National Transportation Safety Board
Office of Railroad, Pipeline and Hazardous Materials Investigations
Washington, DC 20594

DCA24MM031

HAZMAT – CARGO AND RESPONSE

Specialist's Factual Report

February 3, 2025

TABLE OF CONTENTS

A. ACCIDENT

Location:	Baltimore, Maryland
Date:	March 26, 2024
Time:	01:29 05:29
Operator:	Synergy Marine PTE LTD
Vessel:	*Dali*, IMO#9697248

B. HAZMAT – CARGO AND RESPONSE GROUP

Group Chair	Paul L. Stancil, CHMM National Transportation Safety Board Washington, DC

C. SUMMARY

Dali Contact and Collapse of the Francis Scott Key Bridge, Baltimore, Maryland, March 26, 2024.

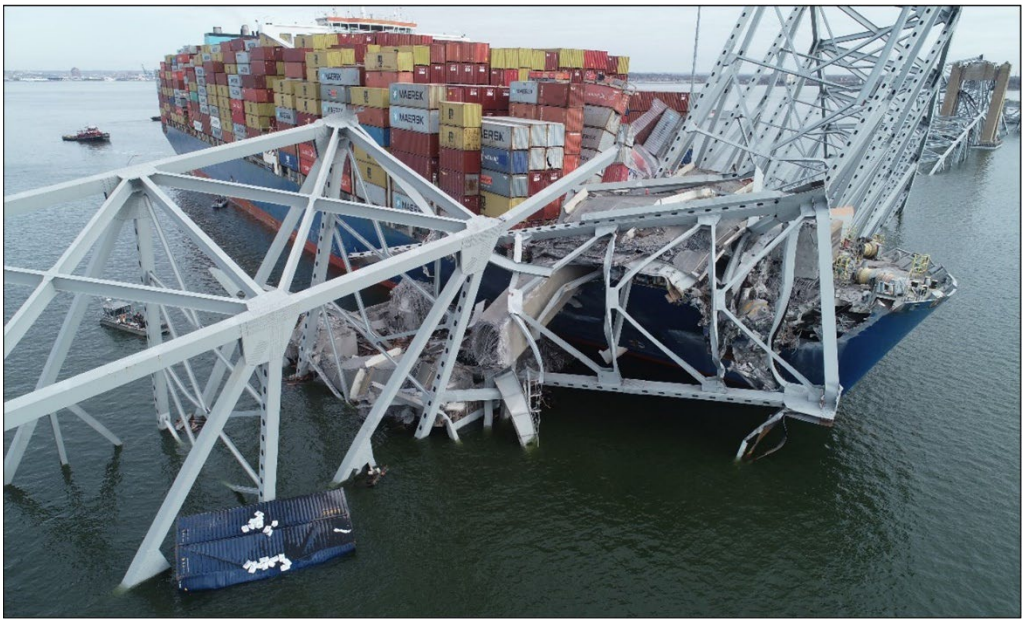

Figure 1. Incident Scene, March 26, 2024.

On March 26, 2024, about 0129 eastern daylight time, the 947-foot-long Singapore flagged cargo vessel (containership) *Dali* was transiting out of Baltimore Harbor in Baltimore, Maryland, when it experienced a loss of electrical power and propulsion and struck the southern pier supporting the central truss spans of the Francis Scott Key Bridge (Key Bridge). A portion of the bridge subsequently collapsed into the river, and portions of the deck and the truss spans collapsed onto the vessel's forward deck (see Figure 1). A seven-person road maintenance crew employed by Brawner Builders—which was contracted by the Maryland Transportation Authority (MDTA)—and one inspector employed by Eborn Enterprises, Inc., a subconsultant to the MDTA, were on the bridge when the vessel struck it. The inspector escaped unharmed, and one of the construction crewmembers survived with serious injuries. The bodies of the six fatally injured construction crewmembers have been recovered. One of the 23 persons aboard the Dali was injured.

D. FACTUAL INFORMATION

The Hazardous Materials Group for this investigation was tasked with documenting the identity, location, and disposition of hazardous materials cargo stowed onboard the *Dali*, including those packages that were impacted or breached in the incident. The Hazardous Materials Group also collected information relative to the initial environmental response and the responsible party's actions to mitigate released oil/petroleum products and hazardous materials.

1.0 Preaccident Events

The *Dali* arrived in the port of Baltimore on March 23, 2024. The vessel had previously taken on some cargo from the port of Norfolk. Cargoes taken on-board the *Dali* prior to its departure from Baltimore included a total of 56 cargo containers of declared hazardous materials, for a total weight of about 764 tons. In total, the ship was loaded with 4,680 combination of 20-foot and 40-foot shipping containers.

In addition to its cargo, the *Dali* was carrying about 1.5 million gallons of bunker fuel.

2.0 Hazardous Materials Information

The fallen Francis Scott Key bridge debris came to rest on the *Dali* forward main deck/upper deck, including cargo Bays 1 through 7. Hazardous materials cargo containers were stowed in Bays 5, 6, and 7 (See Figure 7).

Chapter 7.1 of the International Maritime Dangerous Goods (IMDG) Code provides general stowage specifications applicable to dangerous goods carried in all types of ships.[1] Depending on whether the vessel is carrying passengers, stowage may be limited to on-deck only for certain commodities depending on the associated stowage category.[2] The hazardous materials identified within Bays 5 to 7 near the bow of the ship did not have any restrictions for stowage above or below decks. While stowage of dangerous goods classified as marine pollutants is permitted on-deck or under-deck, under deck stowage is preferred. Where stowage on-deck is required, the code states that preference shall be given to stowage in well-protected decks or to stowage inboard in sheltered areas of exposed decks.

Containers loaded with hazardous materials are generally stowed away from the accommodation areas and sources of heat (engine and fuel tanks).[3] According to the *Dali* general arrangement drawing, materials regulated by the IMDG are designated for holds no. 1 through 3, which are situated forward of the bridge.

The hazardous materials stowed in the bow of the *Dali* were carried in UN portable tanks T22 or ISO 20-foot and 40-foot containers.

Portable Tanks

UN portable tank T22 are designed for the carriage of high-hazard pressurized liquids or liquefied gases (see Figure 2). These tanks are 20- feet in length, 8’0” in width, and 8’6” in height. Typical capacity is about 5,900 gallons. Working pressure

[1] Under 49 CFR 171.22 the use of the International Maritime Dangerous Goods Code (IMDG) is authorized for domestic shipments with certain conditions and limitations.

[2] For the purposes of this report, the terms “dangerous goods” and “hazardous materials” are synonymous. For shipments consigned within, to, or from the United States, the term “hazardous material” means a substance or material the Secretary of Transportation has determined is capable of posing an unreasonable risk to health, safety, and property when transported in commerce.

[3] Fan, Liu; et. al, *Stowage Planning of Large Containership with Tradeoff Between Crane Workload Balance and Ship Stability*. (Hong Kong: International Multiconference of Engineers and Computer Scientists, 2010).

is 96.7 psig, test pressure is 145.0 psig. Under 49 CFR 173.241, UN portable tanks conforming to 46 CFR Part 64 are authorized.

Chapter 6.7 of the IMDG Code states that portable tank shells must be constructed in accordance with the provisions of a pressure vessel code recognized by the competent authority. Among these requirements, shells must be made of metallic materials suitable for forming. Shells are designed to withstand a hydraulic test pressure of 1.5 times the design test pressure. Shells may not be less than 6 mm thick.

Figure 2. Typical UN portable tank T22, image source Seaco America LLC.[4]

Freight Containers

ISO 668 is an international standard that pertains to intermodal freight shipping containers, and standardizes their sizes, measurements, and weight specifications (see Figure 3). ISO 6346:2022 also provides a system for the identification and marking of freight containers.

[4] See https://seacoglobal.com/equipment/tank-containers/

Figure 3. ISO 20 and 40-foot shipping containers stowed in *Dali* forward above deck cargo bays and fallen bridge debris on the bow, March 28, 2024.

The forward above and below deck cargo container bay positions are depicted in vessel profile drawing (Figure 4). The No. 1 through no. 3 cargo holds (below main deck) are designated for general cargo as well as some dangerous goods that are authorized for below deck storage.

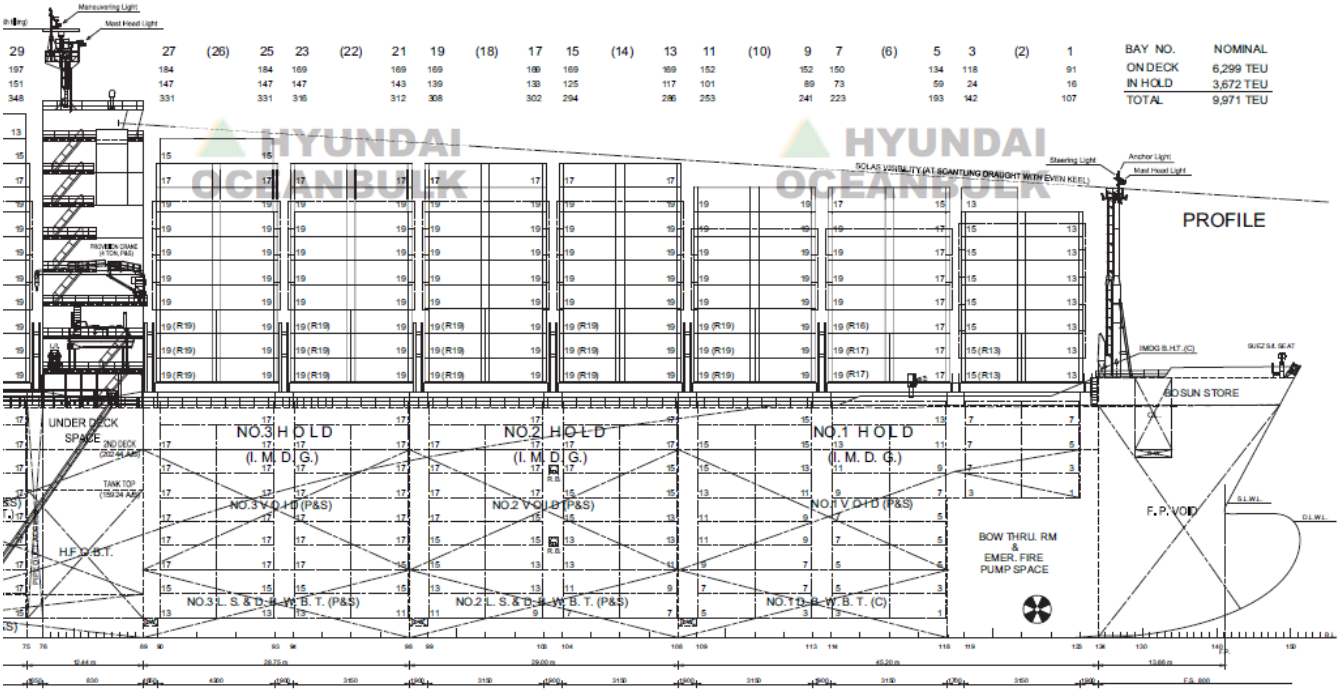

Figure 4. Excerpt of Dali general arrangement drawing showing the bow container bays and cargo hold profile.

