National Transportation Safety Board

Office of Marine Safety

Washington, D.C. 20594

Group Chairman's Factual Report

Engineering Group

DUKW 34 - Caribbean Sea

Allision

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1. ACCIDENT INFORMATION

Vessels:	Allision of the amphibious passenger vehicle *DUKW 34* and towing vessel *Caribbean Sea*
Accident Number:	DCA-10-MM-025
Date:	July 7, 2010
Accident Type	Allision
Time:	1437 Eastern daylight time
Location:	Delaware River near Philadelphia, PA
	N 39° 56.860' - W 75° 8.296'
Complement:	*DUKW 34*: 2 crew and 35 passengers
	Caribbean Sea: 5 crew

2. ENGINEERING GROUP

Chairman:	Thomas K. Roth-Roffy, P.E. Office of Marine Safety Washington, DC 20594
Member – U. S. Coast Guard:	CWO Andrew J. Schock Marine Inspector, Domestic Vessel Inspections Branch U.S. Coast Guard Sector Delaware Bay, Prevention Department Philadelphia, PA Ken Olson Marine Casualty Inspector, Investigations Division Office of Investigations and Analysis U.S. Coast Guard Headquarters, Washington, DC
Member – Ride The Ducks International, LLC	Frank English Fleet Operations Manager Ride The Ducks International, LLC, Branson, MO
	Brian Deckard Director of Supply Chain Management Ride The Ducks International, LLC, Branson, MO
Member – K-Sea Transportation	Christopher T. Palo Vice President, New Construction & Capital Improvement K-Sea Transportation, East Brunswick, NJ

3. SUMMARY

On Wednesday, July 7, 2010, the empty 250-foot-long sludge barge *The Resource*, being towed alongside the 78.9-foot-long towing vessel M/V *Caribbean Sea*, allided with the anchored 33-foot amphibious small passenger vehicle (APV) *DUKW 34* in the Delaware River, near Philadelphia, Pennsylvania. The *DUKW 34*, operated by Ride The Ducks International, LLC, (RTDI) carried 35 passengers and 2 crewmembers. On board the *Caribbean Sea* were 5 crewmembers. Following the allision, the *DUKW 34* sank in about 55 feet of water. Two passengers were fatally injured, and 26 passengers suffered minor injuries. No one on the *Caribbean Sea* was injured.

4. DETAILS OF INVESTIGATION

4.1. Launch and On-Scene Investigation.

4.1.1. The Safety Board learned of the accident from the Coast Guard Command Center on the afternoon of July 7, 2010. A team of three investigators launched to the accident and arrived on scene later that same day. The investigation team was accompanied by two Board Members,[1] the duty Board Member's special assistant, a public affairs officer, and a family affairs specialist. The NTSB led the investigation; parties to the investigation were the U.S. Coast Guard, RTDI, and K-Sea Transportation, Inc. (K-Sea). The on-scene portion of the investigation was completed on July 16, 2010. Additional examination and testing of the *DUKW 34* was performed on September 1 and 2 in Branson, Missouri. Follow-on interviews of company managers were conducted at the offices of K-Sea and RTDI on September 7 and 9. A team of four investigators returned to the scene January 12-13, 2011, to collect information needed for a tugboat visibility study and an accident 2-D animation.

4.2. Vessels Description

4.2.1. *DUKW 34*

4.2.1.1. General. The *DUKW 34* was one of 15 amphibious small passenger vessels operated by the Philadelphia division of Ride The Ducks International, LLC. The APV was operated as a tour vehicle/vessel on the streets of Philadelphia and on the Delaware River near Penn's Landing. The APV was re-built from mostly new parts in 2003, with the chassis and other parts being taken from an original 1945-vintage DUKW, which used a 2.5 ton truck chassis.[2] Although the basic arrangement of the APV closely matches the original 1945 model, most engineering systems in the APV had been updated from the original design, with some new systems added, such as fire detection and suppression, vapor detection system, communications equipment, and additional electric bilge pumps.

[1] The second board member was a recent appointee and in an observer/trainee status.

[2] According to information from the RTDI, the *DUKW 34* chassis came from an original DUKW, and the original DUKWS were manufactured by GMC on 2.5 ton military truck chassis. Conversely, the company's most recent series of APVs ("Truck Ducks") are manufactured on an M-35, 2.5 ton military truck chassis.

