about 2:56 a.m. train 2's assistant conductor made a "Mayday, Mayday" transmission over the railroad-designated radio that was heard by CSXT train 579, waiting at MP 660.4, whose crew repeated it to the yardmaster at the Sibert Yard, Mobile. Also about 2:56 a.m., the assistant terminal trainmaster at Sibert Yard heard train 2 transmitting Mayday over the radio. The yardmaster at Sibert Yard notified the train dispatcher in Jacksonville, Florida, at 2:57 a.m. and the Mobile Police Department's 911 operator about 3 a.m. that train 2 had derailed. The telephone number for the Coast Guard in the Mobile telephone directory was incorrect, and both the yardmaster and the CSXT representative in Mobile did not succeed in their first attempts to contact the Coast Guard.

The bridge tender at the Mobile River bridge and the engineer of train 579 also radioed the train dispatcher in Jacksonville about 2:56 a.m. that train 2 was transmitting a Mayday call. Immediately thereafter, the train dispatcher tried to contact train 2 but was unsuccessful. Train 579's engineer advised the dispatcher that train 2 had derailed at the Mobile River bridge, which is where the assistant conductor said he thought the train was when he made his Mayday call, and was on fire. The Mobile River bridge is about 3.2 miles north of the actual accident site.

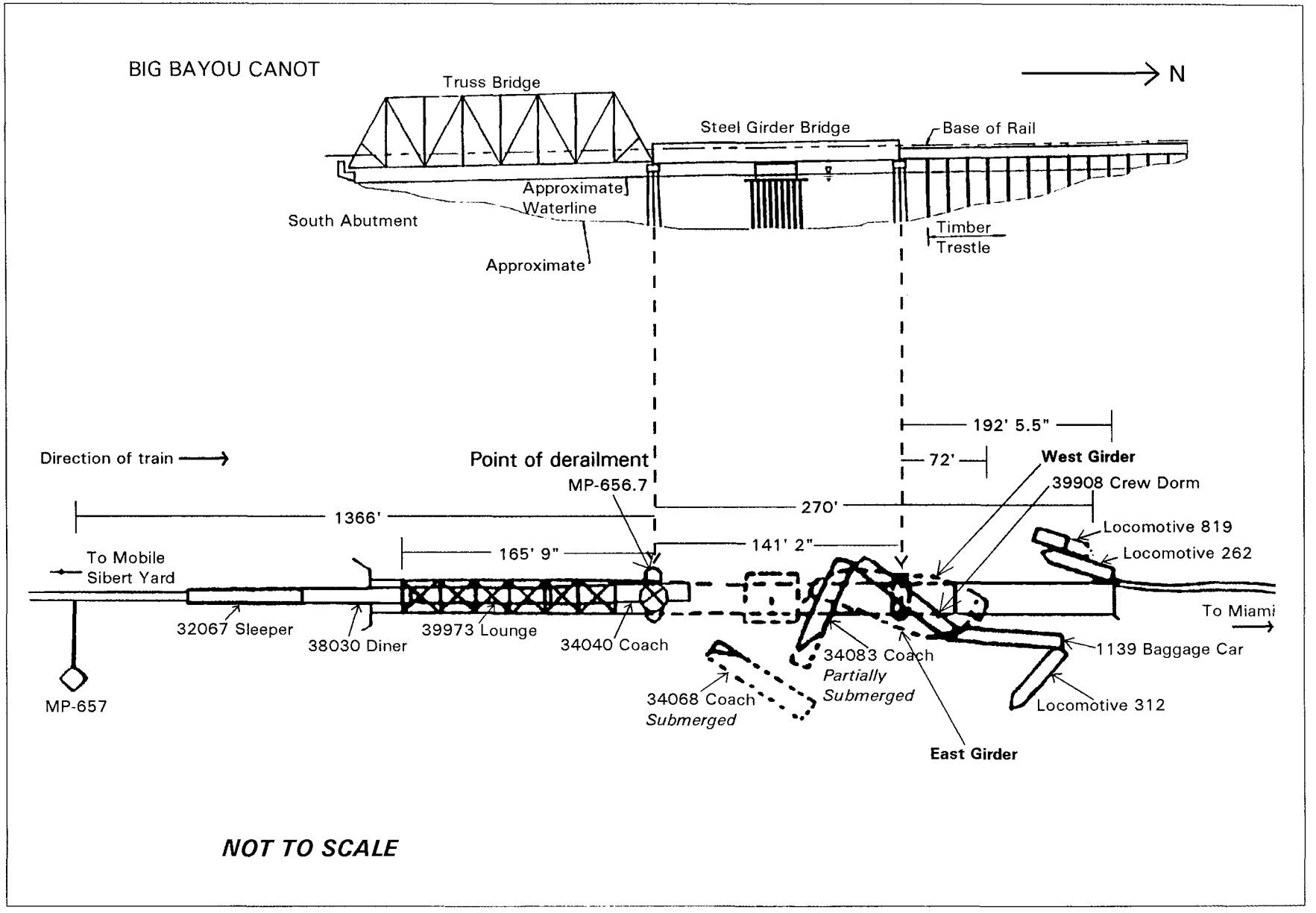


**Figure 6.--Diagram of accident scene.**

Between 3:02 and 3:05 a.m., the Mobile Police Department's 911 operator contacted the Mobile Fire Department and the Coast Guard. Police, fire, and Coast Guard personnel began notifying other emergency responders; more than 60 local departments eventually responded. Train 2's OBS supervisor, using a cellular telephone, called the Mobile 911 operator about 3:05 a.m. and provided additional information about the accident location and what was taking place at the site. The OBS supervisor did not know the exact location of the derailment, however. For about 18 minutes--from 3:02 to 3:20 a.m.--confusion ensued as the Mobile, Saraland, and Chickasaw 911 operators tried to locate the accident site. Exactly where train 2 had derailed was unclear, and no roads lead into the area, which is heavily wooded swampland. Before they knew they would have to respond by water or rail, the emergency responders searched by land for the accident site.

Also about 3:05 a.m., the captain of the MAUVILLA, concerned about his situation with the barges, broadcast a distress message on VHF/FM channel 16: "Mayday, Mayday, Mayday, the motor vessel MAUVILLA [garbled], got a tow broke up right below anchorage end of pier and seems to have a cable or something wrapped in the wheel, barges adrift southbound. . . .If anybody down there can help rounding them up, I would appreciate it."[9] The U.S. Coast Guard Group Mobile (Group) received the radio transmission; the radio operator on watch responded and asked for a position.[10] The MAUVILLA's captain replied: "We're between the upper end of Twelve Mile Island [mile 9.6] and the old maritime cut [Mobile-Tensas Cutoff, mile 12.1, Mobile River], somewhere in that area and I'm not exactly sure on the mileboard over."

Responding to the Group radio operator's questions about 3:06 a.m., the captain said that four people were on board, that the MAUVILLA was unable to move, and that the vessel was in no danger of sinking. He added, "I believe we are right on top of this thing." About 3:07 a.m., the Group told the captain that a train had derailed. The captain replied, "I believe we're right below the train. . . .They's a helluva fire up here in the middle of the river and there ain't supposed to be no fire up here and, like I say, I don't know exactly where we at. It's so foggy I can't tell. . .by looking on the radar, so there's something bad wrong up here."

The Group's radio operator asked the captain about 3:11 a.m. whether he was involved in the train derailment. He replied: "I can't tell you for a hundred percent whether I'm involved in it or not. We are right below it, I'm not sure what's going on. I come up here it was so foggy I can't tell where I'm at. . . .I can't get away from the barges where I'm at. I'm gonna try to get out of here and see if I can't go up there and help somebody."

When the captain arrived in the wheelhouse shortly after he felt the "bump" and assumed control of the tow from the pilot, the starboard quarter of the towboat was up against the bank,

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[9]The vertical clearance of the Big Bayou Canot railroad bridge, about 7 feet, was not sufficient to allow the barges to pass under it. The starboard lead barge, for example, had a freeboard (height of the hull above the waterline) of about 5 feet 10 inches, and its cargo hopper extended an additional 2 feet, for a combined total height of about 7 feet 10 inches.

[10]The Coast Guard Group Mobile continually records radio transmissions. Times were taken from a transcript of the Group's tape recordings.

limiting the vessel's movement. After extensive maneuvering of the MAUVILLA's engines and rudders, he was able to free the towboat from its position between the bank and the port string of barges. The captain ordered the deckhands to release the towboat from the tow (the four barges that remained together), maneuvered the MAUVILLA to the port side of the tow, and pushed all six barges into the bank. Leaving the barges pushed into the northeast bank, he moved the towboat toward the fire.

Meanwhile, the assistant conductor (after broadcasting the Mayday transmission) and the train attendant had started toward the front of the train, and the conductor headed toward the rear. The assistant conductor said he planned to send passengers back to the conductor for evacuation. When he reached the front of the train, the assistant conductor saw that the center section of the bridge was missing and that two cars were in the water below him. He also saw other cars on fire, the lead locomotive unit nose down in the water, and a locomotive unit next to it burning.

The OBS supervisor and three OBS crewmembers (the other eight OBS crewmembers were in the dorm-coach, which was burning on the east side of the bayou) began evacuating the cars that remained on the bridge. They told the passengers to remain calm and evacuated them to the tracks at the rear of the train. The assistant conductor asked whether any medical practitioners were on board; a passenger who was a nurse responded, volunteering to provide first aid at the rear of the train.

The assistant conductor returned from the front of the train and went to the east bank of the bayou. He radioed the mechanical department rider, who was in one of the cars on the bridge, and directed him to help set up a relay system in the water with passengers who could swim. The assistant conductor instructed passengers participating in the relay to space themselves "about 20 yards apart" and to "swim out and meet these elderly people [who were evacuating from submerged cars] and swim them to the next guy and so forth, on up to the bank." The relay passed people from the middle of the waterway to the west bank of the bayou.

According to passengers in the totally submerged car (coach 34068), the lower level and front section of the car filled with water in seconds, limiting the time passengers in those sections had to evacuate. The center and rear sections on the upper level remained out of the water for about 10 minutes, and passengers evacuated through the open rear door and window exits on the upper level.

The assistant conductor told passengers atop the coach that was partially submerged and sinking (coach 34083) to swim to the east bank toward the rear of the train. Passengers inside this coach stated that the lower level and rear of the car filled with water in seconds, limiting the evacuation time for passengers in those sections. Bridge timbers held the upper level and front of the car out of the water; passengers in those sections evacuated through the window exits on the upper level in about 30 minutes.

Six OBS crewmembers evacuated from the dorm-coach, which was on fire. They entered the water, were rescued by the crew of the towboat MAUVILLA, and then helped passengers

out of the water. Two OBS crewmembers died in their bedrooms, which were in the section of the dorm-coach that sustained major structural damage. The engineer and two assistant engineers in the locomotive cab that was buried in mud died.

About 3:19 a.m., the captain of the MAUVILLA called and advised the Coast Guard Group that he had his barges under control. He further stated that he would try to render assistance to survivors. The MAUVILLA's deckhands launched the towboat's skiff, which was near the wreckage on the east side of the river, and one deckhand rowed to people in the water and pulled them aboard. He returned several times to pick up additional survivors. When smoke from the burning oil and wreckage filled the MAUVILLA's wheelhouse, the captain was forced to back the towboat away. Meanwhile, the six barges had slipped off the bank and were drifting toward the bridge. After pushing them onto the bank a second time, the captain returned to the accident site and continued to rescue survivors from the water.

By 3:20 a.m., the Coast Guard Station Mobile's 19-foot, rigid-hull inflatable (RHI) boat was under way to the accident site. About 3:24 a.m., the Group broadcast an "Urgent Marine Information Broadcast," stating "there has been a report of an Amtrak derailment at the junction of Bayou Sara Creek and Mobile River at Twelve Mile Island. There have been reports of persons in the water. All mariners are requested to assist if possible." The captain of the MAUVILLA, still unaware of his location, called the Group about 3:25 a.m. and said: "We have a mess up here, this train has run off the Fourteen Mile Railroad bridge. . . .The bridge is open, the train has run off of it and it's burning. . . ."

About 3:59 a.m., the MAUVILLA's pilot, talking on the radio to the operator of the towboat SCOTT PRIDE,[11] which was approaching the accident site, stated: "I made a wrong turn. I guess I can tell you. You know when you come out of the upper end of Twelve Mile Island you got a left, a river [Big Bayou Canot], go back to your left. . . ." About 4 a.m., when the assistant conductor noticed the SCOTT PRIDE moving toward him, he worked his way back to the bridge and onto the pier on the Mobile end. From this vantage, he began waving his flashlight at the towboat. The assistant conductor said he was concerned that the SCOTT PRIDE would hit the submerged coach or the people in the water. When the towboat got close enough to the bridge pier, he jumped onto it.

The crew of the SCOTT PRIDE pulled 20 people out of the water. The crew of the MAUVILLA rescued 17 people from the water. The Mobile fireboat RAMONA DOYLE, which had to navigate using radar because of the dense fog, arrived about 4 a.m. and, after determining that no other people remained in the water, started fighting the fire. When the towboats and traincrew had rescued most of the people from the water, the conductor and assistant conductor began taking a head count of the passengers and passed out blankets and pillows. The OBS supervisor distributed cushions, and the assistant conductor informed the

[11]About 3 a.m., the operator on watch on the SCOTT PRIDE, which was in the Mobile River near the Chickasaw Creek railroad bridge, had overheard radio transmissions between the Fourteen Mile and Chickasaw Creek railroad bridge tenders about a train derailment. After confirming the derailment with the Chickasaw Creek bridge tender, he proceeded up the Mobile River, arriving at the Big Bayou Canot about 4 a.m.

passengers that a train would take them back to Mobile.

About 4:04 a.m., the Coast Guard launched helicopters from the nearest air search and rescue (SAR) unit, which was in New Orleans. About 4:25 a.m., the Coast Guard's RHI boat arrived and started assisting passengers. The SAR controller testified that the RHI encountered patches of very dense fog while en route to the scene; at times, the crew could not see the bow. The pilot of a Coast Guard aircraft that arrived on scene about 5:10 a.m. said he found visibility clear at 500 to 1,000 feet; he reported communications with Coast Guard boat crews during which the crews mentioned dense fog while traveling upriver. The glow from the fire helped responders locate the accident site.

When Coast Guard helicopters arrived on scene about 5:20 a.m. and started assisting passengers, the fog had dissipated. The MAUVILLA transported the survivors it had rescued to a triage area at the Scott Paper Company pier in Chickasaw, after which the towboat proceeded to the Warrior & Gulf Navigation (W&GN) yard and moored. Coast Guard, local emergency medical services personnel, and other towboats that responded to the distress call also took survivors to the two triage sites established at the Scott Paper Company in Chickasaw. The last survivors were treated and transported to local hospitals or hotels by 8:30 a.m.

## Injuries

| Injury Type* | Operating Crew | OBS Crew | Passengers | Total |
|---|---|---|---|---|
| Fatal | 3 | 2 | 42 | **47** |
| Serious | 0 | 0 | 4 | **4** |
| Minor | 2 | 6 | 99 | **107** |
| None | 1** | 4 | 57 | **62** |
| **Total** | **6** | **12** | **202** | **220** |

*Title 49 Code of Federal Regulations (CFR) 830.2 defines "fatal injury" as "any injury which results in death within 30 days of the accident." It defines "serious injury as "an injury which: (1) requires hospitalization for more than 48 hours, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fracture of fingers, toes, or nose); (3) causes severe hemorrhages, nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns, or any burn affecting more than 5 percent of the body surface."

**The mechanical department rider is included with the operating crew on the injury table.

## Passengers and Crew

The ticket count on the day after the accident indicated that 189 passengers and 18 employees were on board the Sunset Limited. Rescuers recovered 3 unticketed infants, bringing

the passenger and crew count to 210. Their ages ranged from less than 2 to 84 or 85. An Amtrak representative later told Safety Board investigators that after the accident, 10 additional people reported that they had been passengers on the train. Because passengers board and exit at various stops and because some passengers purchase tickets on board instead of making reservations, Amtrak could not determine whether these 10 people were on train 2 during the derailment. Nonetheless, they have been included in the passenger and crew count, bringing the total to 220.

According to the Alabama Department of Forensic Sciences medical examiner in Mobile, autopsy reports show that 42 passengers died from asphyxia due to drowning. Three locomotive engineers died as a result of asphyxia and blunt force trauma while inside the lead locomotive unit cab that became filled with mud. Two OBS crewmembers in a section of the dorm-coach that sustained major structural damage died as a result of smoke inhalation.

Survivor injuries included contusions, fractures, abrasions, lacerations, strains, and multiple trauma. Injured survivors were treated at five local hospitals.

## Damage

*Big Bayou Canot railroad bridge.*--The through-plate girder span was destroyed. The following components also sustained damage: all bridge ties on the south through truss span, nine floor beam braces, two floor beam hangers, the flange angles on the end post, the ballasted deck timber trestle, and the south five panels.

The nose of the south pier sustained some concrete spalling (chipping or scaling) from the MAUVILLA's lead port barge (see figure 7). The east edge of the sole and filler plates for the east girder's south bearing came to rest on the west edge of the east pedestal and the west edge of the pier cap plates. The west girder plates were found on the pier cap adjacent to the west edge of the west pedestal. The bottom of the east girder sole plate had large radius lateral striations (grooves or channels), and the west sole plate had straight lateral striations.

About 15 feet of the top flange of the east girder, beginning at the south girder face, was separated from the web. Part of the top of the plate over this 15-foot section was "accordianed"; the rest of the top flange was comparatively undamaged. The web sustained two tears, one extending from the top to the bottom flange and a large horizontal tear between the fourteenth and seventeenth stiffeners. The bottom flange had two indentations, 21 inches and 22 inches wide, respectively, on the bottom east side.