A list of hazardous materials with position, container number, and proper shipping name are provided in Figure 5. The stowage numbering system used onboard container ships is shown in Figure 6. The approximate stowage locations for dangerous goods onboard the *Dali* is depicted in Figure 7.

Dangerous Goods List

M.V.: **M.V. DALI** Flag: **SINGAPORE**

The format of this list does not preclude the use of electronic devices/computer generated document providing the required information.(e.g.EDI/EDP/Fax)

Date: **3/25/2024** **Voy.No: 405E**

*The **Bold columns** are the required basic information,and other columns are also required if applicable.

Port: DEP BALTIMORE

S.No	Position[1]	Container No.	UN NO./PSN [2]	IMO CLASS Primary	IMO CLASS / Subsidiary	Flash Point C	Packing Group	DG NET Weight.	MP	Limited Quantity	EmS	Port of Load	Port of Disch	Proper shipping name
1	60874	MSDU7285306	1266	3		+18C	II		no		F-E,S-D	USPTM	MYTPP	PERFUMERY PRODUCTS with flammable solvents
		MSDU7285306	1266	3		+18C	II	2526.1	no	yes	F-E,S-D	USPTM	MYTPP	PERFUMERY PRODUCTS with flammable solvents
2	60876	MSDU6336029	1266	3		+18C	II	2515.7	no	yes	F-E,S-D	USPTM	MYTPP	PERFUMERY PRODUCTS with flammable solvents
3	70872	CAIU6327116	3077	9			III	6804	yes		F-A,S-F	USPTM	MYTPP	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S.
4	70272	SLZU2508773	2586	8			III	21709	no		F-A,S-B	USBAL	LKCMB	ALKYLSULPHONIC ACIDS, LIQUID, with not more than 5% free sulphuric acid
5	50072	SLZU2508201	2586	8			III	21491	no		F-A,S-B	USBAL	LKCMB	ALKYLSULPHONIC ACIDS, LIQUID, with not more than 5% free sulphuric acid
6	60478	JXLU7427972	3090	9			-	0	no		F-A,S-I	USBAL	LKCMB	LITHIUM METAL BATTERIES (including lithium alloy batteries)
		JXLU7427972	3480	9			-	0	no		F-A,S-I	USBAL	LKCMB	LITHIUM ION BATTERIES (including lithium ion polymer batteries), transported in accordance with special provision 376 or 377
		JXLU7427972	3481	9			-	0	no		F-A,S-I	USBAL	LKCMB	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)
		JXLU7427972	3091	9			-	0.1	no		F-A,S-I	USBAL	LKCMB	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries)
		JXLU7427972	3481	9			-	0	no		F-A,S-I	USBAL	LKCMB	LITHIUM ION BATTERIES CONTAINED IN EQUIPMENT or LITHIUM ION BATTERIES PACKED WITH EQUIPMENT (including lithium ion polymer batteries)
		JXLU7427972	3091	9			-	0	no		F-A,S-I	USBAL	LKCMB	LITHIUM METAL BATTERIES CONTAINED IN EQUIPMENT or LITHIUM METAL BATTERIES PACKED WITH EQUIPMENT (including lithium alloy batteries)
7	70172	RFCU8218611	2586	8			III	21174	no		F-A,S-B	USBAL	LKCMB	ALKYLSULPHONIC ACIDS, LIQUID, with not more than 5% free sulphuric acid
8	60878	MSNU7758902	1266	3		+18C	II		no		F-E,S-D	USPTM	MYTPP	PERFUMERY PRODUCTS with flammable solvents
		MSNU7758902	1266	3		+18C	II	1975.1	no	yes	F-E,S-D	USPTM	MYTPP	PERFUMERY PRODUCTS with flammable solvents
9	70476	SEGU2099993	1824	8			III	0	no	yes	F-A,S-B	USBAL	LKCMB	SODIUM HYDROXIDE SOLUTION
		SEGU2099993	1987	3		+10C	II	0	no		F-E,S-D	USBAL	LKCMB	ALCOHOLS, N.O.S.
		SEGU2099993	1987	3		+43C	III	1	no		F-E,S-D	USBAL	LKCMB	ALCOHOLS, N.O.S.
10	70072	SUTU2584389	2586	8			III	21754	no		F-A,S-B	USBAL	LKCMB	**ALKYLSULPHONIC ACIDS, LIQUID, with not more than 5% free sulphuric acid**
11	50272	CXTU1142194	2586	8		+100C	III	21319	no		F-A,S-B	USBAL	LKCMB	**ALKYLSULPHONIC ACIDS, LIQUID, with not more than 5% free sulphuric acid**
12	50172	SUTU2581707	2586	8			III	21355	no		F-A,S-B	USBAL	LKCMB	ALKYLSULPHONIC ACIDS, LIQUID, with not more than 5% free sulphuric acid
13	70610	MSDU1817680	3082	9			III	18270.4	yes		F-A,S-F	USPTM	KRPUS	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.
14	50872	MSMU2247260	2920	8		+40C	II	4626.7	yes		F-E,S-C	USPTM	MYTPP	CORROSIVE LIQUID, FLAMMABLE, N.O.S.

Figure 5. List of dangerous goods containers located in Bays 5-7, courtesy U.S. Coast Guard.

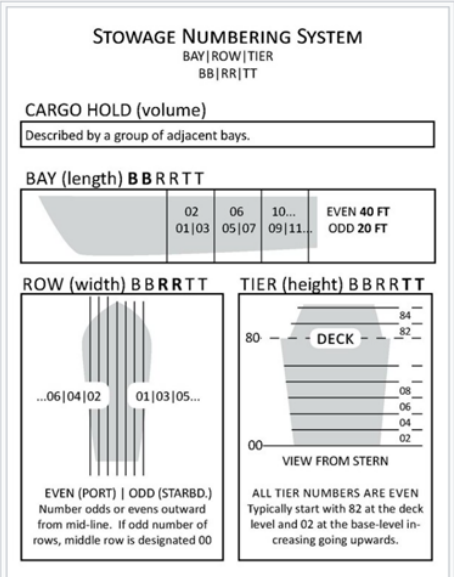

Figure 6. Cargo stowage numbering system used by the Dali.[5]

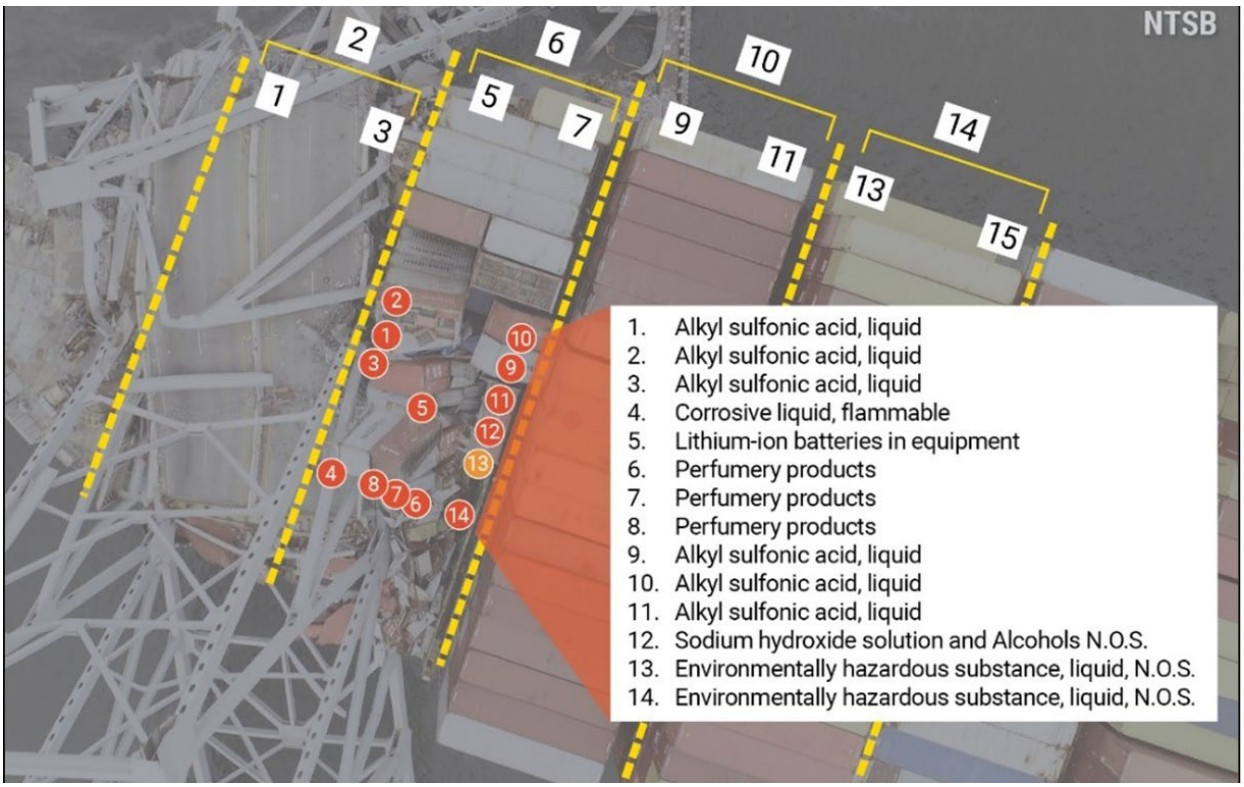

Figure 7. Approximate locations of impacted hazardous materials containers. Inset dangerous goods list indicates stowage location, material identification, and container number.