The *DUKW 34* was a member of a series of sister APVs that were termed "Stretch Ducks" by their builder, Amphibious Vehicle Manufacturing, LLC, (AVM), which merged into RTDI in 2005.The "Stretch Duck" model was lengthened about 2 feet over the original 1945 DUKW. Other models built by AVM included the now discontinued "Fleet Duck" and newest design, the "Truck Duck." In 2008, the RTDI manufactured its last APV, and all new construction operations for RTDI APVs were contracted out to Chance Morgan, Inc., and Chance Rides Manufacturing Inc., of Wichita, Kansas. Although the official name of the APV was *DUKW 34*, the owner/operator of the APV preferred to refer (in writing) to the APV as a "Duck" rather than a "DUKW" because of the extensive differences between an original DUKW and the RTDI upgraded "Stretch Duck."[3]

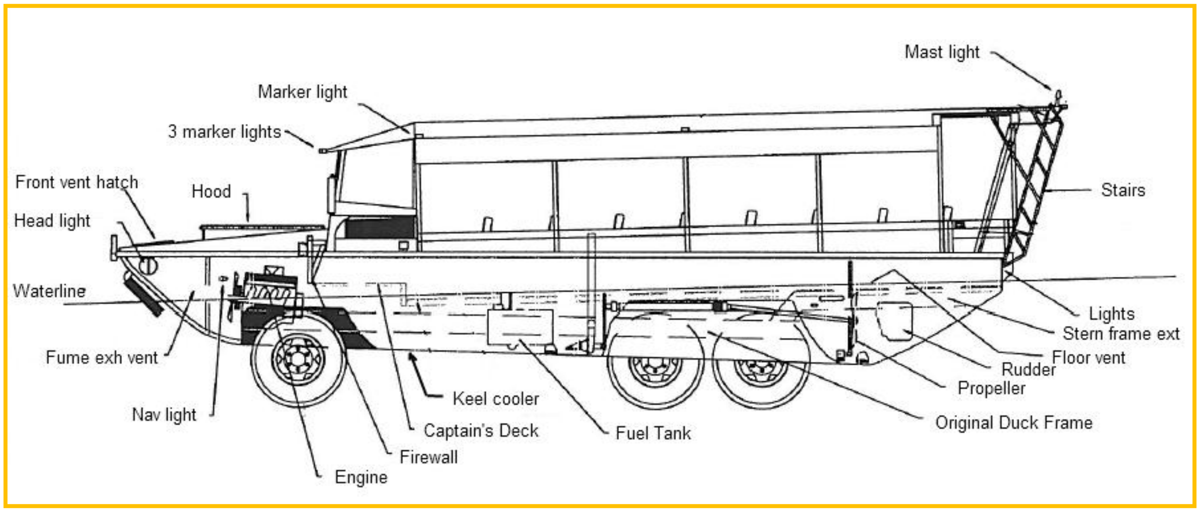

Figure 1. Profile view of APV. Drawing by RTDI.

4.2.1.2. Vessel particulars

Vessel Name	*DUKW 34*
Owner/Operator	Ride The Ducks International, LLC
Port of Registry	Philadelphia, PA
Flag	U.S.
Type	Amphibious small passenger vessel
Built	Built in 1945 by GMC and extensively rebuilt in 2003 by Amphibious Vehicle Manufacturing, LLC, Branson, MO
Official number	USCG 35318940,
Classification society	n/a
Construction	Steel
Draft	5.0 ft
Length	33.0 ft
Beam	8.2 ft

[3] Information from RTDI party coordinator. This report generally uses the term APV (amphibious passenger vehicle) when referring to the *DUKW 34* and similar vessels.

Gross tonnage	9
Engine power and type	Gasoline, 8-cylinder, (vee configuration), 427 cubic inch, 235 hp @3800 rpm
Service speed	55 mph land, 6.4 knots water
Cargo	n/a
Persons on board	37 (2 crewmembers and 35 passengers)
Injuries/fatalities	26 / 2
Damage cost (estimate)	$130,470.

4.2.1.3. Arrangement. The APV hull and mechanical systems were built on the chassis of an original 1945 vintage DUKW, classified by the Army as a “2 1/2 ton, 6 x 6, Amphibian Truck.” The APV had six wheels, of which four (the forward and mid wheels) were driven and two (the back wheels) were non-driven. The operator station had a bucket style seat at the left side of the front of the covered passenger cabin, and the deckhand had a seating position (termed the “jump seat”) to the right of the operator.