The girders, which were about 40 feet apart laterally at the widest point, were displaced some 70 feet to the north. The northernmost and two southernmost floorbeams remained connected to both girders. The other eight floorbeams were severed from the east girder but remained connected to the west girder. The stringers remained connected to the floorbeams. Concrete had broken off the east angular nose of the pier that supported the south end of the girders and off part of the north edge of the pier cap. Surface evidence indicated the fractures were recent.

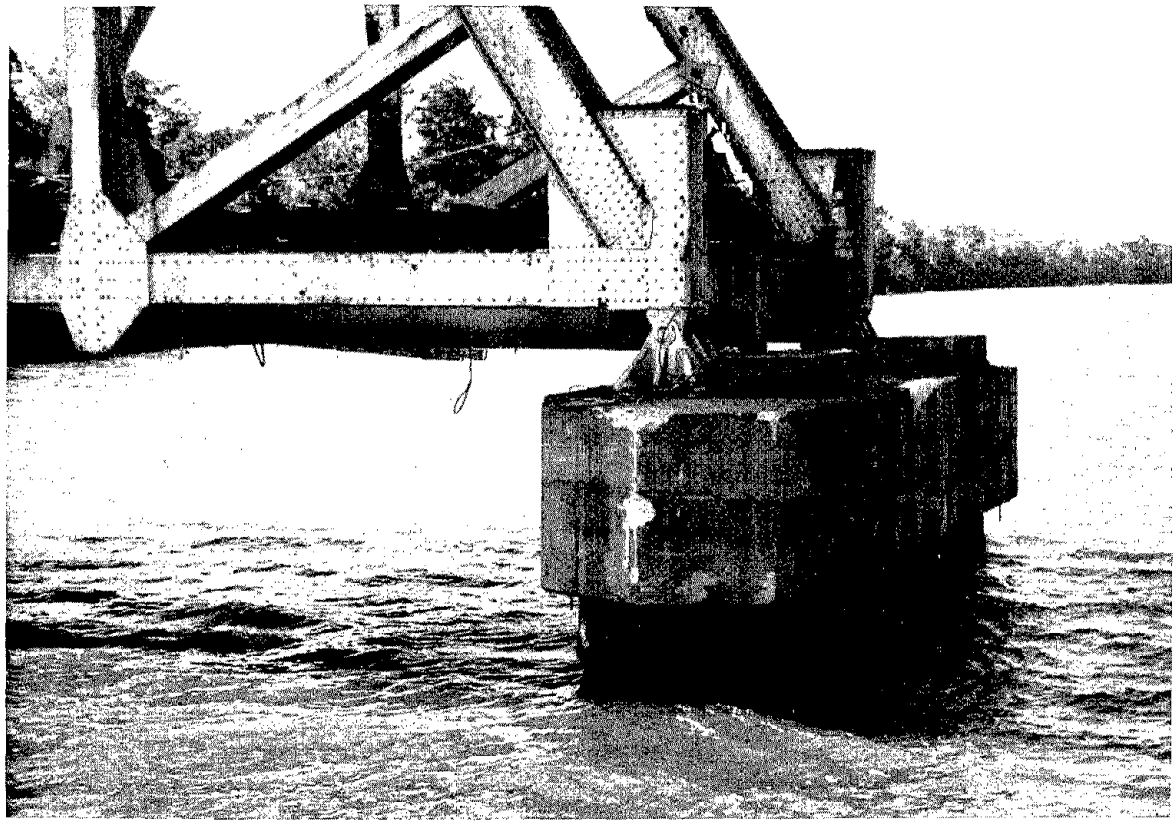

**Figure 7.--Collision marks on Big Bayou Canot bridge.**

During salvage operations, divers assessed the alignment and general condition of the perimeter piles in the cluster supporting the pivot pier. The piles appeared to be in good condition and in alignment after the accident. Portions of the concrete pedestal and some mat timbers were found 50 feet north of their original location.

The continuous welded rail and the track structure on the 165-foot truss section of the bridge sustained extensive damage from massive buff forces during the derailment. The 140-foot through-girder span was displaced 38 inches by the barge and was subsequently destroyed when train 2 struck the displaced girder, knocking the track and bridge section off the piers and piling. The railroad track structure was also displaced, but the rail was not broken. About 500 feet of track on the timber trestle, the third section of the bridge, was destroyed during the derailment.

The signal system, a traffic control system (TCS) operated by a train dispatcher in Jacksonville, Florida, was not damaged when the barge rammed the bridge and thus continued to function even though the track on the through-girder span had been displaced. The train dispatcher had no indication of any problems with the track structure on his TCS signal control board, and all signals were clear (proceed) when the derailment occurred.

*MAUVILLA*.--The vessel's propulsion, steering, radios, searchlights, and all other mechanical and electronic equipment functioned properly after the accident. The MAUVILLA

was drydocked at W&GN's yard on September 27, 1993, for a hull survey. The marine investigative group noted no apparent damage to the hull, rudders, or propellers. Inspection revealed no evidence of a wire or other item having been wrapped around the propellers or rudders. The lead port (WGN 285) and starboard (WGN 208) barges (see figure 8) were slightly dented where they struck the bridge's concrete piers, and the center lead barge (WGN 258) had six marks on its headlog where it struck the vertical stiffeners on the bridge span (see figure 4). The other three barges were undamaged.

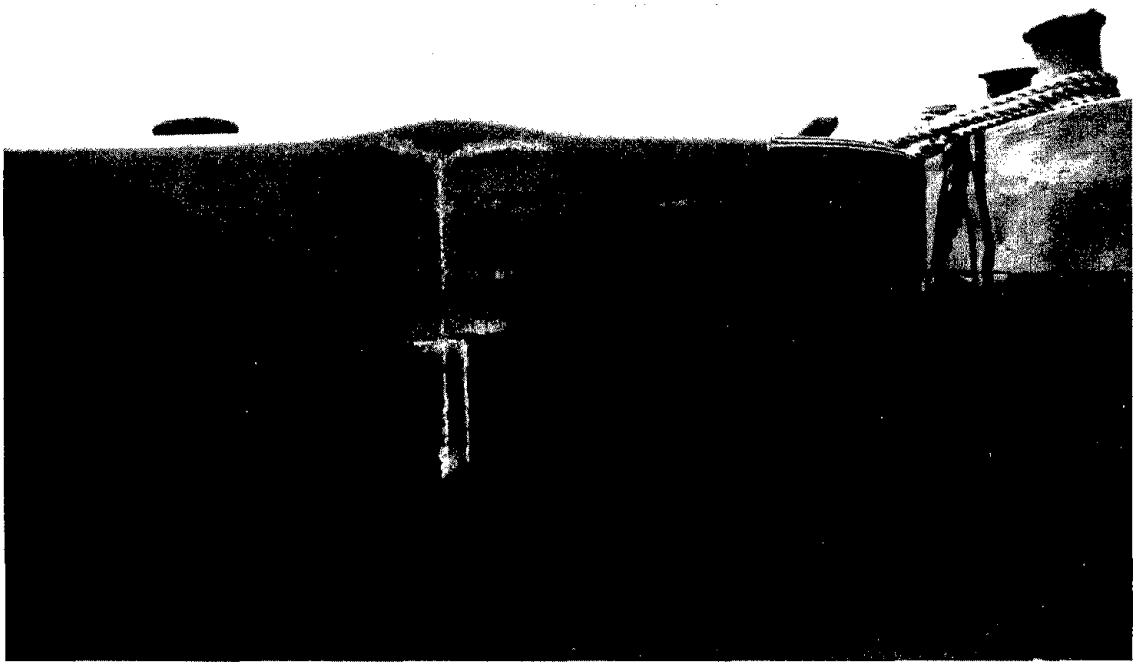

**Figure 8.--Collision marks on barge.**

*Sunset Limited.*--After the lead locomotive unit struck the bridge girder that had been displaced by the MAUVILLA, the three locomotive units, baggage car, dorm-coach, and two passenger cars on the head end fell into the water. The locomotive units, baggage car, and dorm-coach all caught fire and were destroyed. One passenger car sustained extensive damage and one was destroyed. The four passenger cars that remained on the bridge received minor damage.

Damage and rerouting cost estimates, based on data provided by CSXT, Amtrak, and W&GN, are as follows:

| | |
|---|---|
| Rail Equipment | $ 16,000,000 |
| Track and Bridge | $ 2,000,000 |
| Rerouting | $ 1,700,000 |
| Marine Equipment | $ 1,250 |
| Pollution Cleanup | $ 117,000 |
| **Total** | **$ 19,818,250** |

## SAFETY ISSUES

### Exclusions

Investigators eliminated several factors as safety issues in this accident. They included train operations, track and signals, train equipment, and traincrew qualifications.

The Safety Board reviewed event recorder tapes, transcripts of interviews with the operating crew, and crew deposition statements. This review disclosed no anomalies or deficiencies in train 2's operation.

Postaccident inspection of track through the bridge and its approaches revealed no defects or deviations from Federal Railroad Administration (FRA) standards. Before the accident, the CSXT had last inspected the track structure over Big Bayou Canot bridge on September 19, 1993, and the FRA had done so on September 13, 1993; neither inspection uncovered any defects. The track is maintained to class 4 standards.[12] CSXT and Amtrak tests in July, August, and September 1993 revealed no rail defects. Postaccident inspection and testing of the signal system showed that it functioned as designed.

Neither postaccident equipment inspection nor crew testimony indicated any equipment failure on train 2. Lead locomotive unit 819, a new General Electric (GE) design PH40 model delivered to Amtrak on September 1, 1993, derailed at a speed of about 72 mph, traveled some 270 feet through the air, and was buried in about 46 feet of mud. The trailing locomotive units, 262 and 312, were F40PH models that also came to rest in the bayou. The fuel tanks on each of the three locomotive units ruptured, spraying fuel over the trestle and Bayou Canot, and ignited. That part of the lead unit protruding above the mud burned. Both trailing units were destroyed by fire.

The fuel tanks on lead unit 819 incorporated recent design enhancements, including computerized and vented cells to maintain equalization and to minimize spills in the event of a rupture.

In its 1992 rail fuel tank safety study,[13] the Safety Board made the following recommendation to the FRA:

> R-92-10
>
> Conduct, in conjunction with the Association of American Railroads, General Electric, and General Motors Electro-Motive Division, research to determine if the locomotive fuel tank can be improved to withstand forces encountered in the

[12]Class 4 track must be inspected at least twice weekly by a certified track inspector and maintained in a condition that will allow passenger trains to operate over it at a maximum speed of 80 mph.

[13]Safety Study--*Locomotive Fuel Tank Integrity* (NTSB/SS-92/04).

more severe locomotive derailment accidents or if fuel containment can be improved to reduce the rate of fuel leakage and fuel ignition. Consideration should be given to crash or simulated testing and evaluation of recent and proposed design modifications to the locomotive fuel tank, including increasing the structural strength of end and side wall plates, raising the tank higher above the rail, and using internal tank bladders and foam inserts.

In its February 10, 1993, response, the FRA stated that it would act on this recommendation and, together with the Association of American Railroads (AAR), GE, and General Motors Electro-Motive Division, would collect data on fuel tank integrity; it intends to periodically update the Safety Board on the status of this effort. Safety Recommendation has been classified "Open--Acceptable Response."

On December 13, 1993, during the Safety Board's public hearing on the Mobile accident, the FRA's Director of the Office of Safety Enforcement testified that the Congress has directed the FRA to examine the issue of locomotive (including fuel tank) crashworthiness. He stated that the FRA has a research project under way and is considering simulation of locomotive crashes to determine how certain locomotives would perform. He noted that the agency's report is due to the Congress in early 1995. The Safety Board hopes that in conducting this research, the FRA will reconsider its previous decision to include only locomotives built after August 1, 1990.

Train 2's operating crew were fit to perform the duties to which they were assigned. All five men were rested in accordance with applicable regulations, and all were qualified on the operating rules. In addition, each had passed Amtrak's most recent physical examination.

### Toxicological Issues

Neither alcohol nor illicit drug use appears to have been a factor in the accident. The lead locomotive unit in which the three engineers died was not recovered until 1:20 p.m. on September 24, and thus their bodies were submerged for more than 58 hours before test samples could be collected. Toxicological test results for the three men showed evidence of alcohol in their bodies. Laboratory reports noted that all samples were decomposed, and the alcohol levels detected were consistent with expected postmortem generation of alcohol.

Both the conductor and assistant conductor of train 2 stated that they knew of no evidence that any of the engineers had consumed alcohol immediately before or during the trip, and the engineers' medical and personnel records contained no information relating to alcohol-related incidents or problems. The Safety Board therefore believes that the toxicological evidence of alcohol in the bodies of the three engineers resulted from postmortem microbial production of ethanol rather than from antemortem ingestion of alcohol.

Blood and urine specimens were not collected from the conductor and assistant conductor until some 9 hours after the accident because all supervisory personnel were responding to the accident. Those specimens tested negative for alcohol and drugs. But because of the 9-hour lapse between the accident and specimen collection, the Safety Board cannot conclusively state that

alcohol was not present in the conductor and assistant conductor at the time of the accident.

Urine specimens from the four MAUVILLA crewmembers were obtained on the morning of September 21, 1993, for the random drug testing required by 46 CFR 16.230. The specimens tested negative for the presence of the five drugs specified in 49 CFR Part 40, that is, the metabolites of marijuana, cocaine, opiates, phencyclidine, and amphetamines. Subsequent Safety Board tests on samples taken from the MAUVILLA's captain revealed the presence of norpropoxyphene, caffeine, nicotine, cotinine, ibuprofen, and acetaminophen. Norpropoxyphene is the metabolite of propoxyphene, a mild narcotic analgesic drug found in Darvon, a prescription drug for alleviating pain. The captain said that he took Darvocet N 100, as necessary, for pain from an old shoulder injury. Possible side effects of Darvocet include dizziness and drowsiness.

Although the captain was not on watch at the time of the accident, the Safety Board is concerned about the possible effects of medication on performance. Unsupervised use of medication, both prescribed and over-the-counter, by operators in the transportation industry has been an issue in previous accidents.[14] Operators may not understand the potential dangers of many medications, including their effect on performance, and therefore may use them inappropriately. Consequently, the Safety Board concludes that companies such as W&GN should establish procedures that encourage towboat operators to inform management when they are taking medication, determine whether such medication may affect their performance of duties, and arrange for a qualified relief, if necessary.

The Safety Board has urged employers in the transportation industries to implement educational programs for employees that describe and illustrate possible consequences of medication use. As a result of its investigation of the December 17, 1991, derailment of Amtrak's Silver Meteor in Palatka, Florida, the Board asked Amtrak on August 17, 1993, to:

> R-93-17
>
> Develop and implement an educational program for employees that describes and illustrates potential consequences of medication use to enable employees to make an informed decision about the relationship between their use of prescribed and over-the-counter medications and their fitness for duty.

In its October 14, 1993, response, Amtrak stated that it was prepared to develop and implement such a program. The Safety Board classified this recommendation "Open-Acceptable Response" on February 10, 1994, pending further response from Amtrak.

The Safety Board has also discussed the need for employers to be aware that employees are taking medication so that the employers can determine the potential effects on fitness for duty. As a result of its investigation of the grounding of the M/V REGINA on February 15,

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[14]See, for example, Marine Accident Report--*Grounding of the Panamanian-Flag Passenger Carferry M/V A. REGINA, Mona Island, Puerto Rico, February 15, 1985* (NTSB/MAR-86/02) and Railroad Accident Report--*Derailment of Amtrak Train 87, Silver Meteor, in Palatka, Florida, December 17, 1991* (NTSB/RAR-93/02/SUM).

1985, the Safety Board recommended on February 27, 1986, that the operator of the REGINA and the U.S. Coast Guard, respectively:

M-86-13

Establish a procedure to require that your vessel masters and watchstanding officers report when they are taking any medication, determine whether such medication may affect the performance of their duties, and arrange for a qualified relief if necessary.

M-86-15

Require that masters and watchstanding officers on U.S. passenger vessels carrying 50 or more passengers, including ferries, report to the vessel's operation company when they are taking any medication so that a medical determination can be made as to the effect of such medication on their ability to perform watchkeeping tasks properly.

Safety Recommendation M-86-13 was classified "Closed--No Longer Applicable" on October 19, 1987, because the company operating the REGINA no longer operated the vessel between Puerto Rico and the Dominican Republic. However, a different company operating in the same area stated that a directive had been issued requiring all masters and watchstanding officers of the vessel to report when any medication is being taken. When such a report is received, the officers confer with a physician to determine the possible effects of the medication on the employee's performance.

The Safety Board classified Safety Recommendation M-86-15 "Closed--Acceptable Alternate Action" on December 23, 1993, after the Coast Guard implemented a regulation requiring the vessel owner, charterer, managing operator, agent, master, or person in charge to exercise due diligence to ensure that the vessel is not operated by individuals who are intoxicated (including intoxication caused by legal drug use).

Considering these experiences with medication use by transportation industry employees and the events in this accident, the Safety Board concludes that the industry needs to develop intensive educational programs for employees that stress the relationship between medication and possible effects on fitness-for-duty status. The Safety Board believes that the Secretary of Transportation should require that each modal operating administration issue notices, bulletins, circulars, or other documents that stress the need for transportation industry employees to report any use of over-the-counter or prescription medication so that a determination can be made concerning the effect of such medication on the employees' fitness for duty.

The urine specimen collected from the MAUVILLA's pilot tested positive for glucose and contained caffeine and ibuprofen. The pilot's personnel records indicated that he had been diagnosed as having diabetes mellitus in August 1982; his physician stated in a letter that the pilot was an insulin-dependent diabetic who monitored his glucose closely. The physician also said he believed the pilot's condition would not preclude him from discharging his duties as a

"boat pilot." The letter was given to the pilot for submission with his application for an Operator of Uninspected Towing Vessels (OUTV) license, which the Coast Guard eventually granted after requesting and receiving additional information about his diabetic condition.

