NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF MARINE SAFETY
WASHINGTON, D.C. 20594

Nautical Operations, Human Performance, and System Safety Group
Factual Report

Dredge *Waymon Boyd*

Explosion and Fire following Propane Pipeline Strike
Near EPIC Dock, Corpus Christi Ship Channel
Corpus Christi, Texas

August 21, 2020, 0802 CDT

NTSB# DCA20FM026
(57 Pages)

August 20, 2021

Contents

Accident Identification

Type:	Major Marine Casualty, Damages Exceeding $500,000
Date/Time:	August 21, 2020 at 0802 CDT
Location:	EPIC Marine Terminal, Corpus Christi Ship Channel, Corpus Christi, Texas
Vessel:	Dredge *Waymon Boyd*
Owner/Operator:	Orion Marine Group
NTSB No.:	DCA20FM026
Injuries:	6
Fatalities:	4

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1 Overview

On Friday, August 21, 2020, about 0802 central daylight time, the US-flagged, nonpropelled, 151-foot-long cutter-head suction dredge *Waymon Boyd* struck a submerged 16-inch liquid propane pipeline during dredging operations adjacent to the EPIC Marine Terminal, located on the Corpus Christi Ship Channel in Corpus Christi, Texas (see figure 1). A geyser of gas and water erupted adjacent to the vessel. Shortly thereafter, an explosion occurred, and fire consumed the vessel and surrounding shoreline. A total of 18 personnel employed by Orion Marine Group were working or resting on the dredge and assist boats (tender boats, anchor barges, booster barges, and a supply barge) on the day of the accident. Four crewmembers died in the explosion and fire, and six were injured. First responders located the injured and transported them to local hospitals. They were eventually transferred to burn units in San Antonio, Texas, where one of the crewmembers later died from his injuries.

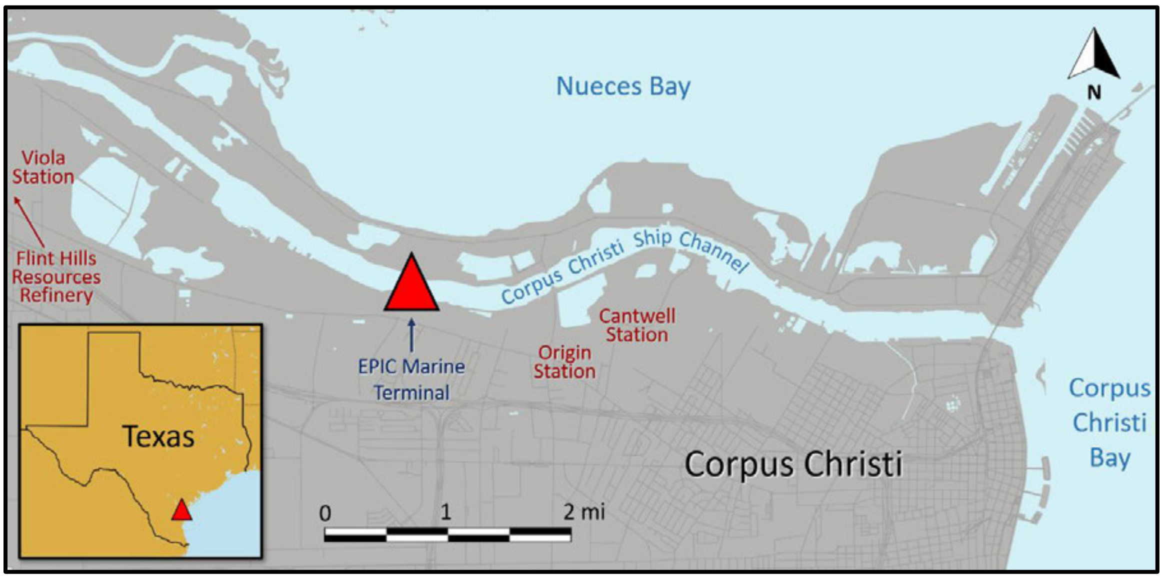

Figure 1. The accident site. (Background source: Google Maps)

2 The Accident

The EPIC Dock Project. In 2019, EPIC Crude Terminal Company, LP, a subsidiary of pipeline operator EPIC, began repurposing the dock at the former Interstate Grain Terminal, located on the Corpus Christi Ship Channel in Corpus Christi, Texas, to onload crude oil to tank ships for export (see figure 2). The facility, which is now known as the EPIC Marine Terminal, loaded its first tanker from the converted pier, designated the West Dock or EP-1, in December 2019. The West Dock is capable of loading "Aframax" sized tankers at a maximum rate of 20,000 barrels per hour.[1]

[1] An *Aframax tanker* is a medium-sized tank vessel with a carrying capacity between 80,000 and 120,000 deadweight tons, which equates to about 750,000 barrels of crude oil in an average-sized vessel of the class. The term Aframax is based on the Average Freight Rate Assessment (AFRA) system, a tanker size-classification system created by Royal Dutch Shell in 1954 to standardize contract terms. Because of its size, Aframax tankers can serve harbors and waterways that are too small to accommodate larger tankers such as Suezmax tankers and supertankers.

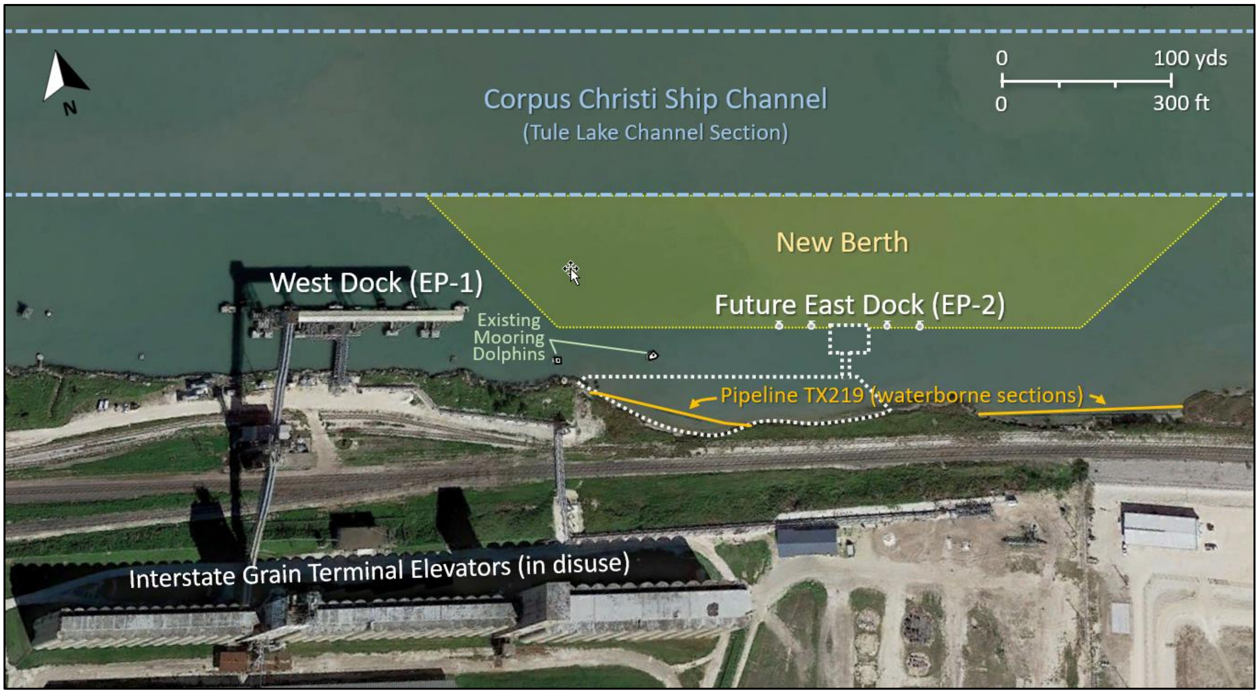

Figure 2. EPIC Marine Terminal, Corpus Christi, Texas. (Background source: Google Earth)

As the West Dock was being modified, EPIC Marine Terminals began planning for a second crude oil loading pier capable of supporting larger "Suezmax"-sized tankers at a maximum pumping rate of 40,000 barrels per hour.[2] The new pier, designated the East Dock or EP-2, was to be located on the same property, about 300 yards to the east of the West Dock. In addition to construction of the pier, the East Dock project required the dredging of a ship berth between the dock and the main shipping channel.

Project Start and Phase 1 Operations. The Orion Marine Group, a marine heavy construction firm, was selected by EPIC Crude Terminal Company to construct the East Dock and dredge the associated berth. The marine construction and dredging operations were contracted separately and undertaken by different divisions within Orion Marine Group, with dredging operations scheduled to be accomplished first. Due to the availability of equipment and access to the dredged material placement area (DMPA – the designated area where the dredged material was discharged), dredging for the East Dock was conducted in two phases. Phase 1 occurred from May to June 2019, and phase 2 was planned to occur from July to October 2020.

The initial plans for the EPIC East Dock and berth were developed by Jacobs, an engineering and construction services firm. The Jacobs dredging plans called for the berth to be excavated to a depth of −49 feet mean lower low water (MLLW). The depth was subsequently modified to −46.5 feet MLLW in the phase 1 plans developed by Jacobs titled "New EPIC Dock

[2] A *Suezmax* tanker is a large-sized tank vessel constructed to the maximum dimensions capable of transiting through the Suez Canal. These vessels typically have a capacity between 120,000 and 200,000 deadweight tons, which equates to between 800,000 and 1,000,000 barrels of crude oil.

Slip Dredging," to conform to the depth of the main shipping channel.[3] To achieve and maintain this depth, the area outward of the boundary of the berth was to be dredged on a slope with a grade of 2.5 feet of run for every 1 foot of rise (2.5:1 – see figure 3).

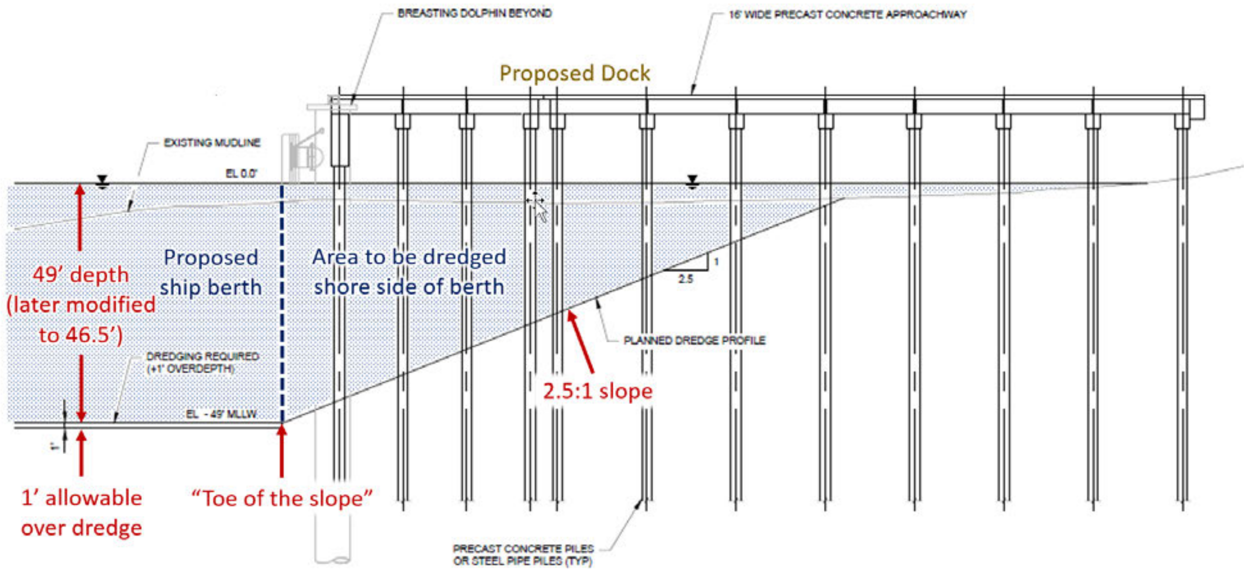

Figure 3. Cross-sectional view of EPIC Marine Terminal East Dock and berth from Jacob's original engineering plans for the project, with color and annotations added by NTSB (Source: Orion Marine Group)

Orion Marine Group's survey department was responsible for conducting hydrographic surveys of the project area before and periodically during dredging operations to determine the total amount of material to be removed and the progress toward removal. The head of Orion's survey department, the survey superintendent, was also responsible for building the dredge plan, also known as the "dredge template," in DREDGEPACK, a module in the hydrographic data collection and processing software HYPACK. Among other functions, DREDGEPACK was used by the operator on the dredge, called the leverman, to display where the digging tool that he was controlling—known as the cutterhead—was in relation to the dredge template. Using the software display, the leverman could determine in real time what areas required dredging and whether the cutterhead was operating within the dredge template (See section 5 for more information on HYPACK/DREDGEPACK).

Prior to the conversion of the West Dock, EPIC Crude Terminal had commissioned a survey to identify all utilities running through the terminal property, including electrical lines, fiber-optic lines, and pipelines. The survey was conducted by TMI Solutions LLC and was dated December 28, 2018. Among other utilities, the TMI surveyors located three pipelines that ran parallel to the shoreline along the entire length of the terminal area. Two of the pipelines were in active use, and the third was abandoned. Due to the undulating shoreline, the pipelines ran partly on land and partly in the water. The lines were buried onshore but partially exposed in the water, lying in the bottom sediment of the waterway. The active pipelines were owned and operated by

[3] *MLLW* is the average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch. Typically, depths on charts and in marine construction plans are measured from the height of tide at MLLW.

subsidiaries of Enterprise Products Partners, LP. The most northerly of the pipelines, designated TX219, carried liquefied propane.

On or about May 3, 2019, prior to the start of phase 1 operations, a pre-construction meeting was held with Orion and EPIC Crude Terminal representatives. Orion representatives present at the meeting included the project manager, the survey superintendent, and two dredge superintendents who shared supervisor responsibilities for the dredge captains. One of the dredge superintendents recalled that during the preconstruction meeting he was told that pipeline TX219 was "between 5 and 10 feet from the top of the [dredging area] slope."

On May 7, 2019, Orion made a notification of its intent to conduct excavation work via the Texas811 "Call Before You Dig," also known as "One-Call," system. Enterprise received notification tickets for their pipelines, and, a day later, two pipeline technicians visited the EPIC East Dock worksite. According to the technicians, they met with the "EPIC lead inspector" who told them that the dredging work would be north of the Enterprise pipelines. Although there was supposed to be no conflict with the pipelines, the EPIC representative stated that "cane poles"—bamboo poles about 18 feet in length—would be placed to mark the location of pipeline TX219. Each pole was stuck in the bottom sediment, with a majority of the pole exposed above the waterline. The Enterprise technicians returned to the site a few days later to confirm the poles were in place, and the One-Call tickets were closed.

On May 8, 2019, the Orion dredge *Leonard M. Fisher* was towed to the site, and dredging operations began the next day. Operations continued until June 27, and there were no issues reported during this phase.

Phase 2 Operations. In October 2019, EPIC Crude Terminal Company applied for and was granted a permit from the Army Corps of Engineers to enlarge the East Dock berth by extending it another 167 feet to the west. Consequently, Orion assigned Schneider Engineering and Consulting, a wholly owned subsidiary of Orion Marine Group's parent company, to update the dredging plans produced prior to phase 1 to reflect the revised berth dimensions.

EPIC Crude Terminal Company's facilities engineering manager stated that he requested that the pipelines identified in the 2018 TMI utilities survey be included in the dredging plans. The survey data was provided to Orion, and the information was subsequently forwarded to the Schneider design engineer tasked with developing the plans. The design engineer said that the survey data was imported into the computer-aided drafting (AutoCAD) software that he was using to develop the drawings. In a set of drawings entitled "EPIC Marine Terminal Dredging Construction Plans" dated June 23, 2020, the pipelines are shown in the "Existing Site Plan" drawing—an overhead view of the berth overlaid on a satellite image of the area—but do not appear in the remaining "Dredge Site Plan" and cross-sectional drawings of the site (see section 4 for further discussion of the Schneider dredging plans).

The design engineer told investigators that during the development of the plans, he determined that the pipelines were outside of the dredge template. He said he measured the distance between the edge of the template (the top of the slope) and the pipelines and determined that it was "in the neighborhood of…8–10 feet" at the closest point. The engineer stated that, while the personnel involved with the project were aware of the pipelines, there was no concern about their proximity to the dredging site. All Orion personnel that were interviewed by the NTSB stated similarly: the pipelines were not a major concern because they believed the pipelines were outside the dredge template. According to the project engineer, the pipelines were "far enough away."

Once the revised engineering plans for the East Dock berth were completed, they were passed to the Orion survey superintendent, who used the plans to build an updated dredge template in DREDGEPACK. He then loaded the template onto the computer on board the *Waymon Boyd*, the dredge scheduled to conduct the phase 2 work (see figure 4).

Figure 4. Dredge *Waymon Boyd* prior to the accident. (Source: Orion Marine Group)

On June 23, 2020, an Orion project engineer, who had not been involved with phase 1 operations, made a One-Call notification for the phase 2 dredging operations. In the notification, the engineer stated, "dredging area beings (*sic*) at waters edge." In response to the notification, tickets were once again generated for the two active Enterprise pipelines. A pipeline company technician—one of the same technicians that had responded to the 2019 One-Call tickets—contacted the Orion project engineer to discuss the project and set up a site visit. On June 29, the Orion project engineer sent the Schneider Engineering dredging plans to the Enterprise technician. In the accompanying email, she stated:

> It looks as though we will be about 60' off the shoreline, and the areas where the shoreline and pipelines are furthest in the water (closest to the new template), we have already completed dredging to grade…so there shouldn't be a need for concern.

A site visit with the Orion and Enterprise representatives was scheduled for June 30; however, due to issues stemming from the COVID-19 pandemic, they did not meet as planned. The Enterprise pipeline technician said that he "looked at the EPIC's plans and saw the prism where [the Orion project engineer] said that we're going to be working, and it was well offshore." According to the pipeline technician, he and the project engineer had a phone call during which they agreed that it was not necessary to physically mark the pipelines because they did not conflict with the dredging area. On the same day, another Enterprise technician closed the 2020 ticket for pipeline TX219 as "3-CLEAR," and included the following in the remarks: "EFQ pipeline TX219 will be clear from work area by 55ft. There will be no dredging near the channel shoreline." According to the Enterprise technician, this remark was based on the June 29 email from the Orion project engineer.

During a subsequent discussion between the Orion project engineer and project manager, concern was raised regarding the placement of anchors used in dredging operations. Although excavation was not expected to be near the pipelines, the Orion project manager suggested that the anchors could be placed in close proximity to them. He directed the project engineer to contact Enterprise again and inform the company about the anchors. The project engineer called the pipeline technicians, and they agreed to go out to the site and install cane poles to "courtesy" mark the pipeline.

On July 16, the project engineer and the two Enterprise technicians met at the dredging site and noted that "about half" of the cane poles put in place the prior year were still in place. They boarded a skiff (small boat) and, after locating pipeline TX219 using a handheld device, the Enterprise technicians re-marked the location using additional cane poles provided by Orion. The project engineer stated that the poles were placed on the channel side of the pipeline. The Enterprise technician estimated that the poles were spaced about 50 feet apart along the roughly 260-foot section of waterborne pipe, with the first being between 30 to 40 feet from the shoreline where the pipeline entered the water. A photograph of the accident site taken after phase 2 dredging operations began but before the accident occurred shows the cane poles beginning about halfway across that the inlet in the channel that the pipeline crossed (see figure 5).

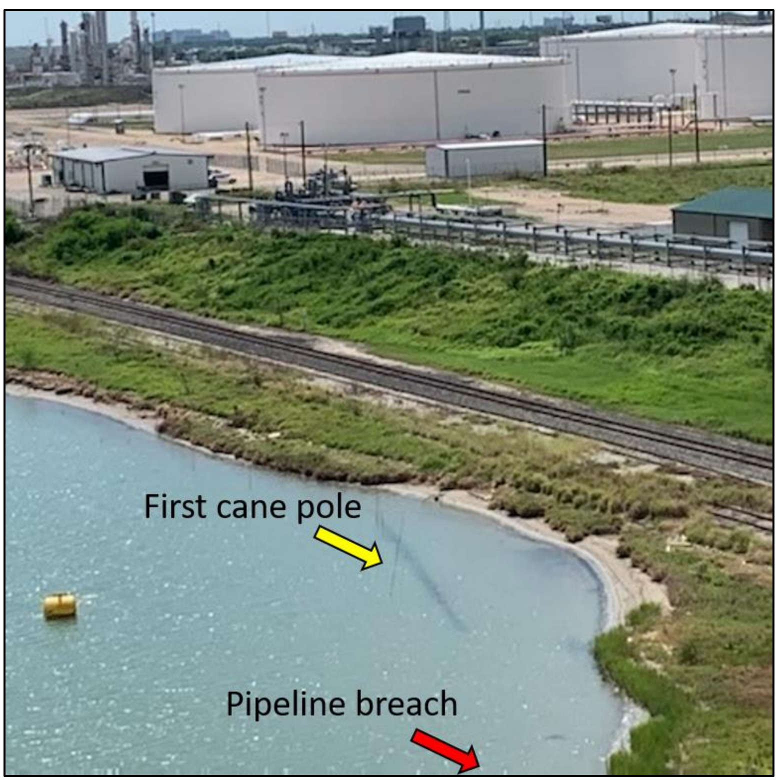

Figure 5. Preaccident photograph of marking cane poles. (Source: Epic Crude Terminal Company)

The technician stated that, whereas a compulsory marking required markers every 20 feet, a courtesy marking only required markers every 200 feet. After the cane poles were installed, the project engineer took photographs of the poles and the pipeline, which she stated was visible under the water.

On July 20, the project engineer emailed the photos to the *Waymon Boyd* with the following message:

> There are 2 pipelines near the shoreline at Epic. They are marked with cane poles and we've been asked to stay 20' away from them. Please keep in mind when working in the area and placing swing anchors.

Both the dredge captain and the deck captain—the first and second in command of the vessel, respectively—stated that they received and read the email. The dredge captain saw the cane poles and judged them to be spaced about 100–150 feet apart. The leverman said that he was not told about the purpose of the cane poles. Further, he stated that there were no cane poles in the area he was dredging on the morning of the accident and that all the cane poles were "behind the dredge," to the west, about "400 feet" away. In a post-accident survey, the nearest cane pole was measured to be about 145 feet east of the accident location.

The dredge captain recalled that he did not discuss the pipelines with the leverman, but he felt that the leverman knew where they were because of the leverman's experience and "because he can physically see it." The leverman said he was aware of a pipeline but believed there was only one —the single pipeline that he could visibly see under the water. He recalled that the captain told him to keep the dredge anchors away from the pipeline but did not give him a specific standoff distance. Multiple other subordinate crew members stated that they were not made aware of the pipelines.