The passenger cabin had nine rows of bench seating for 37 passengers, with a center aisle between the port side and starboard side rows. A canopy that was constructed of welded rectangular and square steel tubular framing supporting a vinyl composite and woven polyester awning material covered the passenger cabin.[4] During inclement weather, the sides of the open canopy could be enclosed using electrically operated roller curtains constructed of clear PVC sheeting.[5] Each side roller curtain was fitted with a manually operated, lever-type releasing mechanism that used gravity to quickly drop the curtain outward in the event the curtains were down when an emergency occurred that required over-the-side evacuation by the passengers. The design and operation of the canopy were compliant with the recommendations of the Coast Guard’s Navigation and Vessel Inspection Circular.[6]

The original DUKW was constructed of 12 gauge steel bottom and 14 gauge sides while the APV’s hull had increased structures constructed of 10-gage steel at its bottom and 12-gage steel at its sides. The hull reinforcements on the APV were modified from the original DUKW hat channels to 3” x 3/16” flat-bar interior framing and exterior 1.5” x 1.50” angle-iron reinforcement ribs. Because of its relatively light hull plating, the APV was prohibited from operating in ice conditions.[7]

4.2.1.4. Propulsion system. The APV was propelled on land and on water by a Chevrolet, 8-cylinder, 235-horsepower gasoline engine that was fitted in an engine compartment forward of the operating station and passenger cabin. For on-land operation, the engine

[4] Canopy awing material was manufactured Snyder Manufacturing Inc., and was classified as its tent/structural grade product, model PRV 1610Q, Weatherspan Plus.

[5] Side curtain material was manufactured by TMI International, and was their model Save-T PVC, Firm Hand Marine Grade Ultra Clear .040" thick

[6] Coast Guard Navigation and Vessel Inspection Circular No. 1-01 provided design guidance for, among other items, side curtains. The NVIC states “If side windows or curtains are installed they should not cause an impediment to passenger egress. Arrangements should be in place to allow the master the ability to open all windows and or curtains on each side from a point located at the control station.”

[7] Its Coast Guard issued Certificate of Inspection specified the conditions of operations, limiting it as follows: “Due to the minimum hull thickness exemption, no passenger operations will be permitted under river icing conditions.”

output shaft was connected to an (Allison model AT-545) automatic transmission, a transfer case,[8] differentials at the forward and mid axles, and then to the forward and mid-wheels. The on-road drive arrangement had been modified from the original DUKW configuration to drive 4 wheels rather than all 6 wheels. For on-water operation, a separate output from the transfer case was connected to the propeller through a 2:1 helical reduction gear and a propeller shaft. Engagement and disengagement of the propeller was performed manually by the operator before and after waterborne operations. The 3-bladed bronze propeller had a diameter of 24 inches and a pitch of 14 inches.

4.2.1.5. Steering. During on-road operation, the vehicle was steered with a conventional (automotive style) power-assisted hydraulic steering system. While on-water, steering of the APV was accomplished by a mechanical linkage from the steering column through a push-pull cable to the rudder tiller at the stern of the APV. The APV was fitted with a redundant steering cable that could be manually connected to the tiller and operated with a hand crank stored in a clip near the operator station.

4.2.1.6. Engine cooling system. The main engine was cooled by a conventional (automotive style) pressurized liquid (mostly water) system, with circulation accomplish through use of an engine-driven cooling water pump. The liquid in the cooling system was a mixture of water and anti-freeze (ethylene glycol), which served to reduce the freezing point of the water, raise the boiling point, and inhibit corrosion. Cooling of the system liquid was accomplished by passing it through both an air-cooled radiator and a water-cooled “keel cooler” mounted on the exterior of the APV, below the waterline. The cooling system consisted of the following major components (refer to figures 2 and 3)[9]:

4.2.1.6.1. Cooling water pump - mounted on and driven by the main engine. It served to circulate cooling liquid through the engine and various system components.

4.2.1.6.2. Air-cooled radiator – mounted at the front of the engine. It served to remove heat from the coolant. Airflow across the radiator was created by an engine driven axial flow fan, as well as by ram air through partially open engine compartment cover (hood). After passing across the radiator, air was directed to port and starboard plenums on either side of the engine bay, then through spring-loaded fire closure dampers, and finally out to the atmosphere through screened openings on either side of the APV.