The pilot's most recent physical examination before the accident took place on July 23, 1992. It included a vision and hearing test, and the physician noted that the pilot could safely continue employment in his current position. The pilot said he took insulin twice a day and had done so the evening before the accident, as prescribed. He stated that he "felt fine" and rested upon assuming the watch at 11:30 p.m. The Safety Board concludes, based on information obtained from his employer and a statement from his doctor, that the pilot had been able to control his diabetic condition satisfactorily since 1982 and that the disease most likely did not preclude him from operating the MAUVILLA safely.

Because all supervisory personnel were responding to the accident, toxicological samples from the MAUVILLA's crew were not collected and tested until about 10 hours after the accident. Because of the 10-hour lapse, the Safety Board cannot conclusively state whether alcohol was present in any of the MAUVILLA's crewmembers at the time of the accident. The Safety Board is concerned about the delay in obtaining samples from both the MAUVILLA crew and the surviving traincrew members, even though the testing took place within Federal timeliness standards in effect at the time, that is, "as soon as practicable." Alcohol at a blood concentration level of 0.10 percent (the legal intoxication level in most States) is eliminated from the body in 6 to 7 hours. Although drugs and their metabolites are eliminated more slowly than alcohol, a 6- to 7-hour delay can also allow drug levels to fall below the testing thresholds established by law.

The Safety Board has long been concerned about drug testing inconsistencies among the transportation modes and about delays in obtaining toxicological samples after accidents. This accident underscores the need for the Coast Guard to develop improved procedures concerning postaccident sampling for toxicological testing. The Coast Guard, which regularly responds to marine accidents and attends to matters of postaccident testing, is fully aware of the law and therefore should provide guidance to employers. However, the Coast Guard has not provided its investigating officers with guidelines for informing marine employers about the law, for stressing the need for timeliness in testing crewmembers, and for assisting marine employers in accomplishing timely postaccident sampling.

In several previous accident investigations, the Safety Board has addressed the need for improved postaccident drug and alcohol testing procedures.[15] The Safety Board believes that the Coast Guard should provide guidelines to boarding officers who investigate marine accidents about informing marine employers of their responsibility to conduct toxicological testing as soon as practicable following a serious marine incident and about providing assistance when necessary

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[15]See, for example, Marine Accident Report--*Grounding of the United Kingdom Passenger Vessel RMS Queen Elizabeth 2 near Cuttyhunk Island, Vineyard Sound, Massachusetts, August 7, 1992* (NTSB/MAR-93/01) and Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03).

(for example, supplying sampling kits and making arrangements for testing with local approved laboratories). This accident reinforces the need for such guidelines, and the Safety Board looks forward to prompt implementation of Safety Recommendation M-94-11, which calls on the Coast Guard to adopt them.[16]

Similarly, although blood and urine specimens were obtained from surviving train crewmembers in accordance with Federal timeliness standards then in effect, that is, "as soon as possible," the Safety Board regards the delay in testing as unjustified. Provisions of the Omnibus Transportation Employee Act of 1991 required that the Federal Aviation Administration, the Federal Highway Administration (FHWA), the FRA, and the Federal Transit Administration promulgate comprehensive alcohol use and detection programs. The new alcohol and drug testing regulations, published in the *Federal Register* on February 15, 1994, address for the first time the issue of timeliness. They require that postaccident testing be conducted "as soon as practicable" and set time limits within which testing for alcohol should be accomplished.[17]

The marine industry was not included in the act because the Coast Guard already had regulations on alcohol use, including mandatory postaccident alcohol testing. The pipeline industry was excluded because, unlike other forms of public transportation, it does not transport people. The Research and Special Programs Administration, which regulates the pipeline industry, nonetheless implemented regulations similar to those of the other Department of Transportation (DOT) operating administrations. The Coast Guard did not, and its regulations pertaining to timeliness of postaccident toxicological testing do not conform with those of the other DOT operating administrations.

The Safety Board concludes that delays in obtaining samples from vessel crewmembers, which prevented definitive determination of whether alcohol was a factor in this accident, could continue to be a factor in marine accidents because Coast Guard regulations pertaining to timely postaccident toxicological testing do not conform with those of the other DOT operating administrations. The Safety Board believes that the Coast Guard should amend 46 CFR 4 and 16 to specify the time limits, not to exceed 8 hours, within which employers must conduct postaccident alcohol testing.

## Pilot's Activities Before the Accident

On Friday, September 17, and Saturday, September 18, 1993, the pilot remained at home and ran errands. He retired shortly before midnight on both evenings. On Sunday, September

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[16]Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03).

[17]If an alcohol test is not administered within 2 hours (4 hours in the case of FRA-regulated employers) following an accident, the employer is to prepare and maintain on file a record stating why the test was not promptly administered. If the alcohol test is not administered within 8 hours, the employer is to cease attempts to conduct the test and state in the record why it was not administered.

19, he awakened about 7 a.m., took a shower, and administered his insulin. He then ate breakfast and left for work about 9 a.m. At 10:35 a.m., the pilot and a deckhand left W&GN and drove to mileboard (MB)[18] 185 or 186 on the Mobile River to meet the MAUVILLA, which was traveling south toward the Mobile, Alabama, area. W&GN had arranged for the vessel to stop at MB 185.5 to allow the pilot and the deckhand to board.

The pilot said he was scheduled to meet the MAUVILLA to relieve a pilot or captain who had become ill. He boarded the vessel at 12:45 p.m., had lunch, and then went on watch. At 6 p.m., he went off watch; after taking a shower and eating supper, he went to bed. He woke up at 11 p.m. and assumed the watch at 11:45 p.m. He stood watch until 5:30 a.m. on Monday, September 20, when he was relieved by the captain. After administering his insulin shot, the pilot went to bed; upon arising at 11 a.m., he ate lunch and then relieved the captain. He stood watch until 6 p.m., exercised for 1/2 hour, took a shower, ate supper, and retired until 11 p.m. He assumed the watch from the captain at 11:45 p.m.

The pilot stood watch until 5:45 a.m., Tuesday, September 21, at which time the captain relieved him. He then administered his insulin shot, had breakfast, and went to bed, sleeping until 11 a.m. After taking a shower and eating lunch, he relieved the captain at 11:40 a.m. and stood watch until 6 p.m., when the captain relieved him. He took a shower, administered his insulin, and had supper. After returning to his room, he read for a while and slept until 11 p.m. The MAUVILLA arrived at the National Marine Fleet about 11 p.m. to pick up two additional barges. The pilot assumed the watch at 11:30 p.m., and the MAUVILLA departed the National Marine Fleet at 12:55 a.m. on September 22.

### Pilot's Performance

About 1/2 hour elapsed between the time the fog set in and the time that the MAUVILLA rammed the Big Bayou Canot bridge. The last navigation aid that the pilot recalled seeing before reaching the north end of Twelve Mile Island was a triangular dayboard, which was probably the dayboard at mile 9.2, about 1/2 mile from the mouth of the bayou. If the MAUVILLA was traveling from mile 9.2 at 2 or 3 mph, as the pilot estimated it was, the vessel would have arrived at the Big Bayou Canot in 10 to 15 minutes.

During the accident investigation, Safety Board staff boarded the MAUVILLA to observe the radar displays[19] presented by the banks of the Mobile River and by the juncture of the river and the Big Bayou Canot. The investigator did so on both the 1/2-mile and the 1-mile range scales, and the radarscope clearly displayed the banks and the juncture of the two waterways.

According to testimony, the pilot found himself in increasingly heavy fog as he proceeded

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[18]Boards are daybeacon navigation aids colored to indicate the proper side of the waterway; they indicate their location by a mile/tenths of a mile distance from mile 0 on a waterway.

[19]W&GN records show that the MAUVILLA's radar was last serviced before the accident on September 5, 1993, and was operating properly.

to the north end of Twelve Mile Island. In accordance with company policy[20] and after conferring with the THOMAS B. McCABE's operator about visibility conditions ahead, the pilot decided to stop his tow and "tie up." Towboat operators on the Western Rivers commonly tie up to trees on the riverbank during periods of restricted visibility. Both the Coast Guard and the U.S. Army Corps of Engineers (USACE) are aware that "tying up" is an accepted practice throughout the river system and do not prohibit it. Except for "pushing in" (shoving the tow onto the riverbank) and using engine and rudder maneuvers to hold the tow in place, towboat operators have no other option if they need to stop when they are away from a dock or mooring facility. They often need to stop due to fog while navigating through sparsely populated areas such as this one. The Safety Board believes that because the dense fog made safe operations difficult, the pilot's decision to tie up and await better visibility conditions was a prudent one.

The pilot indicated that he was unable to see either riverbank at the time he decided to stop. The deckhand on watch testified that he could see "a barge length ahead of me," that is, about 200 feet. The Safety Board believes that the pilot maneuvered his tow closer to the riverbank to try to visually locate a suitable tree to tie up to. He testified that he searched for a tree with his spotlights and twice tried, but failed, to snag one. After these unsuccessful attempts, the pilot told his deckhand to return to the towboat because he wanted to proceed to the Mobile-Tensas Cutoff, about 3 miles north of the intersection of the Big Bayou Canot and the Mobile River, where he knew there was a tree suitable for mooring.

To continue upriver and avoid entering the Big Bayou Canot, a tow following the river curvature must stop its leftward movement (see figure 9). When the shorelines are visible, cues are available to guide an operator through the intersection. When the shorelines are obscured, an operator needs radar information to stay on the intended courses. He or she has to correlate the radar information with chart information or memory of the waterway's geography to determine the tow's location and choose the proper waterway.

Heading upriver about mile 9.1, the Mobile River begins curving to the left and spans an arc of about 95 degrees to the entrance of Big Bayou Canot, a distance of about 0.8 mile. Although the pilot said he did not see the intersection of the two waterways on the radar, it should have appeared on the radarscope about the time the tow passed mile 9.1 and should have remained there even after the MAUVILLA entered Big Bayou Canot if the radar was set to the 1/2-mile scale. Even if the radar was set to the 1/4-mile scale, the triangular point of land marking the north end of the intersection should have appeared on the radar shortly after the tow entered the intersection.

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[20]Both the pilot and W&GN general manager testified that company policy was to stop and tie up a tow when visibility deteriorated to near zero. In the general manager's words, "When a pilot encounters fog of such density that he feels he cannot continue the trip under the existing conditions, the policy is for the pilot to find a suitable place to tie off and wait until the fog lifts."

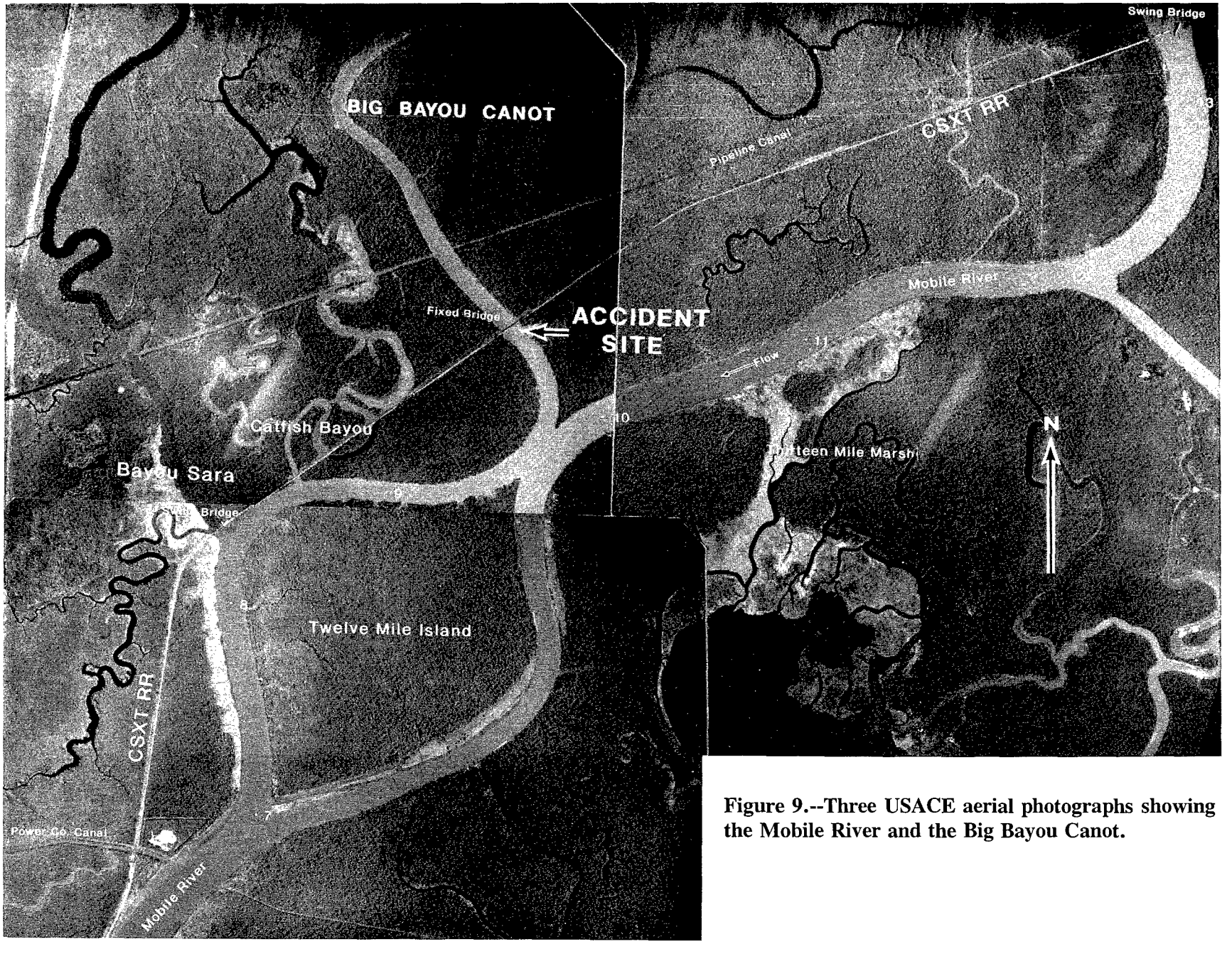


**Figure 9.--Three USACE aerial photographs showing the Mobile River and the Big Bayou Canot.**

The radar presentation varies as the tow proceeds, and the images must continually be interpreted because the outlines may differ from those shown on charts or sighted visually. The pilot either did not observe the radar sufficiently to obtain the information available, was inadequately trained to understand what the radar presented, or both. He testified that after receiving his license, W&GN "trained me as a copilot for almost a year, I believe. I went through to copilot training. That's learning how to operate the boat, running the rivers, and how to operate the radar." The pilot said he learned how to use radar through "on-the-job training," noting that he had not operated the type or model of radar on the MAUVILLA but had been exposed to and operated other models. He testified that he had received no formal training in the use and interpretation of radar: "Not going to school. Not for radar, no."

When he noticed the MAUVILLA's swing meter indicate that the head of the tow was moving left, the pilot said he observed the banks but no "intersection" on the radar and did not realize he was headed into the Big Bayou Canot. Safety Board investigators noted that at 1/2-mile or greater range settings, the image of an intersection is visible on the radarscope at various points when a vessel is proceeding through the intersection. The pilot's failure to notice that he had departed the Mobile River suggests that he did not look at the radar long enough, perhaps because he was simultaneously engaged in maneuvering the vessel, talking on the radio to the deckhand, and using his searchlights. The Safety Board believes the pilot became so preoccupied with his search for a tree that he failed to avail himself of the radar equipment that could have compensated for both the darkness and the fog. The Safety Board concludes that had the pilot used the radar as visibility deteriorated, he would have observed the intersection formed by the Mobile River and the Big Bayou Canot and could have avoided turning his tow and barges into the wrong waterway.

Other than radar, no means of determining his heading was available, since the towboat was not equipped with a compass. If the pilot had access to a compass and had known the general heading of the Mobile River at his location, he might have noticed that he was steering northerly rather than easterly. The Safety Board concludes that the pilot was at a disadvantage because W&GN had not provided him with a compass.

The pilot said that shortly after maneuvering his tow from the riverbank (to snag a tree) back into the waterway (the Big Bayou Canot), he observed an object on the radar that he believed to be another tow. The object, as displayed on the radarscope, appeared to extend across the waterway, and the pilot thought that a tow might have swung out into the river, as was possible if it had been moored by the bow only. His decision to try to moor to this supposed "tow" was compatible with towboat practices.

The pilot did not act prudently, however, in approaching another tow at a 90-degree angle when visibility was limited and a deckhand was not at the head of the tow. The Safety Board believes that the pilot should have more fully assessed the situation before trying to tie up to an object he had seen on radar but been unable to contact by radio. If he had sent the deckhand to the head of the tow, for instance, the hand might have been able to identify the object as the railroad bridge and warn the pilot in time to avoid this accident. The Safety Board concludes that the pilot exercised poor decisionmaking by continuing his approach to an unidentified object under the prevailing conditions without summoning help from other crewmembers.

## Loss of Situational Awareness

Perhaps the most vexing question in this accident is: How did the pilot become disoriented on the Mobile River in an area he had traversed many times as a deckhand and a towboat operator?[21] When asked about his experience operating a tow at night, the pilot replied, "Well, I have a lot of experience operating at night, but we don't operate in fog." The Safety Board believes that the pilot ceased to navigate effectively and safely when visibility deteriorated to the point that he could no longer see the riverbanks. In other words, the pilot lost situational awareness, which one source defines as "an accurate perception of the factors and conditions that affect a vessel and its crew during a specific period of time. In simpler terms," according to the same source, "situational awareness is knowing what is going on around you."[22]

While the pilot's attempt to moor his tow was a prudent action in the Safety Board's view, it did not relieve him of responsibility for remaining aware of the MAUVILLA's orientation and position on the river, that is, for the safe navigation of his vessel. The pilot apparently became increasingly preoccupied with the task of tying off at the expense of tracking the tow's position. When he abandoned the immediate effort to find a mooring spot and redirected his attention to navigating, he had lost track of 10 to 15 minutes, during which time the tow had entered the mouth of the Big Bayou Canot. The Safety Board concludes that under the circumstances, the pilot acted imprudently in deciding to continue to navigate when he could not find a tree to which to tie up.