Figure 6. *Waymon Boyd* cutter-head postaccident. The yellow nylon line was attached during salvage and not part of original equipment (Source: US Coast Guard)

The *Waymon Boyd* was a cutterhead-type dredge. A cutterhead is a rotating, toothed, digging tool (see figure 6) that is mounted at the end of framework, known as the ladder, at the bow of a dredge. The cutterhead can be lowered to the desired dredging depth by pivoting the ladder downward. When operating, the cutterhead breaks up the bottom sediment and other material to be dredged. The loosened material is then drawn away via a suction pipe that begins directly aft of the cutterhead. Suction at the pipehead is provided by pumps mounted on the ladder and/or in the dredge hull. The material is moved aft on the dredge via piping and then via a floating and/or submerged pipeline to a DMPA. Depending on the distance to the DMPA, barges with booster pumps may be placed along the dredge pipeline.

In the early morning on July 29, the *Waymon Boyd* was towed into position at the EPIC East Dock site, and phase 2 dredging began later that day once the dredge material pipeline was assembled and equipment was brought online. From then on, the *Waymon Boyd* operated 24 hours a day in two 12-hour shifts. During a normal 12-hour shift, the dredge and its attendant barges and support vessels were crewed by 17–19 personnel. The dredge captain and deck captain worked an alternating rotation of 10 days on and 4 days off, with the deck captain assuming overall responsibility of the vessel when the dredge captain was off rotation. Although the captains' normal working hours were 0600 to 1800, they were on call 24 hours a day when on board and worked additional time as needed. The remainder of the crew worked a rotation of 14 days on and 7 days off, from 0530 to 1730 or 1730 to 0530. Most of the crew was berthed ashore when not on shift and were boated to and from the dredge each morning and evening.

Through the end of July and the first weeks of August, the *Waymon Boyd* operated at the dredge site (see figure 7), working generally east to west beginning on the channel side and moving progressively inshore, as observed in AIS data. According to the dredge crew and a contractor monitoring progress on behalf of EPIC, the dredge had to stop regularly to clean out rocks and debris that had been sucked up by the dredge and lodged in the pump strainer and other areas. Dredging work was also occasionally halted for emergent repairs to equipment.

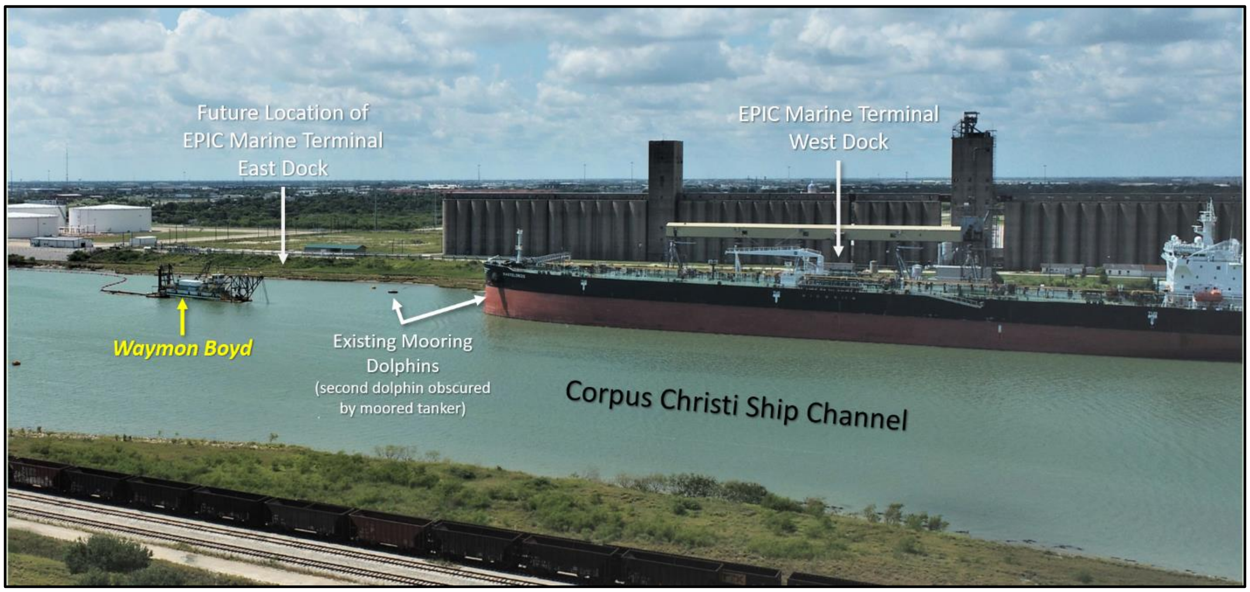

Figure 7. The *Waymon Boyd* at the EPIC Marine Terminal East Dock site, August 7, 2020. (Source: Orion Marine Group, annotated by NTSB)

At the beginning of the week of 16–22 August, a tanker was moored at the EPIC West Dock onloading crude oil cargo. Two mooring dolphins for the West Dock were located within the dredge template for the East Dock project, and the lines from the tanker to the dolphins prevented the *Waymon Boyd* from operating on the west side of the dredging area in the vicinity of the dolphins. Therefore, the dredge superintendent instructed the dredge captain to work the area east of the mooring dolphins until the ship departed.

The tanker departed about noon on Wednesday, August 19, and the dredge superintendent told the captain to reposition the dredge to begin working the area between the mooring dolphins. The dredge was moved into position that evening, and dredging work continued.

About 1730 on August 20, a coupling on the shaft that drove the cutterhead broke, bringing operations to a halt. According to the dredge captain, the coupling had a rubber core that was designed to shear to prevent gearbox damage if the cutterhead “hit something hard.” He stated that the coupling sheared that evening because the dredge had been hitting debris in the area where it had been operating. The night shift crew, along with the captain, began repair work immediately. The captain said that repairs of this kind normally took 3–4 hours, but because of corrosion on the coupling bolts, the repair was not completed until about midnight. After the repairs were accomplished and dredging operations recommenced, the dredge captain went to sleep. The deck captain was off rotation and not aboard the vessel.

About 0445 the next morning, the dayshift leverman took the controls of the vessel after a 10–15-minute turnover discussion with the off-going leverman. The oncoming leverman stated that, during the turnover, he was informed that the dredge was having “a lot of trouble with the rocks,” and that the rocks were preventing the dredge from reaching the top edge of the slope. After being relieved, the nightshift leverman went to the vessel’s berthing area.

The remainder of the crew conducted a shift change at 0530, and soon thereafter the on-coming crew gathered in and around the leverman’s station, called the lever room, on the top level of the dredge for a safety meeting. The safety meeting occurred twice daily, at the beginning of each shift, and included a discussion of one or two safety topics, as well as the assignment of work tasks for the day. Normally, the safety meeting was led by the dredge captain or deck captain; however, the captain was not present in the lever room on the morning of August 21 because he had been up late the night before overseeing the repairs. When the dredge captain and deck captain were not present, the dredge captain expected the leverman to lead the meeting. All crewmembers on board the dredge that morning said that the safety meeting occurred, but the leverman told investigators that he did not lead the meeting nor could he recall who led the meeting. According to the crewmembers, the pipelines were not discussed during the meeting or any previous safety meeting conducted during the project. After the meeting, the crew commenced work and dredging operations continued.

Pipeline Breach and Explosion. The leverman stated that throughout the first hours of his shift, the cutterhead was continuously hitting rocks and cement debris. He said that when the cutterhead was near the surface larger rocks and cement pieces were lifted up out of the water by the cutterhead and thrown through the air, while smaller pieces became lodged in the elbows of the dredge suction piping. Three to four times during the early morning, he had to stop the cutterhead and lift the ladder out of the water so that crewmembers could climb into the suction piping and clear out clogs. Each time, it took 30–40 minutes to unclog the system. The leverman stated that, because of the downtime, the *Waymon Boyd* had dredged for only a short time on the morning of the accident. He also said that the excessive debris continued to hamper dredging near the top of the slope, limiting excavation to about 5 feet from the edge of the dredge template.

The dredge captain told investigators that he awoke about 0700 that morning, checked on the leverman, and then proceeded to his office, located just aft of the lever room, to work on the dredge’s daily report. About 0730, the leverman called him via the vessel’s intercom to report that he was hitting debris. The captain returned to the lever room to assess the situation. When he arrived, he said that the leverman was working the dredge down the slope of the berth, with the cutterhead about 30–35 feet deep in the water at the time. After observing for a few moments, he told the leverman to avoid the debris and “just go around it.”

About 0800, according to the captain, the leverman finished a series of side-to-side swings of the dredge and cutterhead at a particular location and then operated the controls to advance the dredge forward about 3 feet, a maneuver known as a “set” (see section 3.3.1 for a description of dredge operations and movement). While the dredge was moved forward, the cutterhead, still rotating, was raised to its highest operational position. The captain stated that in this position, the cutterhead was 9 feet below the water’s surface.

The leverman explained that, when excavating along a slope, he removed one layer of sediment at a time, beginning at the top and carefully stepping the cutterhead down along the bank with each successive layer. About 0802, after the leverman had completed the set, he swung the dredge slowly toward the shoreline making the first (top layer) cut of the bank in the new position. He said that the anchor winches that he was operating to make the cut were at the slowest speed (“idle”) so that the cutterhead was not moving too fast as it struck debris. He said that when the cutterhead was about 5 feet from the edge of the dredge template, water suddenly began shooting up off the surface of the waterway, about 2–3 feet to landward of the cutterhead. He said the water spray reached as high as the top of the dredge. He did not see or smell any sign of gas. He told investigators that, not knowing what had occurred, he stopped the cutterhead, increased the speed of the motor driving the dredge’s anchor winches, and operated the anchor winch control levers to swing the dredge to starboard, away from the spraying water, as quickly as possible. He then called the dredge captain.

The dredge captain said that when he answered the call the leverman told him that he thought the cutterhead had hit a waterpipe. The captain walked out of his office and saw “some water shooting up” off the port side of the vessel. He said he could not see anything other than the water spray and did not smell anything, and so he believed as the leverman did that the dredge had hit a pipeline carrying water. The captain noted that the cutterhead was at the 9-foot-depth position about 50–60 feet away from the eruption of water, and the dredge was swinging away from the eruption, toward the shipping channel. He returned to his office to call an EPIC contractor and inform him of the incident.

Pipeline TX219 was approximately 5 miles in length and ran from Enterprise’s Viola meter station, located adjacent to the Flint Hills Resources Corpus Christi LLC refinery, to its Cantwell station in Corpus Christi (see figure 1). The pipeline was part of a system that connected the refinery to propane storage at the Enterprise Products Origin Station. TX219 was made of carbon steel, with a 16-inch outside diameter and .219-inch wall thickness, and was encased in coal tar and a 2-inch-thick layer of cement. The line was constructed in 1968 and acquired by Enterprise in 2005. It was not a continuous transfer line; rather, propane was moved through the line in batches at scheduled intervals. The valves which controlled transfers through the line were operated from a control center located in Houston, Texas.

At 0426 on the day of the accident, a pipeline controller at the Enterprise control center opened valves to commence a planned batch transfer of propane through TX219. While the transfer was in progress, the pressure in the line was between 257 and 265 psig. The controller told investigators that, as the transfer was nearing completion at 0802, the pipeline supervisory control and data acquisition (SCADA) system alerted him of a low-pressure condition. The Viola station pipeline pressure at that moment was 156 psig. At 0805, as the line pressure continued to decrease to 149 psig, the SCADA system annunciated a subsequent low-pressure alarm, and an automatic control valve at the Viola station shut to isolate the pipeline.

Figure 8. Screen captures from security camera footage showing, from top to bottom, the water and gas eruption prior to the explosion (as noted by red arrow), the initial explosion, and the ensuing fireball. The *Waymon Boyd* is outside of the frame of the camera. (Source: EPIC Crude Terminal Company)

A shoreside security camera at the Interstate Grain Terminal partially captured the geyser of water witnessed by the leverman and dredge captain (see figure 8; the dredge is not within the frame of the camera view). One minute and six seconds after the water eruption began, an explosion occurred, shaking the security camera violently. Personnel contracted by EPIC who were several hundred yards away on the grain terminal property stated that they heard a large “boom” and that it shook the ground and buildings in the area. In the security video, flames spread from the right of the screen following the explosion, consuming much of the shoreline and the West Dock.

The explosion occurred as the dredge captain was in his office calling the EPIC representative. He stated that “all the fire was in my face…and it was burning on the side and in front of me.” He escaped from his office by climbing through a starboard side window and went down a deck to warn those in the galley and berthing area. He couldn’t reach the space because of the ensuing fire, so he jumped overboard from the starboard side second level. The leverman said that when the explosion occurred he fell on his back and had to stay on the floor because flames were coming in through the windows of the lever room. He eventually evacuated the space and jumped overboard from the starboard side on the third level. He and the dredge captain swam aft along the vessel, then to shore. They were eventually found and transported to a hospital, where they were treated for severe burns.

The chief engineer, second engineer, nightshift leverman and cook died on the vessel. A mate and two deckhands escaped the vessel, were taken ashore, and were hospitalized for severe burns. One of the deckhands died 5 weeks after the accident as a result of injuries sustained in the explosion and fire. The remaining crewmembers, who had been working on the dredge’s support vessels at the time of the fire, were uninjured.

Response Operations. Minutes after the explosion, the Port of Corpus Christi's Security Command Center was notified of the explosion and fire. Corpus Christi Refinery Terminal Fire Company (RTFC) was dispatched to the scene and began fighting fires along the shoreline in the vicinity of the terminal piping. A Port of Corpus Christi Police Department vessel also responded to the fire and assisted with the evacuation of crew, while landside police officers established on-scene command.

The US Coast Guard was notified of the explosion at 0810, dispatched a response boat from Coast Guard Station Port Aransas, located about 26 miles from the accident site, and launched an MH-65 helicopter from Air Station Corpus Christi. After arriving on scene, the helicopter airlifted two injured crew to a hospital, then returned to conduct search and rescue operations. Throughout the day, additional Coast Guard surface and air units joined the response effort, searching for survivors and providing a security perimeter around the accident scene.

At the direction of the pipeline controller in Houston, a local Enterprise pipeline technician drove to the Viola station and verified that the control valve had closed. Additionally, although flow had stopped in the pipeline, the Houston-based controller initiated commands at 0841 and 0843 to remotely close two motor-operated valves and further isolate line TX219. Enterprise later estimated that 6,024 barrels of propane were released from the pipeline.

At 0934, the tugboats *Ted C Litton* and *Evelena* arrived on scene and began using their water monitors (canons) to fight the fire on the dredge (see figure 9). About 20 minutes later, the tugboats *Signet Constellation*, *Signet Courageous*, and *Signet Stars & Stripes*, as well as the prevention and response tugboat *Signet Strength*, took over waterborne firefighting efforts.[4] The *Ted C Litton* and *Evelena* departed the immediate area.

About 1100, the Coast Guard directed the establishment of a formal Unified Command to manage the approximately 50 agencies, facilities, and commercial entities that responded to the accident.

The Signet tugboats remained at the accident site until the fire on the *Waymon Boyd* was extinguished about 1300. Residual propane rising from the breached pipe continued to burn until 1610 local time, when it self-extinguished. The dredge, which continued to smolder, began taking on water 1400. Efforts to stabilize the vessel were unsuccessful, and it sank at 2151.

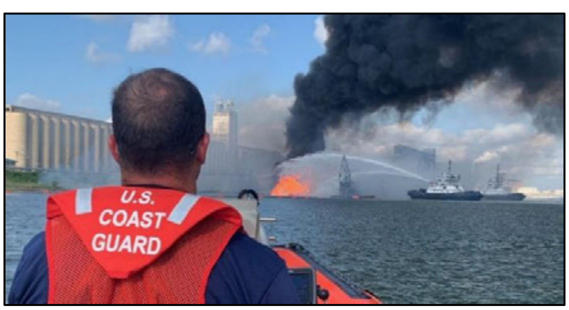

Figure 9. Tugboats *Ted C Litton* and *Evelena* fight fire at the accident scene. (Source: Coast Guard)

[4] A *prevention and response tugboat* is a towing vessel that is specially equipped for firefighting, emergency response, and oil spill recovery, in addition to the equipment normally found on a tugboat.

3 The Vessel

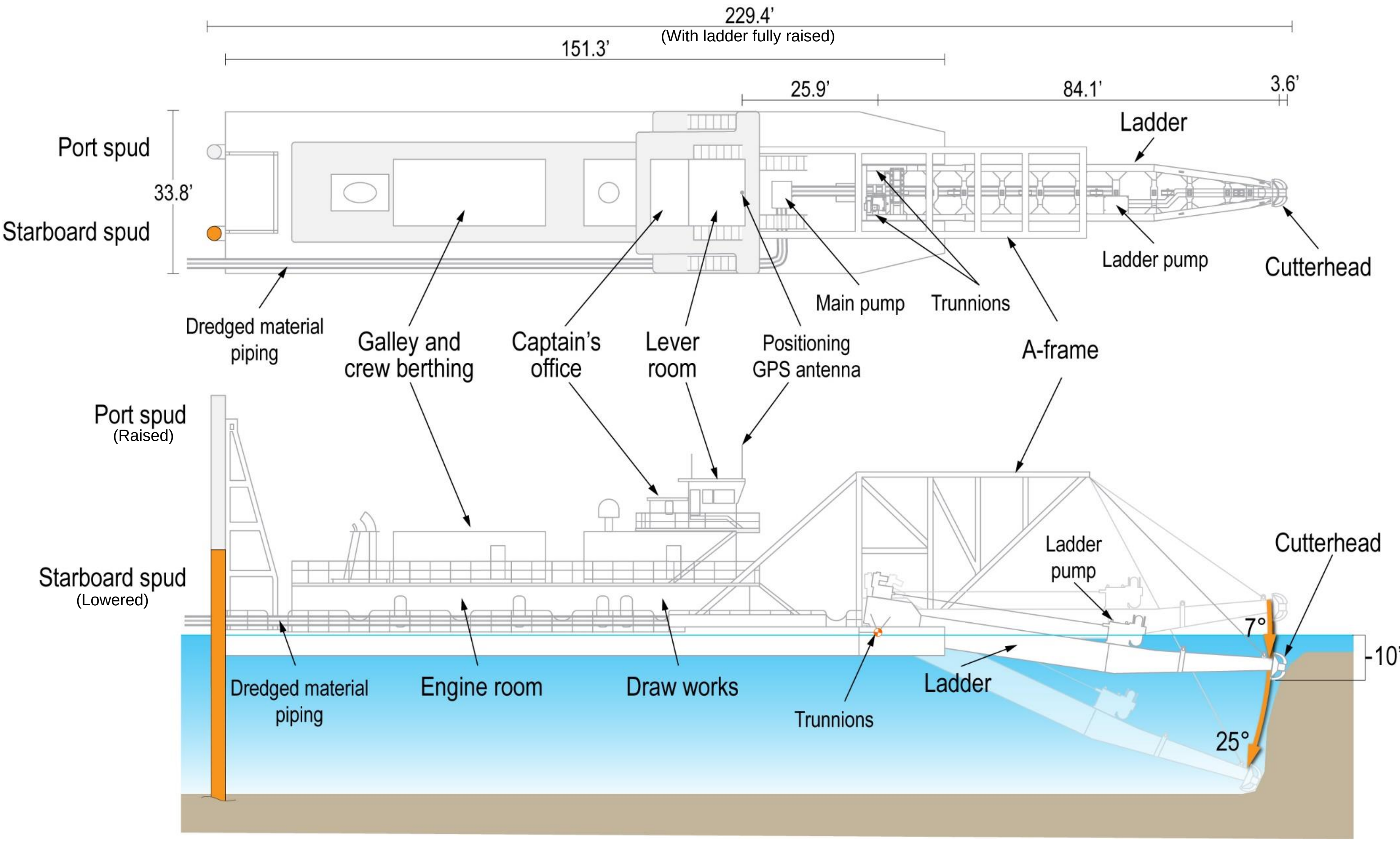

Figure 10. *Waymon Boyd* general arrangements.

3.1 Vessel Particulars

The 290-gross-register-ton *Waymon Boyd* was built in 1950 in Rattlesnake, Florida, and originally named *Dredge No. 6*. In 2005, Orion Marine Group acquired the vessel and began a major rebuild at its dredging operation headquarters in Port Lavaca, Texas, converting the dredge to diesel-electric power. It was renamed the *Waymon Boyd* when the rebuild was completed in 2006.

The hull of the dredge was a barge measuring 151.3 feet long by 33.8 feet wide, with a draft of 5.5 feet (see figure 10).[5] The barge was designed with a slot at the bow in which the aft end of the 84.1-foot-long ladder (the framework on which the cutterhead and ladder pump were mounted) was fitted.[6] The ladder was supported on either side of the slot by trunnions that allowed the ladder to pivot downward during dredging operations. The forward end of the ladder with the cutterhead was raised and lowered via a derrick, called the A-frame, also mounted on the bow of the barge.

The model SC15 cutterhead at the forward end of the ladder was manufactured in the Netherlands by VOSTA LMG. As viewed from the dredge, the cutterhead rotated in the clockwise direction when in operation. It weighed 2.9 tons (2.6 metric tons) and was 6.5 feet in diameter, with an axial length of 3.8 feet. The cutterhead had 5 blades, each with a row of 6 or 7 teeth (see figure 6). Three types of teeth could be installed on the cutterhead, depending on the material being dredged, and the teeth could be changed out on site if damaged during operations. According to the dredge captain, the cutterhead had been replaced with a new or newly refurbished head, including brand new teeth, before phase 2 of the EPIC dock project began. The cutterhead teeth were “wide chisel” type designed for dredging sand and clay, according to the VOSTA LMG manual (the manual recommended “narrow chisel” teeth for harder soil and “pick point” teeth for rock but stated that wide chisel teeth were suitable for all soil types). While the *Waymon Boyd* crew conducted repairs to the cutterhead shaft coupling the night before the accident, they inspected the cutterhead and found no damaged or missing teeth. The leverman stated that the crew reported no issues with the teeth when the ladder was raised to clean out suction piping clogs just prior to the accident.

Two large slurry pumps were installed on the *Waymond Boyd* to move the dredged material from the excavation point through the pipeline to the DMPA.[7] The ladder pump, with a 42-inch impeller, was mounted about midpoint on the ladder and provided the initial suction head and system pressure to lift material from the digging depth. The main pump, with a 46-inch impeller, was located in the hull near the bow, just forward of the superstructure. This pump provided system pressure for the dredged material pipeline. Inlet and outlet piping for both pumps was 20 inches in diameter, and strainers were installed ahead of the inlets to prevent damage to the pump from rocks

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[5] *Gross register tonnage,* or *GRT*, is a US national standard for the measurement of the volume of all enclosed spaces on a vessel. For most vessels 79 feet and over in length, ITC is the primary tonnage measurement system under the law in the United States. For vessels less than 79 feet in length, GRT is used in all cases. Source: Coast Guard, *Simplified Measurement Tonnage Guide 1*, TG-1, 2009.