[5] In the case of the Dali, deck level first tier begins with Tier 72.

Figure 8 provides a summary of cargo containers that had been loaded in Bays 5 through 7, which contain hazardous materials.

Cargo in Bay : Bay 05

Occupied						
Location	Weight	20'	40'	45'	Other	TEU
Deck	1145.9	34	57	-	-	91
Hold	1275.0	1	53	-	-	54
Total	2420.9	35	110	-	-	145

Free		
Location	Weight	TEU
Deck	384.1	43
Hold	1260.0	2
Total	1644.1	45

Cargo in Bay : Bay 07

Occupied						
Location	Weight	20'	40'	45'	Other	TEU
Deck	1164.0	46	57	-	-	103
Hold	1486.2	15	53	-	-	68
Total	2650.2	61	110	-	-	171

Free		
Location	Weight	TEU
Deck	546.0	45
Hold	1048.8	2
Total	1594.8	47

Figure 8. Cargo totals for Bays 5-7.

2.1 Hazardous Materials Safety Data

The following sections describe safety communications for the hazardous materials stowed in 14 freight containers in the forward bays that were damaged by fallen bridge debris.

2.1.1 Alkyl Sulfonic Acid

The MSC-Mediterranean Shipping emergency card advises in the event of a spill, wear suitable protective clothing and self-contained breathing apparatus. Keep

clear of evolving vapors. Use of water on the substance may cause violent reaction and produce toxic vapors. Substance may damage ship's construction materials. For spillage on-deck, keep bridge and living quarters upwind. Protect crew and living quarters against corrosive or toxic vapors by using water spray to drive vapor away. The emergency card recommends washing residues to the bottom of the hold.

The manufacturer was Afton Chemical Corporation of Richmond, VA. The manufacturer's Safety Data Sheet (SDS) identifies the chemical as HiTEC® 052 Performance Additive, for use as a petrochemical industry detergent intermediate. The material is a brown liquid that exhibits an acrid odor. The flash point is 100 °C, relative density is 0.961.

Hazard and precautionary statements in the SDS include:[6]

- Causes severe skin burns and eye damage,
- No known significant effects or critical hazards from inhalation, however if inhaled, remove person to fresh air and immediately call a poison center,
- Headspace of storage vessel may contain hydrogen sulfide or sulfur dioxide,
- Ingredients include benzenesulfonic acid (≥86%), and sulfuric acid (≤2 percent),
- Do not touch or walk through spilled material, do not breathe vapor or mist,
- Keep unnecessary and unprotected personnel from entering a release area,
- OSHA PEL TWA 1 mg/m^3,
- The product is stable under normal storage conditions, hazardous reactions will not occur,
- The material is incompatible with strong oxidizing and reducing agents.

2.1.2 Dialkyldimethylammonium Chloride, Ethanol

The MSC-Mediterranean Shipping emergency card advises the material is a non-water reactive flammable liquid. In the event of a spill, wear suitable protective clothing and self-contained breathing apparatus. Inhalation of small quantities of vapor can cause breathing difficulties. Protect crew and living quarters against corrosive or toxic vapor by using water spray to drive vapor away.

[6] These hazard statements are applicable to all 6 alkylsulfonic acid containers listed in this section.

2.1.3 Lithium Batteries

The Panasonic Corporation, Osaka, Japan, manufacturers' SDS describes the battery as a manganese dioxide lithium battery. The batteries are coin-shaped with a nominal voltage of 3-volts. While it is unknown which cell models were included in the above listed equipment, the SDS provided a list of applicable battery types indicated in Figure 9.

Lithium content per cell

Model Number	Lithium content(g)	Model Number	Lithium content(g)	Model Number	Lithium content(g)	Model Number	Lithium content(g)
CR1025	0.008	CR2012	0.02	CR2330	0.08	CR2412	0.03
CR1216	0.008	CR2016	0.03	CR2354	0.17	CR2430	0.09
CR1220	0.01	CR2025	0.05			CR2450	0.18
CR1612	0.01	CR2032	0.07			CR2450A	0.16
CR1616	0.02	CR2032A	0.06			CR2477	0.29
CR1620	0.02	CR2032B	0.06			CR3032	0.15
CR1632	0.04	CR2050A	0.10				
		CR2050B2	0.10				

Figure 9. Excerpt of Panasonic Corporation SDS, listing lithium battery model number and lithium content per cell.

IMDG Code package instruction SP 188 requires that cells and batteries when installed in equipment must be protected from damage and short circuit, and the equipment shall be equipped with an effective means of preventing accidental activation.

2.1.4 Perfumery Products

The MSC-Mediterranean Shipping emergency card advises the material is a non-water reactive flammable liquid. In the event of a spill, wear suitable protective clothing and self-contained breathing apparatus. Spillage may evolve flammable vapor. Avoid sources of ignition. Keep bridge and living quarters upwind. The emergency card suggests washing spillage overboard with copious amounts of water.

2.1.5 Sodium Hydroxide

The Becton, Dickinson and Company, Franklin Lakes, NJ, SDS, describes the shipment as "Kit Mycoprep 150 ml" with sodium hydroxide reagent and phosphate buffer. According to the SDS, the reagent contained 1.0 percent sodium hydroxide. The material is corrosive to eyes and skin if contacted.

2.1.6 Alcohols, N.O.S.

The Becton, Dickinson and Company, Franklin Lakes, NJ, SDS, describes the shipment as "Gram Crystal Violet" laboratory chemicals with isopropyl alcohol, ethanol, and methanol. The material is a flammable liquid.

2.17 Dodecyl Diphenyl Oxide Disulfonate

The MSC-Mediterranean Shipping emergency card advises in the event of a spill, wear suitable protective clothing and self-contained breathing apparatus. The emergency card recommends trying to avoid disposal overboard, as it may damage the marine environment. For sticky liquids, shovels may be used. Restrict flow of leakage to an enclosed area by barricading with inert material. Collect spillage in drums or metal boxes.

The Dow Chemical Company, Cincinnati, OH, multimodal dangerous goods form indicates the material is trade named "Dowfax 2A1 Solution Surfactant." The material was transported in 530 lb. 1H1/Y1.4/100 polyethylene drums. The manufacturer's SDS describes the material as an odorless and colorless to yellow liquid that exhibits a pH of 8 – 10.5. The SDS states the material may cause serious eye damage on contact. The material is moderately toxic to aquatic organisms. According to the SDS, ingestion of small amounts as a result of normal handling is not likely to cause injury; however, swallowing larger amounts may cause injury.

2.18 Copper Metal Powder

The MSC-Mediterranean Shipping emergency card advises in the event of a spill, wear suitable protective clothing and self-contained breathing apparatus. Discharge of spilled material overboard will damage the marine environment. Restrict flow of leakage to an enclosed area by barricading with inert material. Collect spillage in drums or metal boxes.

According to the SDS, copper powder is a flammable solid and marine pollutant that is very toxic to aquatic life. The SDS cautions to avoid breathing dust and to avoid contact with skin and eyes.

2.2 Bay 5 Dangerous Goods Containers (TEU)[7]

Freight container stowage locations in Bay 5 are depicted in Figure 10.

Figure 10. Bay 5 Freight Container Stowage Plan, March 26, 2024, Synergy Marine, PTD, LTD.

2.2.1 50072: Alkylsulfonic acid, SLZU2508201 (1)

UN2586, Alkylsulfonic acids, liquid, with not more than 5% free sulfuric acid, Class 8, PG III was offered for shipment in a 20-foot UN portable tank T22, container number SLZU2508201.[8] The gross weight was 25,791 kg.

[7] TEUs are twenty-foot equivalent units, whereas FEUs are forty-foot equivalent units. Odd numbered bays are designated for TEUs, and even numbered bays are designated for FEUs.

[8] The Zim American Integrated Shipping Services, Co., LLC international dangerous goods manifest indicates the package was a type T11 general purpose portable tank, while the Maersk dangerous goods declaration under Maersk booking number 237420702, specifies a more robust UN portable tank T22. Investigators were not able to access these items for confirmation which tank type was used. This is applicable to all 6 alkylsulfonic acid shipments referenced in this section.

On March 22, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237420702.

2.2.2 50172: Alkylsulfonic acid, SUTU2581707 (2)

UN2586, Alkylsulfonic acids, liquid, with not more than 5% free sulfuric acid, Class 8, PG III was offered for shipment in a 20-foot UN portable tank T22, container number SUTU2581707. The gross weight was 25,115 kg.

On March 25, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237060990.

2.2.3 50272: Alkylsulfonic acid, CXTU1142194 (3)

UN2586, Alkylsulfonic acids, liquid, with not more than 5% free sulfuric acid, Class 8, PG III was offered for shipment in a 20-foot UN portable tank T22, container number CXTU1142194. The gross weight was 27,970 kg.

On March 22, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237191108.

2.2.4 50872: Corrosive Liquid, Flammable N.O.S., MSMU2247260 (4)

Container MSMU2247260 was loaded with UN2920, CORROSIVE LIQUID, FLAMMABLE, N.O.S.* (dialkyldimethylammonium chloride, ethanol), CLASS 8 (3), PG II, flashpoint 40 °C. The shipment consisted of 24 plastic UN specification 1H1 55-gallon drums, with non-removable head. The gross weight was 4,626.7 kg.

On March 19, 2024, the container was consigned from MSC Norfolk, VA to Manila North Harbor via Tanjung Pelepas. Mediterranean Shipping Company S.A. was the offeror.

The Ecolab Production LLC multimodal dangerous goods form indicates the consignee is Ecolab Philippines, Inc., Muntini Upa City, Philippines.

2.3 Bay 6 Dangerous Goods Containers (FEU)

Freight container stowage locations in Bay 6 are depicted in Figure 11.