The pilot could have avoided losing situational awareness if he had recognized that he became task-saturated in trying to find a suitable mooring spot while simultaneously navigating the tow. Sound resource management[23] dictates that W&GN should have had a written policy to address situations such as this one. Crewmembers are often unaware of either the fact that they overload themselves or the remedies available to them to prevent task saturation unless they receive instruction in resource management principles.

Companies can enhance basic crew resource management by establishing a corporate policy that recognizes the need for and encourages the practice of good judgment and effective communication among crewmembers. The Safety Board believes that W&GN should make its employees aware that task overload can occur. The Safety Board further believes the company should establish procedures that enable towboat operators on watch to identify potentially hazardous situations that materially increase watch operators' workload and allow them to enlist the aid of off-watch operators or other competent crew.

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[21]The pilot, who testified to having operated towboats on the Mobile River, the Black Warrior River, the Tennessee Tombigbee Waterway, and the Mississippi River, stated that he had passed the mouth of the Big Bayou Canot on a towboat 2 days before the accident.

[22]Geiss-Alvarado Associates, *Human Error Accident Training*, U.S. Coast Guard training manual, July 1991.

[23]The effective use of all available resources (people, equipment, and procedures) to achieve a safe and efficient operation.

## Warrior & Gulf Navigation

W&GN, organized in 1940, has about 225 employees, of whom 45 are towboat captains or pilots and 54 are deckhands. The remaining employees are managers, support personnel, and terminal operators. The company and The American Waterways Operators, Inc., (AWO)[24] consider W&GN a medium-size inland towing operation; it has about 250 barges and 24 towboats. About 10 of the former are covered hopper barges (200 feet long and 35 feet wide); the remainder are open hopper barges (195 feet long and 35 feet wide). The towboats built in the 1970s are 1,800 horsepower, and those built in 1982 are 2,100 horsepower.

The company typically moves six barges in a tow and occasionally eight. In fast current or high water conditions, tow size is usually held to four barges. One operator and one deckhand stand watch on a towboat on a 6 hour-on, 6 hour-off rotation, which is typical for the type of towing operation the company is engaged in. The general manager stated that the equipment provided on W&GN towboats is more than that required by regulation and probably more than that provided by other companies. He believes the training provided to operators and deckhands is above average for a company of its size.

Safety Board investigators were able to obtain the accident record for W&GN compiled by the Coast Guard Marine Safety Office, Mobile, Alabama. From 1982 until the date of this accident, W&GN vessels were involved in three minor pollution incidents (less than 100 gallons of oil spilled) and no medium or major incidents. The record also shows 3 fires on board W&GN vessels, 6 barge groundings, 2 barge strikings of unmarked underwater objects, 3 barge structural failures, 1 accidental death of a deckhand, 3 founderings, 3 collisions with an aid to navigation, 3 collisions with bridges, 18 other collisions, and 2 accidents of an unspecified nature that were not classified for recordkeeping purposes.

Thus, in 12 years, the company has experienced 45 reportable marine casualties, including this accident, or 3.75 accidents per year, which is less than 0.2 accidents per towboat-tow per year. A local Coast Guard official stated that he thought W&GN's accident record was better than average for inland towing companies. Coast Guard headquarters does not maintain accident rates for towing companies; therefore, no comparison could be made with the industry overall.

## Towboat Operator Training

Although W&GN operations complied with Coast Guard licensed operator manning regulations, the company did not ensure that the pilot of the MAUVILLA was adequately trained in the use of radar. Had the pilot been adequately trained to use radar, he should have recognized the juncture of the Big Bayou Canot and the Mobile River on the radarscope. When he

[24]A national trade association that represents 350 companies, including 200 that move cargo by tug, towboat, and barge. The AWO also represents shipyards that build and repair barge and towing vessels. It advises members about legislation affecting the industry and comments to regulatory agencies on matters of interest to members. The U.S. towing industry numbers about 700 companies. They operate some 5,800 tugs and towboats that move 27,000 barges transporting dry cargo and some 4,000 tank barges transporting bulk liquid cargo.

inadvertently departed from his course, he should have been able to interpret his position on the radar and respond to the change in course appropriately. To locate a suitable place to secure their tows and wait for visibility to improve, towboat operators need to be trained in use of radar to navigate. The Safety Board found that W&GN did not provide the pilot with radar training beyond the rudimentary experience gained on the job.

W&GN hired the pilot as a deckhand on April 23, 1980. His personnel records show that the company advanced him tuition to attend "sea school" in September 1988, and the pilot stated that he completed "sea school" to prepare him for his OUTV examination. On October 12, 1990, following several unsuccessful attempts, he passed the Coast Guard licensing examination for OUTV[25] Upon Western Rivers. W&GN promoted him to operator trainee on November 8, 1990. The company promoted him to operator second class (pilot II) on October 12, 1991, and to operator first class (pilot I) on January 12, 1993.[26]

After obtaining his license, the pilot testified, he entered W&GN's towboat operator training program, remaining in it for about a year. This program, he said, consisted of on-the-job training (OJT) under the tutelage of an experienced operator, who taught him how to operate the boat, "run the river," and operate the radar. He received no structured radar navigation training, and W&GN did not formally evaluate his radar navigation proficiency before allowing him to serve as an unsupervised towboat operator. Nonetheless, before September 22, 1993, the pilot had no reportable marine accidents.

W&GN's general manager testified that he was aware of no written company policy concerning the hiring and training of towboat operators. In fact, although W&GN occasionally hires licensed towboat operators, it more commonly trains its deckhands to fill such positions. After the deckhands receive an OUTV license, W&GN's practice is to place them in its towboat operator training program, at which point they become "operator trainees."

The general manager stated that he did not know whether operator trainees have the opportunity to listen to lectures, review written material, or demonstrate proficiency in the position based on a written test. He said that the W&GN towboat operators who conduct the training do not themselves receive formal instruction in their role as trainers. Nor does the company give written guidance to its assistant fleet captain, whose responsibilities include oversight of towboat operator training and evaluation.

W&GN's OJT program, as described by the general manager, largely consists of observing wheelhouse operations. After obtaining an OUTV license, trainees receive 6 to 12 months of OJT, which includes standing watches under a vessel operator's supervision. During this time, they are expected to obtain a working knowledge of all aspects of towboat operations, including maneuvering a vessel, use of radar and other equipment, and the geographical areas over which they will operate.

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[25]The MAUVILLA's captain, who had worked on towing vessels since 1974, also held a valid OUTV license.

[26]The duties of the two positions are essentially the same; the salaries are different.

The general manager testified that the purpose of radar on W&GN's towboats is to allow operators to locate banks to tie off vessels and barges and to avoid obstructions in the waterway. The company instructs trainees not to navigate in fog but to find a suitable place to tie up when visibility deteriorates to the point of being completely "shut-out."

The pilot stated that from 1984 until 1988, while serving as a deckhand, he was also "going up to the wheelhouse learning how to operate the vessel." After completing his duties as deckhand, the pilot said he went to the wheelhouse and steered the vessel for 1 to 2 hours under the operator's direction, usually during daylight. He explained that during this period, he learned, by observation, how to operate the radar and observe the swing meter.

Records show that the pilot began entering information about his training in a "Pilot Trainee Log" on January 1, 1991. He recorded dates, times on watch, position by MB, number of hours steered, and descriptions of the tow. The logs indicate that the pilot steered a towboat on some 150 occasions between January 1, 1991, and September 2, 1991, the date of the last entry. He steered a towboat, on average, just under 5 hours per voyage, during both daylight and nighttime, in various locations from MB 0 to MB 367, Mobile, Black Warrior, and Tombigbee Waterways. In October 1991, the W&GN port captain recommended that the pilot be promoted to pilot second class (pilot II).

The pilot probably received adequate OJT in towboat and barge maneuvering and was quite likely qualified to operate vessels under most conditions. Nonetheless, he did not use his radar properly on the night of the accident and certainly was not using it to determine his position on the river. The Safety Board concludes that W&GN did not adequately train the pilot to navigate by radar. If the pilot had received formal radar training, he might have known how to use the radar when visibility began to deteriorate. Considering that W&GN had equipped all its towboats with radar before September 22, 1993, the argument for radar training is compelling. The Safety Board believes that a structured radar training program enhances an operator's ability not only to determine his position but also to navigate his towboat to a safe mooring location and that this training should be required of all operators of radar-equipped towboats.

### Industry Training Standards

One towing industry representative testified that his company prefers to train towing vessel operators in-house through a 5-year program before they take the Coast Guard examination for an OUTV license. He said participants are evaluated twice a year. In addition, the company monitors participants' performance in areas such as vessel personnel turnover and safety violations to determine whether inappropriate operational patterns are developing.

Another industry official stated that his company has established a "steersman program," from 1 to 3 years in duration, to provide training for prospective towboat operators. A participant's only responsibility is to learn, according to the official. He said trainees are "observed constantly" and gradually assigned to more demanding routes or tows until they are qualified to stand watch alone. Following passage of the 1972 towing license law, he said, "We [in the towing industry] were going to have to do much more in the form of training and preparation

for these people [OUTV operators] before we would entrust our vessels to them."

An AWO representative testified that training programs such as the two described are fairly widespread in the industry. He said that these two programs "have more definition" and "they're more structured. But I think the concepts that are embodied in their programs you will find even with smaller operators, although they are probably less sophisticated." At least one of the programs requires that its trainees learn to use waterway charts, as well as "all navigation equipments," including radar, while steering a vessel.

The Coast Guard licensing test cannot assess the extent to which an applicant has the vessel-handling and equipment-use skills needed to operate a vessel under varying conditions of visibility, current flow, tow size, and so forth. Therefore, employers have the responsibility to train and evaluate their operators before placing them in charge of a navigation watch. The limited information available concerning towboat operator training suggests that in the case of smaller companies, such training may not go beyond that to which the W&GN general manager attested. The Safety Board believes that the industry, including W&GN, should provide operators with the radar skills necessary to navigate radar-equipped towboats safely in poor visibility.

### Personnel Evaluation

W&GN's assistant fleet captain and vessel operators periodically evaluate operator trainees and recommend whether they should be promoted to pilot II and pilot I. The assistant fleet captain testified that he rides with a trainee when the individual enters the training program, evaluates the person's performance in writing after that ride, and evaluates the trainee's progress again in about a month. He continues to do an unspecified number of such evaluations, even after the trainee has been promoted to pilot II (that promotion allows an individual to stand watch alone while operating the vessel). The assistant fleet captain said that after an individual has become a pilot II, evaluations are not necessarily written.

The pilot of the MAUVILLA had received 16 written evaluations between January 25 and September 30, 1991, while he was in training, and subsequently received written evaluations on April 5, April 12, and August 30, 1993. All rated him either "good" or "excellent"[27] in every area of performance--"safety consciousness, respects authority, ability to get along with other crewmembers, knowledge of position, quality of work, and aptitude for learning." W&GN was unable to locate any written evaluations for the pilot for the period from September 30, 1991, to April 5, 1993.

The Safety Board believes that systematic, written evaluations of an individual's performance are essential because they allow the organization to continually assess those skills and abilities critical to a position. In addition, written evaluations can highlight deficiencies, thereby serving as a valuable tool for effecting changes in work habits. Such evaluations indicate whether an individual is meeting the employer's stated goals. By providing documented, periodic feed-

[27]The four rating levels for each category were "poor," "fair," "good," and "excellent."

back concerning skills and abilities, they also give employees information that can be used to improve their performance.

W&GN's evaluation form is a check-off sheet rather than an in-depth assessment form for assessing an operator's skills and abilities. Whether management, using this form, could accurately evaluate an individual's abilities is questionable. The criteria for the four rating levels are not listed on the form, and the six areas of performance evaluated are too general to allow meaningful assessment of an operator's skills. For example, "knowledge of position" is not defined. The Safety Board concludes that operators should be evaluated on their proficiency in use of wheelhouse equipment such as radar (under various visibility conditions and circumstances, including finding a suitable place to tie off), the swing meter, and rudders (including backing rudders) and engines in high water and high current conditions. The Safety Board also concludes that W&GN's written evaluation form did not fully identify and assess those skills critical to vessel operation, thereby limiting its value as a management tool for ensuring safe vessel operations.

### Licensing Requirements

Before September 1973, only individuals who were on watch in the wheelhouse on steam-powered towing vessels were required to have a Coast Guard license. After World War II, diesel-powered vessels gradually replaced steam towing vessels. Motor- or diesel-driven towing vessels were not required to have licensed wheelhouse operators. Following an increasing number of casualties involving uninspected towing vessels in the 1960s and early 1970s, the Congress enacted the Towing Vessel Operator Licensing Act of 1972, which requires that individuals standing navigation watch on uninspected towing vessels at least 26 feet long hold an OUTV license. Since the MAUVILLA was 85 feet long, both the captain and pilot were required to have such a license. The licensing regulations recognize the limited formal educational background of many towboat operators by reducing the scope of knowledge required to obtain a license.

The Coast Guard establishes minimum training and experience standards for OUTV license applicants, who must furnish references that establish sufficient character to hold a position of that responsibility. An individual must also present evidence of 3 years of experience on specified vessels, including at least 6 months training or duty in the wheelhouse of a towing vessel. The regulations do not prescribe the level or type of wheelhouse training in vessel handling or equipment use. Evidence of service for an OUTV Upon Western Rivers license takes the form of a letter from the employer attesting to the candidate's service. The letter usually does not elaborate on what training a candidate has received; rather, it states that the individual has received training or has had duty in the wheelhouse. Before a candidate is allowed to take the licensing test, he or she must pass a physical examination, drug screening, and first aid and CPR courses.

Depending on the scope of operation and route covered, the test for operators of uninspected towing vessels, such as the MAUVILLA, consists of four parts: general (60 questions), navigation rules (30 questions), general navigation (15-20 questions), and navigation problems

(10-20 questions). Between 1987 and 1990, the Coast Guard updated the OUTV Upon Western Rivers test, increasing the number of question variations in each module. The purpose of the changes was to better reflect the knowledge requirements and duties of operators; the substance of the examination remained the same.

License applicants must pass all four modules, and they have three opportunities for passing each one before failing the test. The Coast Guard does not limit the number of times an applicant may be examined for this (or any other) license. If a candidate does not pass all four modules in a 3-month period, he or she is counted as a test failure. The failure rate for the OUTV license, based on the latest records available, is as follows: 6.4 percent in 1989 (26 of 283 candidates), 6.8 percent in 1990 (92 of 1,263 candidates), and 2.9 percent in 1991 (12 of 398 candidates). The Coast Guard does not compile data on the number of retakes or the number of times an individual is reexamined before passing a test. To monitor the licensing program, the Coast Guard is developing a system to retrieve pass-fail data on candidates; implementation is expected in early 1995.

To meet requirements for the license, an operator does not have to be trained in the use of radar, and the MAUVILLA pilot was not so trained. Marine employers should ensure that their operators have essential skills, even though such skills are not required to obtain the Coast Guard license. As this accident shows, regardless of the tow size, towboat operators need to be qualified and proficient in navigating and operating in restricted visibility. Because radar skills are necessary for safe operation of a vessel in restricted visibility, the Safety Board believes that the Coast Guard should establish higher standards for inland towing vessel operator licensing.

Like the MAUVILLA's pilot, OUTVs typically learn to use radar through OJT. The knowledge imparted and skills learned through OJT vary, and a formal written examination is rarely given. The accident involving the MAUVILLA illustrates the shortcomings of such an approach to acquiring radar skills. Had the pilot received formal training in and been tested for radar skills, he should have been able to navigate his vessel properly without becoming lost. If the pilot had known how to navigate using radar, the MAUVILLA could have proceeded when the fog developed until the pilot was able to safely stop the tow. Operators need radar navigational skills because tows are not always in locations suitable for stopping when fog occurs. While the prudent course of action is to stop the tow until visibility improves, pilots must continue to operate until they find a safe place to stop.

Deck officers licensed to stand watch on radar-equipped, inspected vessels of 300 gross tons or more must successfully complete a Coast Guard-approved radar observer course to obtain their original license (have "radar observer" endorsed on the license with the date of completion) and must successfully complete a refresher course every 5 years thereafter. In the case of OUTVs, only those holding a license for ocean waters are required to have a radar observer endorsement. As this accident demonstrates, radar observer training should be required of all OUTV licenseholders. Inland Navigation Rule 7(b), which applies to OUTVs, states: "Proper use shall be made of radar equipment if fitted and operational." Safe operation of a vessel includes proper use of radar, and only if a person successfully completes radar observer training at approved facilities can minimum proficiency in radar use be ensured.

The formal radar observer training currently available focuses on navigation of vessels offshore and in harbors. It emphasizes skills such as plotting of courses and collision avoidance maneuvers between vessels, which are useful on offshore waters and in harbors. This training is not directed at inland river navigation. The Coast Guard should develop radar observer course standards that, in addition to collision avoidance, teach navigation skills necessary for safe river operations. The Safety Board believes that current minimum licensing requirements are insufficient and that maritime safety would be enhanced by requiring that OUTVs be trained to use radar properly in a Coast Guard-approved radar observer course.

As a result of this accident, the Commandant of the Coast Guard directed that a review of safety issues relating to uninspected towing vessels be conducted. The review, completed on December 1, 1993, resulted in 19 recommendations concerning licensing, radar observer training, equipment requirements, and other issues. The Commandant accepted all of the recommendations and forwarded his action plan to the Secretary of Transportation. The Coast Guard held a public meeting on April 4, 1994, to discuss safety issues, including manning, inspection, licensing qualifications, and navigation equipment, and to develop additional information in preparation for changes to towing safety regulations.

The Coast Guard is to report its findings on manning and inspection of towboats by July 31, 1994, and is to publish a notice of proposed rulemaking for towing vessel navigation equipment by December 1994. Changes in towing vessel license requirements, such as levels of qualification (restrictions on route, towing vessel gross tonnage or horsepower, and towing configuration) and successful simulator course completion, are expected to be published by midsummer 1994.