4.2.1.6.3. Surge tank and pressure cap – mounted near but external to the radiator. The pressure cap served to maintain an elevated pressure on the cooling system liquid and raise the boiling temperature of the system liquid. The pressure cap, which was set to relieve at 13 psi (gage), was attached to the fill neck for the surge tank, not to the radiator itself.

[8] According to the army technical manual for the original amphibious truck (TM 9-802), the transfer case is a gear case that is used to transmit power from the engine transmission to front and rear axles and to the propeller shaft. The transfer case fitted on the *DUKW 34* was a single speed model, manufactured by Truck Coach Division.

[9] System components were similar to those found in a conventional automotive design. Component descriptions provide here are consistent with information contained in reference book: Newbold, Derek, and Allan Bonnick. "Chapter 2 - Cooling Systems". A Practical Approach to Motor Vehicle Engineering and Maintenance, Second Edition. Butterworth-Heinemann. © 2005. Books24x7. <http://common.books24x7.com/book/id_17847/book.asp> (accessed January 24, 2011).

4.2.1.6.4. Thermostat – served to maintain the temperature of the cooling system liquid at a nearly constant temperature under varying engine loads and cooling air temperature. The thermostat was set for 160 degrees F.

4.2.1.6.5. Keel cooler – mounted at the underside of the hull, port side. The keel cooler served to provide additional cooling capacity to the system. A manually operated ball valve could be used to close flow to the keel cooler during low ambient temperature conditions. The ball valve was found in the open position after the accident.[10]

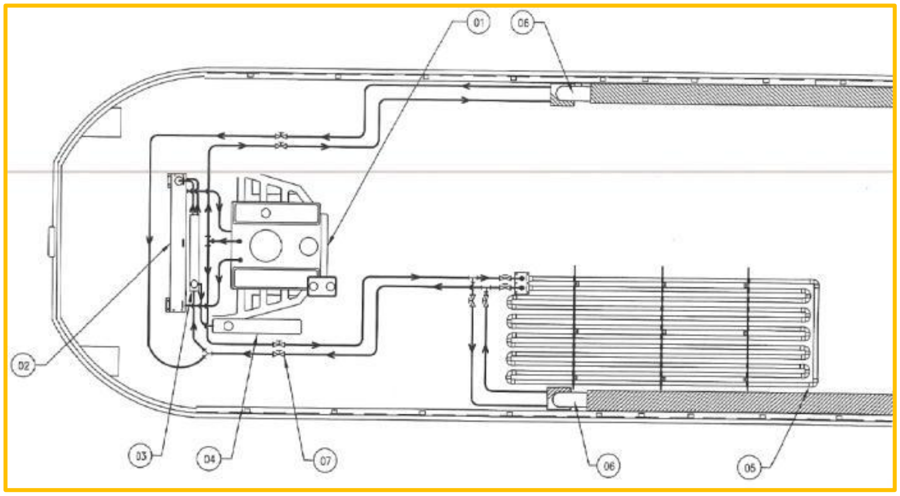

Figure 2. Stretch Duck cooling system schematic - plan view. Item descriptions: 01-Engine, 02-radiator, 03-surge tank, 04-overflow tank, 05-keel cooler, 06-heater, 07-ball valve. Drawing by RTDI.