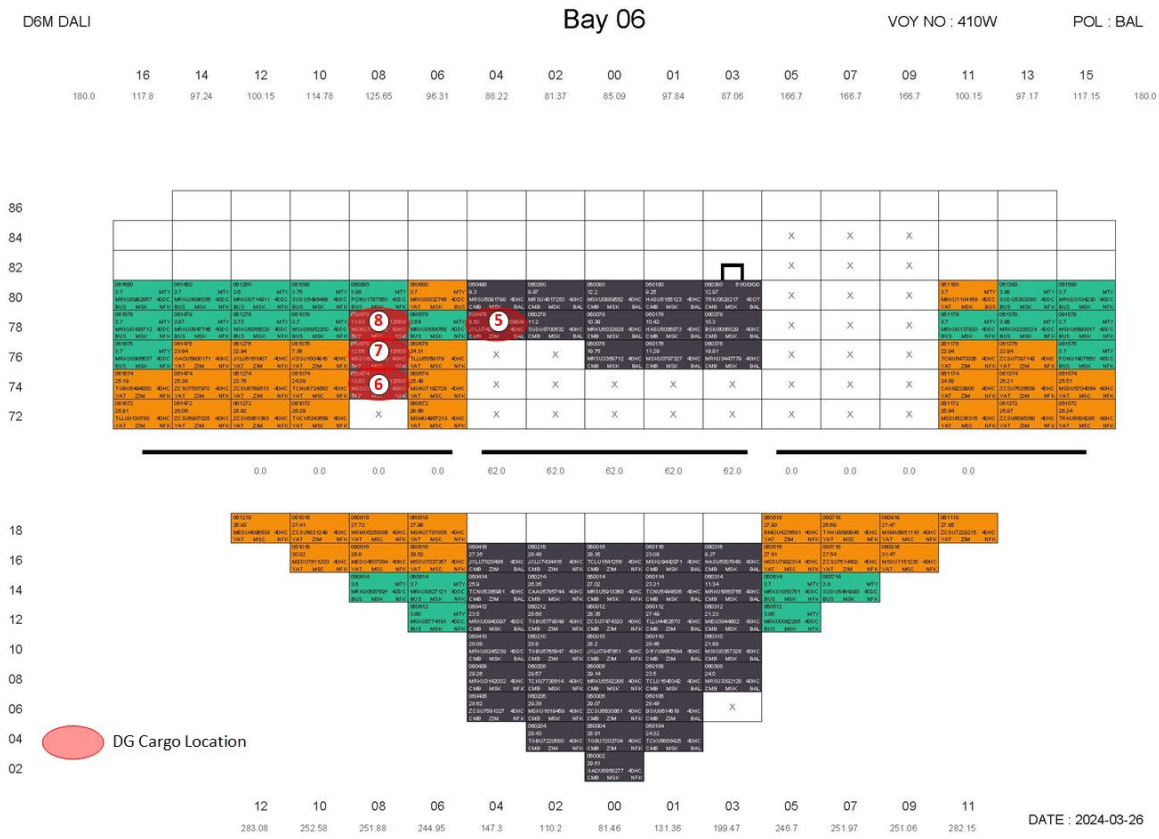

Figure 11. Bay 6 Freight Container Stowage Plan, March 26, 2024, Synergy Marine PTE, LTD.

2.3.1 60478: Lithium Batteries, JXLU7427972 (5)

The following articles containing lithium batteries were offered for shipment in a 40-foot reefer HC container JUXL7427972:

- 1 UN 4G fiberboard box containing UN3090 Lithium metal batteries and articles, Class 9. The gross weight was 32.0 kg, net weight was 0.018 kg.
- 1 UN 4G fiberboard box containing UN3091 Lithium metal batteries contained in equipment, Class 9. The gross weight was 168.0 kg, net weight was 0.018 kg.
- 1 UN 4G fiberboard box containing UN3481 Lithium-ion batteries contained in equipment, Class 9. The gross weight was 164 kg, net weight was 0.017 kg.

- 1 UN 4G fiberboard box containing UN3091 Lithium metal batteries contained in equipment, Class 9. The gross weight was 167 kg, net weight was 0.099 kg.
- 2 UN 4G fiberboard boxes containing UN3480 Lithium-ion batteries, unspecified, Class 9. The gross weight was 3.0 kg, net weight was 0.018 kg.

The offeror was Zim American Integrated Shipping Services Co., LLC, Baltimore, MD. Port of discharge was LKCMB/Columbo.

The international dangerous goods manifest prepared by Zim did not match the quantity and weights listed in the Maersk dangerous goods declaration under Maersk booking number 237288471. According to the Zim manifest, the container was loaded with 25 packages having a gross weight of 8,233 kg. However, the above listed hazardous materials descriptions are the same.

Further package quantity and weight discrepancies are noted in the IMO shipping document referenced to container JXLU7427972, which lists the exporter as ED Diagnostic Systems, Sparks, MD, and the consignee as Becton Dickinson Holdings PTE LTD, Singapore, SG. The equipment is further described as medical supplies. The shipping paper indicates:

- 19 pallets with a gross weight of 3,471 kg.
- 1 fiberboard box/1 pallet with a gross weight of 168 kg.
- 1 fiberboard box with a gross weight of 3 kg.
- 1 fiberboard box/1 pallet with a gross weight of 32 kg.
- 1 fiberboard box/1 pallet with a gross weight of 167 kg.
- 1 fiberboard box/1 pallet with a gross weight of 164 kg.
- 2 fiberboard box/2 pallets with a gross weight of 388 kg.

2.3.2 60874: Perfumery Products, MSDU7285306 (6)

Container number MSDU7285306 was loaded with 1,344 specification 4G fiberboard boxes containing 27,640 plastic or glass receptacles on 12 pallets, UN1266 Perfumery Products, Class 3, PG II, flash point 18 °C. Gross weight 2,526 kg, Limited Quantity. All units are less than or equal to 1 liter.

On March 19, 2024, the container was consigned from Norfolk, VA to Port Klang via Tanjung Pelepas. MSC Mediterranean Shipping Company S.A. was the offeror.

2.3.3 60876: Perfumery Products, MSDU6336029 (7)

Container number MSDU6336029 was loaded with 1,154 specification 4G fiberboard boxes containing 18,430 plastic or glass receptacles, UN1266 Perfumery Products, Class 3, PG II, flash point 18 °C. Gross weight 2515.7 kg, Limited Quantity. All units less than or equal to 1 liter.

On March 19, 2024, the container was consigned from Norfolk, VA to Singapore via Tanjung Pelepas. MSC Mediterranean Shipping Company S.A. was the offeror.

2.3.4 60878: Perfumery Products, MSNU7758902 (8)

Container number MSNU7758902 was loaded with 1,318 specification 4G fiberboard boxes containing 11,404 plastic or glass receptacles, UN1266 Perfumery Products, Class 3, PG II, flash point 18 °C. Gross weight 1,975.1 kg, Limited Quantity. All units less than or equal to 1 liter.

On March 19, 2024, the container was consigned from Norfolk, VA to Port Klang via Tanjung Pelepas. MSC Mediterranean Shipping Company S.A. was the offeror.

2.4 Bay 7 Dangerous Goods Containers (TEU)

Freight container stowage locations in Bay 7 are depicted in Figure 12.

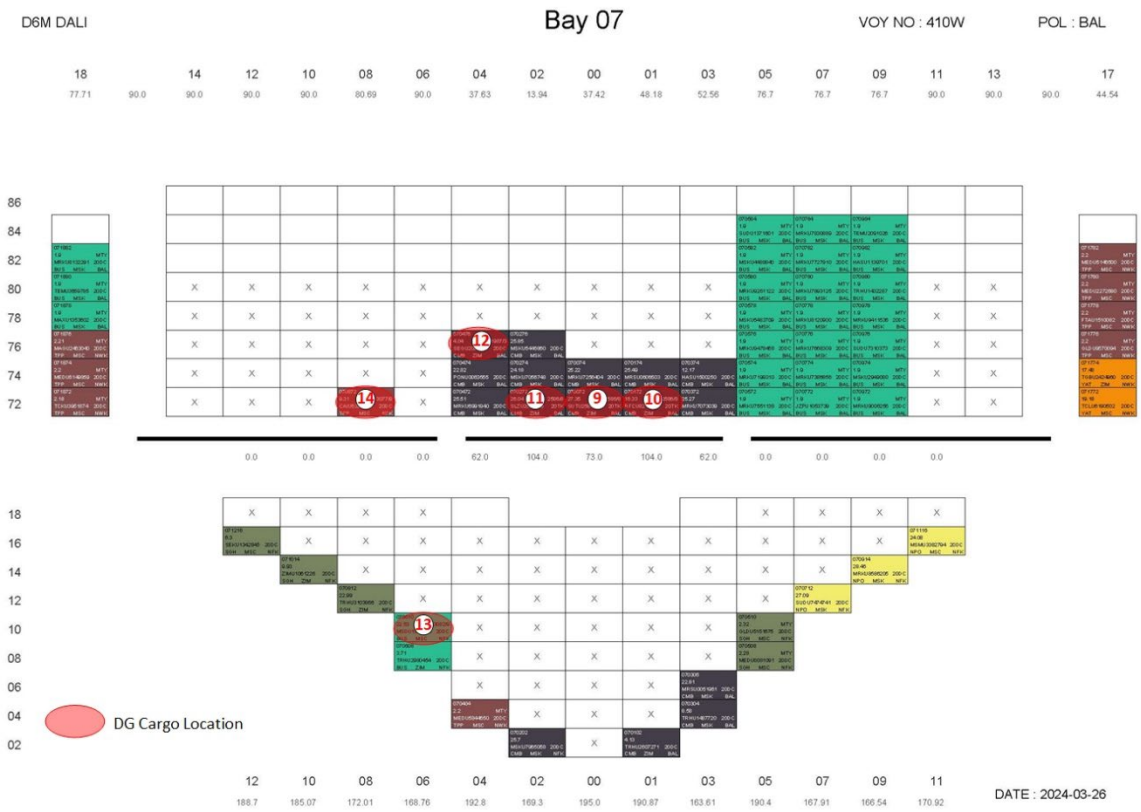

Figure 12. Bay 7 Freight Container Stowage Plan, March 26, 2024, Synergy Marine PTE, LTD.

2.4.1 70072: Alkylsulfonic acid, SUTU2584389 (9)

UN2586, Alkylsulfonic acids, liquid, with not more than 5% free sulfuric acid, Class 8, PG III, was offered for shipment in a 20-foot UN portable tank T22, container number SUTU2584389. The gross weight was 21,754 kg. On March 22, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237060663.

2.4.2 70172: Alkylsulfonic acid, RFCU8218611 (10)

UN2586, Alkylsulfonic acids, liquid, with not more than 5% free sulfuric acid, Class 8, PG III, was offered for shipment in a 20-foot UN portable tank T22, container number RFCU8218611. The gross weight was 24,934 kg.