### Towboat Navigation Equipment

Title 46 CFR Parts 24 through 28 set forth equipment requirements for uninspected vessels. The regulations cover life preservers and other lifesaving equipment; fire extinguishing equipment; emergency position indicating radio beacons for vessels on the high seas; and cooking, heating and lighting systems, as well as other equipment; they do not cover navigation equipment. Thus, the MAUVILLA, an uninspected towboat of less than 1,600 tons, was not required to be fitted with a radar, charts, or a compass.

*Radar.*--Like almost all uninspected towing vessels,[28] the MAUVILLA did have a radar, which is an important navigation aid widely used to detect the presence or movement of objects in a waterway. To require that radars be installed on uninspected towing vessels would be to regulate what is accepted practice and would not be an imposition on the industry, but it would prevent such vessels from operating legally unless their radar was in proper working order and would encourage operator reliance on radars. Operators trained in radar observation would be more likely to use radar and would know how to use it properly. They would also be less likely

[28]The most common exceptions are tugs and towboats that operate in limited confines such as fleeting areas or shipyards.

to become disoriented in fog. Proper use of radar by the MAUVILLA's pilot could have prevented this accident. The Safety Board concludes that all uninspected towing vessels, except those operating in very limited areas, should be required to have a radar installed. The Safety Board believes that the Coast Guard should require that towing vessels be equipped with radars and that towing vessel operators be trained in its use for navigation.

*Charts.*--Graphic representations of the geographic features of a waterway, or charts, are another aid to safe navigation. They depict landmarks, hazards to navigation, bridges, and other features an operator may need to be aware of to safely guide the vessel. Most trainee operators use river charts to help familiarize themselves with the rivers they navigate. Many river towboat operators carry their own charts, known as "bar books" or "bar charts," which are generally USACE waterway charts annotated by the operators to assist them in navigating a waterway. On the night of the accident, the MAUVILLA had no charts on board, and the pilot did not have his personal set with him.

The pilot had marked geographic and other information on a personal set of charts but did not usually carry them with him after he had been trained on the river. He testified, "I used to carry my chart with me all the time. I had it about a month, I guess, and I started leaving it at home." He added, "Once you know the river and places, positions where you'll be at, you don't have to have it. Nobody requires you to have a chart because you don't navigate by the chart." W&GN's general manager testified that "charts are not required as standard operating equipment on Warrior & Gulf vessels or any other towboats or vessels under 1,600 gross tons." He said company "policy is to encourage our pilot trainees or anyone else who wishes to use a chart to do so, if it will help them to familiarize themselves with the river system."

Had the pilot, mistakenly thinking he was on the river rather than the bayou, looked at a chart as he approached the Big Bayou Canot bridge, the chart alone would not have helped him. But if he had used a chart, in conjunction with radar, to track his progress as soon as visibility began to decrease, he could have avoided making a wrong turn into the bayou and thus prevented the accident. Most towboat operators who operate frequently over the same route become very familiar with that waterway. During clear visibility, especially in the daytime, they have no need to refer to charts and generally do not do so.

But when towboat operators are in unfamiliar waters or when visibility is low, whether due to fog, rain, sleet, snow or other cause, charts are important reference tools. Because visibility can deteriorate rapidly and with little notice, charts should be available in the pilothouse at all times. The Safety Board concludes that the Coast Guard should require that all uninspected towing vessels have charts on board appropriate for the vessels' route. In addition, the Safety Board believes that the AWO should urge member companies to equip their towing vessels with appropriate charts and to implement a method of assessing their vessel operators' navigation skills, including use of radar.

The USACE and the National Oceanic and Atmospheric Administration (NOAA) make available paper navigation charts for use by mariners. The USACE does so for the inland river system, and NOAA provides such charts for harbors and adjacent coastal areas, the Great Lakes, and some rivers in which ocean vessels operate (for example, the Mississippi River from the

Gulf of Mexico to Baton Rouge, Louisiana).

Recent advances in computer technology have made possible the development of digitized electronic charts that can be presented on a video screen. NOAA is digitally scanning all of its charts, which number about 1,000, and expects to complete the project by the end of 1995. Beginning in fall 1994, NOAA, in cooperation with a commercial enterprise, will issue about 400 charts on floppy disks, which are expected to cost about the same as the paper charts. The USACE does not plan to digitize its river charts for distribution to users, but it has digitally scanned its St. Louis-to-New Orleans charts for internal use in survey and river maintenance operations. USACE charts for the Tombigbee River from Demopolis, Alabama, to the Tennessee River are also being digitized for internal use and should be completed next year.

The NAVSTAR Global Positioning System (GPS) provides a highly accurate[29] navigational aid that is available worldwide, and international organizations are cooperating to develop standards for GPS equipment and electronic charts. Navigating in rivers and restricted waters requires a more accurate system, and the differential GPS (DGPS) is being developed to meet this need.[30] DGPS land stations, which have broadcast ranges of up to 240 miles, broadcast corrections for use by GPS receivers. The station network for the U.S. east and south coasts is being tested and evaluated, and the entire network is scheduled to be operational by January 1996. The USACE, in cooperation with the Coast Guard, has built DGPS stations in St. Louis, Missouri; Memphis, Tennessee; and Vicksburg, Mississippi. The DGPS station network for the Mississippi River, which is also being tested and evaluated, is expected to be operational by June 1997. The Coast Guard plans to build 11 more DGPS stations in the Western Rivers area.

Digital chart technology, coupled with GPS navigation technology, has made possible continuous electronic representation of navigational positions on computer. Mariners have long plotted their positions based on where they were rather than where they are. Electronic charting will give them continuous, real-time data, allowing them to monitor their positions by looking at the screen. The Safety Board welcomes these advances in technology, which should significantly improve navigation safety. If an electronic charting system and the DGPS had been available and installed on inland towing vessels such as the MAUVILLA, the accident at the Big Bayou Canot railroad bridge could have been avoided. The Safety Board believes that the Coast Guard and the USACE should promote the development and application of low-cost electronic charting navigation devices for inland rivers.

*Compasses.*--Most inland river towing vessels do not have a compass on board, nor do they usually need one to navigate rivers safely. Nonetheless, a compass can be a useful, inexpensive navigation aid that allows an operator to determine the vessel's heading and to verify information obtained from the radar. Used in conjunction with charts and radar, a compass can enable an operator to determine his heading without having to rely on visual cues. It can indicate

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[29]It can give positions accurate to 100 meters.

[30]Accuracy is in the 8- to 10-meter range, and greater accuracies are possible. Newer GPS receivers are of higher quality and yield greater accuracy, which is also a function of the vessel's closeness to the DGPS station.

the amount of heading change, a particularly important feature when no visual cues are available, as is the case during dense fog, for example.

If the MAUVILLA had been equipped with a suitable compass and if the pilot had been trained to read one, he would have been able to determine the amount of heading change between the Mobile River and the Big Bayou Canot, and this cue alone may have alerted him to the fact that he was in the wrong waterway. The difference in compass headings between the two bodies of water is about 95 degrees.

As a result of its investigation of the collision of the towboat FREMONT and tow with the containership JURAJ DALMATINAC, in the Houston ship channel on December 21, 1992,[31] the Safety Board recommended on January 21, 1994, that the Coast Guard:

M-93-41

Require that tugs and towboats operating on the navigable waters of the United States be equipped with a suitable compass.

On April 26, 1994, the Coast Guard responded that it concurs with the recommendation and has initiated rulemaking that will address this issue. Pending publication of the final rules, the Safety Board has classified Safety Recommendation M-93-41 "Open--Acceptable Response." The Coast Guard is also studying the need for radar, swing meters, and navigation charts aboard towing vessels.

The Safety Board made a similar recommendation to the AWO:

M-93-46

Recommend that member companies operating tugs and towboats on the navigable waters of the United States equip their vessels with a suitable compass.

The AWO supports this recommendation and disseminated it to AWO members in the February 11, 1994, issue of the *AWO Letter*. In some areas of the Western Rivers system, according to the AWO, a swing meter may be more appropriate than a compass. The Safety Board has classified M-93-46 "Closed--Acceptable Action."

### Bridge-Related Factors

The Mobile and Montgomery Railroad built the original bridge at this location--two truss

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[31]Marine Accident Report--*Collision of the U.S. Towboat FREMONT and Tow with the St. Vincent and the Grenadines-Registered Containership JURAJ DALMATINAC, Houston Ship Channel, December 21, 1992* (NTSB/MAR-93/02).

spans and a trestle--between 1880 and 1885, having been granted permission to do so by act of Congress. In 1909, the Louisville and Nashville Railroad, which had purchased the line, removed one truss span and replaced it with a through steel-plate girder span. The second, southernmost truss span was replaced by a longer one in 1925. The bridge became part of the Seaboard Coastline system in 1983 and part of the CSXT system in 1986.

The through steel-plate girder span, about 140 feet long, rested on three piers and was anchored to the center and north piers with bolts. It rested on a bearing plate on the south pier and, in accordance with the design, was not bolted to that pier. The girder span was designed so that it could be readily modified for use as a swing span, but the machinery was never installed and the bridge remained a fixed bridge.[32] The track structure on the bridge was continuous over the spans. Neither the USACE nor the Coast Guard required bridge protection systems, such as lights, markers, dolphins, and fenders, and none were in place at the time of the accident. CSXT testified that the bridge did not warrant such systems because it is not on a commercially navigable waterway.[33]

Postaccident inspection of the bridge revealed no structural deficiencies that would have decreased the load-carrying capacity for which it was designed. The damage found was that caused by the impact from the MAUVILLA and its six barges and by train 2's collision with the structure. The bridge was built according to design and was sufficient to carry the vertical loads and horizontal wind loads for which it had been designed.

CSXT informed the Safety Board that it replaced the Big Bayou Canot railroad bridge with a permanent structure following the accident. The 140-foot through-girder span and 60-foot timber approach were replaced with three rolled-steel beam spans (49 feet, 46 feet, and 43.5 feet long, respectively) and one 63.5-foot steel riveted girder span. Supporting the spans are four steel-pipe pile towers and the existing south pier. Replacement began on September 27, 1993, and was completed on October 3, 1993. No permit was required and none was requested.

*Bridge vulnerability to vessel collision.*--Various factors, alone and in combination, make bridges such as the one over the Big Bayou Canot vulnerable to impact from or collision with marine traffic. Vulnerability, by definition, is "a function of the estimated risk *and* the ability to cope with consequences should they occur."[34]

Many vulnerability factors were relevant in this accident. For example, the bridge is over

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[32]A stationary span, that is, one that remains in position and does not move.

[33]Since the accident, the Coast Guard has instructed CSXT to provide navigation lights on the bridge and has installed dayboards at the entrance to the Big Bayou Canot to alert mariners to the bridge's presence in the bayou. In a recommendation on its Report of Vessel Casualty or Accident (Form CG-2692), W&GN asked the Coast Guard to review the need for additional aids to navigation on the waterway.

[34]See William D. Rowe, "Risk Assessment Processes for Hazardous Materials Transportation," National Cooperative Highway Research Program, *Synthesis of Highway Practice 103*, November 1983, Washington, D.C., p. 8.

a tidal waterway and has a low vertical clearance, about 7 feet, that is not shown on all river charts. Occasional use of the Big Bayou Canot for barge fleeting was another vulnerability factor. In addition, the bridge had no warning devices, and the bayou had no navigation aids. Fog also sometimes limits visibility in the vicinity, which includes the heavily traveled Mobile River less than 0.7 mile to the east.

Until about 1950, the standard inland river dry cargo hopper barge used to transport grain and other dry bulk cargoes was 175 feet long, 26 to 27 feet wide, and about 10 feet deep; it carried about 900 tons of cargo. Today, the standard hopper barge is 195 feet long, 35 feet wide, 11 to 12 feet deep, and has a capacity of 1,400 to 1,500 tons of cargo (about 4 to 5 times the weight of the barge). About 1965, 200-foot hopper barges began to be built. In 1969, the AWO estimated the number of tugs and towboats at 4,300 and the number of barges at 18,400; today, those numbers are about 5,800 and 31,000, respectively.

During the past 30 years, waterway traffic has increased significantly between mile 3 and mile 427 on the Mobile, Black Warrior, and Tombigbee Waterways, as these data show.[35]

| Calendar Year | Statement of Traffic |
|---|---|
| 1960 | 5,801,107 tons |
| 1970 | 11,132,650 tons |
| 1980 | 14,708,012 tons |
| 1990 | 21,949,000 tons |
| 1992 | 23,191,000 tons |

The Mobile District, USACE, Lock Utilization Report for the Demopolis, Alabama, Lock & Dam,[36] mile 213.4, Tombigbee River, shows that the number of tows locking north and southbound, averaged 3,624 per year from 1983 through 1987 and 4,064 from 1988 through 1992. In 1993, the last year for which figures are available, 4,056 tows used the lock.

The CSXT provided drawings and records that include references to two incidents involving the Big Bayou Canot bridge, one in 1927 and another in 1979.[37] A handwritten note dated January 27, 1927, on one drawing refers to the north pier of the through-plate girder span; it states that the bridge was "hit by boat and concrete cracked" but does not indicate the "boat" type or size. According to the records, concrete on the north pier and pier cap had been damaged; a crack under the east bearing support extended about 5 feet below the pier cap through the full thickness of the cap, which was subsequently repaired.

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[35]Waterborne Commerce of the United States, Part 2, Gulf Coast, Mississippi River System and Antilles. Published annually by the U.S. Army Corps of Engineers, Navigation Data Center, Waterborne Commerce Statistics Center, New Orleans, Louisiana. The 1992 data was published in January 1994.

[36]Mobile District, USACE, reports usage on this lock because most of the river traffic on the Black Warrior and Tombigbee Waterways passes through it.

[37]Neither the FRA nor the Coast Guard has a record of the 1927 or 1979 incidents, and the Coast Guard had not received any complaints about the Big Bayou Canot bridge from mariners.

Two repair plans were prepared for the bridge in 1979. The first, dated October 5, 1979, was for repairs to the concrete cap of the south pier on both the east and west ends (upstream and downstream) of the through-plate girder span. The repairs included reconstruction of the top of the south pier cap. A retired Louisville & Nashville Railway (L&N) bridge engineer told the Safety Board that he went to Mobile in 1979 to inspect a bridge at Escambia Bay that had been damaged as a result of Hurricane Frederic. Following that inspection, he traveled, at the local bridge supervisor's request, to the Big Bayou Canot bridge, where the supervisor proposed to repair the concrete on the south pier of the through-plate girder span. The engineer said that these repairs were part of routine maintenance.

The second plan, dated November 1, 1979, was for replacement of five steel stiffener angles, five fill plates, and two splice plates and for straightening of the web and two other steel stiffener angles on the north end of the east girder's east (downstream) side. This plan indicated that the span had been "struck" but did not state what had struck it. Two L&N memorandums, one dated October 4, 1979, and one dated November 5, 1979, attribute the damage to the span's north end to barge strikes. The damage did not affect the serviceability of the bridge and did not disrupt rail traffic.

NOAA reported that Hurricane Frederic, a category 3 hurricane, came inland near Mobile along the Mississippi-Alabama State line on September 12, 1979. According to the Saffir-Simpson hurricane scale, a category 3 hurricane has winds of 111 to 130 mph, a storm surge of 9 to 12 feet above normal, and serious coastal flooding. It blows down large trees and results in floating debris that batters larger structures; terrain lower than 5 feet above sea level may be flooded inland 8 miles or more. Frederic was the most serious hurricane thus far in this century to affect the Mobile, Alabama, and Pascagoula, Mississippi, area. The highest reported wind was a gust of 144 mph on Dauphin Island bridge, about 40 miles south of Big Bayou Canot at the mouth of Mobile Bay.

As recently as 1986, commercial vessels navigated in the bayou between the Mobile River and the bridge to fleet (moor barges along a riverbank) and to tie off.[38] If barges were moored in the bayou during Hurricane Frederic, one or more may have broken loose from the mooring and struck the bridge. Large, water-borne debris may also have struck the bridge during this storm. The Safety Board believes that the damage to the north end of the span, which was discussed in the November 1, 1979, repair plans, was probably due to a barge strike that may have occurred as a result of high water and winds generated during Hurricane Frederic.

American Railway Engineering Association (AREA) standards recommend that bridges be designed for the combined effects of dead load, live load, impact load, wind load, centrifugal load, other lateral loads, and longitudinal loads. Railroad bridges, like highway bridges, are designed to withstand lateral loads resulting from wind, stream flow, and, depending on the site,

[38]The USACE has not issued any permits for permanent fleeting facilities in the Big Bayou Canot, and the Coast Guard was unaware of any commercial navigation there until the accident occurred. W&GN applied for a fleeting permit in 1981 but subsequently withdrew the application.

ice and drift, but not the extreme lateral loads generated by events such as barge collisions.[39] The Big Bayou Canot bridge was designed in accordance with the standards in effect when it was built, and a recent structural analysis by CSXT showed that it conformed with current AREA standards. However, the bridge was not designed to resist loads from a vessel collision. The mass of the piers provided inherent lateral resistance to lateral loads from the collision. However, the bearing supports of the through-plate girder span provided comparatively little lateral resistance to movement due to a vessel collision, and the span's low vertical clearance made the structure vulnerable to severe damage.

*Track and bridge alignment protection.*--Although the collision of the MAUVILLA with the Big Bayou Canot bridge moved the south end of the structure horizontally about 38 inches out of alignment, the rails remained intact. Track wayside signal circuitry is dependent upon the continuity of the rails. Had the rail broken as a result of the collision and subsequent displacement of the bridge and track, the signal at Bayou Sara railroad bridge, about 1.7 miles from the accident site, would have displayed a red or "stop" aspect. Because the rails remained intact and rail continuity was maintained, the signal circuitry was not interrupted. The signal displayed for train 2 on the night of the accident was clear or "proceed," as the assistant conductor confirmed when he said he heard the locomotive crew call the signal over the radio. According to tests performed after the accident, the signal system operated as designed.