[6] The *Waymon Boyd*’s ladder was cut into two pieces during salvage. The length of the ladder as presented here is the combined length of both sections, from the aft end of the cutterhead to the center of the trunnions, as recorded by investigators during a postaccident examination of the salvaged vessel.

[7] *Slurry* is a mixture of solids suspended in a liquid, commonly used as a means of transporting the solids by using pumps to move the carrier liquid.

and large debris picked up during dredging. Crewmembers stated that, prior to the accident, they had to clean out the strainers frequently.

Two 70-foot-tall, 2.5-foot-diameter spuds—metal pilings that could be lowered to the bottom to provide anchor and pivot points for the dredge—were mounted on the stern of the barge. The spuds could be lowered to a maximum depth of about 50–55 feet.

The *Waymon Boyd* did not have main propulsion machinery, propellers, or rudders; it was towed to each project site by tugboats (see section 3.3.1 for more information about maneuvering the vessel during dredging operations). Electrical power aboard the dredge was provided by a 3,300 horsepower (hp) Alco 251 diesel generator. The generator was mounted about midship and centerline within the hull of the barge and extended up into the first level of the superstructure. (For the remainder of this report, the entire space, including the area within the hull and within the superstructure above, will be referred to as the engine room.) The generator was oriented with its diesel engine aft and its alternator forward. A turbocharger was fitted on the aft end of the engine, and exhaust piping was routed aft and up to a stack mounted atop the aft end of the first level of the superstructure. In addition to basic services such as lighting, the main generator supplied electricity to several motors, ranging between 400 and 1,500 hp, which delivered dedicated motive power for each of the major mechanical components on the dredge: the ladder pump, main pump, cutterhead, and winches. A 450-hp backup generator was also located in the engine room aft of the main diesel generator.

Fuel for the generators was supplied from one of seven fuel tanks via a manifold located on the port side of the engine room. The fuel tanks were located within the hull outboard of the engine room, three on the port side and four on the starboard side. Emergency fuel shutdown valves for the engines were located near the fuel manifold.

The control station for the main and backup generators was on the port side of the engine room on the deck of the barge. In addition to the generator controls and monitoring gauges, the station was equipped with an "emergency voltage disconnect" switch that, when actuated, cut off all electrical loads from either generator.

Ventilation for the engine room was supplied by two fans mounted in the overhead, with the inlets on the top of the first level of the superstructure on either side of the stack.

Winches for the cable that raised and lowered the ladder and cables that heaved in or paid out anchor cables and raised and dropped the spuds—winches collectively known as the draw works—were located in a space forward of the engine room. The engine room and draw works were separated by a partial bulkhead and metal grating.

A berthing and galley space was on the second level of the *Waymon Boyd*'s superstructure, midship above the main generator. A transformer room, which converted the AC output of the generator to DC power for the motors, was located forward on the second level above the draw works.

The lever room and dredge captain's office were on the third level above the transformer room. The lever room sat on a raised deck that was accessible via a short ladder. Windows on all sides of the lever room afforded the operator a 360-degree view of the worksite. During normal operations, the cutterhead, draw works, and pumps on the dredge were all operated by the leverman from a single control station in the lever room. The winches were operated by five levers on the forward operating panel of the control station, organized from port to starboard as follows: port spud raise/drop, port anchor cable heave-in/payout, ladder raise/lower, starboard anchor cable heave-in/payout, and starboard spud raise/drop (see figure 11). On/off and speed controls for the anchor winch and cutterhead motors were located on the starboard side of the console. The display and keyboard for the DREDGEPACK computer was mounted in the starboard corner of the console. A display showing parameters for the dredge pumps and dredge material booster pumps was mounted port corner.

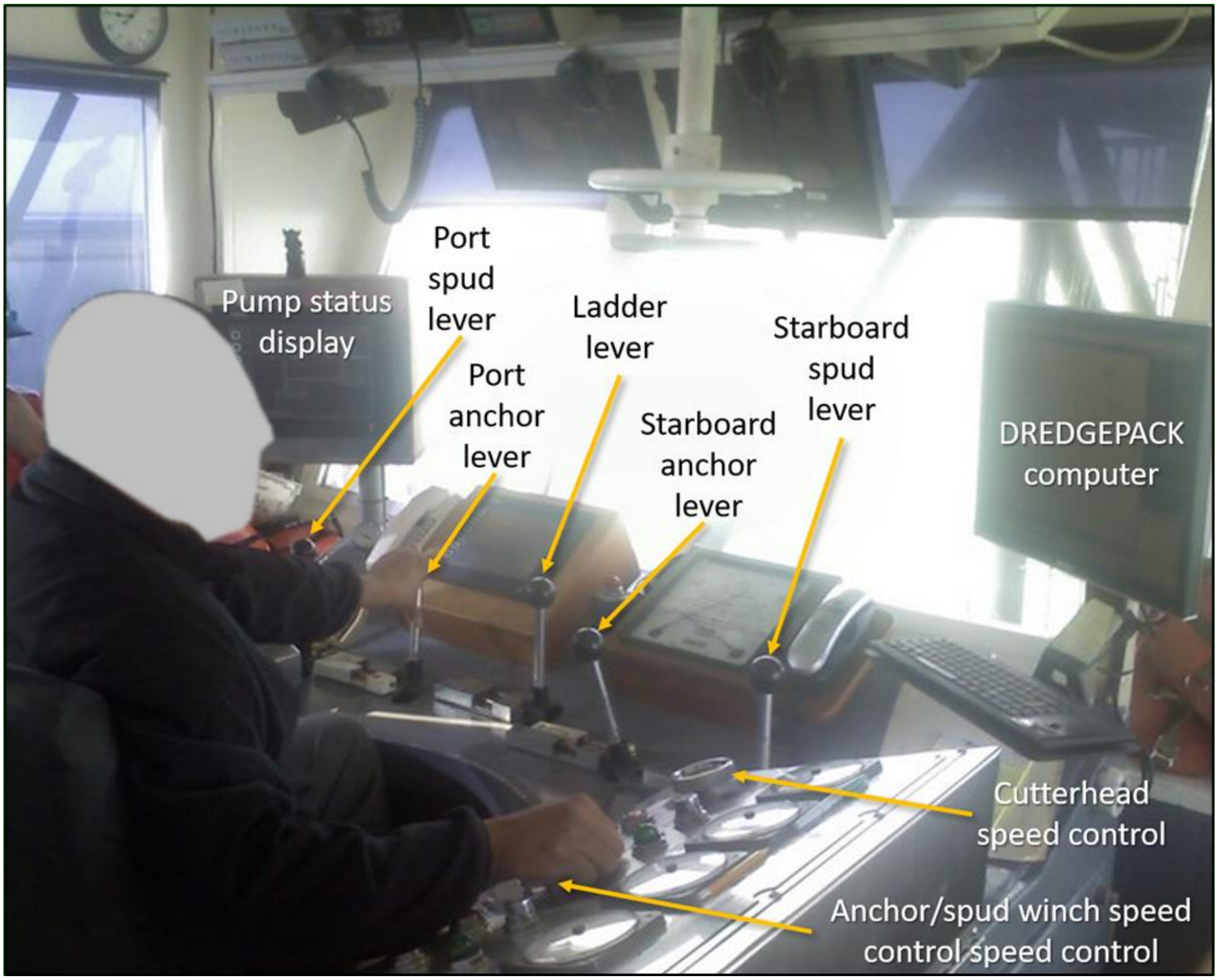

Figure 11. *Waymon Boyd* lever room preaccident. In this photo, the leverman is pushing the port anchor lever forward with his left hand, which is heaving in the associated cable. The starboard anchor lever has been pulled back, which has disengaged the starboard anchor cable winch, allowing it to pay out. The leverman is controlling the speed of the anchor winches with his right hand, as he monitors the DREDGEPACK computer. (Source: Orion Marine Group)

The crew reported no major equipment casualties prior to or during the accident, other than the sheared shaft coupling that was repaired the night before. The leverman stated that all equipment was operating correctly at the time the pipeline was breached.

3.2 Vessel Damage

A photo of the *Waymon Boyd* taken after the fire had been extinguished and before the vessel sank shows the engine room bulkheads on the port side bowed outwards (see figure 12). The draw works and engine room doors are missing, along with a bolted-on bulkhead patch panel. The main deck railing outboard of the opening created by the missing patch panel is bent outward. The aft deck above the first level of the superstructure, upon which the stack sits, is bent upward and forward. The galley and berthing compartment is displaced from its normal position on the first level and sits at an angle on the deck. Fire and smoke damage is visible throughout the vessel.

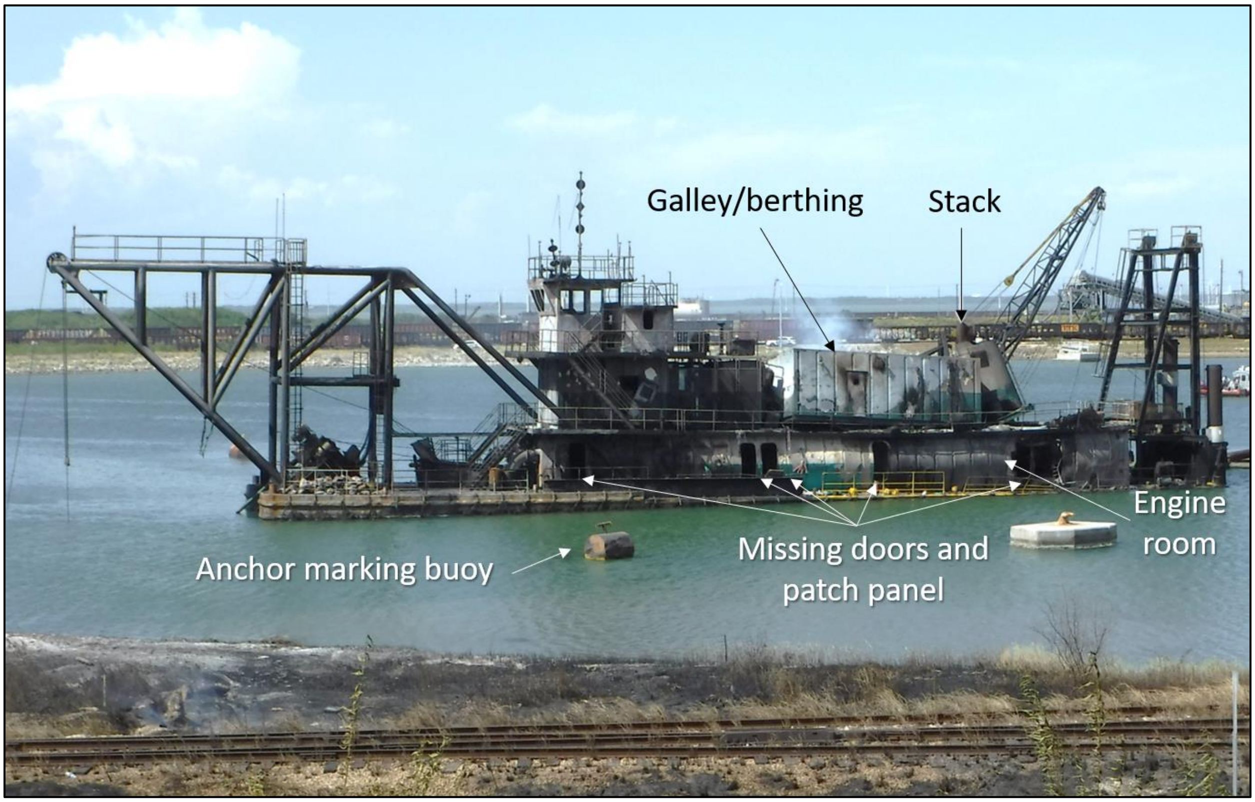

Figure 12. Postaccident photo of the *Waymon Boyd*, prior to sinking. (Source: Coast Guard)

During a post-salvage examination of the vessel, investigators confirmed that the bulkheads on both the port and starboard sides of the engine room were bowed outwards (see figure 13). Inside the engine room, four fuel valve and two crankcase covers on the port side, aft end of the main generator engine were missing, while the covers on the forward end of the engine remained in place. A beam in the overhead of the space above the engine's turbocharger and exhaust system was bent upward. Paint was not visible on the aft part of the engine, but increasingly more paint was visible moving forward. The generator alternator, sitting forward of the engine block, was largely undamaged, although a gantry crane had fallen from the overhead and laid across it.

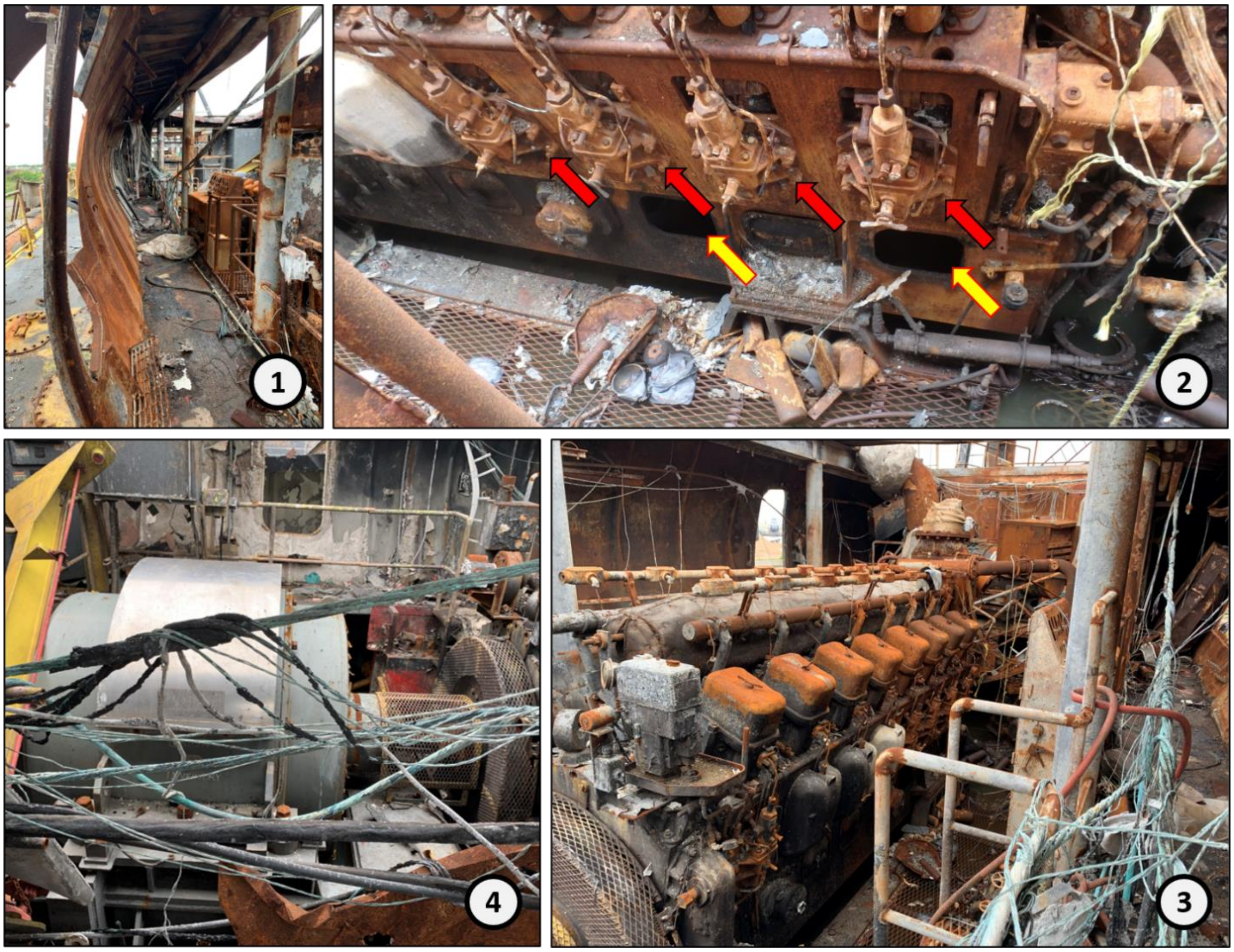

Figure 13. Post-salvage images of the *Waymon Boyd* engine room. Clockwise from top left: 1. Bowed portside bulkhead; 2. Aft generator engine block with missing fuel valve covers (red arrows) and crankcase covers (yellow arrow); 3. Generator engine forward, looking aft; 4. Generator alternator, with fallen wiring in the foreground and gantry crane to the left of the image.

Investigators also found that a door to an electrical equipment box forward and above the main generator alternator was caved inward. The standby generator aft of the main generator engine had been displaced from its mounts. The fuel system had no visible breaches in either the piping system or the tanks.

When the cutterhead was salvaged, investigators found one tooth was damaged and another was missing. Rocks and pieces of cement were discovered in the ladder-pump strainer clean-out box.

On the top two levels of the *Waymon Boyd*'s superstructure, which had broken free of the dredge when it sank, all exterior paint had been burned away, and the aluminum door to the captain's office was almost completely melted (see figure 14). The starboard aft corners of the lever room and captain's office roofs were bent downward; however, an Orion representative stated that this damage had occurred during salvage.

Figure 14. The lever room and captain's office post-salvage. The arrow shows the remnants of the office door, which had melted in the fire.

An anchor barge had been moored on the starboard side aft of the *Waymon Boyd* when the accident occurred. During a postaccident examination of the barge, investigators observed that steel plating on the starboard side deckhouse bulkhead, which was facing the *Waymon Boyd*'s starboard side (the dredge and barge were oriented in opposite directions), was inset (see figure 15). Additionally, the deckhouse sustained impact damage to plating forward on the starboard side bulkhead. The entire stern and starboard sides of the barge were scorched and buckled.

Figure 15. Stern (left) and starboard (right) bulkheads of anchor barge deckhouse.

3.3 Vessel Operations

3.3.1 Dredging Operations Overview

Excavating. During normal dredging operations on the *Waymon Boyd*, the starboard spud—known by the crew as the "digging spud"—was lowered to the bottom of the waterway to anchor the stern of the vessel. Using barges equipped with lifting derricks, two stockless anchors were set out, one on either side of the dredge, with their flukes oriented in the direction of the dredge. Cables from each anchor ran through blocks on the port and starboard sides of the *Waymon Boyd*'s ladder and back to the winches in the draw works room. To begin dredging, the leverman lowered the ladder to set the cutterhead at the desired depth and engaged the pump and cutterhead motors. Then, by paying out or heaving in the anchor cables, he swung the dredge from one side to the other, pivoting the entire vessel around the starboard spud. This action moved the cutterhead and dredge suction in an arc (see figure 16), breaking up and carry away material as the dredge swung. Once the dredge had completed a swing and a layer of material had been removed, the leverman lowered the cutterhead a designated amount and repeated the process in the opposite direction to remove the next layer. The dredge captain told investigators that when digging in an area that had not been previously dredged, known as making a "virgin cut," the cutterhead was lowered about 1 foot between each swing of the vessel. The leverman worked the cutterhead to successively lower depths with each swing until the desired dredge depth was reached, after which he operated the controls to move the dredge forward.

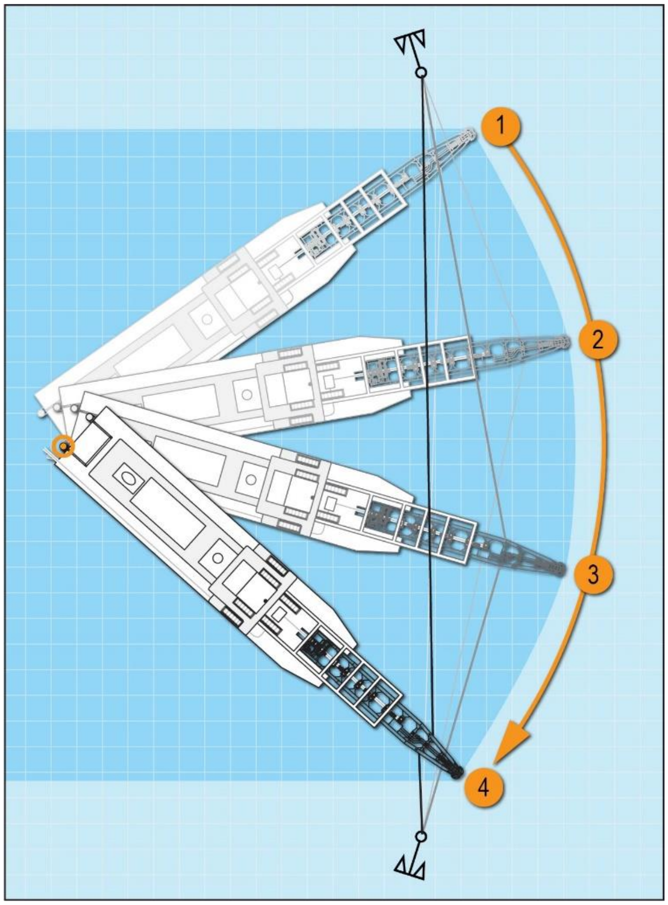

Figure 16. Typical dredging operations. Starting in position 1 with the starboard spud planted in the bottom sediment of the waterway, the leverman operates the levers to heave in the starboard anchor cable and pay out the port anchor cable. This action swings the vessel through points 2, 3, and 4, breaking up and suctioning away sediment in the path of the cutterhead. In position 4, the leverman lowers the cutterhead a designated amount and then repeats the procedure in the opposite direction, excavating the next layer. This process continues until the cutterhead reaches the planned depth of the excavation area.

Forward Movement (Set). To move the vessel forward, a maneuver known as a set, the leverman raised the ladder to the highest position such that it could continue to operate without the ladder pump taking in air. The dredge captain stated that at this position the cutterhead on the *Waymon Boyd* was about 9–10 feet below the water's surface (7 degrees down angle on the ladder, per vessel drawings). The leverman then lowered the port spud—the "walking spud"—and raised the starboard spud (see figure 17). Using the anchors, he next swung the dredge about the port spud. He then lowered the starboard spud and raised the port spud. The combined actions advanced the dredge forward before beginning a new series of sweeps of the cutterhead. The dredge captain stated that during virgin cuts, the dredge moved 3–4 feet forward with each set.