On March 25, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237060990.

2.4.3 70272: Alkylsulfonic acid, SLZU2508773 (11)

UN2586, Alkylsulfonic acids, liquid, with not more than 5% free sulfuric acid, Class 8, PG III, was offered for shipment in a 20-foot UN portable tank T22, container number SLZU2508773. The gross weight was 21,708 Kg.

On March 22, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237290145.

2.4.4 70476: Sodium hydroxide, Alcohols, N.O.S., SEGU2099993 (12)

The following articles containing sodium hydroxide and alcohols were offered for shipment in 20-foot container number SEGU2099993:

- 1 UN 4G fiberboard box with 10 plastic inner packagings, containing UN1824 Sodium Hydroxide Solution, Class 8, PG III. The gross weight was 10 Kg, net weight 0.015 kg. Limited quantity.
- 1 UN 4G fiberboard box with 4 plastic inner packagings, containing UN1987 Alcohols, N.O.S., Class 3, PG III (technical name Ethanol, Methanol, Isopropanol), flash point 43.0 °C. The gross weight was 83 Kg, net weight 1.0 kg.
- 1 UN 4G fiberboard box with 1 plastic inner packagings, containing UN1987 Alcohols, N.O.S., Class 3, PG III (technical name Ethanol, Methanol, Isopropanol), flash point 10.0 °C. The gross weight was 91 kg, net weight 0.017 kg.

On March 22, 2024, the container was consigned from Baltimore – Seagirt Terminal C324 to Colombo International Container Terminals (LTD), Colombo, Sri Lanka. The Maersk booking number was 237288754.

2.4.5 70610: Environmentally Hazardous Sub., MSDU1817680 (13)

Container number MSDU1817680 was loaded with 76 UN specification 1H1 plastic drums with non-removable head, containing UN3077, Environmentally Hazardous

Substance, Liquid, N.O.S. (dodecyl diphenyl oxide disulfonate), CLASS 9, PG III. The gross weight was 18,270 kg.

On March 19, 2024, the container was consigned from Norfolk, VA to Singapore via Taichung via Ningbo. MSC Mediterranean Shipping Company S.A. was the offeror. The consignor was Dow Chemical Company, Cincinnati, OH, and the consignee was Hung Shiuan Enterprise Co. LTD, Hsi Tun, Taiwan.

2.4.6 70872: Environmentally Hazardous Substance, CAIU6327116 (14)

Container number CAIU6327116 was loaded with 30 UN specification 1G fiber drums containing UN3077, Environmentally Hazardous Substance, Solid, N.O.S. (copper metal powder), CLASS 9, PG III. The gross weight was 6,804 kg.

On March 19, 2024, the container was consigned from Norfolk, VA to Port Klang via Tanjung Pelepas. MSC Mediterranean Shipping Company S.A. was the offeror.

The consignor was SCM Metal Products, Inc., RTP, NC, and the consignee was Portie (Malaysia), Selangor Darul Ehsan, Malaysia.

3.0 Overview of the Oil Spill/Hazardous Materials Release and Response

Several key objectives established by the unified command included:

- Missing persons recovery,
- Implementing a temporary channel for commercially essential vessels,
- Establishing a limited access deep draft channel,
- *Dali* relocation for channel reconstitution,
- Full channel reconstitution,
- Wreckage and debris removal,
- Response to released oil and hazardous materials.

This report is limited to describing the latter – response to oil and hazardous materials releases.[9]

[9] A website describing the unified command's response to this incident can be found at the following URL: https://www.keybridgeresponse2024.com

3.1 Incident Command

On March 26, 2024, a unified command was established with the following organizations (see Figure 13):

- U.S. Coast Guard
- U.S. Army Corps of Engineers
- Maryland Department of the Environment
- Maryland Transportation Authority Police
- Maryland State Police
- Witt O'Briens, representing the responsible party

Assisting and coordinating agencies included NTSB, CPB, FBI, Navy Sup Salv, MDOT, MPA, NRP, Air National Guard, Baltimore City, Baltimore County, NOAA, CISA, MDEM, PHMSA, and EPA.

The incident command post had been situated at the Maryland Cruise Terminal, 2001 E. McComas Street, Baltimore, MD.

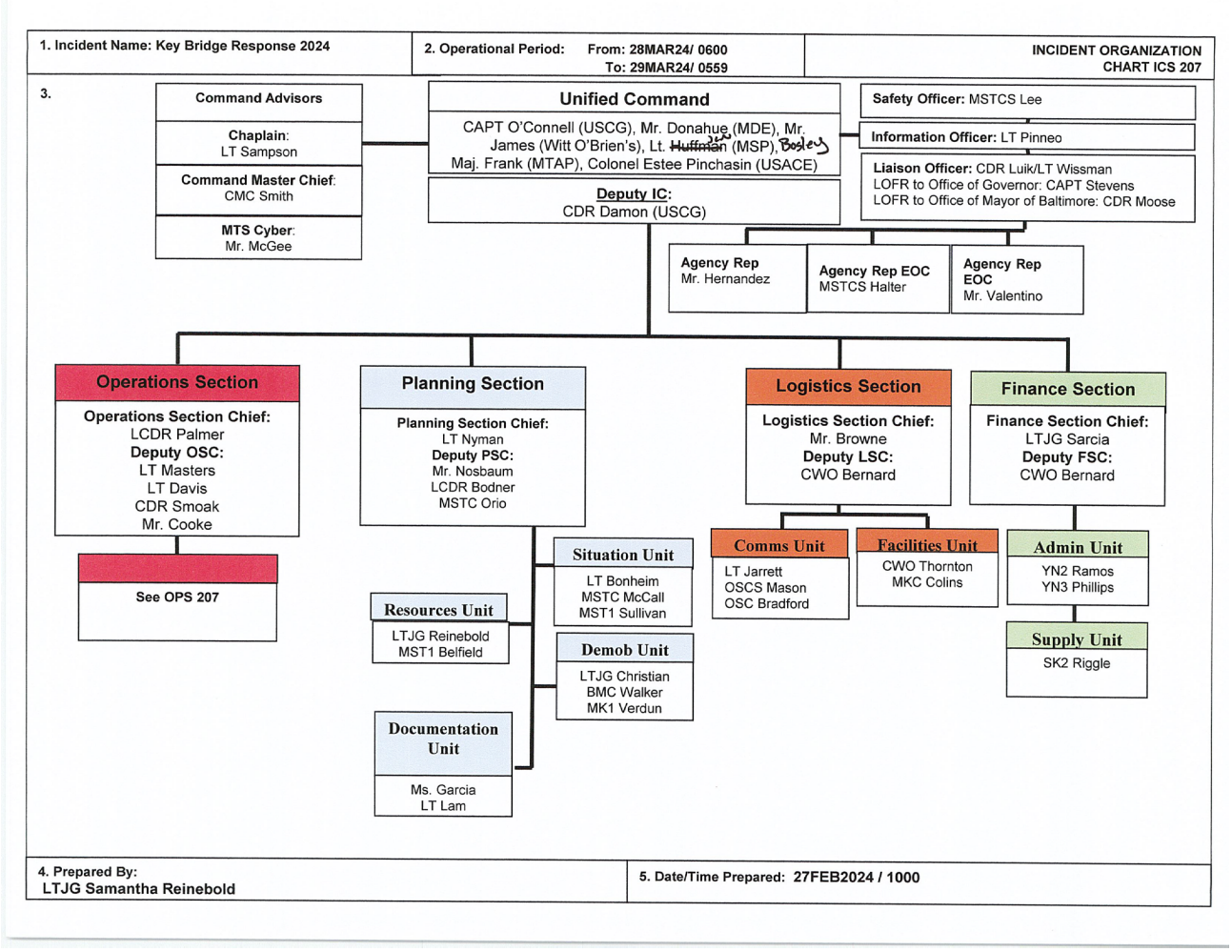

Figure 13. Unified command structure as of March 28, 2024.

3.2 Oil and Chemical Spill Response

On March 26, 2024, the National Oceanic and Atmospheric Administration (NOAA) published the following statement:

> Initial Notification: At 0600, USCG Sector Maryland notified the NOAA SSC that The Port of Baltimore is closed due to a major marine casualty. The 948-foot Singapore-flagged vessel *DALI* struck the Francis Scott Key Bridge. A safety zone is established for all navigable waters of the Chesapeake Bay within a 2000-yard radius of the Francis Scott Key Bridge. Search and Rescue (SAR) operations are underway. Vessel has sustained major damage to the bow. An unknown number of containers fell into the water and a number of containers on board the vessel are damaged.

Figure 14 provides NOAA's estimate of the potential worst-case oil discharge for this incident.

Incident Details	
Primary Threat:	**Oil**
Products Of Concern:	**Bunker Fuel**
Total Amount At Risk Of Spill:	**1,500,000 Gallons**
Latitude (Approximate):	**39° 16.22′ North**
Longitude (Approximate):	**76° 34.48′ West**

Figure 14. Potential worst-case discharge reported by NOAA, March 26, 2024.

Synergy Marine PTE. LTD possesses an approved non-tank vessel response plan (VRP) no. 27102, which was approved on September 1, 2011, and is valid until March 13, 2029. The plan preparer was Witt O'Briens, Houston, TX. Vessel response plans outline what the vessel will do in the case of an offshore spill and are required by the U.S. Coast Guard for maritime operators that carry certain quantities of chemicals or refined petroleum products. According to the VRP, the worst-case discharge for the *Dali* was 51,020 barrels, while its largest oil tank was 12,603 barrels. The cargo carried included Group I non-persistent oils, and Groups II through IV persistent oils.

While there was no report of oil releases from the *Dali's* bunker tanks, a persistent light oil sheen was visible on the starboard side of the ship. The unified command assigned Marine Spill Response Corporation (MSRC) and Resolve Marine, emergency response and oil spill removal organizations (OSROs), to deploy a 15-person team for on-water recovery as part of the unified command's Recovery and Protection Branch. Their initial tasks included deployment of:

- 2,400-feet of 18-inch hard boom starboard and aft of the Dali,
- 2 work boats, 28′ and 25′,
- 1,000-feet of hard boom at staging area,
- 41 bags of sorbent boom and assorted sorbent material,
- Response truck and trailer.