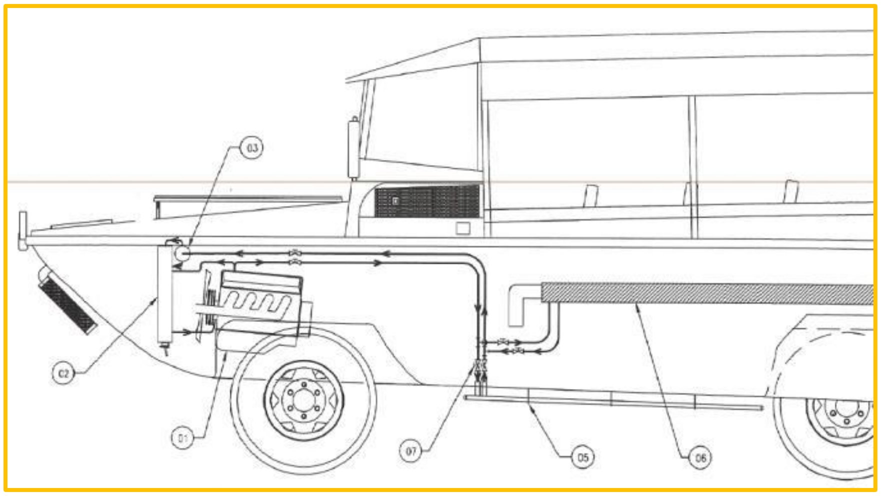

Figure 3. Stretch Duck cooling system schematic - profile view. Item descriptions: 01-Engine, 02-radiator, 03-surge tank, 04-overflow tank, 05-keel cooler, 06-heater, 07-ball valve. Drawing by RTDI.

[10] The APV was fitted with a second keel cooler, mounted on the starboard underside of the hull that was used for cooling the engine transmission oil.

4.2.1.7. Navigation and communications equipment. The APV was fitted with marine VHF-FM radio, mounted near the operator's station at the front of the cabin, and a spare handheld VHF-FM marine radio. The master was also provided with a Nextel push-to-talk cellular phone for communications with the company personnel ashore, including the company tour coordinator, known as "Dispatch."

In his interview after the accident, the master stated that he had attempted to warn the oncoming tug and barge by sounding the APV's air horn, but that it did not function. During the postaccident examination of the APV, it was noted that the ignition shutoff switch was in the off position; the electrical system arrangement required the switch to be in the on position in order for electrical power to be routed to the horn. Since the accident, RTDI has modified the electrical connection to the horn to be active with the ignition switch in the "off" position.

4.2.2. *Caribbean Sea* and *The Resource*

4.2.2.1. General. The *Caribbean Sea* (figure 4) was a 78.9-foot-long, 148 gross tons tug boat, which was towing alongside the barge *The Resource* (figure 5), a 250-foot-long, 2,100-gross-ton sludge barge. The *Caribbean Sea* was operated by K-Sea Transportation under contract with the City of Philadelphia to transport partially processed wastewater sludge, using two city-owned barges (*The Resource* and *The Recycler*), from the city's Northeast Water Pollution Control Plant to the privately operated Biosolids Recycling Center in the city's southwest.

Figure 4. Tug *Caribbean Sea*

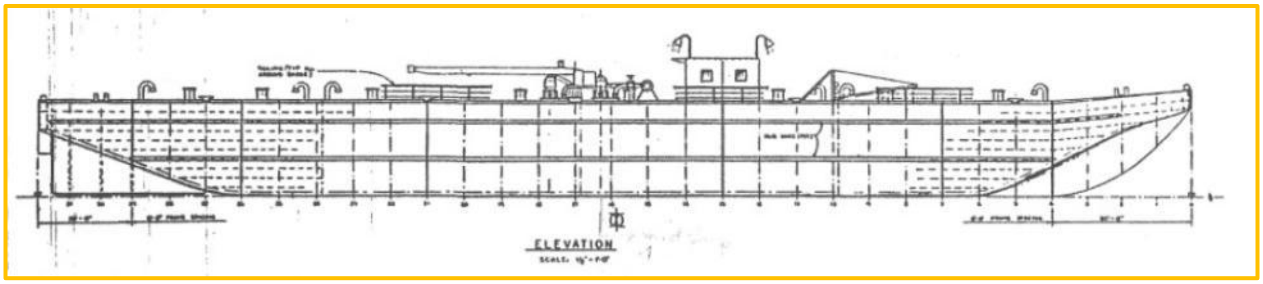

Figure 5. Barge *The Resource* - profile view

4.2.2.2. Vessel particulars

Vessel Name	*Caribbean Sea*, ex- *Vivian L. Roehrig*, *Peter M.*, and *H.D. Campbell*	*The Resource*
Owner/Operator	K-Sea Transportation	City of Philadelphia/K-Sea
Port of Registry	New York, NY	Philadelphia, PA
Flag	U.S.	U.S.
Type	Uninspected towing vessel	Uninspected sludge barge
Built	1961, Equitable Equipment Company, Madisonville, LA	1989, Nashville Bridge Company, Nashville, TN
Official Number	287211	925049
Classification society	n/a	American Bureau of Shipping (✠ A1, Tank Barge, River Service)
Construction	Steel	Steel, double hull
Draft	8 ft	3 ft
Length	85 ft LOA / 78.9 ft registered	250.0 ft
Beam	24.0 ft	50.0 ft
Gross tonnage	148	2100
Engine power and type	Medium speed diesel, twin screw, twin rudder, 2400 hp	None
Service speed	6 knots	n/a
Cargo	n/a	Sewage sludge
Persons on board	5 crewmembers	Unmanned
Injuries/fatalities	None	n/a
Damage cost	None	Minimal, not repaired