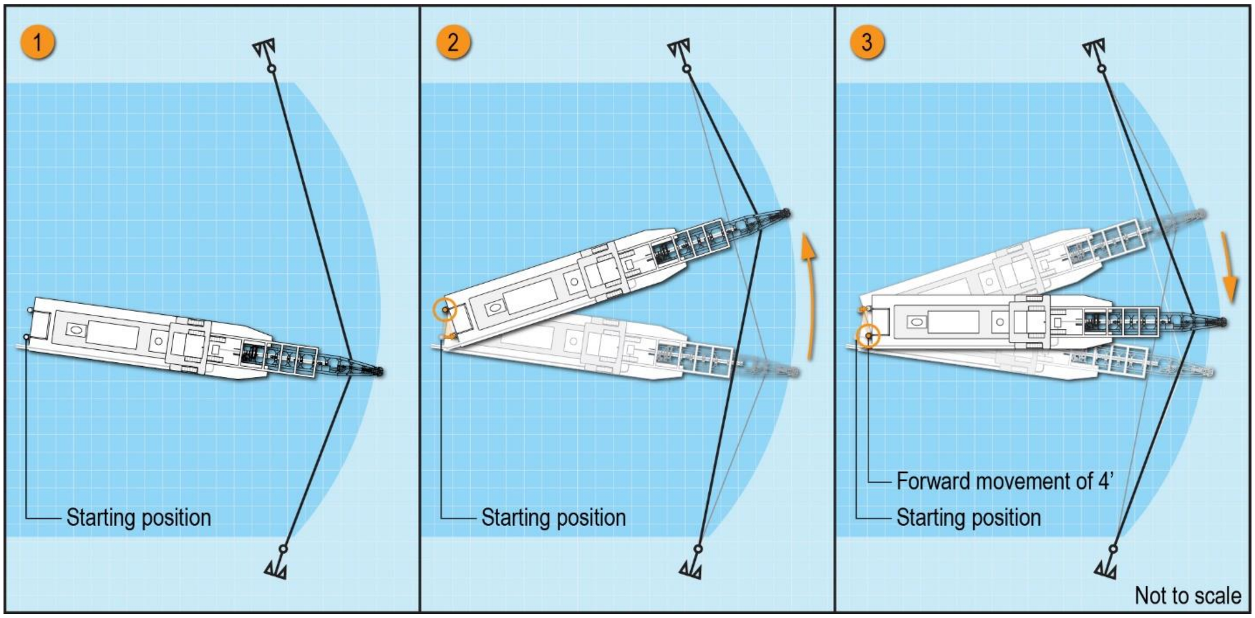

Figure 17. Typical maneuver to move the dredge forward. (1) The leverman lowers the port spud and raises the starboard spud, allowing the vessel to pivot around the port spud; (2) he operates the levers to heave in the port anchor cable and pay out the starboard anchor cable—this action advances the starboard spud, as well as the entire dredge, forward; and (3) the leverman drops the starboard spud and raises the port spud, anchoring the vessel in the advanced position. The leverman then begins excavation in the new position.

3.3.2 *Waymon Boyd* Automatic Identification System (AIS) Data

AIS data from the *Waymon Boyd* shows the vessel's movement in the minutes surrounding the accident. Beginning at 07:57:25, the dredge swung in a rough arc in a southeasterly direction, toward the shoreline, with a speed over ground between 0.1 and 0.3 knots (see figure 18). At 08:02:45 (5 minutes 20 seconds time elapsed), the southeasterly swing stopped. At this point, the AIS position of the vessel was about 119 feet from the location of the breach in pipeline TX219. The AIS and GPS antennas were mounted on roof of the *Waymon Boyd*'s lever room. Also, the dredge's direction of movement did not reflect its orientation (heading information was not reported by the vessel's AIS). The dredge captain indicated that, about the time the water erupted from the surface of the waterway, the vessel's heading was southwesterly.

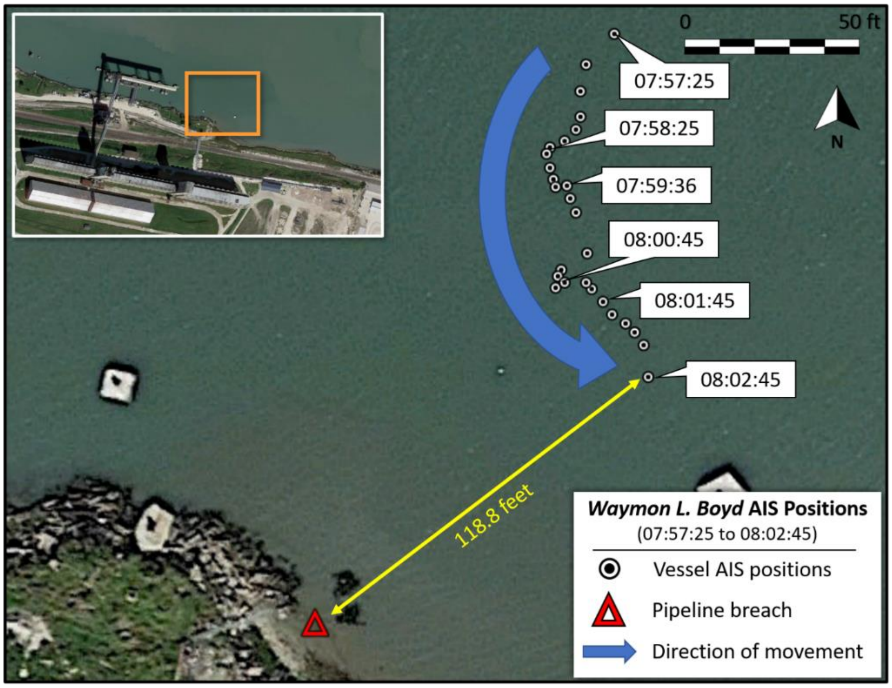

Figure 18. *Waymon Boyd* AIS data from 07:57:25 to 08:02:45 on the accident date. (Background source: Google Earth)

Following the 08:02:45 AIS report, the *Waymon Boyd* moved back to the north, away from the shoreline (see figure 19). The vessel's speed over ground during this motion accelerated from 0.4 knots to 1.3 knots, until the movement stopped about 08:03:55. Ten seconds later, the dredge transmitted its final AIS position report in nearly the same location.

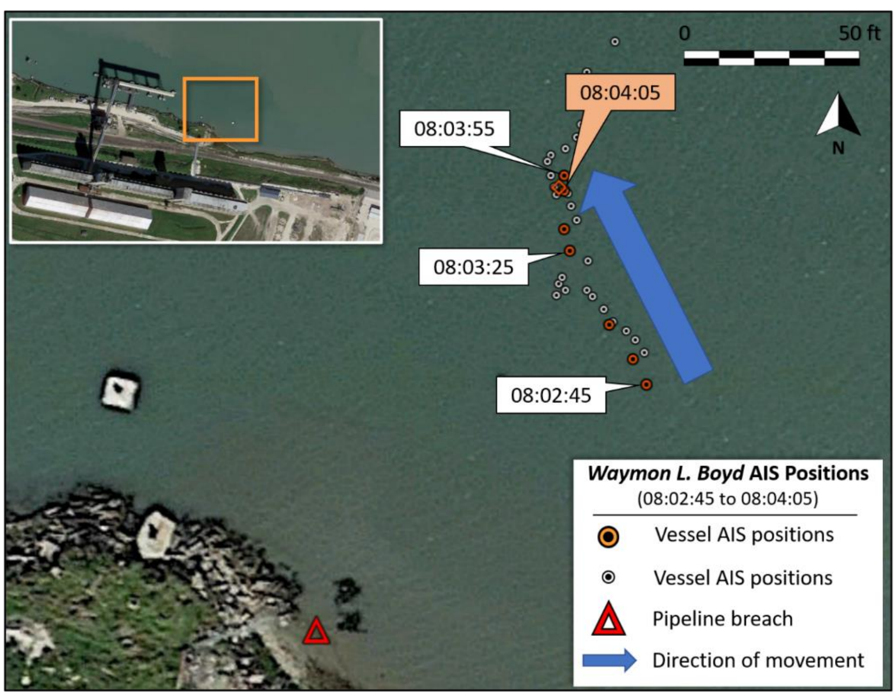

Figure 19. *Waymon Boyd* AIS data from 08:02:45 to 08:04:05 on the accident date. (Background source: Google Earth)

3.4 *Waymon Boyd* Operating and Emergency Procedures

The *Waymon Boyd* and other Orion dredges did not have standardized, written manuals or guidelines for normal operations. Procedures and common practices were instead passed down from crewmember to crewmember during on-the-job training.

Emergency procedures for collision, man overboard, fire, sinking, and abandon ship were provided in a single-page document, dated September 20, 2001, that, according to company representatives, was posted in the lever room, galley, and engine room of all Orion dredges (see figure 20). Instructions for the leverman in the posted procedures included distinct whistle signals to notify the crew of the type of emergency that was occurring or being exercised in a drill. The leverman told investigators that crewmembers often attached a card listing the emergency whistle signals onto the underside of the brims of their hard hats to aid them in responding to drills.

EMERGENCY PROCEDURES FOR DREDGES

DRILLS	COLLISION	MAN OVERBOARD	FIRE	SINKING	ABANDON SHIP
Captain	In Charge	In Charge	In Charge	In Charge	In Charge
Leavermen	Sound 5 short blasts on the dredges whistle. Lift spuds Slack anchor cable on the side of the collision Call for tenders to tow dredge	Sound 2 long and 1 short blast on the dredges whistle Secure the engines Lock out controls Call for assistance on channel 16 VHF FM Muster all personnel	Sound 2 long and 3 short blasts on the dredges whistle Call for assistance on channel 16 VHF FM Secure all equipment Lock out controls	Sound 2 long and 5 short blasts on the dredges whistle. Call for assistance on channel 16 VHF FM	Sound 2 long and 7 short blasts on the dredges whistle Call for assistance on channel 16 VHF FM Secure all equipment Lock out controls Muster all personnel
Chief Engineer	On scene leader Make temporary repairs	Assist as directed	On scene leader	On scene leader Make temporary repairs	Secure all engines
Deckhand 01	Assist with tow	Throw life ring to person in the water Point to person in the water	Man fire hose 01	Assist with tow	Launch skiff if tender is not avail
Boatman 01	Tow dredge clear	Maneuver boat to recover man in the water	Assist as directed	Tow dredge to shallow water	Pickup crew from dredge
Deckhand 02	Assist with tow	Assist as directed boat man 01 Throw life ring to man in the water Assist man overboard onboard Perform first aid as needed	Man fire hose 02	Assist with tow	Assist as directed boatman 01
Boatman 02	Tow dredge clear	Recover man in the water	Assist as directed	Tow dredge to shallow water	Pickup crew from dredge
Deckhand 03	Assist as directed	Assist as directed boat man 02 Throw life ring to man in the water Assist man overboard onboard Perform first aid as needed	Provide fire extinguishers	Provide pump and pump out compartment	Assist as directed boatman 02
Engineer 02	Assist as directed	Assist as directed	Man engineer room	Assist with repairs	Assist as directed
Oiler	Assist as directed	Assist as directed	Assist engineer 02	Assist as directed	Assist as directed
Deckhand 04	Assist as directed	Assist as directed	Provide fire extinguishers	Provide pump and pump out compartment	Provide survival supplies
Deckhand 05	Assist as directed	Assist as directed	Provide fire extinguishers	Assist as directed	Assist as directed
Remaining crew	Assist as directed	Assist as directed	Assist as directed	Assist as directed	Assist as directed

Safety/forms/ drills 9/20/01

Figure 20. Emergency procedures for Orion Marine Group dredges.

The crew periodically ran drills for the emergencies contained in the procedures form. The company's regional health, safety, and environmental (HSE) manager, who was responsible for safety oversight of the *Waymon Boyd*, told investigators that an "environmental spills drill" was also conducted on a regular basis. According to company representatives, each drill was required to be run monthly. The company's HSE director stated that the monthly periodicity was "per the Coast Guard" requirements; however, investigators could not find any regulatory requirements for drills on uninspected vessels such as the *Waymon Boyd*. The dredge captain said that the crew conducted drills "once a week," and a mate from the off-watch crew also reported weekly drills. The leverman stated that drills were conducted "maybe every 3, 4 months," while a mate from the accident crew told investigators that drill were conducted every 2–3 months. Any records of drills that may have been kept by the crew were lost in the fire, so crewmember accounts could not be verified.

3.5 Operations near Pipelines

3.5.1 Industry Guidelines

The Council for Dredging & Marine Construction Safety (CDMCS) is an organization of commercial and government organizations whose purpose is "creating an injury-free workplace and safety-first culture for the dredging and marine construction industry."[8] The council was formed in 2008, and its 40+ members include the US Army Corps of Engineers, dredging and marine construction contractors, and pipeline operators. Orion Marine Group is a member of the CDMCS.

In May 2018, following an accident in which a spud from the dredge *Jonathan King Boyd* struck a gas pipeline in Matagorda Bay, Texas, the CDMCS formed the "Pipeline Task Force (PTF)."[9] The PTF was a "joint inter-agency, public-private initiative focused on ensuring safe operations in waterways with submerged oil and natural gas pipelines through enhanced communication, collaboration, and exchange of best practices among all stakeholders."[10] The task force broke the effort into three teams: the Best Practices Team; the Training, Awareness and Education Team; and the Government Coordination & Information Exchange Team).

In January 2020, the PTF published *Pipeline Incident Prevention*, a best practices guide for dredging and pipeline industries.[11] In its recommendations to dredging companies, the guide states that "it is important to know the product in each pipeline. . . . The product must be clearly stated in the dredging company's contingency plans to minimize safety and environmental risks if a release occurs." *Pipeline Incident Prevention* also discusses tolerance zones, which are "areas near pipelines where no activity or work should occur." It further explains:

> A tolerance zone is a predefined horizontal distance extending from the outer edge or wall of a pipeline/utility. The exact distance is defined by law, and it varies from state to state, ranging from 18 to 30 inches on each side. Those small distances, however, were designed for on-land application and may not apply to marine activities like dredging. . . . Although tolerance zones vary among dredging companies, 75 feet appears to be the no-go working distance for most.

To accompany the prevention guide, the CMDCS published the *Checklist for Safe Dredging Near Underwater Gas & Hazardous Liquid Pipelines*. Among 17 recommended practices, the checklist included the following:

- Verify all pipelines have been properly surveyed and marked.

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[8] CDMCS, "Vision & Mission," cdmcs.org/vision-mission/, accessed June 21, 2021.

[9] For more information about the *Jonathon King Boyd* accident, see NTSB, *Pipeline Breach and Subsequent Fire aboard Cutter Suction Dredge* Jonathon King Boyd *and Towboat* Bayou Chevron, MAB-19/19, Washington, DC: 2019.

[10] CDMCS, "Pipeline Task Force," cdmcs.org/pipeline-task-force/, accessed June 21, 2021.

[11] CDMCS, *Pipeline Incident Prevention*, Washington, DC: CDMCS, 2020.

- Verify all known pipeline locations and maps are uploaded into onboard navigation guidance software of all floating plant, especially dredges.
- Verify all known pipeline locations are identified in onboard dredge plan.
- Verify a pipeline company representative will be onsite before work begins.
- Review tolerance zone distances ("No Go Zones") around each pipeline and confirm they are agreed to by pipeline operator and dredger.
- Discuss updates and concerns from previous days regarding the pipelines.
- Review emergency response and evacuation procedures.

In the event of an emergency involving a pipeline breach, both the *Pipeline Incident Prevention* guide and the checklist recommended, among a list of actions, the following:

- Immediately stop all operations and keep yourself safe.
- Shut down or minimize the use of all possible ignition sources: motors, generators, lights, etc.
- Account for all crewmembers and communicate the hazards to them.
- Call 911 (required), Channel 16, or the U.S. Coast Guard and describe your location.
- If possible, drift out of the area before starting an ignition source.
- Evacuate the vessel if needed.
- Contact the pipeline company emergency number in your plan to shut down the line.

3.5.2 Orion Marine Group Dredging Operations near Pipelines

Orion Marine Group's HSE director stated that, although the company was a member of CMDCS, it did not follow the guidance provided in *Pipeline Incident Prevention* or in the accompanying checklist. The HSE director said, "Orion has our own internal methods for a best practice on how to negotiate around pipelines," which he described as "very similar" to the CMDCS checklist. However, when asked by investigators, he stated that these methods were not contained in a written document.

Regarding standoff distances/no-go areas around pipelines, Orion had no company-wide policy. The only written documentation of any standoff distance was provided in the proposal for dredging work that the company presented to EPIC for the East Dock project. The proposal stated, "Orion will not operate a dredging cutterhead within ten (10) feet of any structure, including piling and sheet pile walls." Understanding of no-go zones varied among Orion employees. The *Waymon Boyd* dredge captain stated that the standoff distance for a pipeline was 25 feet on a virgin cut. According to the deck captain, the distance was as directed by a supervisor. The leverman did not know of a set standoff distance for pipelines running parallel to the channel. The regional HSE manager believed that Orion had a standard no-go zone for pipelines but told investigators that he did not know the exact dimensions. When asked by investigators, the project engineer, who was responsible for coordinating with pipeline companies via the One Call system, did not know of any set no-go zone, stating, "That's a better question for a project manager." According to the project manager, the standoff distance was, in the case of the EPIC East Dock, dictated by Enterprise at 20 feet. Orion's director of operations confirmed that "There is no written policy, and every job is different. On this job, the pipeline operator had asked us to stay 20 feet off the pipeline."

Crewmembers told investigators that it was not unusual to have pipelines running through an area being dredged, but the pipelines normally ran across dredging area, vice parallel to it, and were buried below the planned dredging depth. The dredge captain and leverman said that they had never worked a job in which pipelines ran parallel to the dredging area. The leverman stated that the only information he would have had about the location of pipelines would have come from his DREDGEPACK computer and that there were no pipelines entered into the computer for the EPIC East Dock project. He said that information about the product carried in the pipelines was never shared with him.

Members of the crew stated that, before dredging near a known pipeline that crossed the channel, the leverman would stop the cutterhead and the crew would run a cable through it, tying the ends of the cable off to the ladder so that the cutterhead could not rotate. The dredge would then operate using suction only. The dredge captain stated that this procedure was followed whenever the dredge was operating within 25 feet on either side of a buried pipeline; the leverman stated that the procedure was done whenever operating within 50 feet of a pipeline. On the day of the accident, the cutterhead was not tied off and was rotating under power. The dredge captain said that it was not tied off because the *Waymon Boyd* was making a virgin cut and because the pipeline was outside the dredge template. Prior to the accident, he had estimated that the closest the cutterhead would come to pipeline TX219 was 20–25 feet.

Crewmembers told investigators that, when operating near pipelines, a pipeline company representative sometimes came aboard the vessel to assist with pipeline avoidance. The leverman told investigators that the pipeline representative was usually stationed in the lever room, but he noted that pipeline personnel had not been aboard the vessel during projects in recent years. There was no Enterprise representative aboard the *Waymon Boyd* during the EPIC East Dock project.

Orion Marine Group did not have an emergency procedure in the event of a pipeline strike, and the *Waymon Boyd* leverman was not aware of the CDCMS recommended procedure.

4 EPIC Dock Project Dredging Plans

The design engineer for Schneider Engineering and Consulting developed the dredging plans for phase 2 of the EPIC dock project primarily using the 2019 version of AutoCAD. The dredging plans comprised four parts, the first part containing the front matter (title page and signature) and the Existing Site Plan, an overhead view of the project overlaid on a satellite image (see figure 21). The Existing Site Plan included boundary lines for the proposed ship berth, contour lines for the bottom topography at project start, and blue-colored lines depicting the locations of pipelines in the area. It did not include a depiction of the sloped area that was to be dredged outside the berth (the Jacobs plans for phase 1 of the project included a drawing similar to the Schneider Existing Site Plan but without the pipelines depicted). The bottom topography indicated that the slope in the center section of the berth had been excavated during phase 1 operations, but the slope had not fully been dredged on the eastern and western extremities of the berth. The geodetic datums used in the dredging plan were the North American Datum of 1983 (NAD83) Texas South plane

4205 (horizontal datum) and MLLW (vertical datum).[12] The units of length for the datums were feet. According to the design engineer, the pipeline location data came from the December 2018 utilities survey conducted by TMI Solutions. The horizontal datum for the TMI survey was also NAD83 Texas South plane 4205; a vertical datum was not listed.

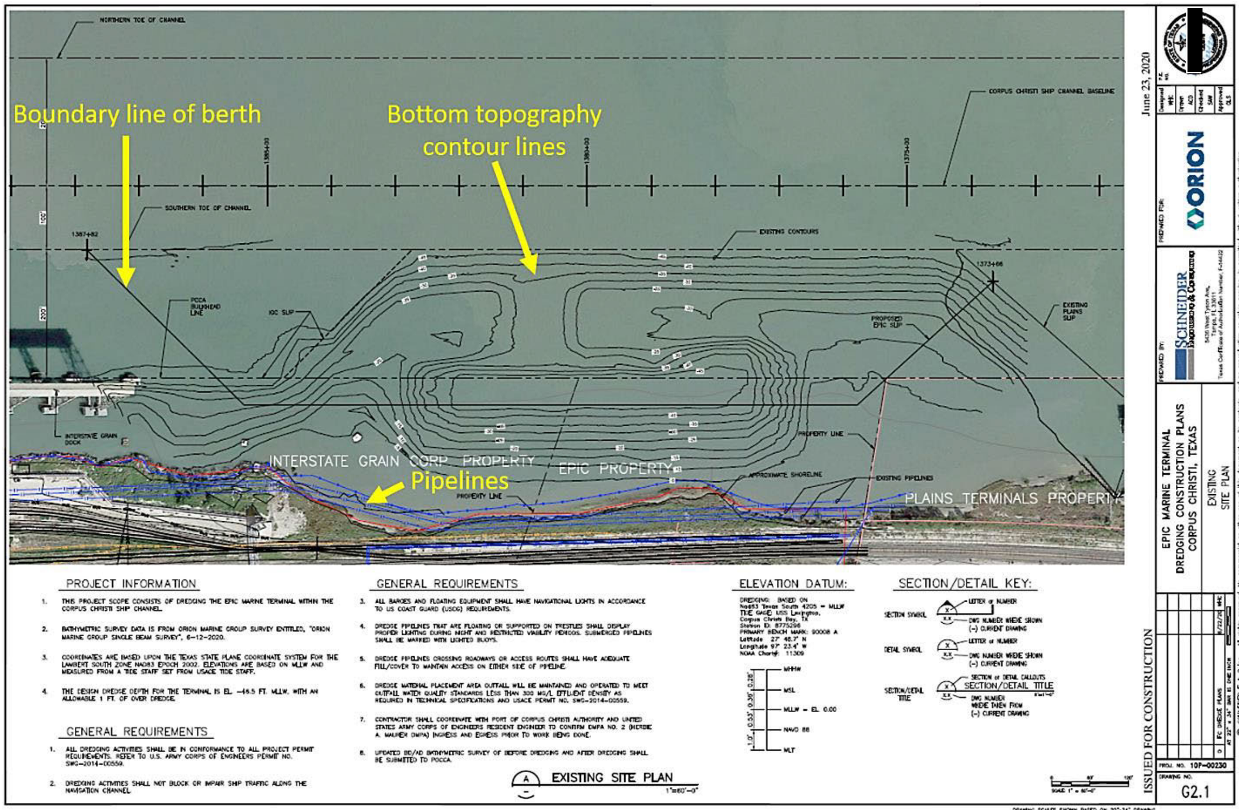

Figure 21. Existing Site Plan from EPIC East Dock dredging plans, with annotations in yellow by NTSB. (Source: Orion Marine Group)

The second section of the dredging plans was the "Dredge Site Plan," an overhead drawing of the berth, along with the proposed dock, mooring dolphins, and a bulkhead that would extend out from the shoreline and be backfilled and covered (see figure 22). A table in the plan labeled "Dredge Limit Coordinates" listed the coordinates of the boundary of the berth in eastings (X) and northings (Y).[13] The drawing included a partial depiction of the sloped areas to be dredged during phase 2 of the project, as indicated by contour lines decreasing in depth at 5-foot intervals (the sloped area dredged in phase 1 was not shown). The top of the slope was indicated by the 0-foot depth line, except in the area of the proposed bulkhead where it terminated at about 10-foot depth at the structure (the original Jacobs plans included a similar drawing, with the slope fully depicted. When interviewed, the project engineer stated that the absence of the slope in the vicinity of the

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[12] a) A *geodetic datum* is a coordinate system within a surface that provides a known point from which the location of other points can be determined. There are two main datums in the United States: horizontal datums, which measure positions on the surface of the Earth, and vertical datums, which measure land elevations and water depths.