The Safety Board first addressed the issue of bridge alignment protection after a Union Pacific freight train, traveling westbound at 50 mph, struck a displaced bridge at Devil's Slide, Utah, on November 17, 1979, derailing 5 locomotive units and 56 cars. Damage estimates exceeded $5 million. As a result of its investigation of that accident, the Safety Board issued Safety Recommendation R-80-36, asking the FRA to study "the feasibility of installing a mechanism which can be incorporated in the automatic block system to indicate when bridges are displaced."

On May 6, 1981, the FRA responded, noting that the 98,000 route-miles of track currently within block signal territory in the continental United States contain some 85,000 bridges. The cost of installing a mechanism to detect bridge displacement on each of those 85,000 bridges would be about $850 million, according to the FRA, and maintenance costs would total an additional $85 million per year. The FRA also stated that of the 41,627 railroad accidents that occurred between 1976 and 1979, only 20 were caused by displaced bridges or bridges that failed under load. Of those 20, four resulted from misalignments that could have been detected by the recommended mechanism. The FRA weighed the cost against the number of accidents and concluded that projected costs far outweighed the benefits.

In its August 1981 reply to the FRA, the Safety Board noted the FRA's comments concerning installation and maintenance costs for such a mechanism. The Safety Board also stated that these costs, an average of $10,000 to install and $1,000 to maintain annually, were excessive and asked for a copy of the FRA's analysis. The FRA did not respond to the Safety

[39]Railroad bridges are also designed to resist the lateral loads resulting from nosing, which is the horizontal thrust that a wheel flange can deliver to the rail.

Board's request.

On April 30, 1984, the FRA stated that it had reviewed railroad accident data from 1980 through 1982 and found only six accidents involving bridges, most of which were due to overloading, weakened support systems, or both. None were caused by misalignment that could have been detected by an automatic device.

On February 25, 1985, the Safety Board classified Safety Recommendation R-80-36 "Closed--Acceptable Action." The FRA had done the feasibility study that the Safety Board requested. The Safety Board urged the FRA to review periodically the merit of this safety recommendation in light of advances in signal technology, and the FRA agreed to do so.

Since January 1982, the FRA has received reports of five other incidents, including the Mobile accident, in which derailments occurred as a result of displaced bridges. Four of the five were caused by trucks, which damaged bridges, displacing the track ahead of a train.

According to the FRA, the railroad industry has not adopted a standard system for detection of bridge misalignment. Some carriers have designed site-specific detection devices for bridges vulnerable to damage from impact or rail displacement. The devices comprise commonly available components, combined to meet the unique requirements of each structure, and typically transmit an alarm indication through the wayside signal system.

In an October 1993 Safety Board telephone survey, five major railroad signal suppliers stated that no mechanisms or devices have been designed to detect bridge misalignment on signal or nonsignal track. They indicated development costs would be high and would require extensive research. The Safety Board has observed demonstration projects of such devices (as yet untested by the railroads), and the results concerning their effectiveness have been inconclusive. Whether such a device is needed and, if so, what level of resources should be devoted to developing one are important questions. The FRA is evaluating the need for bridge alignment protection and assessing the availability of new technology that can be used in this effort.

*Bridge lighting protection.*--Before 1967, the USACE regulated bridges over navigable waterways of the United States. In 1967, these functions were transferred to the Coast Guard. The USACE had not issued a permit for the Big Bayou Canot railroad bridge, and a Coast Guard administrative decision exempted all existing bridges for which a permit had not been issued from having to have one.[40] Moreover, the Big Bayou Canot bridge was in the "advance

[40]The term "permit" refers to the license that allows construction of bridges and approaches in or over navigable waters of the United States. Title 33 CFR 114-118, which sets forth the licensing regulations, states: "The decision as to whether a bridge permit. . .regulation will be issued. . . must rest primarily upon the effect of the proposed action" on "the reasonable needs of navigation after full consideration of the effect of the proposed action on the human environment." The law requires that plans submitted with permit applications show the least clear height of the lowest part of the superstructure over navigation openings; only structural details necessary to illustrate the effect of the proposed structure on navigation have to be provided. Additional factors that must be considered include Federal and State environmental issues, comparison with existing bridges over the waterway, and the attitude of local authorities.

approval" construction category and normally would not have to obtain a permit because it spanned a waterway not usually used for commercial navigation. According to Coast Guard testimony:

> There was never a permit issued to this bridge. Our indication was that it was built in 1909, but it might have been before that based on the testimony we've heard. And there hasn't been one required since that time, because it was grandfathered in when we took the program over.

While bridges over waterways in the advance approval category do not require a permit, they are subject to the regulations for lighting and marking. Nonetheless, "the Coast Guard may exempt bridges over waterways with no significant nighttime navigation from lighting and other signal requirements."[41] The owner is responsible for the cost of installing and maintaining such devices. Neither the USACE nor the Coast Guard required that the Big Bayou Canot railroad bridge be lighted, and CSXT did not do so.

On March 15, 1994, the Coast Guard Research and Development Center, Groton, Connecticut, analyzed the detection range of bridge hazard lights. According to the Coast Guard's data, if visibility is 200 feet, a hazard light is not detectable until a mariner is 400 feet from it; if visibility is 100 feet, the detection range is 236 feet. At the time of the accident, visibility was about 200 feet. Therefore, the MAUVILLA's pilot, in a pilothouse that was more than 400 feet from the head of the tow, probably would not have detected a hazard light, if one had been installed on the railroad bridge. Had the deckhand been on the head of the tow to guide the pilot, as is the usual practice when approaching an object to tie up to, he might have detected the lights in time to avoid hitting the bridge. However, the MAUVILLA's pilot, concerned about the deckhand's safety in the dense fog, had ordered him back to the towboat.

On November 30, 1993, the Coast Guard required CSXT to mark the Big Bayou Canot railroad bridge with permanent lighting by April 30, 1994 (CSXT did so on April 27, 1994), citing the following reasons:

> The bridge site on Big Bayou Canot is in close proximity to the Mobile River, which has a deep and wide channel heavily utilized by commercial traffic.
>
> The bridge crosses Big Bayou Canot, a tributary of the Mobile River, which has a natural channel like the Mobile River. There are few natural landmarks that allow mariners to visually distinguish between this waterway and the Mobile River.

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[41]Commander, Eighth Coast Guard District, New Orleans, Louisiana, letter file 5800, November 17, 1993. An application to construct a bridge includes a description of proposed lighting and other signals. Even if the Coast Guard approves the markings as proposed and requires no modifications or additions, it may alter the requirements for display of lights and other signals after construction when local conditions warrant such changes.

There are no obstructions or other hindrances to navigation between the Mobile River Channel and the bridge site, thereby allowing commercial vessels access to the bridge site.

The geography of Bayou Sara, Big Bayou Canot, and the Mobile River in the vicinity of the CSX Railroad Bridge is similar enough that in periods of reduced visibility or at nighttime, mariners could become disoriented without additional visual aids.

Vessels transiting the Mobile River may enter Big Bayou Canot in error, particularly at nighttime or during periods of limited visibility.

*Waterway bridge protection.*--The Coast Guard decides what type(s) of navigation aids will be placed in waterways. Through surveys under the Waterways Analysis and Management System (WAMS), the Coast Guard determines whether current aids are sufficient or changes are necessary. The last WAMS on the Black Warrior/Tombigbee/Mobile River System, completed in January 1988, revealed few problems with navigational aids. The Coast Guard also conducts daytime and nighttime patrols of waterways and meets with waterway users every 2 months. Towboat operators are usually the first to call attention to a problem with a navigation aid or lack of one. Neither towboat operators nor companies had complained to the Coast Guard about the Big Bayou Canot bridge before the accident.

No warning sign(s), waterway markings, or aids to navigation had been placed in the Big Bayou Canot indicating the presence of a railroad bridge across the waterway before the accident. In November 1993, the Coast Guard installed two standard, all-waterways warning markers, one on each side of the Big Bayou Canot about 700 yards from the bridge, or 350 yards from the Mobile River.[42] The markers' range of visibility is 1 mile in daylight and clear weather, although vessels have to be much closer for observers to read the warning; visibility in fog is a function of the density of the fog and the distance of the observer. The signs were lighted on May 4, 1994, and should therefore be more useful during periods of reduced visibility. The Coast Guard will maintain them.

On January 24, 1994, Coast Guard Headquarters initiated a survey of bridges across navigable waters that is being conducted by all Coast Guard districts.[43] The purpose of the survey is to assess the effectiveness of navigation aids in approaches to bridges over navigable waters, as well as the need for additional bridge protection measures, including lighting and fendering systems. The survey extends to those tributaries and waterways used as fleeting areas or sufficiently deep and wide to allow commercial vessels access to a bridge; the approaches to

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[42]The signs, which meet the requirements of the Coast Guard's *Aids to Navigation Technical Manual*, are 3-foot by 3-foot white diamonds, with a 2-inch orange retroreflective border; the word DANGER in 6-inch black letters is in the center, with FIXED above and BRIDGE below in 3-inch black letters.

[43]Commandant Notice 16590, January 24, 1994, subject: Survey of Bridges Across Navigable Waters of the United States.

the Big Bayou Canot railroad bridge are examples of such waterways. In the first 6 months, district personnel will consider various safety issues, including lighting and fendering systems on bridges over waterways used by commercial vessels. Then, district staff will evaluate the need for fendering and lighting on each bridge and follow up with bridge owners to ensure timely and appropriate corrective action.

Coast Guard Headquarters will receive and maintain on file reports describing the actions required by the districts and taken by bridge owners. Headquarters did not provide the districts with uniform, objective criteria to use in conducting the survey. The Safety Board is therefore concerned that the district staff evaluations will be subjective, when what is needed is a set of objective criteria against which to evaluate bridges over navigable waterways nationwide. Nonetheless, the Coast Guard survey is long overdue. It should be part of an ongoing process, not a one-time effort.

*Comprehensive bridge risk assessment.*--The Big Bayou Canot railroad bridge, like thousands of other railroad and highway bridges in the United States, is vulnerable to marine vessel collisions. Vessels commonly strike bridges, but because most of these collisions are minor, they go unreported. They generally do not result in damage to the bridge or the vessel and do not meet criteria for reporting an incident to the Coast Guard or the FRA. Nonetheless, the Safety Board has been notified of 21 significant marine vessel collisions with highway and railroad bridges since the accident at Big Bayou Canot occurred. CSXT alone has 11,000 railroad bridges in service (1.7 million linear feet; CSXT classifies as a bridge any span more than 48 inches long). The Safety Board examined CSXT records of bridge strikes for the 4-month period from December 2, 1993, to April 4, 1994, and found that of 48 incidents, only one met the threshold for reporting to the Coast Guard or the FRA.[44]

Although no significant commercial traffic uses the Big Bayou Canot, the railroad bridge over the bayou is at some risk because it is adjacent to a commercially navigable waterway. Risk from marine vessel collisions is probably greater to bridges that span such waterways than to those located near them. The Mobile River bridge, for example, about 3 miles north of the Big Bayou Canot railroad bridge, is 1,846 feet long and consists of an 80-foot through-girder span, three 210-foot through trusses, a 340-foot through-truss swing span, and a 796-foot timber trestle. It is equipped with navigation lights and pier fender protection (which meet local Coast Guard standards) only near the swing span, where marine traffic passes through the swing span, and is manned 24 hours a day by a bridge tender whose job is to open and close the swing

[44]Title 46 CFR 4.05 requires that marine casualties be reported as soon as possible to the nearest Coast Guard Marine Safety or Marine Inspection Office and in writing within 5 days. One reporting criterion is damage to property that exceeds $25,000. On December 10, 1993, the Secretary of Transportation reported that the Coast Guard will initiate rulemaking, expected to be published in midsummer 1994, requiring that casualties be reported immediately and that a notice of a hazardous condition include vessel collisions with a bridge, shore structure, or other stationary object. In addition, the Coast Guard will seek to increase, through legislation, the maximum civil penalty for failing to report a marine casualty from $1,000 to $25,000. Title 49 CFR Part 225 requires that any accident involving a train collision or derailment be reported to the FRA if the damage is $6,300 or more. FRA policy is to investigate accidents resulting in the death of a railroad employee or passenger or in five or more injuries; such accidents must be reported to the agency immediately by telephone.

bridge for marine and rail traffic.

However, the Mobile River bridge has no lights or pier protection on the approach spans. In reduced visibility, a bridge tender at the swing span could have difficulty detecting a problem on the approach spans. Because of its greater exposure to river traffic, the Mobile River bridge is more likely to be the site of a catastrophic barge collision than the Big Bayou Canot bridge. The former could have sustained an accident similar to the one at the latter, and in fact, barges have hit the Mobile River bridge three times in the 6-month period from December 1993 through May 1994.

While bridge strikes are fairly common, comprehensive tracking of their occurrence and systematic evaluation of bridge vulnerability to vessel collision are lacking. Ensuring that appropriate protective measures are provided for bridges such as the one over the Big Bayou Canot is an issue that requires a coordinated national effort. This accident emphasizes the need for such an undertaking to avoid similar mishaps. The actions taken to protect the Big Bayou Canot railroad bridge, however laudable, may not be sufficient to prevent a similar incident, and the degree to which thousands of other bridges are at risk is unknown.

Determining which protective method or combination of methods is appropriate depends on the vulnerability of each structure and thus should be preceded by a comprehensive risk analysis, which will make possible a rank ordering of bridges in need of protection. The accident in Mobile occurred only a few months after another serious vessel collision and bridge collapse that the Safety Board investigated.[45] These incidents underscore the urgent need to develop a comprehensive risk assessment methodology for bridges and to ensure that it is uniformly applied to all bridges in the United States.

The term "risk," according to a previous Safety Board study, refers to the probability of an event occurring and the consequences of the occurrence.[46] Risk assessment is the process by which risks are identified, quantified, qualified, analyzed, and presented; it combines these variables into a single measure of risk, thereby allowing a comparison and ranking of the factors being analyzed. Risk management uses the results of this analysis to reduce risk to an "acceptable level" and can be applied to any bridge in the Nation, including the one that spans the Big Bayou Canot. The operational factors for each bridge in the United States are unique and should determine the type of protection provided for each structure.

Protection from vessel collision can be provided in several ways. New bridges can be built with large vertical and horizontal clearances. In the case of existing bridges that cannot be moved or replaced, other measures are available to minimize risk. They include changes to the channel or aids to navigation such as signs, buoys, retroreflective material on the structure,

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[45]Highway-Marine Accident Report--*U.S. Towboat CHRIS Collision with the Judge William Seeber Bridge, New Orleans, Louisiana, May 28, 1993* (NTSB/HAR-94/03).

[46]Special Study--*Protection of Transportation Facilities Against Earthquakes*, (NTSB/STS-72/01).

bridge lighting, radar reflectors, radar beacons (RACONS),[47] and fog signals.[48] Islands, caissons, dolphins, and fenders are also means of affording protection. Manually activated traffic control devices, alignment or movement detection systems, and clear bridge identification to facilitate the notification process are all measures that can reduce loss of life or property in the event of an accident. The Safety Board believes that the DOT should consider the use of RACONS, radar reflectors, and other devices to make bridges more identifiable on radar.

Bridges for which the chance of a catastrophic accident is highest should receive the greatest protection. A railroad bridge that carries numerous passenger trains, hazardous material loads, or both across a waterway merits more attention than a bridge over the same waterway that does not. Similarly, a bridge that spans a waterway with traffic of 200 barges a day is at greater risk than one that spans a waterway carrying 5 barges a day. The location of a bridge is another consideration. A railroad bridge upstream of the Big Bayou Canot bridge, for example, would be exposed to less risk from marine vessel collision because vessels would have to pass under the Big Bayou Canot structure first.

Several factors, including the volume of railroad traffic, numbers of passenger and hazardous material trains, proximity to commercial navigation channels, and volume of marine traffic, should be considered when assessing the vulnerability of railroad bridges to collisions from marine vessels. Only when the vulnerability of a bridge has been adequately assessed can an informed decision be made on the appropriate type of protection. The assessment method should allow vulnerability to vessel collision among bridges to be compared so that priorities for protective measures can be assigned.

Highway bridges are also at risk from vessel collisions, as the collapse of the Judge William Seeber Bridge in New Orleans, Louisiana, on May 28, 1993, demonstrated. The Safety Board discussed the factors that must be considered in conducting a risk assessment of highway bridges in its report on that accident. Among those factors are daily vehicle traffic over the bridge and the structure's importance to the local economy.

The Safety Board reviewed various State and other programs that affect bridge safety through design, construction, inspection, maintenance, and regulatory oversight. Navigation safety, including the granting of bridge permits, is the responsibility of the Coast Guard. The USACE maintains navigation channels. The FHWA and the States oversee regulatory requirements relating to design standards for new highway bridges and vulnerability of highway bridges to vessel collisions. FRA regulations for railroad bridges are limited to protecting personnel who are doing work on bridges. Responsibility for railroad bridges rests with the individual railroads, which use the AREA's *Manual of Recommended Practice* for the design,

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[47]When triggered by a vessel's radar signal, RACONS transmit a coded reply display on the vessel's radarscope and provide the approximate range and bearing to the beacon.

[48]As provided at 33 CFR 118, Coast Guard District Commanders can require such items for bridges. Often they are not required, especially on bridges in the advance approval category, until the maritime industry, having experienced problems with a structure, requests a change in existing protective measures from the Coast Guard. Until an accident occurs, whatever protective measures are in place are considered adequate.

construction, inspection, and maintenance of bridges, together with their own specifications, as dictated by the nature of their operations. The following section provides an overview of some initiatives affecting new and existing bridges.