During the operational period March 28 to March 29, the Recovery and Protection Branch was assigned to assess the condition of the sorbents placed within the containment boom around the vessel and to maintain the 2,400-foot boom during salvage assessment operations (Figure 15). MSRC continued to deploy and

maintain containment boom as necessary around the *Dali* to contain any discharges of oil/petroleum products. Meanwhile, Resolve Marine Group coordinated containment of spilled oil and hazardous substances on-board to prevent releases from the vessel into the environment. This included establishment of collection points for spilled material and the use of scupper plugs, sorbent material, pumps and hoses to contain released material. Resolve Marine Group also deployed a 4-person fire team as a precaution for immediate flash suppression if needed.

Figure 15. Spill response operations for oil sheen on starboard side of the Dali, March 28, 2024.

The State on-scene coordinator (SOSC) told NTSB investigators that all released hazardous materials aboard the *Dali* were contained within the forward ship holds. He confirmed that following contact with the bridge, two cargo containers fell from the ship into the Patapsco River, but neither container displayed hazardous materials placards. On the morning of March 26, NTSB investigators observed the two floating containers secured to bridge wreckage (Figure 16).

Figure 16. Two unidentified non-placarded cargo containers floating in the Patapsco River next to fallen bridge debris, March 26, 2024, 09:54.

4.0 Pipeline Information

The Resolve Marine Group salvage master became aware of the presence of a Baltimore Gas and Electric (BGE) gas pipeline in the area where the *Dali* came to rest. He told NTSB investigators that he was concerned about the integrity of the pipeline should the *Dali*, spud barges, or wreckage clearing operations impact the line. Consequently, he arranged for BGE to provide a pipeline safety briefing for Resolve Marine Group divers tasked with marking the pipeline location with buoys.

The BGE Harbor Crossing intrastate transmission pipeline was a 1.75-mile segment of 24" steel 0.375" wall thickness, Somastic-coated pipe, with a maximum allowable operating pressure (MAOP) of 300 psig and bidirectional flow.[10] The section traversing the Patapsco River was about 11,430' from the north to south shoreline. The pipeline was constructed in 1974 and is located about 50-feet west and parallel to the bridge. Outside of the shipping channel, the pipeline was provided with 10-feet of cover, and within the shipping channel it was provided 30-feet of cover. However, since original construction, the channel had been deepened with dredging, leaving the depth of cover in the shipping channel less than the original 30 feet (Figure 17). The pipeline serviced the Maryland Transportation Authority

[10] Somastic® was a trade name for an asphalt-mastic mixture of anti-corrosion pipe coating that sealed out moisture.

facilities at the Francis Scott Key Bridge, as well as some customers in Anne Arundel County, Maryland.

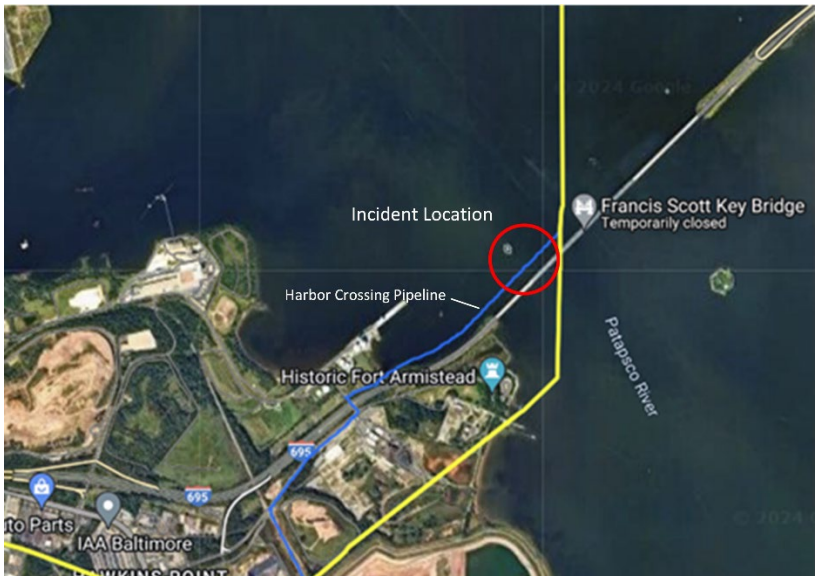

Figure 17. Approximate pipeline location parallel to Francis Scott Key Bridge, BGE 24-inch transmission pipeline, National Pipeline Mapping System public viewer.

On Wednesday, March 27, 2024, BGE was first notified about potential damage to the pipeline when the company was contacted by the unified command with a request to participate in a conference call. According to the BGE manager of gas transmission engineering, the unified command sought information about the location and depth of the Harbor Crossing pipeline. During this conference call, BGE learned the *Dali* had run aground and may have damaged the pipeline. BGE documented this communication on a Safety-Related Condition Report it filed with PHMSA on March 28, 2024.[11] The report stated that although no abnormal operating conditions had been observed, a salvage dive team surveying damage to the *Dali* discovered the vessel had run aground in close proximity to the underground gas transmission pipeline. BGE reported there was a possibility that vessel movement could impact the pipeline, and therefore on March 27, 2024, it closed valves on each side of the Patapsco River crossing. There were no customer service outages because of the incident.

On March 28, 2024, the BGE manager of gas transmission engineering, who had been working with the Maryland Transportation Authority (MDTA) to assess

[11] PHMSA regulations at 49 CFR part 195, subpart B require pipeline operators to submit reports for certain conditions before a leak has actually occurred, including safety-related conditions that could cause an imminent hazard.

possible impacts to the pipeline during wreckage clearing operations, told NTSB investigators BGE had no concern the pipeline sustained breaching damage. He explained the pipeline is monitored by SCADA and there was no evidence of pressure anomalies following the bridge contact and collapse. He said the operating pressure at the time of the incident was about 185 psig.

On March 28, 2024, the Pipeline and Hazardous Materials Safety Administration (PHMSA) director of pipeline accident investigations told NTSB investigators the agency confirmed with BGE the pipeline was shut in on both sides of the river. However, PHMSA was concerned the natural gas has not been purged from the line. PHMSA was not aware of any pipeline location or depth of cover surveys conducted since the line was installed in 1974. BGE reported its most recent pipeline leak survey was completed on March 1, 2024, during which the company identified no adverse conditions or leaks.

BGE initially had no plan to depressurize or inert the pipeline because of a concern that depressurization could have led to pipe collapse if the weight of the vessel rested upon it. However, on March 30, 2024, the unified command reported that it coordinated with BGE to reduce the pressure and inert the underwater pipeline.

As of the date of this report, BGE has not reported that the pipeline sustained any damage. On June 28, 2024, BGE announced that it had reconnected the harbor crossing gas pipeline.[12] BGE stated it continues to monitor and inspect the pipeline.

5.0 March 28, 2024, Container Inspection

On March 28, 2024, NTSB investigators boarded the *Dali*, accompanied by two U.S. Coast Guard Atlantic Strike Team chief petty officers, each equipped with MultiRae 5-gas meters. The group was escorted by a Synergy Marine mate to forward locations on-deck in an effort to identify and document the condition of cargo containers with hazardous materials. The entry team was not able to proceed beyond the starboard side of Bay 5 or the port capstans due to hazardous conditions of shifted cargo and overhead bridge debris (Figure 15). At no time during this inspection did air monitoring reveal any elevated levels of volatile organic compounds or abnormal oxygen levels.

[12] https://www.bge.com/news/news-releases/bge-update-on-harbor-crossing-gas-pipeline

All on-deck cargo containers in Bays 1, 2, and 3 were covered with fallen bridge debris. There were no hazardous materials reported to have been stowed in these locations.

The cargo containers in Bays 5, 6, and 7, which included 14 hazardous materials containers, were displaced and damaged as well. From starboard-to-port, damaged cargo containers include those stowed in rows 7, 5, 3, 1, 0, 2, 4, 6, 8, 10, 12, 14, 16, and 18.

All on-deck cargo containers stowed aft of Bay 7 did not sustain any visible impact damage.

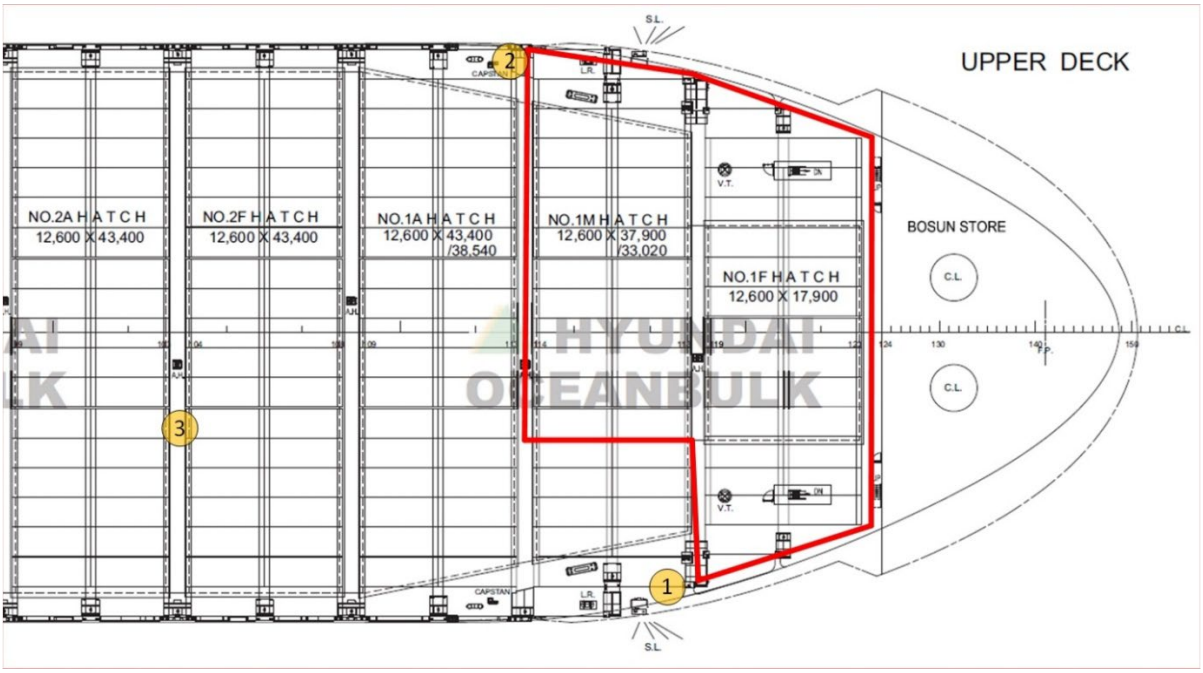

Figure 18. Damaged on-deck cargo containers in Bays 1 through 7 within the red line. Points of closest approach for inspection are indicated by orange circles – starboard side location 1, port side location 2. Several ISO tanks were inspected at location 3. March 28, 2024.