[13] *Eastings* and *northings* are the coordinates of a specific location expressed as the distances eastward and northward of the reference point in a horizontal geodetic datum.

bulkhead was "clearly a gap in these plans" and that, in cases where there were gaps in the plan, "we typically play it conservatively."

The 2018 TMI Solutions survey data was not included in the Dredge Site Plan. According to the Orion project engineer, there was no company policy providing a minimum distance between pipeline and dredging area for which the pipeline was required to be included in the plan. When asked how she determined the distance between the top of the sloped area and the pipelines, the engineer stated, "I repeatedly just looked at [Dredge Site Plan] and then the [Existing Site Plan] that actually shows the approximate location of the blue lines." The datum for the Dredge Site Plan was NAD83 Texas State plane 4205, and the. The units of length were feet.

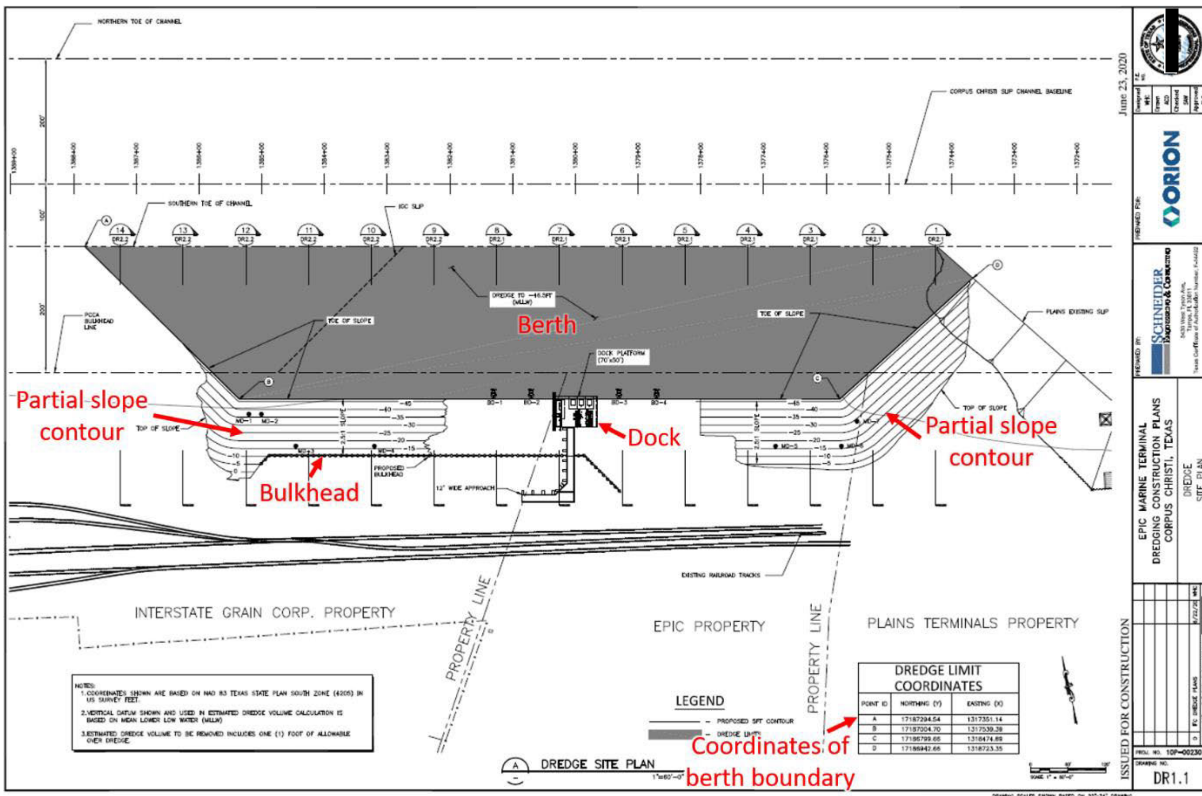

Figure 22. Dredge Site Plan from EPIC East Dock dredging plans, with annotations in red by NTSB. (Source: Orion Marine Group)

The third section of the dredging plans provided drawings of cross-sectional views of the dredging area at 100-foot increments (see figure 23). These drawings showed the proposed 46.5-foot depth of the berth and the sloped areas to be dredged outside the berth boundary. The bottom of the planned berth included a 1-foot "allowable over dredge." *Allowable over dredge* (or overdepth dredging) is excavation that occurs outside the required authorized dimensions of a dredge plan to compensate for conditions and inaccuracies in the dredging process and to allow for efficient dredging practices.[14] The amount of allowable over dredge is predetermined and must be approved by the permitting authority (in the case of the EPIC East Dock project, as with most

[14] Tavolaro, J. F., J. R. Wilson, T. L. Welp, J. E. Clausner, and A. Y. Premo. *Overdepth Dredging and Characterization Depth Recommendations*, ERDC/TN EEDP-04-37, Vicksburg, Mississippi: U.S. Army Engineer Research and Development Center, 2007

projects in the navigable waterways in the United States, the permitting authority was the US Army Corps of Engineers). The slopes of the dredge area did not have an allowable over dredge. The cross-sectional drawings also included a depiction of the components of the proposed dock, where applicable, and the existing surface of the bottom that was to be removed by the dredging work. The cross-sectional drawings did not show the location of the pipelines in the TMI Solutions utilities survey.

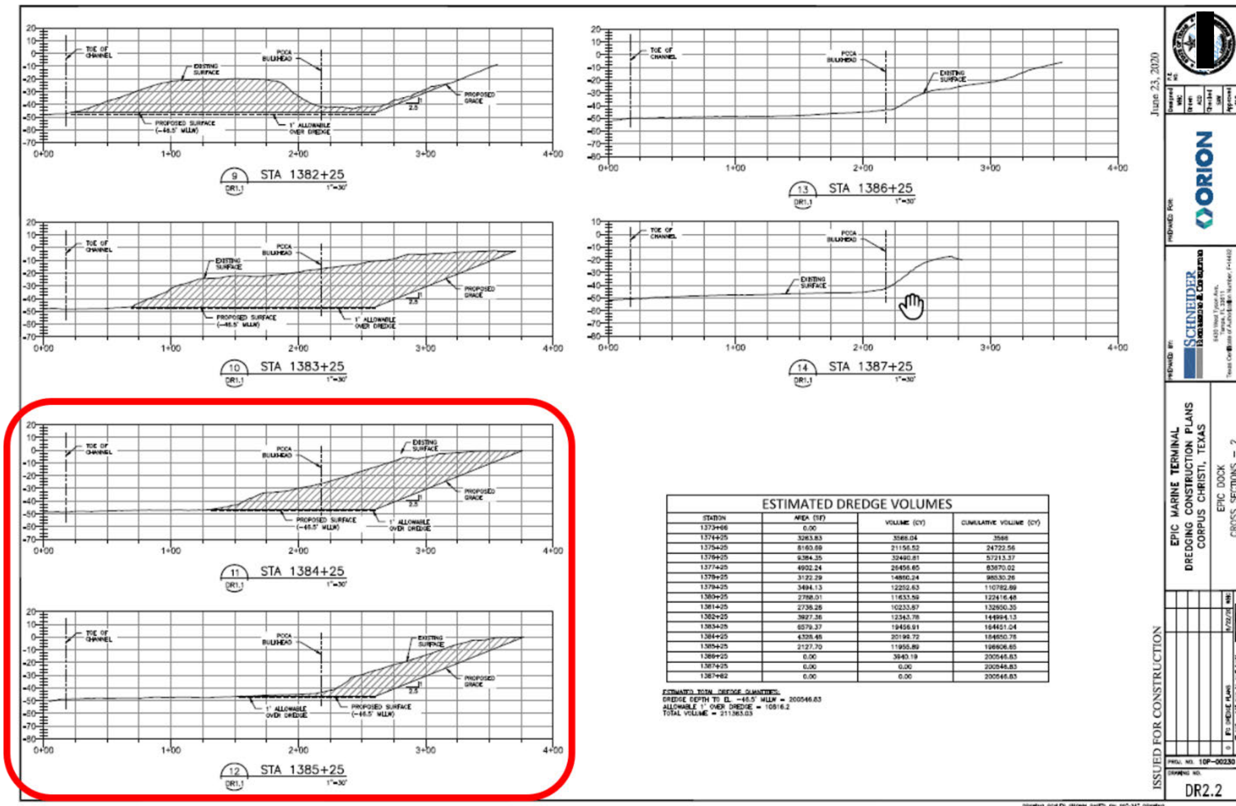

Figure 23. Sample of cross-sectional views from EPIC dock dredging plans. Cross-sections 11 and 12, circled in red by NTSB, were on either side of the accident site. (Source: Orion Marine Group)

The final section of the plans provided a general layout of the pipeline that moved the dredged material from the work site to the dredge material placement area.

The Schneider design engineer stated that he determined that pipeline TX219 was outside the dredge template by 8–10 feet by measuring the distance in an AutoCAD 2-dimensional plan (overhead) view of the project. When investigators requested documentation showing this measurement, they were provided a cross-sectional drawing that was generated on August 24, 2020, three days after the accident. The company did not respond to requests for preaccident documentation of the measurement. In the August 24 cross-sectional drawing, the location of the center of pipeline TX219 relative to the dredge template was depicted by a dotted red line. Investigators measured the distance between the dotted line and the top of the slope in the template. Assuming that the drawing was to scale, this distance in cross-section 11 (station 1384+25 – about 40 feet to the east of the accident site) was measured at 11.6 feet. The distance in cross section 12 (station 1385+25 – about 60 feet to the west of the accident site) was 2.8 feet (see figure 24).

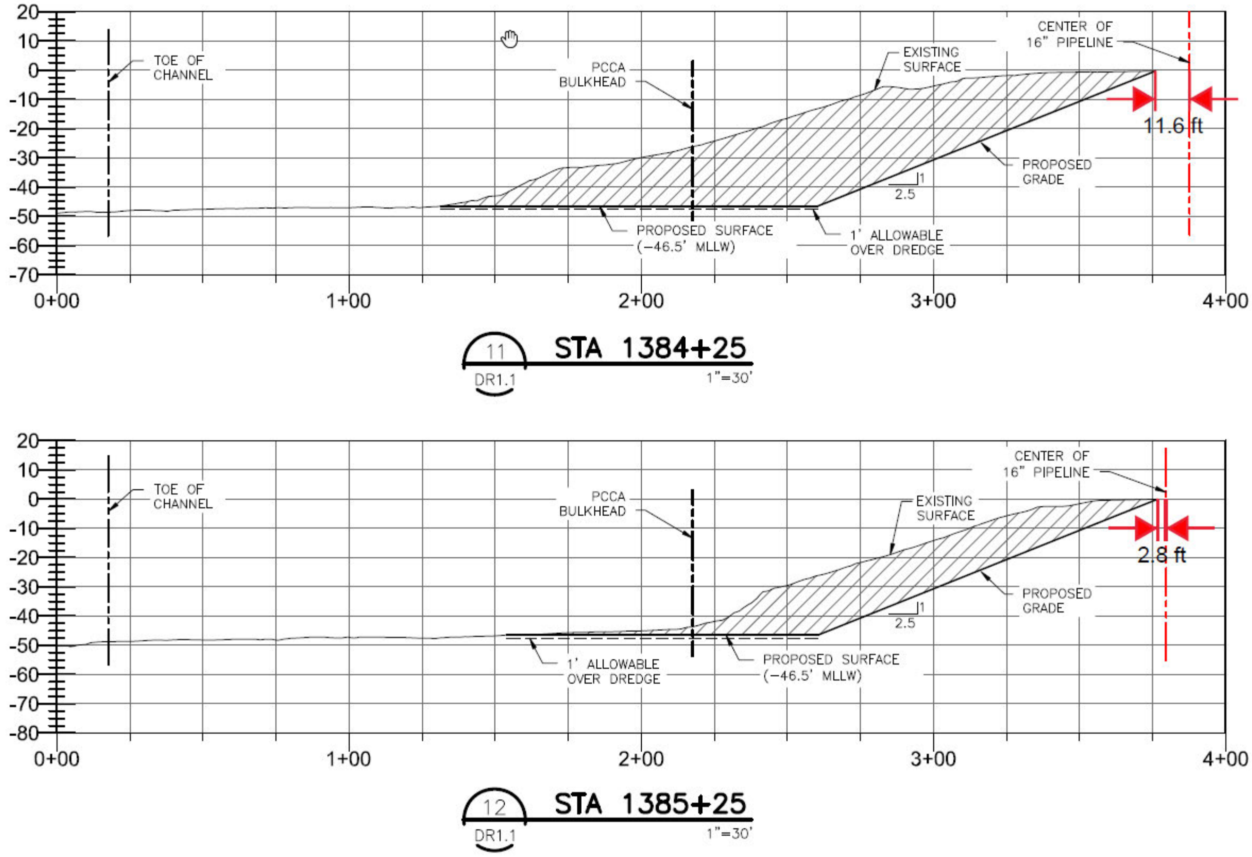

Figure 24. Cross-sectional drawings showing proximity of the center of pipeline TX219 to the dredge template. Red dotted line depicting pipeline center is original to the document. Measurement information added by NTSB using measurement tool in Adobe Acrobat Pro DC. (Source: Schneider Engineering and Consulting)

5 Hydrographic Survey and Dredging Software Applications

5.1 HYPACK and DREDGEPACK Software Overview

Orion Marine Group used the hydrographic surveying and data processing software HYPACK, along with its dredging-industry-specific module DREDGEPACK, to plan, execute, and monitor its dredging projects. HYPACK has been in use for over 35 years by a broad range of industries and government agencies, both foreign and domestic, including the US National Oceanic and Atmospheric Administration (NOAA) and the US Army Corps of Engineers. HYPACK allows users to directly record data from hydrographic survey equipment (such as multibeam and sidescan sonars), process the data, and then present the data in various forms, including two-dimensional and three-dimensional models (see figure 25). A menu within the HYPACK software provides project planners with the option to select the geodetic datum used by the application from a list of common standards, including World Geodetic System 1984 (WGS84) and NAD83.

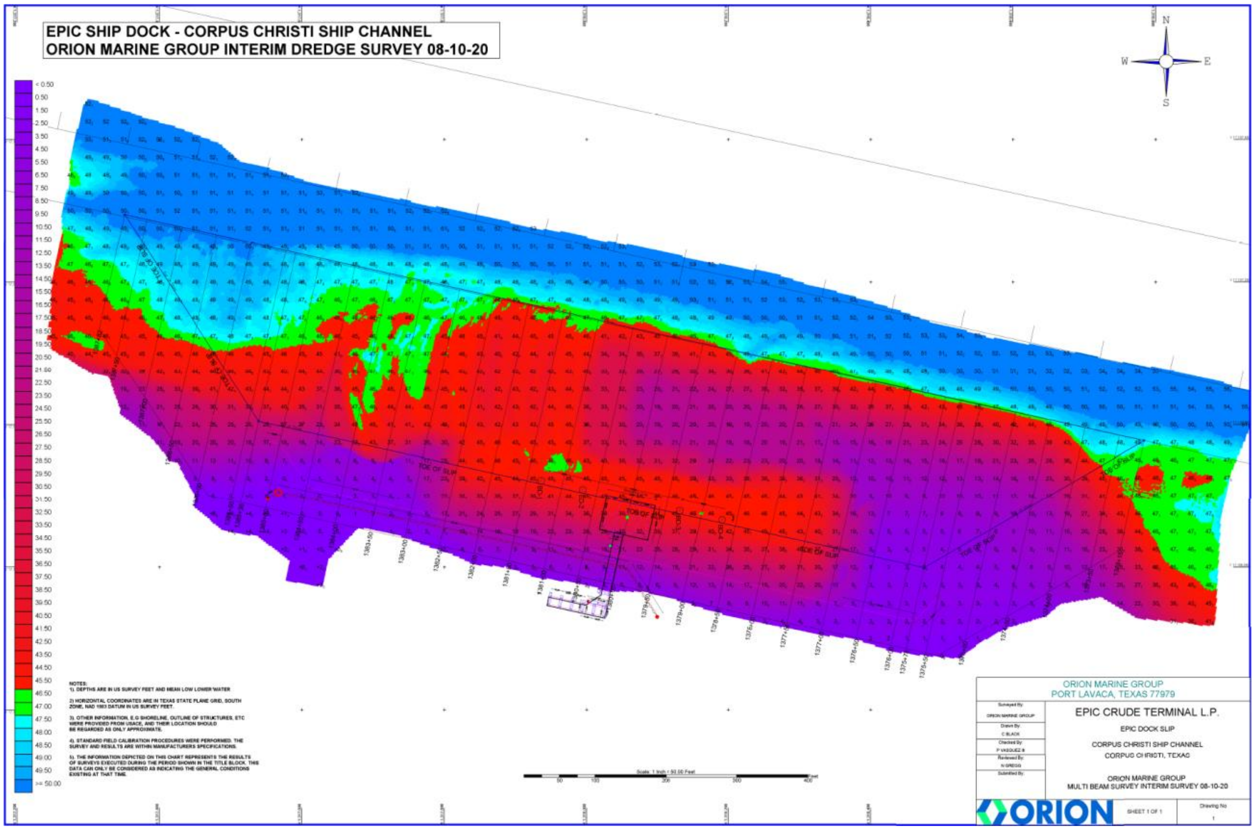

Figure 25. Two-dimensional representation of EPIC Dock site hydrographic survey data developed using HYPACK. Data was collected on August 10, 2020, using multibeam sonar installed on an Orion survey boat. (Source: Orion Marine Group)

The DREDGEPACK module was introduced in 1996 in response to industry demand for an application that can use HYPACK data to plan dredging projects, monitor their progress, and provide the leverman a tool to aid in the dredging work. Within DREDGEPACK, planners can develop a dredge template based on the engineering plans of the project. A DREDGEPACK template is a set of planar surfaces that represent the bottom and sides of a planned dredge area (see figure 26). Each planar surface is defined by 3 or more nodes—points in space that are the corners of the plane. A template is constructed in DREDGEPACK by entering the coordinates for the nodes (easting, northing, and depth below MLLW). The coordinates are usually taken from the engineering plans for the project, although the sloped sides of the template can also be constructed by entering the coordinates for the bottom of the dredge area and selecting a desired rise to run ratio for the slope. In this automated process, the coordinates for the top of the slope are generated by the software.

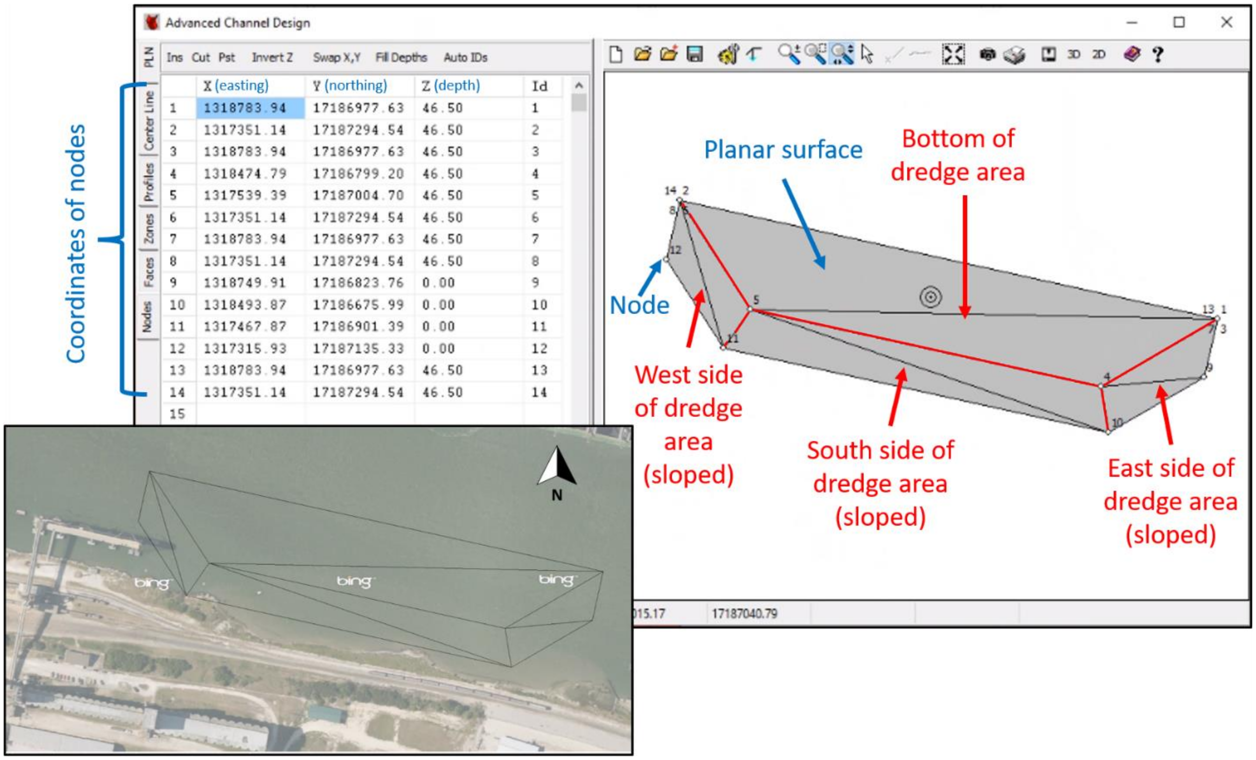

Figure 26. DREDGEPACK dredge template for EPIC Dock project, annotated in blue and red by NTSB. Inset is dredge template overlaid on satellite image of site. (Sources: template data source - Orion Marine Group; satellite imagery as displayed in DREDGEPACK - Microsoft Bing)

Once the dredge template has been created, the planner uses the hydrographic data to create a "matrix" file in DREDGEPACK. A matrix is a color-coded representation of the bottom topography of the dredging area, divided into square cells. The cell height/width is selectable by the planner. The color scheme used in the matrix is configurable by the planner, and most use a single color with shade differences to indicate the depth within the dredge template boundaries, a distinctly different color to indicate the depth at the boundary of the template or within the allowable over dredge, and another distinct color to indicate when the depth exceeds the template boundaries.