The Safety Board is aware of two States that have a risk assessment methodology for bridges to ensure a thorough and systematic analysis of highway bridge vulnerability. The California Transportation Department (CALTRANS) has developed a program to prioritize more than 24,000 highway bridges in the State for seismic retrofit upgrading; CALTRANS adjusted its risk analysis procedure over a 3-year period, as more information became available.[49]

New York State bridge engineers developed a "safety assurance" program[50] that the Safety Board also examined. Under this program, a review of previous failures, imminent failures, and actual closures provides the basis for identifying probable causes and modes of bridge failures. Using a rating system based on considerations such as site and structural characteristics, engineers categorize and rank structures according to their vulnerability to various failure modes. They also formulate strategies to reduce or eliminate vulnerability over the short and long term.

To evaluate vulnerability to vessel collisions, the New York program reviews factors such as barge traffic, accident history, and structural continuity. It also categorizes bridges over waterways according to type--navigable, nonnavigable, and the State canal. Since bridges may be vulnerable to more than one extreme event, vulnerability is analyzed according to a structure's rank in each failure mode. As circumstances change, for example, if waterway traffic increases or corrective action is implemented, each risk is reevaluated. The last phase under the program is implementation of actions recommended to reduce the bridge's vulnerability.

In 1991, the American Association of State Highway and Transportation Officials (AASHTO) published a *Vessel Collision Guide*, and the FHWA has recommended its use for design of highway bridges. The specifications embody new concepts not included in previous design guidelines. They focus on vessel collisions with piers and also cover superstructure above-water clearances and vessel impact potential, albeit by ship masts. To identify bridges that must continue to function after impact from a design vessel,[51] the guide recommends classifying bridges as either "critical" or "regular" using social-survival and security-defense requirements as criteria. It also discusses several analytical methods for selecting a design vessel, and it recommends probability-based risk analysis because that method requires the least number of judgment calls by the analyst. Current provisions do not address assessment of the highway

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[49]James E. Roberts, "Practical Lessons From the Loma Prieta Earthquake-Highway Bridges," paper presented at the American Association of State Highway and Transportation Officials (AASHTO) Bridge Conference, Denver, Colorado, May 1993.

[50]A.M.Shirole, "Planning for a Comprehensive Bridge Safety Assurance Program," paper presented at the March 1991 Bridge Engineering Conference sponsored by the Transportation Research Board and the FHWA, Denver, Colorado.

[51]The design vessel that has the minimum impact requirement is an empty drifting barge.

bridge and surrounding area as a whole to identify factors that make a structure vulnerable to vessel collisions.

Although the AREA's *Manual for Recommended Practice* does not prescribe guidelines for extreme events, such as vessel or vehicle collision, it does recognize the effects on the substructure by allowing for pier protection, additional reinforcement, collision walls, or an increase in mass to provide overturning resistance. Because the AREA manual does not provide guidelines for performing a risk assessment of new or existing railroad bridges, the Safety Board contacted several class 1 railroads concerning their methods of performing a risk assessment on bridges that may be vulnerable to being struck by maritime or surface equipment.[52]

Each railroad stated that it maintains the accident history for bridge impacts with the file for that structure. Not all impacts are reported; some are discovered during the inspection process. The railroads indicated that they do not record information for data base-type retrieval. Most bridge engineers recalled only major collisions that required either bridge replacement or substantial repairs. They estimated that fewer than three such incidents occur a year, accounting for less than 1 per cent of total impacts. These events generally involve either movable spans over navigable streams that are struck by a vessel, resulting in major repairs to the structure, or spans that are struck by highway vehicles, resulting in a train derailment due to track misalignment.

The railroads stated that annual inspections of the superstructure and periodic underwater inspections are the basis for determining whether changes to a bridge are necessary. None of the carriers said they had a formal risk assessment plan. Those structures that require more than routine maintenance are reviewed by bridge engineers, using their engineering judgment and taking into account railroad traffic projections, economics, increased loading, and estimated remaining life (fatigue evaluation). Extreme events such as floods; slides; and impact from ice, debris, and collision are considered, in accordance with regulations and design standards. Evaluation of each structure is site-specific for location and previous accident history.

On April 1, 1994, the AREA adopted new guidelines for seismic design of railway structures. The guidelines were specifically developed to reduce structural damage from earthquakes, and they integrate seismic criteria into railroad bridge design, maintenance, and retrofit for the first time. The AREA stated that the major reason for developing these guidelines was that railroad bridges have historically performed well in seismic events, sustaining little or no damage. The AREA noted three important factors: (1) "the bridges are traversed by a track structure that functions very effectively as a restraint against longitudinal and lateral movements during an earthquake"; (2) "railroad bridges are typically very simple in their design and construction"; and (3) "the types of damages that are permissible for railroad bridges are completely different from highway and other bridges that are used by the public in an environment far less controllable than the movement of trains."

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[52]The carriers contacted were the Canadian National Railroad, the Atchison, Topeka & Santa Fe Railway Company, the Consolidated Rail Corporation, the Chicago and North Western Railroad, and the Illinois Central Railroad.

Lacking a coordinated national bridge risk assessment program, bridge owners have implemented their own risk assessment programs, either formally or informally. In the absence of a comprehensive risk assessment methodology, standards to judge the adequacy of such programs are not available.

No single entity is responsible for the safety of the Nation's bridges. Federal, State, and local governments, as well as private industry, share that responsibility, and such fragmentation of authority often leads to a piecemeal, uneven approach to bridge safety. What's more, bridge safety involves several transportation modes, including marine, railroad, and highway; and several Federal agencies, including the Coast Guard, the FRA, the FHWA, and the USACE, have a role in oversight of these modes. The Safety Board concludes that development of a national risk assessment program for determining bridge vulnerability to vessel collision is needed and believes that the DOT modal agencies should develop one. The Safety Board further concludes that the transportation regulatory agencies need a standard methodology for determining the vulnerability of the Nation's highway and railroad bridges to collisions from marine vessels, for formulating a ranking system to identify those bridges at greatest risk, and for providing guidance on the effectiveness and appropriateness of protective measures.

The Safety Board believes that the DOT should convene an intermodal task force for this purpose. At a minimum, the methodology should address the highway bridge factors discussed in the Safety Board's report on the collapse of the Judge Seeber Bridge and the railroad bridge factors discussed in this report. It should include a ranking system that will identify bridges at greatest risk so that protective measures can be prioritized. In addition, it should provide guidance on the effectiveness and appropriateness of protective measures such as warning signs, lighting, navigation markers, alignment detectors, pier protection, dolphins, caissons, and radar beacons.

As the DOT agency that regulates the railroad industry, the FRA should maintain close contact with all railroad companies and with the AAR and the American Short Line Railroad Association (ASLRA), which represent the owners of the majority of the Nation's railroad bridges. The FRA should work with the AAR and the ASLRA on matters pertaining to railroad bridge safety. The Safety Board believes that in the absence of a single entity charged with oversight of all U.S. bridges, the FRA is the appropriate agency to assume responsibility for railroad bridge safety and should require that all railroad bridges be included in a national risk assessment program that employs the comprehensive risk assessment methodology developed by the DOT.

While the DOT is developing a national risk assessment methodology, the AAR and the ASLRA should independently initiate certain activities. They should immediately begin to collect data on vessel collisions with railroad bridges from their members. By doing so, the information needed to understand the bridge collision problem and to develop an effective national risk assessment program will be available to the DOT early in its methodology development process. Data on bridge-vessel collisions may also be helpful in identifying the types of bridges that should be included in the risk assessment, as well as those bridges that are especially vulnerable to collisions and thus require immediate protective action by the railroads, the Coast Guard, or other agencies. The Safety Board believes that the AAR and the ASLRA should immediately

begin to collect such data from their members and, if appropriate, take steps to increase protection for bridges identified as vulnerable.

The railroad industry must also fully cooperate with the DOT to determine the appropriateness of each bridge protection system and the actual level of protection and risk reduction that each protective method provides. The interests of bridge safety are not served by the railroad industry standing by while the DOT devises a national bridge risk assessment methodology. The Safety Board believes that the AAR and the ASLRA should cooperate with the DOT in developing a national risk assessment program for railroad bridges.

The Safety Board also believes that the Nation's highway bridges should be included in this process. Since no single entity has oversight of all U.S. bridges, the FHWA is the appropriate agency to assume responsibility for highway bridge safety and should require that all highway bridges be included in a national risk assessment program that employs the methodology developed by the DOT.

## Emergency Response

Several circumstances hampered emergency response efforts. The accident site was remote, accessible only by rail, water, or air; fog in the area was dense, requiring the use of radar to navigate boats; limited modes of transportation were available for bringing in personnel and equipment; and the magnitude of the accident was great. Nonetheless, following a delay while responders identified the location of the accident, emergency response activities were efficient and effective.

The Mobile Police Department's 911 operator, who contacted the Mobile Fire Department about 3:02 a.m., had been told that the accident occurred at the Bayou Sara bridge and the Mobile River instead of the Big Bayou Canot,[53] about 1 1/2 miles away. Some 18 minutes elapsed as police and fire departments and CSXT personnel determined the location and jurisdiction of the accident. Units from the Mobile Fire Department, which was prepared to respond regardless of the jurisdiction, were dispatched at 3:20 a.m.

After emergency responders arrived at the accident site, they began rescue operations, recovery of bodies, triage, and firefighting activities. The Coast Guard on-scene commander provided assistance and resources, including planes, helicopters, boats, and manpower, throughout the emergency. The MAUVILLA's crew, SCOTT PRIDE personnel, train crewmembers, and volunteers were all instrumental in rescuing people from the water and evacuating passengers from the train immediately following the accident. Once under way, these activities proceeded smoothly and in a timely manner. The Safety Board concludes that, overall, the emergency response was well-coordinated and effective.

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[53]The Mobile Fire Department's map, which has since been replaced, did not even show the Big Bayou Canot due to an omission during photocopying.

However, Amtrak's portable emergency lighting measures, its safety briefing procedures, and its method for compiling passenger lists all need to be improved, as do State emergency drills involving railroad operations.

### Portable Emergency Lighting

According to passengers in coach 34040, which remained on the bridge, darkness prevailed outside the car after the derailment. Battery-powered emergency lighting, available inside the coach, provided some illumination, but only the traincrew had flashlights, which were not part of Amtrak's emergency equipment. A few passengers had penlights to use while walking down the tracks in the dark. The Safety Board concludes that because Amtrak did not equip its passenger cars with portable lighting, passengers were at a disadvantage in evacuating the train. The Safety Board believes train 2 should have been equipped with portable lighting for use by passengers in an emergency.

Passengers reported that once cars entered the water, emergency lighting became inoperable, further complicating evacuation from the submerged cars.[54] Without light from a few penlights and from the fire that ensued following the accident, no light would have been available to passengers in these cars. Because emergency lighting was unavailable in the submerged cars, passengers had difficulty locating and moving to exits in the dark. The Safety Board is unable to determine whether emergency lighting, if operable, would have been effective in the muddy water.

### Safety Briefings

Amtrak uses signs and placards, as well as briefings, to inform passengers about the safety features on its trains. This accident casts doubt on the effectiveness of Amtrak's briefing system for communicating such information.

Signs in Amtrak cars indicate the location of first-aid kits, fire extinguishers, and emergency windows; signs on the ceilings adjacent to emergency windows are phosphorescent. Each emergency window has signs explaining how to remove it from both the inside and the outside. Signs posted in the car vestibules and elsewhere throughout the cars also give instructions about window removal.[55] Some passengers on train 2 reported having noticed the signs on the emergency windows.

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[54]According to Amtrak, each car had about 15 receptacles, equipped with 15-watt bulbs, in the ceiling, as well as emergency lighting at the ends, the exit signs, and down the stairs. Amtrak noted that possible reasons for the emergency lighting failing in this accident include impact damage to the batteries or cables connecting the batteries to the cars, impact damage to the light fixtures, and water damage to the circuits and fixtures.

[55]Placards, approximately 17 by 22 inches, at the end of each car read as follows: "Attention Passengers. Emergency Instructions. Each car is equipped with a minimum of 4 marked emergency window exits in addition to the marked emergency door exits. Emergency equipment is also provided." The "Emergency Window Removal" instructions state: "Locate red plastic handle on window. Use red handle to strip away rubber molding. Locate metal handle on window and pull towards you to remove window pane."

Amtrak has provided written guidelines on safety briefings in two employee publications. The *General Rules/Manuals of Service Instructions for On Board Service Employees* state:

> All train attendants are responsible for including the following information as part of their routine passenger orientation:
>
> - That they have received special training in handling unusual or emergency situations and are prepared to assist in the event of such occurrence.
> - That passengers should notify their attendant immediately if they become aware of any emergency on the train.
> - That they are available for passengers' questions about procedures and locations of exit doors, emergency windows in their cars and fire extinguishers.

According to the "Guidelines for Effective Announcements" in Amtrak's *Manual of Instruction for Transportation Department Employees*, conductors are required to make the following announcement during departures from all stations:

> Please observe in the seat pocket in front of you or on the bulkhead at each end of your car, an Emergency Exit Instruction Card. Please take a moment to read the procedures for emergency door and window exit instructions.

Thus, both OBS personnel and conductors have responsibility for safety briefings on Amtrak trains. Amtrak's written guidelines do not further delineate their duties in this area. Train 2's assistant conductor testified that he usually reinforces the safety briefings provided by the OBS supervisor. The lead service attendant said he believed that he heard a safety briefing over the public address system, and two passengers indicated that because of information provided by the traincrew, they knew the location of emergency exits. Several passengers did not recall hearing a safety briefing by anyone during their trip from Los Angeles to Mobile. If safety briefings were provided in all sections of the train, they were not effective because some passengers reported that they did not receive the information.

Moreover, while Amtrak's manuals state that such briefings are to be routinely given at all stations, an Amtrak official testified that the briefings are to be provided at the beginning of a trip and at major stops, noting that a "major stop" has not been defined. He added, "You want to have enough announcements that are informative but not so many that it becomes a burden. . .so it varies by route and type of service." Los Angeles might reasonably be considered a major stop; however, some passengers boarding there said they were not given a safety briefing. They believed that such a briefing would have helped them evacuate the train quickly.[56]

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[56]The conductor on train 2 in Los Angeles is no longer employed by Amtrak; despite repeated attempts, investigators were unable to contact him after the accident to ask him whether he had given a safety briefing.

After the accident, several passengers said they did not recall hearing a safety briefing when they boarded the train. One passenger provided the following account:

> My mother-in-law [had] asked us did we know where the emergency exit was. It was at her seat. . .I woke up as the train started derailing. . .water began rushing in then we went straight to the emergency exit. We only had a few seconds because it was sinking fast. I don't remember seeing any other passengers besides the three of us and our actions were to escape from the car through the emergency window. . .only because [my mother-in-law] asked before we left New Orleans. We didn't have time to look. . .We just knew where it was and without question we were there.

Another passenger stated, "The car filled with water so fast it was very dark. . .I only wanted to find the door. . .I did not know about any emergency exits. . .No one told me what to do in an emergency. . .I got on in Los Angeles." A third passenger said he could not swim and that a fellow passenger helped him evacuate through an exit. He added, "Crewmembers must point out the emergency exits when passengers board the train. . .we boarded at 11 p.m. so even though I sat next to an exit, I didn't consciously notice it."

One passenger who helped several other passengers testified that this trip was his first one on Amtrak and that he did not recall hearing a safety briefing when he boarded in Los Angeles. A fellow passenger commented: "There needs to be emergency instructions provided by the crew (like the airlines). You don't think something like this will ever happen to you. . .so emergency instructions aren't that important. I know emergency procedures for a plane from hearing it so many times."

Since most OBS crewmembers were asleep in the dorm-coach and since the train attendants were in the cars on the bridge, passengers in the submerged cars had to make decisions on their own and evacuate without assistance. The fact that at least some apparently had not received safety briefings added to the confusion. Fortunately, a few passengers took control of the situation, located exits, and told others what to do. Safety briefings give passengers confidence that they know what actions to take in the event of an emergency and thus help motivate them to respond appropriately.

The Safety Board concludes that some passengers on board train 2 were unaware of safety information and that Amtrak does not have an effective system for apprising passengers of such information. Current written guidelines allow the OBS supervisor and train attendants to determine at which stations they will give briefings about emergency procedures, and the guidelines direct conductors to make an announcement about such procedures during departures from all stations. However, according to an Amtrak official, the conductor's announcement is required at the beginning of the trip, and either the conductor or OBS personnel are to give additional briefings at "major" stops, which have not been defined. The Safety Board believes Amtrak needs to develop and implement a uniform system to effectively apprise passengers of information pertaining to safety features.

### Adequate Passenger Lists

During rescue activities on the day of the accident, an Amtrak representative provided the incident commander with a partial passenger and crew list and told him that about 200 people were on board. A list compiled later the next day showed 207 people. The delay in providing an exact count caused problems because the incident commander had to assign personnel to spend a day counting tickets to help develop a passenger list. In addition, emergency responders did not know when to discontinue rescue operations because the count changed frequently. The railroad was not aware that three infants were on board because they were not ticketed. If Amtrak had issued nonrevenue tickets for the infants, they would have been included on the passenger list.

The Safety Board concludes that emergency responders were at a disadvantage because they were unable to obtain an adequate passenger and crew list from Amtrak until the next day. The Safety Board believes Amtrak needs to improve its passenger and crew count procedures so that accurate passenger lists can be furnished to local authorities with minimum delay.

### Event Recorder Crashworthiness

Each locomotive unit was equipped with an event recorder. The lead locomotive unit (819) had a Pulse Electronics solid-state memory unit, and the two trailing locomotives (262 and 312) had Bach-Simpson paper-strip chart speed recorders. Locomotive 819's solid-state memory unit did not sustain significant damage due to impact, but large amounts of mud and water were found inside its enclosure, which was not watertight. Data for the period from 12:43 a.m. on September 22 until the time of the accident could not be recovered from 819's event recorder because of fluid immersion-induced corrosion, electrolysis of the power pins on some battery-backed memory devices, or both. The paper recording media from locomotives 262 and 312, although slightly damaged by moisture, were legible and provided time, speed, and distance data from New Orleans to the accident site.