Because the inspection team was not able to access areas within the red outline in Figure 18, no containers carrying hazardous materials were able to be found and identified within this area.

However, while at location 1, starboard side of Bay 7, the inspection team observed 4 x 55-gallon steel drums marked "Weston 705T" antioxidant that had fallen from an open and severely damaged container that had been impacted by bridge structure and had fallen from its stack (Figures 19 and 20). The cargo container

number was not visible, but it appeared to be one of six containers that had been stationed in Bay 3, Row 13. The drums did not bear any hazardous materials labeling. The SI Group SDS for the material indicates the material is a colorless and odorless liquid with a flash point of 228 °C. According to the labeling, the product did not contain any regulated hazardous substances and is not regulated in transportation as a hazardous material. The 20-foot transport container was torn in several locations, from which it was evident there were many additional drums within. An organic liquid was weeping from a couple of tears in the bottom of the container.

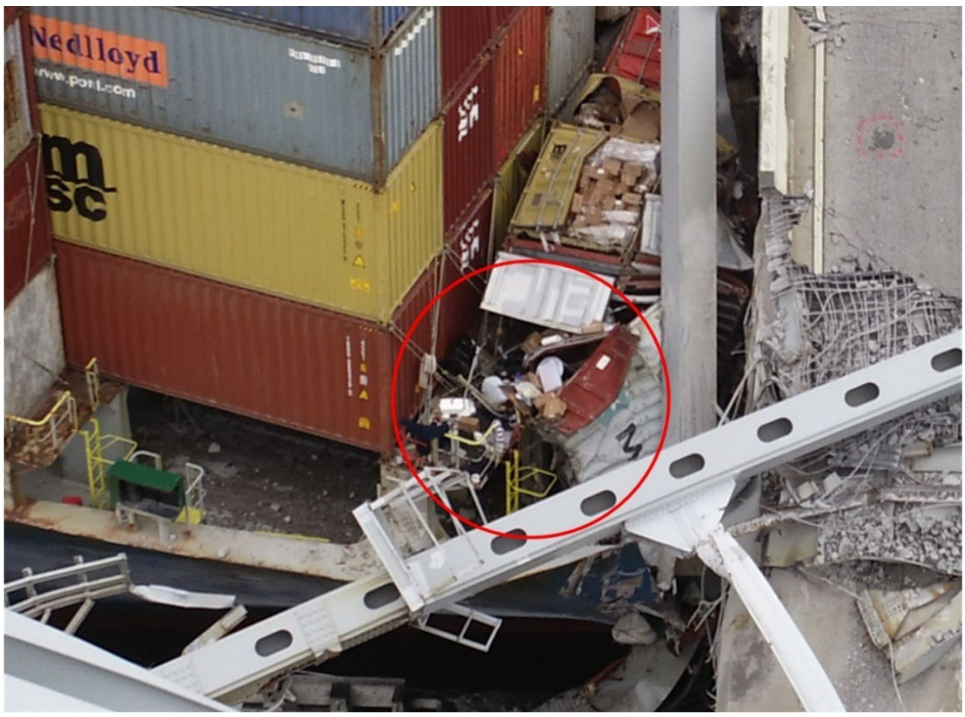

Figure 19. Location of damaged container impacted by bridge debris, loaded with 55-gallon drums of non-hazardous Weston 705T, from Bay 3, Row 13. March 28, 2024.

Figure 20. 55-gallon drums of Weston 705T that had come to rest on the main deck. The bottom surface of the damaged cargo container is visible on the left side of the photograph. March 28, 2024.

Investigators found no evidence of surface spillage on the main deck at location 1 in Figure 18.

Investigators found no evidence of hazardous materials releases in the aisle way area between Bays 7 and 9 (Figure 21).

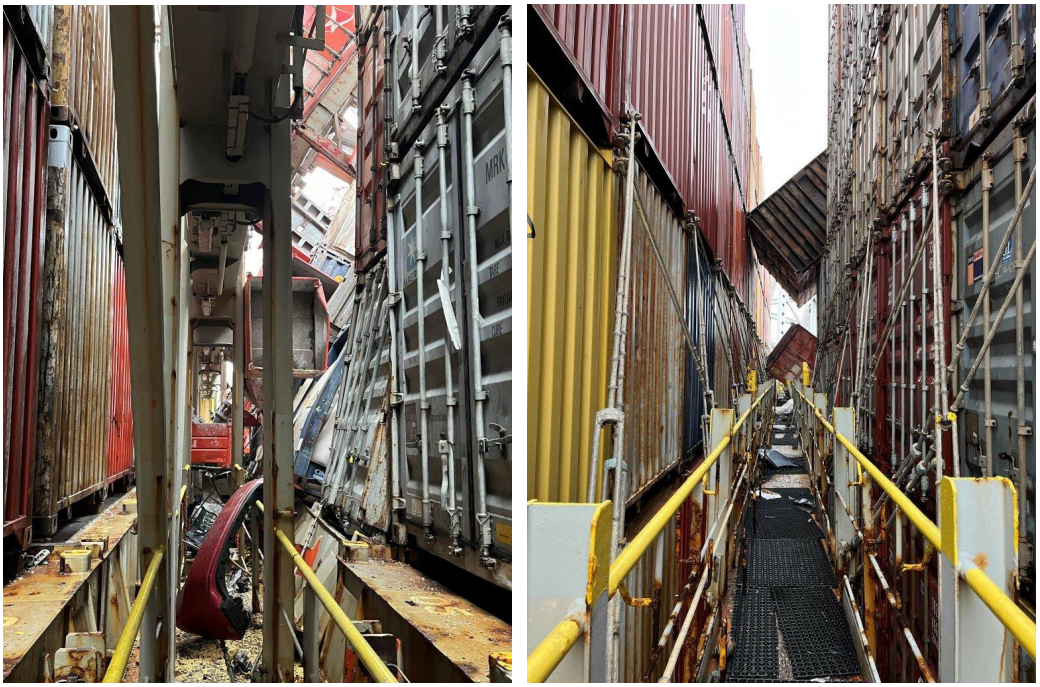

Figure 21. No evidence of hazardous materials releases in the walkway between Bays 7 and 9. Toppled containers suspended overhead made entry to the area unsafe. March 28, 2024.

NTSB investigators further examined the aisle-ways between Bays 11 - 13, and Bays 15 -17, finding no visual evidence of hazardous materials releases. At location 3 in Figure 18, investigators checked several ISO-tanks containing hazardous materials between Bays 15-17, finding no evidence of releases (Figure 22). Tank numbers and locations matched the Dali loading plan documents.

Figure 22. Iso-tanks stationed in Bay 15 (right) and Bay 17(left). No evidence of material releases were observed. March 28, 2024.

Next, investigators progressed to the port side main deck area between Bays 7 and 9. Investigators observed containers in Bay 7 collapsed under the weight of fallen bridge structure. Access to observe on-deck container numbers was impeded by this wreckage. The bottom of a cargo container in Bay 7 was buckled over the main deck, preventing further access to this area. The aisle-way between Bay 7 and Bay 9 was wet from recent rain, but there was no visual evidence of a chemical release.

At least 4 breached cargo containers with missing contents were suspended from the port side of the vessel in the area of Bays 1 through 7 (Figure 23). Two of these breached and empty containers were identified as:

- 71872: TCKU3989184
- 71874: MEDU6149859

Neither of the two containers had been loaded with dangerous goods.

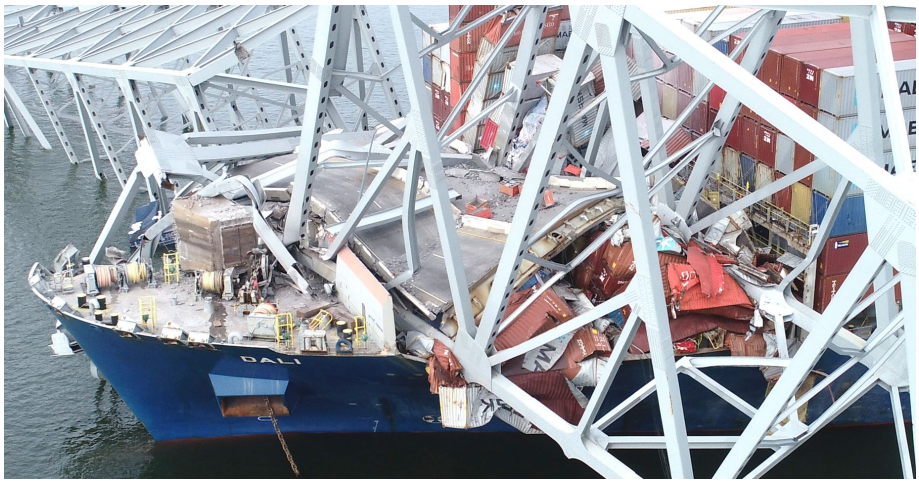

Figure 23. Breached cargo containers suspended from the port side of the Dali, March 26, 2024.

NTSB investigators then entered the 2nd deck below the main-deck damaged cargo containers to observe whether any released material was accumulating below.

From the area just forward of Piller 17 in Bay 10, the deck of at least four compartments had an accumulation of a viscous liquid with surfactant-like foam on the surface. USCG Strike Team personnel did not detect any evidence of elevated volatile organic compounds during air monitoring of this area or near the spillage. Liquid was continuing to drip down from debris suspended from the collapsed main deck of Bay 6, which could only be observed from a circular cutout in the bulkhead separating Bay 10 from Bay 6 (Figure 24).

Figure 24. 2nd Deck below Bays 6-10. Surfactant-like material on deck at bulkhead between Bays 6 and 10 (left); view into area below Bay 6 with fallen debris and accumulating liquid (center); view through bulkhead into area below Bay 6 with liquid dripping from above (right). March 28, 2024.