Once the dredge template and matrix are created, they are loaded onto a DREDGEPACK-equipped personal computer (PC) at the leverman station on board the assigned dredge. The DREDGEPACK display on the PC is fully configurable by the user, but most presentations used aboard a dredge include an overhead or "Map" view of the dredge area, a cross-sectional or "CutterProfile" view of the area, and a listing of key dredge parameters, such as the cutterhead location, cutter depth, tidal correction, and vessel heading (see Figure 27). The overhead view shows the matrix file, as well as a representation of the dredge and cutterhead. The cross-sectional view shows the location of the cutterhead in relation to the bottom topography and the dredge template.

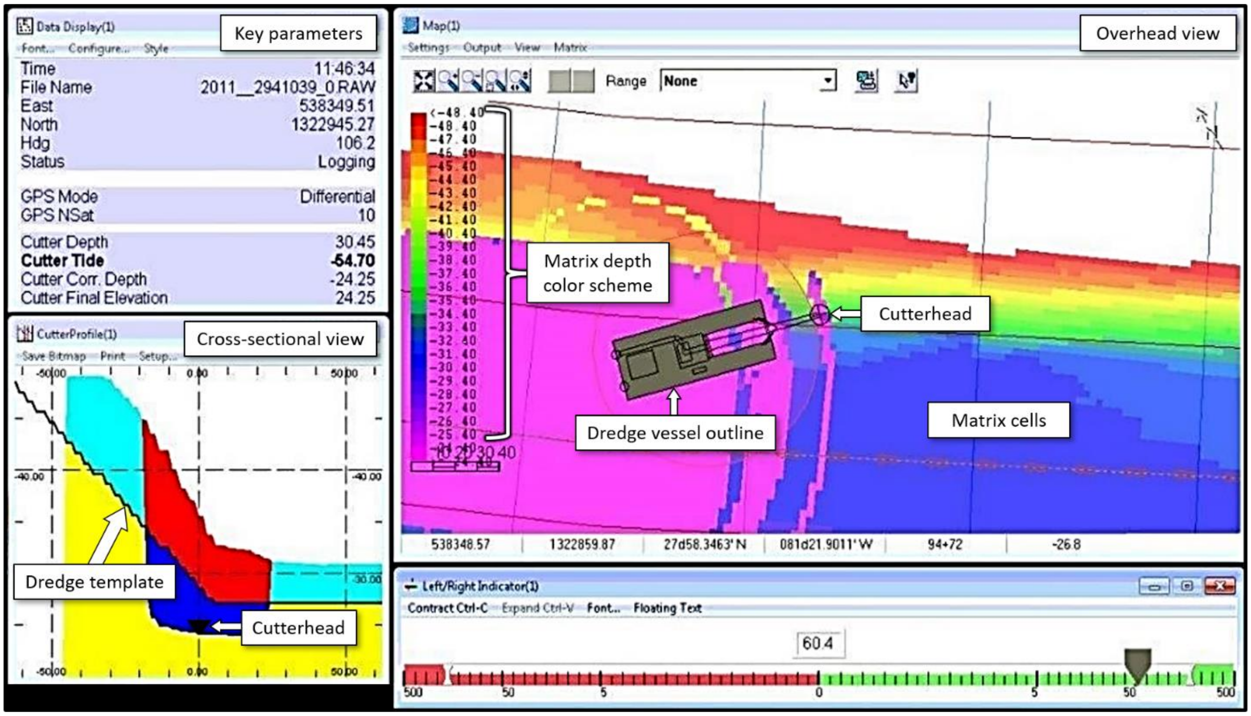

Figure 27. Sample DREDGEPACK display (does not reflect accident vessel or site). As shown in the key parameters in the upper left, a significant tidal correction has been entered into the system. In the overhead view on the right of the display, the matrix cells range in color from red (shallowest) to purple (deepest). The cells are shown changing to purple as the cutterhead sweeps the channel. Note in the cross-sectional view on the lower left, the slope in the template at the channel sides and that the cutterhead is outside the template. (Source: HYPACK)

During dredging operations, the leverman monitors DREDGEPACK while the dredge swings. As the cutterhead indicator on the overhead display moves through a matrix cell, the cell changes color to indicate a new bottom depth based on the cutterhead depth. In this manner, the leverman "repaints" the matrix to reflect the area being dredged. Thus, the leverman can use the matrix color coding, in conjunction with the cross-sectional view, to determine when he has reached the planned boundaries, plus allowable over dredge, of the dredging area. Changes in matrix cell colors during dredging operations are based on the cutterhead depth and not actual hydrographic data, and thus periodic surveys are required to validate the dredging work and to update the matrix file.

To ensure that the dredging work is accurately being reflected in DREDGEPACK, the software requires accurate horizontal and vertical location data for the cutterhead, both geographically and with respect to the template. Inputs for horizontal position are normally provided by GPS for heading and location, and DREDGEPACK automatically converts the GPS's WGS84-datum-based location data to the datum used in the template. Input for the vertical position is provided by an inclinometer mounted on the ladder, along with a correction for the height of tide that can be automatically or manually updated. DREDGEPACK calculates the location of the cutterhead based on these inputs, the dimensions of the ladder and cutterhead, and the location of the GPS positional antennas on the vessel. All distance and depth dimensions are measured in relation to a reference point on the dredge vessel, which is commonly a point centerline between the ladder trunnions. These dimensions are configured in DREDGEPACK manually by the project planner. When needed, the inclinometer must be recalibrated to ensure accurate depth information, and tidal information must be entered by the leverman at regular intervals.

HYPACK and DREDGEPACK files are organized into "projects," and HYPACK survey data and DREDGEPACK templates and matrix files are generally organized under the same project for a single worksite. Data from dredging operations are recorded by DREDGEPACK on the PC aboard the dredge. These data can be downloaded for later playback and reconstruction.

HYPACK and DREDGEPACK are updated by the developer every 1–2 years based on feedback by users. HYPACK conducts training on its product at a conference each January, usually coinciding with the release of a new version. The Orion Marine Group Survey Superintendent stated that he attended the HYPACK training conference about every other year. One of his two survey teams would attend with him, alternating between the two teams from conference to conference. Orion personnel last attended the conference in 2018.

5.2 EPIC Dock Project HYPACK/DREDGEPACK Data

At the time of the accident, Orion Marine Group was using HYPACK version 2018 to plan and execute the EPIC East Dock dredging operation. HYPACK survey data and the DREDGEPACK dredge template and matrix files for the excavation site were organized under a single project in the application, and the horizontal geodetic datum used for the project was NAD83 Texas State plane 4205. During dredging operations, GPS horizontal position data for DREDGEPACK was provided by a Trimble SPS855 marine global navigation satellite system (GNSS) receiver and associated equipment, accurate to within 1 meter.

5.2.1 Survey Data

Pre-accident Surveys. In normal practice, Orion Marine Group personnel used the HYPACK software and boats equipped with multibeam and single beam sonar to survey a site before a project started, at 1–2 week intervals during the project, and at project completion. The initial survey for the EPIC East Dock phase 2 operations was conducted on June 12, 2020, and periodic surveys were conducted on August 10 and August 17. Sample data from these surveys are shown in Figure 28.

AIS data from the *Waymon Boyd* showed that the dredge worked an area east of the existing mooring dolphins from August 12–16, between the two periodic surveys. Cross-sectional views of the hydrographic data reflected the results of this work. Specifically, cross-sectional views 1382+50 and 1383+00 from the August 17 survey data showed dredging work completed along the sloped area of the template.

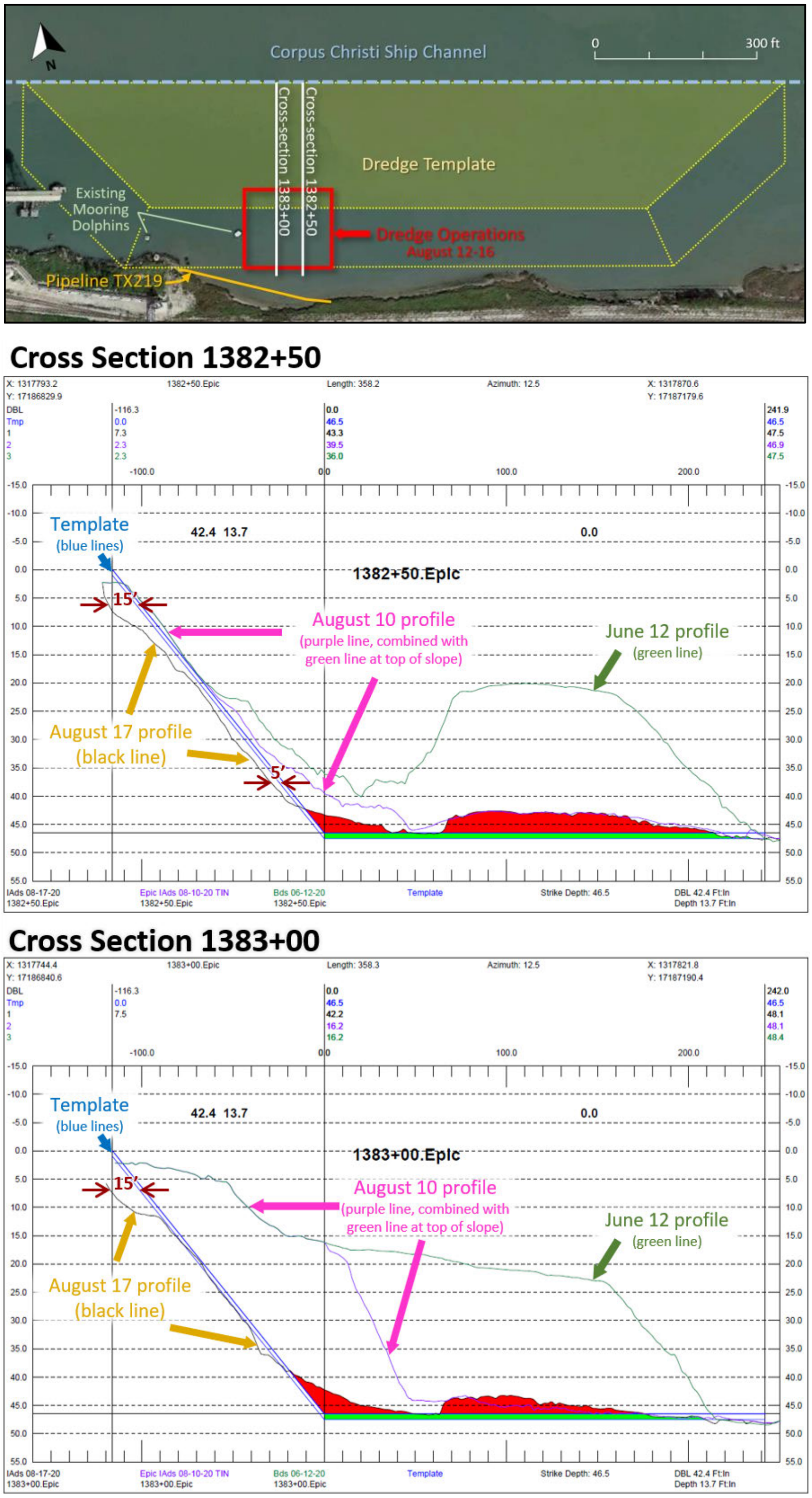

Figure 28. Cross-sectional survey data from dredging operations conducted August 12–16, 2020. Colored lines show the profile of the bottom topography in relation to the dredge template during the pre-dredge survey (June 12) and periodic project surveys (August 10 and 17). Red fill indicates material remaining to be dredged within the template. (Source: Orion Marine Group, with annotations by NTSB.)

In view 1382+50, it appears material has been removed outside of the template by 15 feet at the top of the slope and by 5 feet for the remainder of the slope. The Orion survey superintendent stated that, while the removal of excess material could have been caused by over-dredging, it could also be the result of soft or loose material on the slope that collapsed after dredging to the template. He noted the additional material at the toe (bottom) of the slope, which may have come from the collapsed slope. The leverman stated similarly that the material outside the template "maybe just cave in" after the cutterhead excavated along the shoulder of the template.

In cross-sectional view 1383+00, the dredged area roughly follows the template until 12 feet from the top of the slope. In this area, material loss exceeds the template by about 15 feet. Cross-sectional views of the slope on the eastern side of the template—areas which had been dredged during phase 1 of the EPIC East Dock project—show profiles similar to cross-section 1383+00: the contours roughly follow the template, except at the top of the slope where material has been removed in excess of the template by about 15 feet (see figure 29). The superintendent explained that the additional loss of material at the top of the slope could be the result of wave action and other forces created by passing ships in the channel.

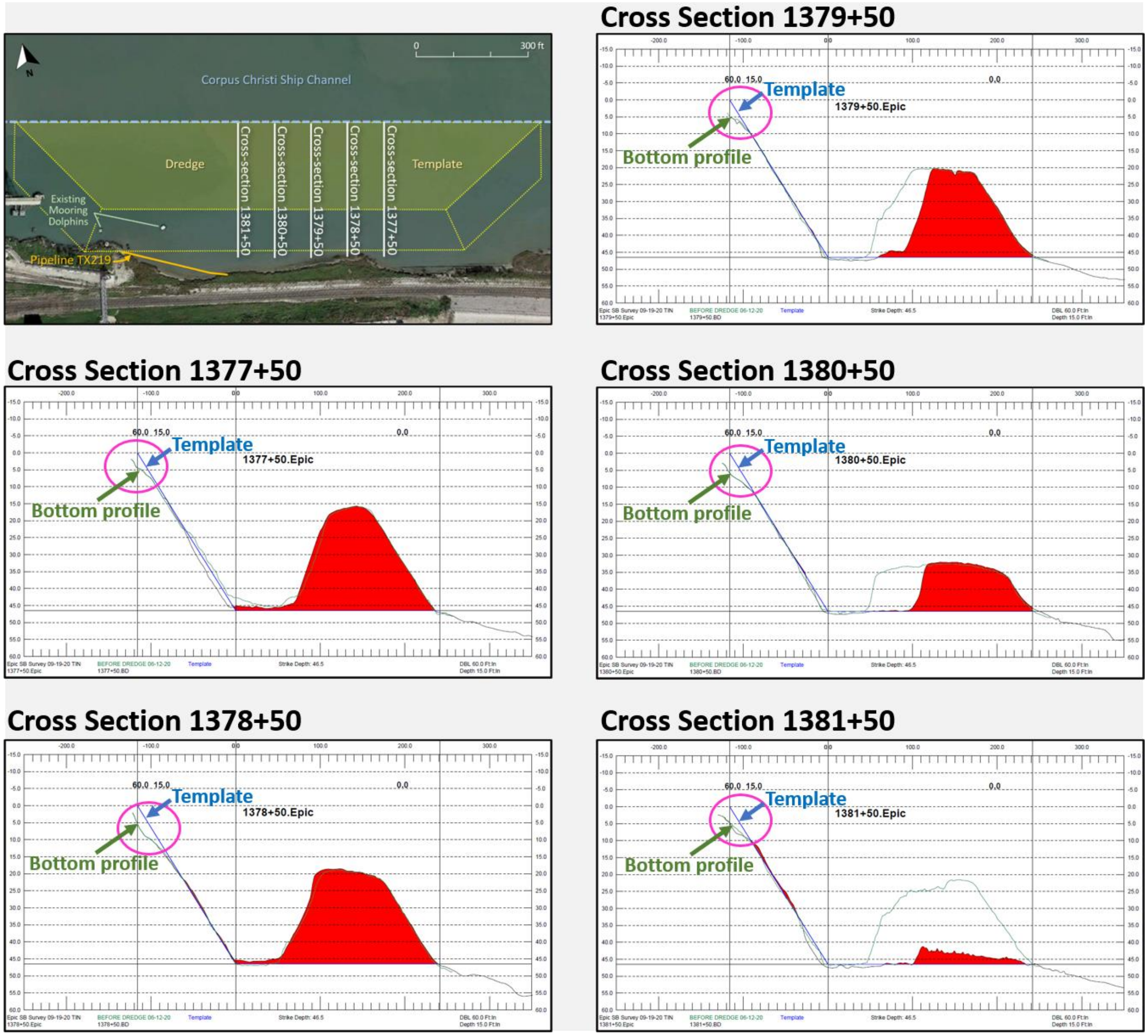

Figure 29. Cross-sectional views of area dredged during phase 1 of EPIC dock project. (Source: Orion Marine Group, with annotations by NTSB)

Postaccident Survey. On September 19, 2020, Orion personnel conducted a postaccident survey of the project site. They also surveyed the damaged pipeline using a real-time-kinetic (RTK) GPS-enabled probe to physically determine its location (see Figure 30). Data shows an arc of deeper water between the two existing mooring dolphins, sloping up toward the bank. The pipe breach is located at the apex of the arc.

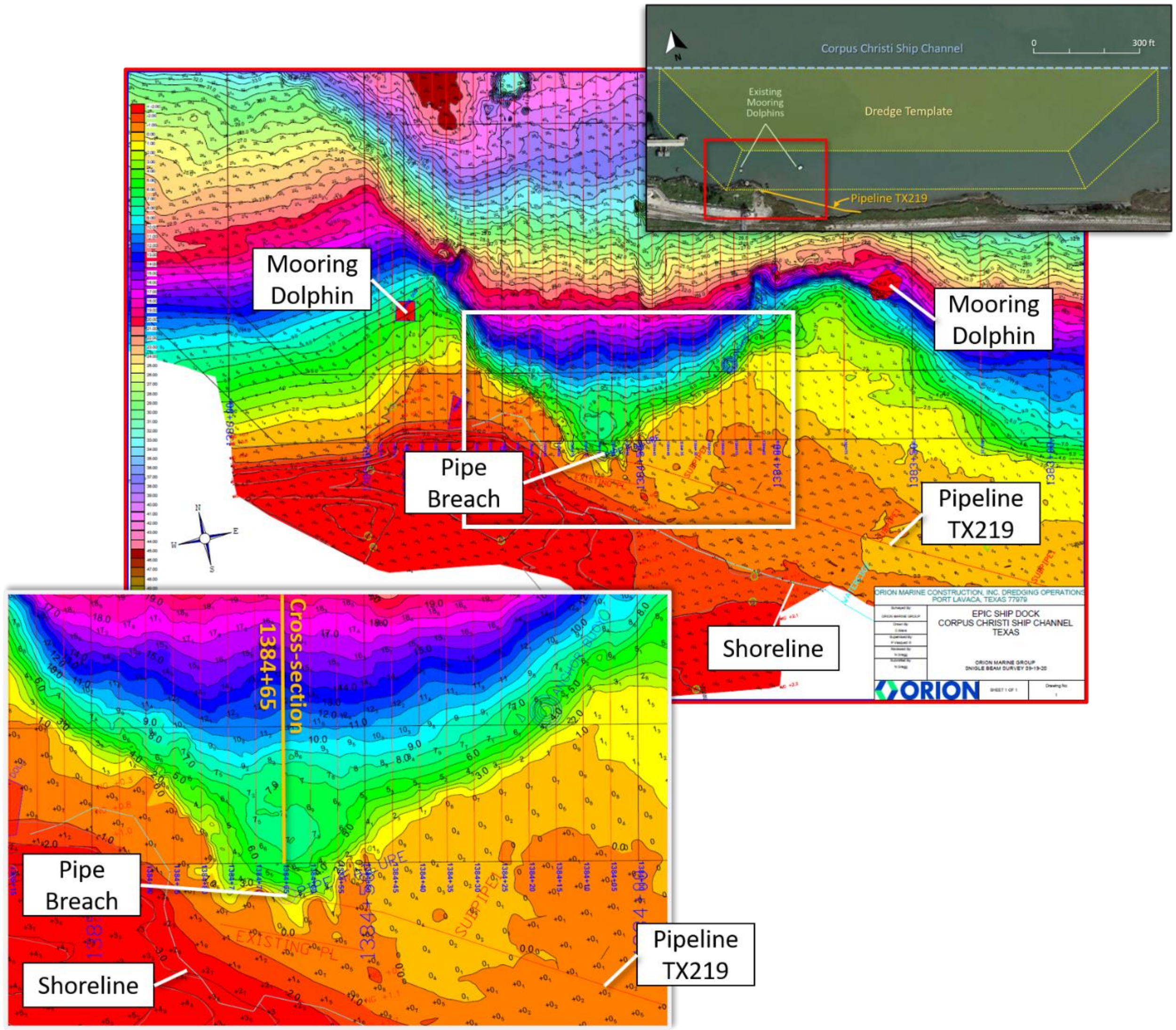

Figure 30. Results of September 19, 2020 hydrographic survey of accident site. Inset top shows survey area. Inset bottom is an exploded view of the accident area. (Source: Orion Marine Group, with annotations by NTSB)

The cross-sectional view at the accident site shows that, similar to cross-sections from earlier dredging, the excavation follows the template except at the top of the slope where material has been removed in excess of the template (see figure 31). Unlike the previous cross sections, however, the area where material has been removed at the top of the slope forms a pocket vice a smooth curve. The pocket lies directly below the damaged pipeline, labeled in figure 31 as "PL."