The data recovered from the paper recording media on the two trailing locomotive units indicated that the Sunset Limited's speed at the time of the derailment was about 72 mph. Because of the water damage to 819's Pulse Electronics unit, important data about the train's operation in the 2 hours preceding the derailment could not be recovered. When functioning properly, such a unit records the following information that is often vital to accident investigation: date and time, drive wheel rotations, traction motor current (load amps), automatic brake pressure, throttle position, horn (on/off), cab signal acknowledgement (on/off), PCS OPEN (open/closed), independent and dynamic brakes (on/off), and alerter and brake valve cutouts (on/off).

The Safety Board has investigated other accidents in which event recorder data were lost

as a result of fire or water damage.[57] The Safety Board believes that the loss of event recorder data during this accident is further evidence of the need to develop and implement crashworthy locomotive event recorders, and in 1993, the FRA issued a final rule on event recorders that acknowledges this need.[58]

As indicated in the rule, because of the time required to develop crashworthy event recorders and equip trains with them, the FRA is seeking first to expeditiously equip locomotives on trains traveling at more than 30 mph with acceptable existing event recorders and then to proceed with crashworthiness and standardization issues. The Safety Board looks forward to helping the FRA and the railroad industry increase the likelihood that recorded data are available to support railroad accident investigations.

## Disaster Preparedness

*CSXT notification.*--The owner of the Big Bayou Canot bridge, CSXT, did not have an up-to-date telephone listing of local authorities. The number for the Coast Guard in the Mobile telephone directory was incorrect. Consequently, the yardmaster was unsuccessful in his initial attempt to contact the Coast Guard and had to call the operator for assistance.

On November 30, 1993, following its investigation of the July 31, 1991, train accident at Lugoff, South Carolina, the Safety Board recommended that CSXT:

R-93-20

Maintain an up-to-date emergency response telephone list.

On April 15, 1994, CSXT informed the Safety Board that it is preparing emergency contact notebooks that will provide emergency numbers for counties within each of its operating subdivisions. CSXT reported on June 24, 1994, that it has completed notebooks for all 15 of its subdivisions and noted that it is developing a program to computerize the information.

*Emergency drills.*--Although the Mobile County Emergency Management Agency (MCEMA) held drills to simulate transportation accidents before this accident, those drills did not include simulations of an accident involving railroad operations. In testimony, representatives from Amtrak, CSXT, Mobile County, and the Coast Guard said that they had never discussed the potential for an accident on the CSXT bridge.

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[57]See, for example, Railroad Accident Report--*Head-on Collision Between Burlington Northern Railroad Freight Trains 602 and 603 Near Ledger, Montana, on August 30, 1991* (NTSB/RAR-93/01); the Safety Board has also identified this issue in its investigation of the Kelso, Washington, collision between Burlington Northern train 01-111-10 and Union Pacific train NPSEZ-09 on November 11, 1993 (report forthcoming).

[58]On July 8, 1993, the FRA published its final rule, which amends 49 CFR 218 and 229, Chapter II, Subtitle B.

The MCEMA had most recently conducted a drill, simulating an aircraft accident, on June 17, 1993, in Mobile Bay. The local police and fire departments, Coast Guard, Sheriff's Department, and other agencies involved in the September 22 Amtrak accident participated. Similar drills for accidents involving railroad operations would give participating agencies an opportunity to learn about their responsibilities and jurisdictions and to practice notification procedures, as well as methods of accounting for passengers and crew.

The Safety Board concludes that if the MCEMA had held drills to simulate a train accident, the incident commander may have known about Amtrak's procedures for ticketing passengers, and CSXT may have had the correct telephone number for the Coast Guard. The Safety Board therefore recommends that the Federal Emergency Management Agency encourage local authorities to conduct emergency drills that simulate transportation accidents involving railroad operations.

*MCEMA critique of emergency response.*--In testimony, both the incident commander and the SAR controller discussed the emergency response to this accident. On September 28, 1993, the MCEMA conducted a critique of the emergency response that included representatives from many responding agencies. A synopsis of major suggestions and observations follows:

- Because the Civil Air Patrol provided real-time television pictures to the MCEMA, the agency was able to monitor conditions at the accident site.

- Agencies and volunteers shared their resources and helped transport equipment to the accident site.

- Cellular phones were used to reduce radio communication problems and to limit battery use.

- Had smaller boats been available to the Mobile Fire Department, it could have used them to transport personnel and equipment around the accident site.

- Amtrak representatives had to show divers the layout of cars that remained on the bridge because they were not familiar with the train equipment. Since the accident, floor plans and a videotape describing Amtrak's emergency procedures have been provided to the Mobile Fire Department.

A postaccident critique such as this one, especially when done in conjunction with periodic drills, is a valuable tool for identifying and implementing improvements in emergency response procedures.

### Bridge Identification

Emergency responders were delayed in identifying the location of the accident site because Big Bayou Canot bridge had no waterway mile marker or nameplate, thereby creating confusion and hindering marine response activities. When the captain of the MAUVILLA notified the Coast Guard Group Mobile that an accident had occurred, he was unable to identify the bridge; train 2's crew was unable to do so as well. Marine responders were uncertain which bridge was involved until about an hour after the accident.

The MAUVILLA's captain and pilot thought they were near either the Bayou Sara railroad bridge (mile 8.2) or the Fourteen Mile railroad bridge (mile 13.3). At 3:20 a.m., the captain reported to the Group that he was north of Twelve Mile Island and, at 3:25 a.m., that the train had run off the Fourteen Mile bridge. Coast Guard radio traffic shows that the captain and pilot did not know until 3:55 a.m. that they were in the Big Bayou Canot (mile 9.7). Coast Guard, City of Mobile, and other vessels responded to the accident by heading up the Mobile River to the Bayou Sara railroad bridge. Upon arrival there, they realized the accident was at another location, and they continued upriver until they sighted the glow of flames on the Big Bayou Canot. This confusion about the accident location would have been eliminated had the bridge borne a marking that response centers could recognize.

Not long after the accident at Mobile, another bridge striking occurred that posed a similar identification problem. At 9:55 a.m. on December 1, 1993, the towboat JENNIE DEHMER and its two-barge tow struck the Norfolk Southern Railroad bridge at mile 647.3, Tennessee River, in Knoxville, Tennessee, displacing the bridge pier 12 to 18 inches and the track 9 inches. The towboat operator on watch reported the accident at 10 a.m. to the Coast Guard Group Ohio Valley radio operator, giving the location as the Louisville and Nashville (L&N) Railroad bridge "just above the 647 point something or other [646.6], here in downtown Knoxville."

About 11:10 a.m., CSXT, which owns the L&N bridge, informed the Coast Guard that the bridge involved was in fact the Norfolk Southern Railroad bridge at mile 647.3. The dispatcher in Knoxville called about 11:45 a.m. to advise the Coast Guard that someone looking out his office window had seen the accident and immediately called Norfolk Southern Railroad, which was able to prevent a train about 4 miles from the damaged bridge from crossing it.

If bridges over waterways had some form of marking visible from both water and land, making identification simple and quick, confusion could be eliminated. Marking a bridge would help mariners and others readily identify it and advise emergency response personnel of the location, thereby facilitating notification of the bridge owner and proper authorities, who could control or stop bridge traffic. As the Mobile and Knoxville accidents demonstrate, prompt bridge identification is critical to ensure efficient movement of response forces to the accident scene and to halt land traffic about to transit damaged structures.

The Safety Board concludes that all bridges vulnerable to impact by commercial marine traffic should be required to have appropriate markings so that they can be identified promptly

from land and water in the event of an accident or other emergency. The Safety Board believes that the Coast Guard should require such markings and periodically publish a list of them as part of a national bridge register. Such an inventory should be available to emergency response organizations and, following publication, should be included on navigation charts.

## CONCLUSIONS

### Findings

1. The traincrew's qualifications and the condition of the track, signals, and train equipment did not contribute to this accident.

2. The Sunset Limited, traveling about 72 mph, derailed after striking a girder that had been displaced about 38 inches when the towboat MAUVILLA, pushing six barges, struck the Big Bayou Canot railroad bridge.

3. Had the pilot used the radar as visibility deteriorated, he could have observed the intersection formed by the Mobile River and the Big Bayou Canot and could have avoided turning his tow and barges into the wrong waterway.

4. The pilot exercised poor decisionmaking under the prevailing conditions by continuing to navigate when he could not find a tree to which to tie up, by continuing his approach to an unidentified object, and by not summoning help from other crewmembers.

5. Warrior & Gulf Navigation Company did not provide adequate radar navigation training to the pilot, nor did it provide him with a compass.

6. Warrior & Gulf Navigation Company's written evaluation form did not fully identify and assess those skills critical to vessel operation, limiting its value as a management tool for ensuring safe vessel operations.

7. The American Waterway Operators, Inc., should encourage member companies to incorporate into towboat operator evaluations a practical method of assessing proficiency in navigation, including the use of radar.

8. Coast Guard standards for inland towing vessel operator licensing are inadequate because they do not address the radar skills that are necessary for safe operation of vessels in restricted visibility.

9. All uninspected towing vessels should be required to carry appropriate navigational devices, including charts, in the wheelhouse; and all such vessels, except those operating in very limited areas, should be required to have a radar installed.

10. Delays in obtaining samples from vessel crewmembers, which prevented conclusive determination of whether alcohol was a factor in this accident, could continue to be a factor in marine accidents because Coast Guard regulations applicable to postaccident alcohol testing do not specify the time limits within which such testing must be conducted.

11. As evidenced by information provided by his employer and a statement from his doctor, the pilot had been able to control his diabetic condition satisfactorily since 1982 and the disease most likely did not preclude him from operating the MAUVILLA safely.

12. Warrior & Gulf Navigation Company should establish procedures that encourage towboat operators to inform management when they are taking medication, determine whether such medication may affect their performance of duties, and arrange for a qualified relief, if necessary.

13. The transportation industry needs to disseminate information and educational materials that stress the relationship between use of medications (over-the-counter and prescription) and an employee's fitness for duty.

14. Damage to the bridge discussed in repair plans issued on November 1, 1979, was probably due to a barge strike that may have occurred as a result of high water and winds generated during Hurricane Frederic.

15. Currently available data pertaining to bridge-vessel collisions are insufficient to allow the U.S. Department of Transportation to develop a bridge risk assessment methodology or to allow the railroads to systematically identify vulnerable bridges and take action to increase protection for them.

16. Development of a national risk assessment program for railroad bridges requires the full cooperation and support of the railroad industry.

17. The U.S. Department of Transportation's development of a national risk assessment program for determining bridge vulnerability to vessel collision is needed.

18. To carry out a national risk assessment program for highway and railroad bridges, the transportation regulatory agencies need a standard methodology so that they can determine the vulnerability of the Nation's highway and railroad bridges to collisions from marine vessels, formulate a ranking system for identifying those bridges at greatest risk, and provide guidance on the effectiveness and appropriateness of protective measures.

19. Bridges vulnerable to impact from commercial marine traffic should bear unique, readily visible markings so that waterway and bridge users are better able to identify bridges involved in accidents when reporting such mishaps to emergency responders; a list of bridge identification markings should be published periodically in a national register of bridges.

20. Considering the remoteness of the accident site, the weather conditions, and the limited modes of transportation available, the emergency response was well-coordinated and effective.

21. Amtrak did not have an effective system of apprising passengers of safety features, and some passengers were unaware of safety information.

22. Because Amtrak did not equip its passenger cars with portable lighting, passengers were at a disadvantage in evacuating the train.

23. Emergency responders were at a disadvantage because they were unable to obtain an adequate passenger and crew list from Amtrak until the next day.

24. If the Mobile County Emergency Management Agency had held drills to simulate a train accident, the incident commander may have known about Amtrak's procedures for accounting for passengers, and CSXT may have had the correct telephone number for the Coast Guard.

## Probable Cause

The National Transportation Safety Board determines that the probable causes of Amtrak train 2's derailment were the displacement of the Big Bayou Canot railroad bridge when it was struck by the MAUVILLA and tow as a result of the MAUVILLA's pilot becoming lost and disoriented in the dense fog because of (1) the pilot's lack of radar navigation competency; (2) Warrior & Gulf Navigation Company's failure to ensure that its pilot was competent to use radar to navigate his tow during periods of reduced visibility; and (3) the U.S. Coast Guard's failure to establish higher standards for inland towing vessel operator licensing. Contributing to the accident was the lack of a national risk assessment program to determine bridge vulnerability to marine vessel collision.

## RECOMMENDATIONS

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

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

Convene an intermodal task force that includes the Coast Guard, the Federal Railroad Administration, the Federal Highway Administration, and the U.S. Army Corps of Engineers to develop a standard methodology for determining the vulnerability of the Nation's highway and railroad bridges to collisions from marine vessels, to formulate a ranking system for identifying bridges at greatest risk, and to provide guidance on the effectiveness and appropriateness of protective measures. (Class II, Priority Action) (I-94-3)

Require that the Federal Railroad Administration and the Federal Highway Administration, for their respective modes, use the methodology developed by the intermodal task force to carry out a national risk assessment program for the Nation's railroad and highway bridges. (Class II, Priority Action) (I-94-4)

Require the modal operating administrations to develop and disseminate bulletins, notices, circulars, and other documents that call attention to the need for an employee reporting procedure concerning use of medication (over-the-counter and prescription) while on duty and that urge the transportation industry to develop and implement informational and educational programs related to this subject. (Class II, Priority Action) (I-94-5)

Consider the use of RACONS, radar reflectors, and other devices to make bridges more identifiable on radar. (Class II, Priority Action) (I-94-6)

--to the U.S. Army Corps of Engineers:

Cooperate with the U.S. Department of Transportation in developing a standard methodology for determining the vulnerability of the Nation's highway and railroad bridges to collisions from marine vessels, formulating a ranking system to identify bridges at greatest risk, and providing guidance on the effectiveness and appropriateness of protective measures. (Class II, Priority Action) (I-94-7)

Promote, in cooperation with the U.S. Coast Guard, the development and application of low-cost electronic charting navigation devices for inland rivers. (Class II, Priority Action) (M-94-30)

--to the U.S. Coast Guard:

Amend 46 CFR 4 and 16 to specify the time limits, not to exceed 8 hours, within which employers must conduct postaccident alcohol testing. (Class II, Priority Action) (M-94-31)

In consultation with the inland towing industry, develop radar training course curricula standards for river towboat operations that emphasize navigational use of radar on rivers and inland waters. (Class II, Priority Action) (M-94-32)

Upgrade licensing standards to require that persons licensed as Operators of Uninspected Towing Vessels hold valid river-inland waters radar observer certification if they stand navigation watch on radar-equipped towing vessels and to require that employers provide more specific evidence of training. (Class II, Priority Action) (M-94-33)

Require that all uninspected towing vessels carry appropriate navigational devices, including charts, in the wheelhouse. (Class II, Priority Action) (M-94-34)

Promote, in cooperation with the U.S. Army Corps of Engineers, the development and application of low-cost electronic charting navigation devices for inland rivers. (Class II, Priority Action) (M-94-35)

Require that radar be installed on board all uninspected towing vessels except those that operate within very limited areas. (Class II, Priority Action) (M-94-36)

Require that all bridges vulnerable to impact by commercial marine traffic bear unique, readily visible markings so that waterway and bridge users are better able to identify bridges involved in an accident when they report such accidents to emergency responders. (Class II, Priority Action) (M-94-37)

Periodically publish a list of bridge identification markings in a national register of bridges. (Class II, Priority Action) (M-94-38)

--to the National Railroad Passenger Corporation (Amtrak):

Develop and implement a uniform system to effectively apprise passengers of information pertaining to safety features. (Class II, Priority Action) (R-94-6)

Develop and implement procedures to provide adequate passenger and crew lists to local authorities with minimum delay in emergencies. (Class II, Priority Action) (R-94-7)

Equip cars with portable lighting for use by passengers in an emergency. (Class II, Priority Action) (R-94-8)

--to the Federal Emergency Management Agency:

Encourage local authorities to conduct emergency drills that simulate transportation accidents involving railroad operations. (Class II, Priority Action) (I-94-8)

--to The American Waterways Operators, Inc.:

Recommend that member companies equip their tugs and towboats with suitable navigation devices, including charts. (Class II, Priority Action) (M-94-39)

Assist the Coast Guard in developing a curriculum for a training course on river radar navigation. (Class II, Priority Action) (M-94-40)

Recommend that member companies incorporate into towboat operator evaluations a practical method of assessing proficiency in navigation, including the use of radar. (Class II, Priority Action) (M-94-41)

--to the Warrior & Gulf Navigation Company:

Require that company towboat operators complete a recognized training course on river radar navigation after the curriculum for such a course has been developed. (Class II, Priority Action) (M-94-42)

Establish a training protocol that requires company towboat operators to demonstrate proficiency in use of radar, compasses, and charts and incorporate into towboat operator evaluations a practical method of assessing proficiency in river navigation techniques, including use of radar. (Class II, Priority Action) (M-94-43)

Equip all company towboats with a suitable compass, a complete, up-to-date set of navigation charts for the waters over which the vessel is intended to operate, and other appropriate navigational devices. (Class II, Priority Action) (M-94-44)

Establish procedures that encourage towboat operators to inform management when they are taking medication, to determine whether such medication may affect performance of their duties, and to arrange for a qualified relief, if necessary. (Class II, Priority Action) (M-94-45)

--to the Association of American Railroads:

Immediately begin to collect data on vessel collisions with railroad bridges from your members and, if appropriate, take steps to increase protection for bridges identified as vulnerable. (Class II, Priority Action) (R-94-9)

Cooperate with the U.S. Department of Transportation in developing a national risk assessment program for railroad bridges. (Class II, Priority Action) (R-94-10)

--to the American Short Line Railroad Association:

Immediately begin to collect data on vessel collisions with railroad bridges from your members and, if appropriate, take steps to increase protection for bridges identified as vulnerable. (Class II, Priority Action) (R-94-11)

Cooperate with the U.S. Department of Transportation in developing a national risk assessment program for railroad bridges. (Class II, Priority Action) (R-94-12)

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**September 19, 1994**

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