Finally, NTSB investigators came to the Bay 2 water-tight door to the starboard bow thruster room. The Synergy Marine mate warned that he was unable to open this door because liquid had accumulated behind it. A viscous sticky liquid was weeping from the bottom of the door onto the deck (Figure 25). The material did not exhibit any evidence of flammability as indicated by the USCG's flammable gas detector (LEL/PID meter).

Figure 25. Viscous non-volatile sticky liquid leaking from the Bay 2 bow thruster room water-tight door. March 28, 2024.

6.0 Cargo Container and Released Hazardous Materials Removal Actions

The organizations involved in remediating the released materials onboard the *Dali* included:

- Grace Ocean Private LTD – vessel owner
- Synergy Marine PTE, LTD – vessel operator
- Resolve Marine Group – salvors and project managers
- Witt Obrien's – Qualified Individual, spill management team, unified command[13]
- Ambipar Response – waste transporter

[13] Under 33 CFR 155.1026, a Qualified Individual is an English-speaking representative of an operator, located in the United States, available on a 24-hour basis, with full authority to activate and implement oil removal actions and to serve as liaison to the federal on-scene coordinator.

6.1 Container Removal in Baltimore Maryland

Between April 7 – 28, 2024, the Resolve Marine salvors removed 183 containers from the *Dali* as part of an effort to gain access to the portion of the Key Bridge that remained on top of the ship's bow and to facilitate associated heavy equipment movements. The Resolve Marine senior salvage master reported the condition of 57 twenty-foot and 126 forty-foot freight shipping containers removed from Bays 5, 7, 9, and 11 on the *Dali*, and landed on Weeks Marine barges for transfer to shore-based temporary storage at the Seagirt Marine Terminal in Baltimore, Maryland. The undamaged or slightly damaged containers were later stored at the CSX Railroad yard located at 900 Chesapeake Avenue, Baltimore, Maryland 21225. None of the 183 removed containers included any of the 14 impacted hazardous materials containers in Bays 5 through 7. However, the removed freight containers included 8 containers of hazardous materials, including:

- 1 container with 10.5 tons of UN1080 sulfur hexafluoride,
- 1 container with 18.2 tons of UN1999 liquid tar,
- 5 containers with 125.4 tons of UN3082 alkoxylated alkylamine, and
- 1 container with 5.5 tons of various substances, including Class 3 (isopropanol), Class 8 (alkyl sulfonic acid), and Class 9 (potassium chromate and zinc chromate).

The senior salvage master found no evidence of hazardous materials releases from the 8 placarded freight containers.

On May 13, 2023, salvors used explosives to remove sections of the collapsed Francis Scott Key Bridge and free the *Dali* from the wreckage. On May 20, 2024, the *Dali* was towed 2.5 miles to the Seagirt Marine Terminal.

6.2 Waste Materials Removal in Norfolk Virginia

Released materials from damage to intermodal containers onboard the *Dali* following the bridge collapse resulted in non-hazardous and hazardous cargoes accumulating and mixing in the vessel's cargo holds. Resolve Marine Group identified the following hazardous material waste streams resulting from the damaged container releases:

- Perfume
- Household chemicals, cleaning supplies, medical supplies
- Lithium-ion batteries
- Alkyl sulphonic acid

- Copper powder
- Denatured alcohols
- Automobiles

On June 24, 2024, the *Dali* departed the Seagirt Marine Terminal in Baltimore, Maryland. On June 26, 2024, the *Dali* arrived at Talton Marine Terminals, Pier 3, 8791 Hampton Blvd, Norfolk, Virginia, to commence salvage and repair operations. Resolve Marine Group managed salvage operations, which consisted of removing remaining pieces of bridge debris, damaged containers above and below deck, and released materials that had accumulated in the cargo hold.

Hazardous and non-hazardous liquids released from damaged containers, along with contaminated rainwater, had accumulated in *Dali's* Cargo Hold 1 (Bays 6 and 10). Resolve Marine Group pumped the contents of the cargo hold to two frac tanks stationed on the deck of barge *RMG 1000* that was brought alongside *Dali*.[14] Remaining steel and concrete bridge debris were loaded on a barge and sent to a recycling facility. Damaged containers were loaded on barges where they were sheared/cut up if required and sent to Sims Metal for recycling.

On July 12, 2024, a Resolve Marine Group subcontractor collected samples of the Cargo Hold 1 liquid/sludge for waste characterization. Resolve Marine Group general manager of compliance services described the sludge as a brown viscous liquid that exhibited a noxious odor due to the material comingling with spoiled soybeans released from several damaged containers. According to the Resolve Marine Group Hazardous Liquids Transfer Plan dated July 28, 2024, the cargo hold sludge was heavier than water, had a pH of 0.9 – 2.2, and did not ignite when exposed to flame.[15] The plan described the sludge as a mixture of:

- Decomposing soybeans,
- Alkyl sulfonic acid,
- Rainwater, and
- An unknown quantity of pesticides.

[14] The *RMG 1000* is a 4,735 gross-registered-ton, 100 ft. by 288 ft. crane barge, operated by the Resolve Marine Group.

[15] 40 CFR 261.22 states that a waste exhibits the characteristic of corrosivity, and thus is a hazardous waste, if a representative sample is aqueous and has a pH of less than or equal to 2, or greater than 12.5, as determined using Method 9040C in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," EPA Publication SW-846.

The plan stated the primary hazardous waste constituent was alkyl sulfonic acid. The Resolve Marine Group general manager of compliance services told NTSB investigators that because of infiltration of a large amount of rainwater, the pH of the cargo hold liquid/sludge mixture had over time risen to about 5.7 (mildly acidic) such that it no longer met the RCRA characteristic of corrosivity for waste disposal. Consequently, Resolve Marine Group was able to ship material as non-hazardous waste for disposal to Clearfield MMG in Chesapeake, Virginia, or the Waste Management Middle Peninsula Landfill, Gloucester County, Virginia. The disposal method was solidification with absorbents and landfilling.

The Resolve Marine Group general manager of compliance services told NTSB investigators that the putrefying soybeans in combination with the acidic liquid produced a significant amount of highly toxic hydrogen sulfide gas within the cargo hold confined spaces. This scenario led to the required use of respiratory protective equipment for crews involved in the waste removal operations. No injuries were reported during these operations.

Between July 8 and September 24, 2024, over 3,032 tons of waste materials associated with the damaged cargo containers and remaining bridge debris were removed from the *Dali* pier-side in Norfolk, Virginia for off-site disposal, as summarized in Table 1. This included about 542 tons of construction and demolition debris; 1,761 tons of perishable and mixed non-hazardous wastes; 619 tons of non-hazardous liquid wastes; 22.5 tons of hazardous waste liquids, and over 33.5 tons of Universal Wastes.[16] Resolve Marine Group provided NTSB investigators with hazardous waste manifests and non-hazardous waste manifests documenting 327 individual shipments during this time.

In the midst of these salvage operations, the *Dali* was moved to the International Gateway in Portsmouth, Virginia between August 11-13, 2024, where remaining sound cargo containers were offloaded.

[16] Dali Waste Disposal Final Report. (Fort Lauderdale, FL, Resolve Marine Group, November 5, 2024).

Table 1. Summary of hazardous and non-hazardous materials removed from the *Dali* in Norfolk, Virginia[17]

Waste Stream	Quantity	Disposal Facility
UN2586 Waste Alkyl Sulfonic Acids, liquid, 8, PGIII	550 gallons	Heritage Environmental Service
UN1993 Waste Flammable Liquid, N.O.S., 3, PGII	10.05 tons	Heritage Environmental Service
UN3266 Waste Corrosive Liquid, Basic, Inorganic, N.O.S 8, PGII	0.25 tons	Heritage Environmental Service
UN3264 Waste Corrosive Liquid, Acidic, Inorganic, N.O.S., 8, PG II	4.5 tons	Heritage Environmental Service
UN2920 Waste Corrosive Liquids, Flammable, NOS 8(3), PG III	3.75 tons	Heritage Environmental Service
UN3480 Lithium-ion Batteries, 9	6.5 gallons	Lighting Resources LLC
UN3481 Lithium-ion Batteries Contained in Equipment, 9	13 gallons	Lighting Resources LLC
Mercury thermometers (universal waste)[18]	6.5 gallons	Lighting Resources LLC
Electronics waste	1.5 tons	Lighting Resources LLC
Lead-acid batteries	32 tons	American Scrap Iron and Metal
Cargo hold liquids/sludge (neutralized alkyl sulfonic acid / soybeans / rainwater / unknown pesticides)	420 tons	Clearfield MMG
Oily water/sludge from forecastle and starboard passageway	244 tons	Clearfield MMG
Soybeans	275 tons	Bethel Landfill
Scrap metal (damaged shipping containers, deck plate, automobile parts)	346 tons	Sims Metal
Tires	27 tons	Suffolk Transfer Station
Used oil	385 gallons	Clearfield MMG
Miscellaneous non-hazardous materials[19]	2,048 tons	Bethel landfill

[17] The source of this data are applicable hazardous waste manifests and non-hazardous waste manifests.

[18] As provided in 40 CFR part 273, mercury-containing equipment that is classified as hazardous waste can be collected under the streamlined collection standards for universal waste. This section provides regulatory relief for certain widely generated wastes, including batteries, pesticides, lamp bulbs, and mercury-containing equipment, which are intended to promote environmentally sound recycling or treatment.

[19] Miscellaneous non-hazardous materials included demolition debris, paper, cardboard, oil contaminated soil and absorbents, empty containers, and perishable goods that consisted of soybeans, animal skins, mayonnaise, tobacco, and flour.

E. ATTACHMENTS

1. Maersk Dali Full Dangerous Goods List
2. Baltimore IMO Dangerous Goods List
3. Safety Data Sheets Disposed Dangerous Goods
4. Dangerous Goods Declarations for Damaged Containers
5. General Stowage Plan
6. Cargo Bay Plans
7. Stowage IMDG Plan
8. Incident Action Plan – Key Bridge Response Operational Period 3/28/24 to 3/29/24
9. State of Maryland Emergency Operations Center Incident Briefing March 26, 2024
10. *Dali* Vessel Response Plan Details
11. BGE Safety Related Condition Report, March 28, 2024
12. Resolve Marine Group, *Dali* Container Removal Summary – Baltimore MD
13. Hazardous and Non-Hazardous Manifest Summary – Norfolk VA
14. Resolve Marine *Dali* Waste Disposal Final Report, November 5, 2024

Submitted by:

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