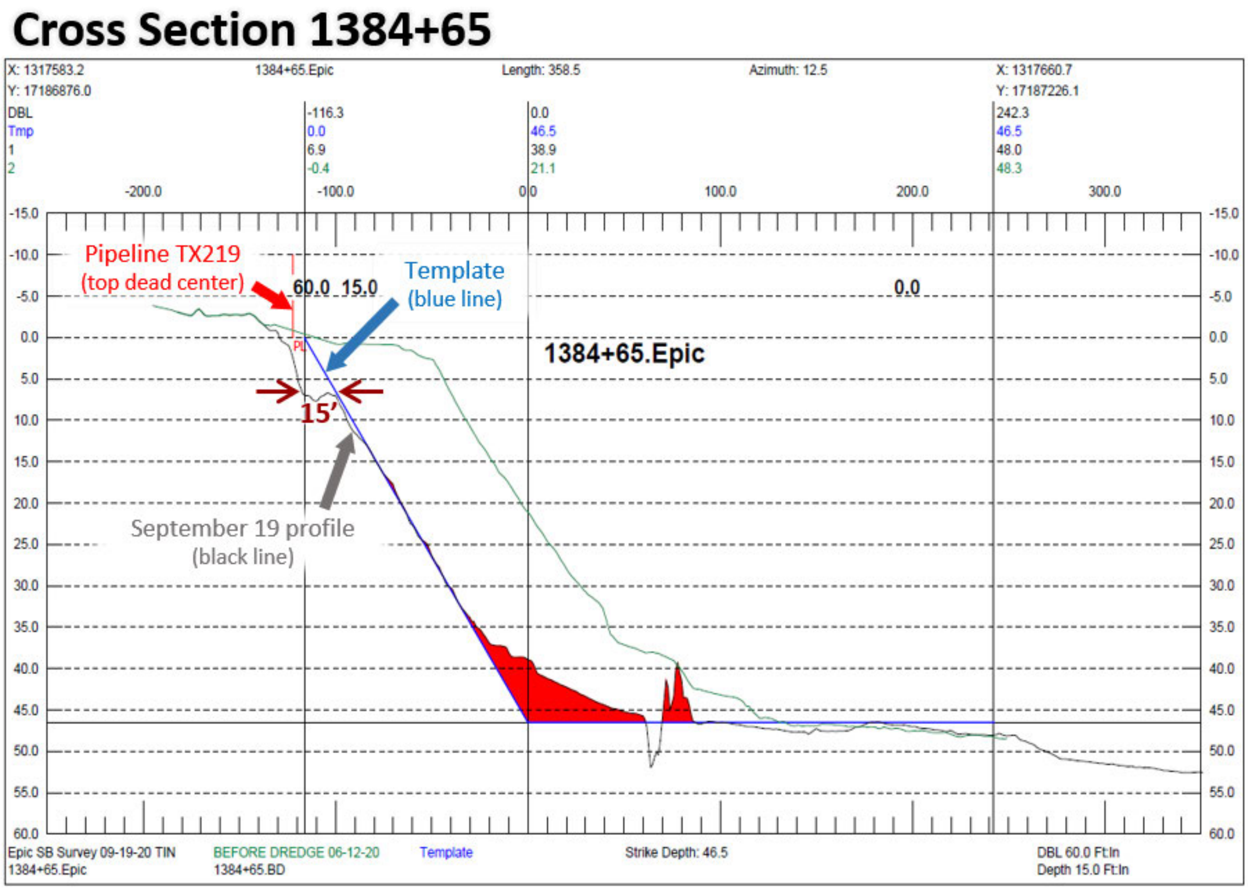

Figure 31. Cross sectional view of dredging area at accident location from September 19, 2020, survey. Red line and "PL," which appear in the original document, denote top dead center of pipeline as located by Orion personnel during the survey.

5.2.2 DREDGEPACK Data

The Orion Marine Group survey superintendent told investigators that he developed the DREDGEPACK dredge template for phase 2 of the EPIC East Dock project (figure 26 above) from the June 23, 2020, Schneider Engineering and Consulting drawings. Using the coordinates listed in the Dredge Site Plan (figure 22 above), he created the nodes for the boundary of the berth floor. He stated that he adjusted the coordinates of the north east corner of the berth (point D in the engineering drawing, node 1/3/7/13 in the DREDGEPACK template) so that the boundary of the berth terminated at the ship channel. After entering the given coordinates, the survey superintendent used DREDGEPACK's slope creator tool to determine the coordinates for the nodes at the top of the sloped sides, entering a slope ratio of 2.5:1 per the engineering drawings. Note that in the completed template that the southwest corner of the dredging area lies over land. This area is immediately to the west of the pipeline breach location.

The survey superintendent stated that, if a pipeline was within a dredging project area, he included the pipeline in the DREDGEPACK dredge template, usually as a black line with a label. If required for the project, he would also include lines showing standoff distances on either side of the pipeline. The superintendent relied on the project manager and project engineer, using the One Call process, to identify any pipelines and, if required, provide him with the location data to include in the DREDGEPACK template. For the EPIC East Dock project, he did not receive any data for pipelines from the project engineer, and so he did not include them in the DREDGEPACK dredge template. He told investigators that, based on the engineering plans, he was aware of the pipelines near the project area but believed that they were “up on the bank in the rocks, kind of out of the way.” When he developed the DREDGEPACK template, the pipelines “were not considered at all.”

According to the survey superintendent, no one was assigned to conduct a quality assurance check of the DREDGEPACK dredge template once he had developed it. However, he stated that any issue with the template would have been discovered by the dredge crew or by independent surveyors who conducted a pre-start survey for contract verification.

Investigators reviewed the DREDGEPACK dredge template for the EPIC East Dock site developed by the survey superintendent. The depth of the berth in the template was 46.5 feet with a 1 foot allowable over dredge, in accordance with the engineering plans. The two nodes marking the western boundary of the berth matched the coordinates of the boundary provided in the Schneider Dredge Site Plan. The coordinates of the node marking the southeastern corner of the berth template differed from the engineering drawing by .10 feet northing and .46 feet easting, for a total offset of .47 feet to the southwest. As the superintendent had stated, the coordinates of the node marking the northeast corner of the template had been adjusted and so did not match the engineering plan for the berth. However, investigators noted that the coordinates of the adjusted node were in the same line as the original eastern corners of the berth. Thus, the adjustment did not alter the position of the eastern boundary line, but only lengthened it in the northeast direction. The coordinates for the nodes marking the sides of the dredge template (the sloped surfaces outside the berth boundary) corresponded to a slope of each surface of 2.5:1, matching that of the engineering plan.

Following the June 12, 2020, survey, the superintendent created a matrix file for the project area. When the *Waymon Boyd* was assigned to the project, he uploaded the template and matrix files to the vessel by remotely accessing the dredge’s DREDGEPACK computer from his computer at his office. He later updated the matrix files based on the August 10 and August 17 hydrographic surveys. The leverman told investigators that on his DREDGEPACK display, the cutterhead was indicated by an “X” in the cross-sectional view. He stated that, when excavating the slope, he put the middle of the X on the line marking the slope in the DREDGEPACK dredge template as he worked the cutterhead down the incline.

The computer running DREDGEPACK on the *Waymon Boyd* was destroyed during the accident, and all data from this PC was lost. Although dredge superintendents had a feed from the dredge and could view the DREDGEPACK display in their office in real-time, the information from this feed was not recorded ashore. Thus, investigators were unable to playback and reconstruct the *Waymon Boyd*’s information from the accident. Configuration information entered into DREDGEPACK, such as the ladder and cutterhead dimensions and GPS antenna locations, was also lost and could not be verified.

6 Pipeline Location Data

The NTSB obtained location data for pipeline TX219 from multiple sources, to include Enterprise Products in-line inspection (ILI) data, the 2018 TMI Solutions utilities survey, a postaccident survey performed by Orion Marine Group personnel, and a postaccident survey performed by Enterprise Products contractor SAM, LLC. The location data varied among all sources (see figure 32). At the point of damage to the pipeline, none of the data showed the pipeline within the DREDGEPACK dredge template in use by the *Waymon Boyd* at the time of the accident.

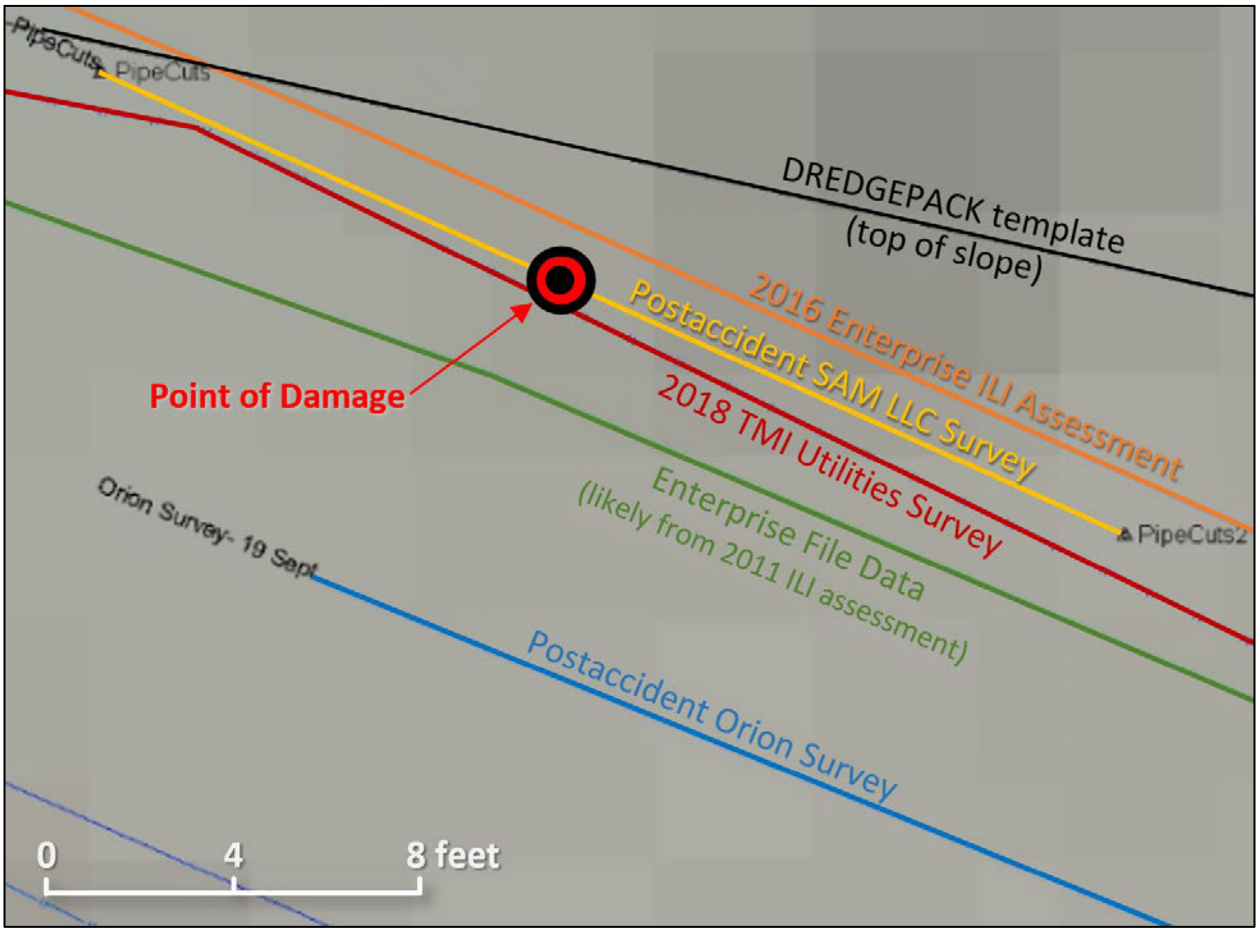

Figure 32. Sample of various pipeline location data near accident site.

With the assistance of a HYPACK technical representative, NTSB investigators imported the TMI Solutions survey data (the data provided to Orion Marine Group and Schneider Engineering and Consulting for planning the EPIC dock project) into DREDGEPACK and used the system's tools to measure the distance between the center of pipeline TX219 and the outer edge (top of the slope) of the EPIC East Dock dredge template in use by the *Waymon Boyd* at the time of the accident. At its nearest point, the center of pipeline TX219 was 0.8 feet from the DREDGEPACK dredge template, and at the accident location, the pipeline was 1.9 feet from the template (see figure 33). A similar projection of the data from 2016 Enterprise ILI assessment (the most recent assessment by the pipeline owner), showed the distance from the pipeline's center to be 1.0 feet from the dredge template.

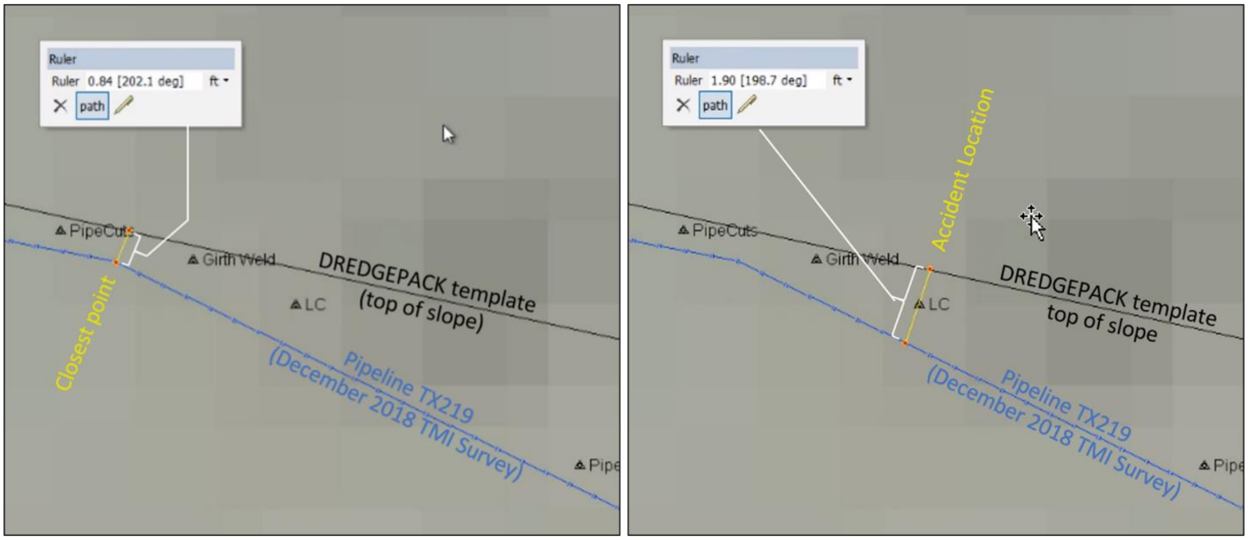

Figure 33. Screen captures from DREDGEPACK dredge template for the EPIC dock project, with imported location data for pipeline TX219 from 2018 TMI Solutions utilities survey. Left image shows distance between pipeline and template at closest point. Right image shows distance from pipeline to template at the accident location.

7 Dredging and Marine Engineering Companies

The Orion Marine Group is a heavy civil marine construction and specialty services firm founded in 1994 and based in Houston, Texas. The company operates in the United States, Canada, and the Caribbean basin on projects including port facilities and terminal construction, marine pipeline repair and construction, and environmental projects such as wetlands preservation and creation. Orion Marine Group entered the dredging segment in 1998 when it acquired the Port Lavaca-based King Fisher Marine Service, a company that had been operating in the industry for 58 years at the time of acquisition. Since the acquisition of King Fisher, Orion has grown its dredging services division through the acquisition of assets and another company.[15] In 2011, the company consolidated its brands and dropped the King Fisher Marine Service trade name. As of December 2019, the Orion Marine Group had about 900 employees.[16] At the time of the accident, the company owned seven cutterhead dredges (also known as hydraulic dredges), two mechanical dredges, and various other support vessels.[17] The company owned the *Waymon Boyd* and employed its crew.

Schneider Engineering and Consulting Inc. is an engineering design firm that specializes in planning, permitting, and designing marine structures and infrastructure.[18] The company was established in 2012 and is based in Tampa, Florida. The company has a staff of about 15 people,

[15] Orion Marine Group, *History – Orion Marine Group*, https://www.orionmarinegroup.com/company-history/, accessed March 5, 2021.

[16] Orion Group Holdings Inc., *2019 Annual Report*, Houston, Texas: Orion Group Holdings, 2019, page 13.

[17] A *mechanical dredge* is a vessel that performs underwater digging using an excavator or other bucket- or grab-type mechanical equipment.

[18] Schneider Engineering and Consulting Inc., *Planning & Design – Marine Structures and Infrastructure*, http://www.schneiderec.com/index.html, accessed March 5, 2021.

including 8 licensed professional engineers. Schneider Engineering and Consulting developed the dredging and marine structural plans for the EPIC East Dock project.

Both the Orion Marine Group and Schneider Engineering and Consulting are wholly owned subsidiaries of Orion Group Holdings, Inc. In 2019, the marine segment of Orion Group Holdings reported revenues of $369.1 million.[19]

8 Personnel

8.1 Vessel Crew and Key Company Personnel

Seven on-shift and one off-shift crewmembers, along with the dredge captain, were on board the *Waymon Boyd* at the time of the accident (as previously noted, the deck captain was not aboard). Nine other on-shift crewmembers were aboard the associated dredge tenders or booster-pump barges. Additionally, several shore-based Orion Marine Group and Schneider Engineering and Consulting personnel supported the overall dredging project and the day-to-day operations of the dredge. The following are summaries of the background and experience of key personnel on the dredge and ashore.

8.1.1 *Waymon Boyd* Crew

Dredge captain. The dredge captain was overall in charge of the vessel. He was in his office, directly aft of the lever room, at the time of the explosion. He did not have, nor was he required to have, a Coast Guard merchant mariner credential or any other operator license or certification. According to company training files, he had been tested and was qualified to operate the survey boat and dredge tender, the anchor barge derricks, and various types of excavation equipment. The dredge captain began working on dredges since 2000, starting at the entry-level deckhand position, and throughout his career he was promoted to positions of higher authority, including leverman. He had served as a deck captain on several company dredges, including the *Waymon Boyd*, from 2010 to March 2019, when he was promoted to dredge captain. During his time as dredge captain on the *Waymon Boyd*, the vessel had worked seven projects in ports along the Texas Gulf Coast, including phase 2 of the EPIC East Dock project. The dredge captain's direct supervisors were the dredge superintendents.

Deck captain. The deck captain was second overall in charge of the *Waymon Boyd*. He was not aboard the vessel at the time of the accident because it was his normal time off. He did not have, nor was he required to have, a Coast Guard merchant mariner credential or any other operator license or certification. He had been tested and was qualified by the company to operate the survey boat and dredge tender, the anchor barge derricks, and various types of lifting appliances and excavation equipment. Since 1981, the deck captain had been working off and on in the dredging industry and had a total of about 30 years' experience on dredges. He had worked for Orion Marine Group continuously since 2012, starting as a relief leverman (an on-call leverman assigned to fill in for permanently assigned levermen when needed). He was promoted to leverman and then, in 2013, to deck captain. In 2017 he was assigned to the *Waymon Boyd* and worked numerous projects

[19] Orion Group Holdings Inc., *2019 Annual Report*. Page 27

on the vessel. The deck captain’s direct supervisor was the dredge captain, unless the dredge captain was off rotation, during which time he reported directly to the dredge superintendents.

Leverman. The leverman on duty at the time of the accident was in the lever room and at the controls of the vessel when the pipeline was breached and the explosion occurred. He did not have, nor was he required to have, a Coast Guard merchant mariner credential or any other operator license or certification. According to employment records, he was hired as a deckhand in 1980 by King Fisher Marine Service. Except during periods of industry contraction when he had been laid off, he had worked for King Fisher Marine Service/Orion Marine Group for his entire career and had been working as a leverman since the early 1990s. The leverman’s direct supervisors were the dredge captain and deck captain.

Other crew. Experience levels for other crewmembers ranged from 6 days for an entry-level booster-barge oiler to 16 years for a mate. Each crewmember stated that there were no formal classroom or on board training requirements (other than basic requirements such as CPR), and all skills were passed down from senior to junior crewmembers while on the job.

8.1.2 Shore-based Personnel

Director of operations. The director of operations managed Orion Marine Group’s dredging operations and its facilities at Port Lavaca. He had worked for King Fisher Marine Service/Orion Marine Group since 1984, starting in an entry level position and promoting through various yard (shore-based) positions. In 2008, he was promoted to operations manager and then, in 2017, to director of operations. As the director, his supervisor was the Orion Marine Group’s senior vice president for construction. The director was based at Orion’s Port Lavaca facilities, and he stated that he visited each dredging site at least once a month.

Regional health, safety, and environmental manager. The regional HSE manager was responsible for overseeing safety programs and training for Orion Marine Group’s dredging fleet. He managed a team of five safety supervisors and a safety coordinator, who conducted safety training and responded to safety concerns or incidents. In consultation with the project manager, the regional HSE manager also drafted “site specific safety plans” for each dredging project. These plans provided safety policies and procedures relevant to the work site (see section 9.2 for more information on site specific safety plans). The regional HSE manager had worked for Orion since April 2019. His supervisor was Orion Marine Group’s HSE director.

Project manager. The Orion Marine Group project manager reported to the director of operations and was responsible for business development, estimating project costs, reviewing project plans, providing project oversight, procuring materials and services, and supervising project engineers, among other duties. He did not supervise the dredge crew; he exercised his project oversight duties by monitoring field reports and estimates for customer payments. The manager stated that he typically oversaw three projects at a time and had oversight of the EPIC East Dock project when the accident occurred. He held a bachelor’s degree in agricultural systems management and had worked for Orion as a project leader and project manager since his university graduation in 2007.

Project engineer. The Orion Marine Group project engineer reported to the project manager and was responsible for the day-to-day oversight of dredging projects, including reviewing lost time reports (down time on the dredge for maintenance and repairs), leverman logs, and water quality control reports and generating production recap reports, among other duties. The project engineer was also responsible for making One-Call notifications, working with utility providers as necessary and notifying Orion personnel of potential conflicts between utility lines and dredging projects. She conducted the One-Call notifications and follow-up for phase 2 of the EPIC East Dock project. The project engineer held a bachelor's degree in offshore and coastal systems engineering and began working for Orion upon graduation from university in May 2019. At the time of the accident, she had been a project engineer for about 11 months. When asked by investigators, the project engineer stated that she had not received any training on pipeline safety since being hired by Orion.

Survey superintendent. The Orion Marine Group survey superintendent reported to the director of operations and was responsible for overseeing hydrographic and inland surveys of marine dredging projects. He told investigators that the purpose of the surveys was to "check quality behind the dredges to make sure that they're digging correctly and they're removing the correct amount of dirt." As part of his responsibilities, he directly supervised Orion's survey crews, each consisting of a hydrographic survey boat operator and survey technician. The superintendent was also responsible for building the dredging template for each project in DREDGEPACK software and installing the template on the assigned dredge. He had created and loaded the DREDGEPAK template in use by the leverman on board the *Waymon Boyd* at the time of the accident. He held a high school diploma and had worked for King Fisher Marine Service/Orion Marine Group since 2000, beginning as a boat operator and advancing to survey technician, before being promoted to superintendent.

Dredge superintendents. Two Orion Marine Group dredge superintendents reported to the director of operations and shared responsibilities for the overall direction and coordination of the day-to-day activities on each of the company's dredges. According to the position description for the dredge superintendents, they were also responsible for working with the dredge captains, deck captains, and other dredge crew members to ensure that dredge work was progressing consistent with the projected time schedule and that all operations were being performed in a safe and efficient manner. They were the direct supervisors for all dredge captains and exercised their duties by monitoring dredging operations via a real time display of DREDGEPAK data linked from the dredges to their office, through regular phone calls to the captains and levermen, and by making visits to the dredges.

Superintendent 1 had worked for King Fisher Marine Service/Orion Marine Group for his entire career, starting as a deckhand in 1981. He had held various deck and engineering positions on dredges, including leverman, deck captain, and dredge captain, before being promoted to superintendent in 1999. Superintendent 2 had also worked for King Fisher/Orion for his entire career, starting as a deckhand in 1982. He had held various deck and engineering positions on dredges, including leverman, deck captain, and dredge captain, before being promoted to superintendent in 2010.

Design engineer. The Schneider Engineering and Consulting design engineer reported to the firm's principal engineer and was responsible for making calculations and using design software to develop plans for structures and other construction elements used in the marine environment. He worked with drafters to produce drawings based on the plans he generated, and the plans and drawings were then reviewed by the principal engineer. The design engineer developed the dredging and construction plans and drawings for the EPIC East Dock project. He held a bachelor's degree in civil engineering and worked for Orion Marine Construction, a part of the Orion Marine Group, for 2 years following graduation from university. He moved to Schneider when it was established in 2012 and had held the position of design engineer since he obtained his professional engineer's license in the state of Florida in 2015. He was also licensed as a professional engineer in Texas, Louisiana, and South Carolina.

8.2 Crew Work/Rest

The dredge captain told investigators that his normal working hours were 0600 to 1800. He said that he regularly got eight or more hours of sleep each night, going to bed between 2000 and 2100 and waking up at around 0500. He slept on the dredge and could be woken up during the night to handle issues with the dredge, but he stated that these occasions were rare. The night before the accident, he was awake until about midnight while repairs were made to the cutterhead shaft coupling, but he stated that he slept until 0700 on the morning of the accident to make up for lost rest.

The leverman's normal working hours were from about 0445 to 1645 when working dayshifts. He stated that he occasionally worked overtime if the opposite shift was delayed in arrival. The leverman slept on the dredge, but he said that he was never bothered or awoken during his off-shift time. He stated that he always slept well when on the dredge, with the exception of the first day of night shifts as he adjusted to the opposite schedule. He said that he was well rested on the accident day. The leverman told investigators that he drank one cup of decaffeinated coffee each morning and drank no other caffeinated beverages on the dredge. He said that he drank no alcoholic beverages the night before or morning of the accident or at any time while on board the dredge (see NTSB Medical Factual Report for more information regarding toxicology for the *Waymon Boyd* crew).

The remainder of the crew's working hours were between 0530 and 1730 when working dayshifts. The crew slept in a hotel or at their homes when off-shift, and they were boated to and from the dredge each morning and evening. Crewmembers reported getting 7-9 hours of sleep each night, and most reported that they slept well.

8.3 Crew Cell Phone Usage

Investigators reviewed records for cell phones assigned or belonging to key members of the crew and a company cell phone assigned to the vessel. Results of the records review is as follows:

Dredge captain (company phone). Information for this phone only included voice call information. There were no data or SMS (text) information available. There was an outgoing call placed at 8:03:45 CDT that lasted 36 seconds. There was a series of incoming calls beginning about 08:05 CDT. These calls appeared to be "missed" until 08:21:21 CDT, at which time there was a connection lasting 26 seconds. There were no other pertinent phone calls.

Deck captain (company phone). (Note: the deck captain was not on board the vessel at the time of the accident.) Information for this line only included voice call and SMS (text) information only. There were no data information available. There were no pertinent calls in the timeframe just prior to the accident. There were two potential incoming calls at 08:05:42 CDT and 08:05:43 CDT; these calls appeared to have not connected. There was a series of outgoing calls beginning at 08:05:53 CDT. There were no pertinent SMS transactions in the timeframe just prior or after the accident.

Leverman (personal phone). Information for this line included voice call, data usage, and SMS (text) information. There were no pertinent calls in the timeframe just prior to the accident. Just after the accident there was a series of outgoing calls. There were no pertinent data usage in the timeframe just prior to the accident. There was no data usage after the accident. (Note: that data usage information may not reflect active user input on the device and may be a result of background activity on the device.) There were no pertinent SMS transactions in the timeframe around the accident.

Dredge Crew (company phone). Information for this line only included voice call information. There were no data or SMS (text) information available. There were no pertinent calls in the timeframe around the accident.

9 Safety Programs & Processes

9.1 Health, Safety & Environmental (HSE) Program Policies

Orion Marine Group’s health, safety, and environmental program policies manual was organized into the following categories:

- Health, Safety & Environmental (HSE) Responsibilities
- HSE Environmental Cultural Elements
- General HSE Policies and Procedures
- Project Hazard Mitigation
- Corporate HSE Policies & Procedures[20]

According to the document, within the cultural elements section (page 20):

> As a minimum requirement, the Health and Safety Training Program for all employees shall include:
>
> - An initial HS&E orientation conducted at the time of hire.
> - A pre-work briefing and demonstration by the site superintendent/competent person to educate each new employee regarding safe working procedures and potential job hazards (JHA Review).
> - Daily HS&E training meetings will be held by supervisors for the crews during stretch and flex activities.
> - These daily start up meetings shall emphasize the project’s safety requirements, established rules, the causes of incidents and ways each craft worker can assist in preventing future incidents.

[20] See *OMG HSE Program Policies - Rev. 2020 (Complete)* which specifies the update date: January 2020.

- Follow up field training and supervision to ensure project safety rules and regulations are fully understood and followed.
- Weekly "Tailgate" Meetings will focus on training and policy review applicable to Orion at that time. Topics are distributed by the Regional HS&E Managers each week through the "Weekly HS&E Communication".
- Special training is required for unique or unusual operations or to deem an employee a competent person.

Within the project hazard mitigation section (page 200), job hazard analysis is discussed:

> A job hazard analysis (JHA) is one of the most important elements in any safety program. It is our policy to have a written JHA for all scopes of work in a project. We will not begin any operation without a thorough hazard analysis that has been reviewed and signed by the crew.

The document contains further discussion of hazard analysis (page 200, note that these excerpts are not all inclusive):

> A hazard analysis is best prepared when planning for each work activity. . . Superintendents/foreman with his or her crew will be involved in the preparation, review and revision of each hazard analysis. Superintendents/foreman are responsible to ensure that a proper and useable hazard analysis is completed for each work activity. The hazard analysis is a good tool to train the crew whenever the work operation starts or is changed, and to aid in instruction with new crew members.

Further discussion, pertaining to hazard mitigation is also contained in the document (page 201):

> The hierarchy of controls should be used to mitigate hazards. When a hazard is identified, first attempt to eliminate the hazard. If elimination is not practicable, use engineering controls. If engineering controls are not practicable, implement administrative controls. If the hazard cannot be adequately controlled using engineering and/or administrative controls, employees must use Personal Protective Equipment. A combination of engineering controls, administrative controls, and Personal Protective Equipment is usually best.

Site specific safety plans are discussed in several locations in the document, including, but not limited to:

> The project manager in conjunction with the Regional HSE Managers are responsible for the implementation of the HSE Program contained herein. The project manager, in conjunction with the Site Superintendent will be responsible for ensuring that a pre-startup checklist and Site Specific Safety Plan is completed reviewed by the Regional team prior to commencing with any work.
>
> When planning a project, the manager will consider any safety related items and discuss these items with the General and site superintendents. During this preplanning stage the project manager is responsible for authoring (along with

HSE) the Job Hazard Analyses with assistance from the Site Superintendent and Crew. The project manager will copy the contract documents and drawings for the project and give to General Superintendent and field Superintendents. (page 8)

The Superintendent(s) / Captains, along with the General / Dredge Superintendent and project manager are responsible to enforce the Site Specific Safety Plan (SSSP), Job Hazard Analysis documents, complete required safety training, ensure safety is held at the highest standard on the project, verify all cranes, rigging and other mechanical equipment have been inspected prior to use; perform new hire safety orientation; maintain emergency response and communication equipment; provide PPE per the SSSP and maintaining records of the above. The Site Superintendent / Captains will ensure that the Regional HSE Manager, VP of Risk Management and project manager is up-to-date of any near misses, incidents or injuries. The Site Superintendent will hold a valid First Aid/CPR Certification and an OSHA 10-hour training card (at a minimum). (page 10)

Site specific safety plans are also discussed with the context of Utility Location Services (page 197):

Prior to the start of any excavation a Utility Locate Service must be contacted. Jobs may utilize the 811 Service which will automatically route your call to the local One Call Center. Call USA at 1-800-642-2444 or 811, each state has a different locate service with specific rules outlining their services. It is very important to understand the state or local guidelines in advance of your excavation. Typically locate companies require 7 days advanced notice before performing their service. Before calling for a locate the excavation area must be pre-marked with white paint stakes or flags. Once all utility companies have confirmed that their utilities have been marked, the Dig Safe Ticket will be considered valid. Until then, it is unlawful to perform ground disturbing activities.

OMG must obtain as-built plans and any other site information from the client in order to locate any underground pipes or utilities which would interfere with the excavation. Beware that these records may not be accurate. Therefore, these obstructions should be physically located and either removed, or protected from damage.

Traffic signal wires and illumination for intersections ARE NOT covered by locate services. The superintendent is expected to exercise all due diligence in locating the traffic signal wires.

It is the responsibility of the job to understand and implement additional safety measures which may be required by the owner of the utility. These safety measures may include an owner representative to be present when working near their utility, emergency contact protocol should the safety of their utility be compromised, etc. The superintendent will verify those additional measures on their JHA and site specific safety plan (SSSP).

9.2 Site Specific Safety Plan (SSSP)

Orion Marine Group provided the NTSB with the *Epic Dock Site Specific Work Safety Plan*, as well as several other site specific safety plans (SSSPs) and accident prevention plans for *Waymon Boyd* projects.[21] Orion Marine Group indicated that, for two of the projects in which the NTSB requested HSE plans, no such plans were developed.

In the *Epic Dock Site Specific Work Safety Plan*, hazards were generally discussed for several topics, including bio-hazardous waste, hazardous material spills, hazard labels, and storms. In addition, the plan contained general discussion of several hazard prevention and control "items," including the Job Safety Analysis Form, equipment inspections, hazard hunts, behavior-based safety observation, stop work report, and near miss report. The plan generally discussed the company's system to track hazard conditions and preventive maintenance systems. The plan generally discussed training, water rescue procedures, personal protective equipment, emergency response, fire response, lighting, helicopter landing zones and helicopter safety. Pipeline hazards were not discussed.

The other SSSPs contained similar general language about hazards. The accident prevention plans also discussed a wide range of hazards. The *Accident Prevention Plan for the Sabine-Neches Waterway, Texas Deep Draft Pipeline Dredging* had a unique section on biological hazards such as jellyfish, stingrays, fish, snakes, bees, ticks, and poison ivy/oak. The section provided recommended controls for each these as well. For instance, to mitigate bees, the plan stated:

> Be aware of the possibility of beehives, in the ground or in equipment. Use caution using heavy equipment in new areas. If any bees are noticed, obtain the "Bee suit" for further investigation.

None of the SSSPs or accident prevention plans provided contained discussion about pipeline hazards.

The HSE director said that SSSPs were developed by the safety department prior to the job commencing. He said that he was not involved in the development of the SSSP for the EPIC Marine Terminal project. He said that the SSSP contained a risk assessment. He said that the SSSP for the EPIC Marine Terminal project did not contain a risk matrix, and neither did the company's SSSPs for other projects. Investigators asked why the SSSP for the EPIC Marine Terminal project did not contain discussion about site specific risks, and the HSE director responded:

> [Risk management is] done as the project goes forward, when we're actually on site. You can't mitigate for hazards until you're actually on the project identifying what the hazards are. You can, you know, put a plan together in the office, but construction and dredging are in the field and that's where we actually need to be

[21] See documents *EPIC DOCK Specific Safety Plan 4P02235*, 04P02225.7.20.01.CHSP.20191109 Rev3, 06P00897.7.20.01.CHSP.20180522, 06P00923.5.60.01.SMTL.20190909.APP R9, and 06P00949.5.30.01.04.04.APP.20200211 R1.

boots on the ground before we can identify what the hazards are that we need to keep our crews safe from.

Investigators asked why the pipelines were not discussed in the SSSP for the EPIC Marine Terminal project, and the HSE director indicated that it was because the pipelines were not in the dredge template. He indicated that if the pipelines had been inside the template, he would have expected them to be discussed in the SSSP, the JHAs, and the daily communication for the project.

The regional HSE manager said the SSSP was essentially an emergency response plan, which he completed by inputting applicable maps and phone numbers. He said that he was not involved with a risk assessment, nor a pre-startup checklist for the EPIC Marine Terminal project. He indicated that the SSSP did not contain a risk assessment. He indicated that he relied on the operational team for information about the project and did not independently collect any safety information. He said that he was unaware of the pipelines in the vicinity of the dredge template. He said that he had enough time to devote to the project and was able to carry out all the tasks that he intended. He acknowledged that incorporating a risk assessment into the SSSP of future projects could enhance safety.

A dredge superintendent said that a job safety analysis was not completed prior to the start of a project. However, he said that, prior to starting a project, an internal meeting was held, during which time safety was discussed.

The dredge captain indicated that a risk assessment was completed prior to work commencing at the dredging site. He said that a group visited the site to "look at it and we just see the hazards around us and that's it." He indicated that hazards identified in this process were not documented in written form but would remain "on the mind."

The deck captain said the information he received from the project engineer about the pipelines in vicinity was not part of a risk assessment.

9.3 Job Hazard Analysis (JHA) / Safety Meeting

(Note: Orion Marine Group uses JHA and JSA [job safety analysis] interchangeably.)

According to Orion Marine Group's *Epic Dock Site Specific Work Safety Plan*:[22]

> Daily meetings shall be held by Supervisors and Foreman to discuss scheduling and planning. Job Safety Analysis (JSA) will be part a major component of these meetings ensuring that all employees are made aware of the hazards and trained when necessary, in the safe work procedures planned for specific tasks to which they may be assigned. No work or operations can take place prior to the completion of a JSA.

At the request of NTSB, Orion Marine Group provided several completed JHAs.[23] These largely covered the same topics, including personal protective equipment for the body, eyes, feet,

[22] Page 5 – document: "EPIC DOCK Specific Safety Plan 4P02235"

[23] See documents: "06-11 through 06-14-2020 JSAReport" "06-15 through 06-30-2020 JSAReport" "07-01 through 07-13-2020 JSAReport" "07-14 through 07-31-2020 JSAReport" & "08-01 through 08-19- 2020 JSAReport"

hands, and head. The JHAs discussed numerous primary hazards, including caught in between (e.g., pinch points), electrical, falls, health (e.g., sprain/strain), physical hazards (e.g., fire), and struck by (e.g., falling object). The JHAs discussed job steps, the hazards potentially presented at those steps, and controls. For example, crew members tasked with positioning the dredge with tender boats needed to be cautious to avoid the hazard of the vessel capsizing. The JHA indicated that to control this hazard:

> Ensure that operators are qualified for boat operations. Ensure maritime terminology is used. (Port, Starboard, Stern, Bow) Ensure towing/position setup of tenders does not pose risk to vessel.

Other job steps for which safety guidance was provided include safety meetings, equipment inspection, connecting and disconnecting pipe, anchor movement, removal of debris from pump, changing spud/swing cables, loading fuel on dredge, welding, and maintenance. The JHAs provided did not address safety issues pertaining to the leverman's control of the dredge and cutterhead. The JHAs did contain a section that reviews inspection and training requirements for tools and equipment.

The HSE director provided the following description of Orion Marine Group's usage of JHAs:

> The captain has JHAs in his tablet that he has developed or his team has developed. The captain is also responsible for developing task-specific JHAs throughout the life of the project. If there's something that changes, then they need to redraft the JHA and adjust it. If it's an ongoing operation that is not going to change, it doesn't have any variations to the work, then the captain is required to review that JHA at least every 2 weeks. Now, if he chooses to review it every morning, that's great, you know, more is always better. But there's more to the morning meeting than just the JHA.

Investigators asked him if it was acceptable for a leverman to simultaneously operate a dredge while participating in a safety meeting, to which he responded, "I don't think so."

A dredge superintendent said that dredge operations require that a safety meeting is conducted "every 12 hours in the morning when the day crew gets there and then in the evenings when the night crew gets there, every day." He said that a JSA was completed every day on the dredges.

The dredge captain said that he led the morning safety meetings. However, he did not attend the meeting on the morning of the accident because he had been up until about midnight the prior night addressing an issue and needed to sleep longer into the morning to prevent fatigue. He indicated that the leverman typically led the safety meeting in his absence. He indicated that when this occurs, the leverman stopped the dredge and focused on the meeting. However, when the dredge captain led the interview, he said the leverman sometimes continued to swing the dredge, depending on what was being discussed. He assumed that the leverman led the safety meeting on the morning of the accident but was not sure because he did not discuss it with him. He said that the safety department provided safety information, which was accessed on a tablet and discussed during the meetings. He indicated that topics reviewed typically included personal safety issues, such as pinch points, and lifting with correct form. He said that a typical day involves the discussion of a chosen safety topic for about 10–15 minutes.

The deck captain indicated that the safety meetings took place in the lever room. He said that the leverman was typically operating the dredge during the meeting. He said that dredging was a slow process, so "there's nothing to – that he cannot do." He added "He's still listening to us, and sometimes when he has to say something, [he will] stop the dredge and turn back and let us know his opinion." The deck captain said that JSAs were conducted every morning and evening. He indicated that discussion about the JSAs typically pertained to what tasks were going to be performed.

Subordinate crewmembers provided various accounts of the safety meeting that took place on the accident morning. A mate said that the safety meeting lasted about 20–30 minutes. He said that there was no discussion about a pipeline during the meeting, nor at any other time during the project. The mate stated that the leverman was operating the dredge during the safety meeting. An engineer on the crew said that the safety meeting was held in the same room that the leverman operates the dredge. He also stated that the leverman was working the dredge during the meeting, and another engineer confirmed this statement. The engineer recalled discussion about personal protective equipment (PPE). A second deckhand said that, during the safety meeting, they discussed the work to be performed and PPE but did not discuss the gas pipeline in the area.

A tender operator said that the safety meetings were held in the "leverman's room, over on the very top of the dredge." He said that they usually lasted about 20–30 minutes. He stated that the group talked about the work to be performed, and a job safety analysis was completed. He did not recall discussion of risks, dangers, or concerns. He said there was no discussion of the pipeline or areas that needed to be avoided while working. A welder said that the safety meetings typically included discussion of PPE. There was no discussion of working near the pipelines.

The second deckhand said that the entire crew spoke Spanish and the safety meetings were conducted in that language.

10 Waterway Information

The Port of Corpus Christi comprises the harbors surrounding Corpus Christi Bay, including facilities at La Quinta and Ingleside, Texas, the Rincon Industrial Area north of Corpus Christi, and the Corpus Christi Ship Channel (see figure 34). The port is the third largest port in the United States, based on total revenue tonnage, and the second largest exporter of crude oil.[24] In 2020, the port recorded 6,907 ship and barge movements and cargo operations totaling 160 million tons.

[24] Port of Corpus Christi, "About Us," https://portofcc.com/about/port/about-us/, accessed 3/12/2021.

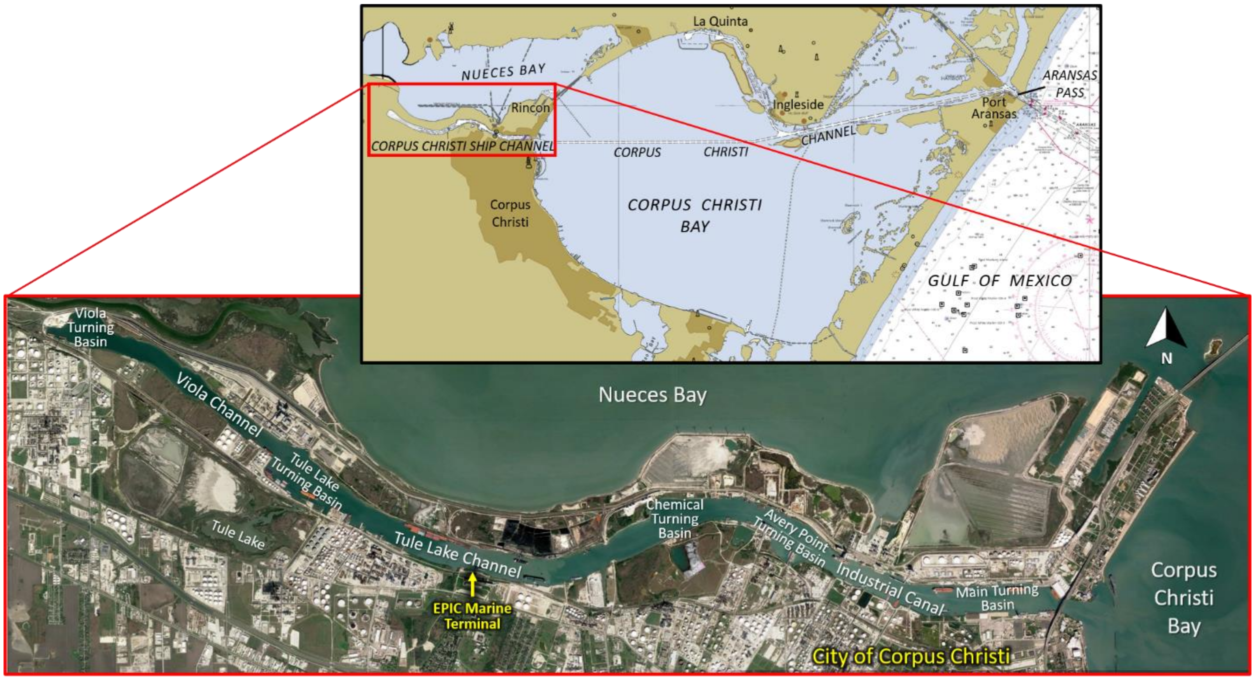

Figure 34. The Corpus Christi Ship Channel. (Satellite imagery from Google Earth; chart data from National Oceanic and Atmospheric Administration NOAA ENC Viewer.)

The 9-mile-long, 47-foot-deep Corpus Christi Ship Channel, also known as the Inner Harbor, runs along the north side of the city of Corpus Christi from its entrance at Corpus Christi Bay west to its terminus at Viola. The channel is divided into three sections, the Industrial Canal, the Tule Lake Channel, and the Viola Channel, with turning basins at the ends of each section. Liquid and bulk cargo loading terminals line both sides of the channel, which is restricted to commercial traffic only. The channel is connected to the Corpus Christi Channel, which crosses Corpus Christi Bay and provides access to the Gulf of Mexico via the Aransas Pass.

11 Environmental Conditions

At the time of the accident, conditions were clear with unlimited visibility. The air temperature was 83 degrees, and the water temperature was 88 degrees. Winds were from the southwest at 12 knots, and the water was calm in the Corpus Christi Ship Channel. The tidal range was 0.6 feet on the accident date, with low tide at 0400 and high tide at 1930, as measured at the USS Lexington, a display ship moored near the entrance to the ship channel.