4.2.2.3. History. The tug *Caribbean Sea* was built in 1961 by Equitable Shipyard of Madisonville, Louisiana, as the *H.D. Campbell*. After construction, the tug was acquired by Manson Construction Company and renamed *Peter M*. In 1998, the tug was acquired by Roehrig Maritime of Staten Island, New York, and renamed *Vivian L. Roehrig*. In 2008, K-Sea Transportation acquired the marine assets of Roehrig Maritime and renamed the tug *Caribbean Sea*.[11] The tug *Aegean Sea* (ex-*Francis E. Roehrig, Jersey Coast, John C. Barker*), also operated by K-Sea Transportation, was a sister vessel built in the same shipyard in 1962.[12]

4.2.2.4. Arrangement. The tug was a twin-screw, twin rudder tugboat of all-welded construction that was built for coastwise ocean towing service. The vessel had a single deck, slightly raked stem, double-chine hull[13] and an elliptical stern. Three watertight transverse bulkheads divided the hull below the main deck into a forepeak, fuel tanks, water tanks, engine room, after fuel tank; and a lazarette with steering system.

Located amidships was a 2-level deckhouse that contained the pilothouse, crew quarters, and galley. An upper wheelhouse, with a reported height of eye of 32 feet, was fitted atop the wheelhouse some time after initial construction.

Fitted at both the bow and stern was a set of double towing bitts (H-bitts). Fitted at the stern work deck was a Markey model TYS24 electro-hydraulic single drum towing winch.

Two Caterpillar diesel generators, one rated at 55 KW, the other rated at 30 KW, provided electrical power at 115 volts a.c..

4.2.2.5. Propulsion. The *Caribbean Sea* was fitted with a twin screw, medium speed, diesel propulsion system. The engines and reduction gears were fitted with pneumatic control systems to control the engine speed and direction. The two 1,200-RPM propulsion diesel engines were Caterpillar model 3512, rated 1,200 horsepower each. According to information from the operator, the main engines were rebuilt in December 2007.[14] The engines were connected through hydraulic clutches to Caterpillar model 7251 reduction gears with a 4.3:1 reduction ratio (1,200 to 279 rpm). The reduction gears were connected through 6-inch-diameter tailshafts to 72-inch-diameter, 52-inch-pitch, 4-blade, stainless steel propellers.[15]

4.2.2.6. Steering. The *Caribbean Sea* had an electro-hydraulic steering system that positioned twin rudders mounted at the stern. Two hydraulic pumps positioned two hydraulic actuating rams connected to the two linked rudder tillers, which were located below the deck grating on the aft work deck. The steering system could be controlled from either the upper wheelhouse or the lower wheelhouse. After the accident, investigators tested the steering system, see Tests and Research section below.

[11] Some historical information on *Caribbean Sea* obtained from <www.tugboatinformation.com>, accessed January 18, 2011. Recent historical information provided by K-Sea Transportation.

[12] Information on *Caribbean Sea* sister vessel from Equitable Equipment company information at<www.shipbuildinghistory.com> (accessed January 18, 2011) and vessel drawings provided by K-Sea Transportation.

[13] A hull chine is an abrupt change in transverse shape where a vessel's side and bottom come together. A double chine is a transition between a vessel's side and bottom employing two longitudinal knuckles. Benford, Harry. Naval Architecture for Non-Naval Architects. The Society of Naval Architects and Marine Engineers. © 1991. Books24x7. <http://common.books24x7.com/book/id_11871/book.asp> (accessed January 18, 2011).

[14] Information sheet for *Caribbean Sea*, ex-*Vivian L. Roehrig*, (provided by K-Sea Transportation) indicates that “In December 2007 the tug Vivian underwent a massive refit. Main engines, generators, shafts, wheels, and rudders, were all rebuilt.”

[15] Propeller information from Manson Construction and Engineering Company survey report (c. 1995).

4.2.2.7. Navigation and communications equipment. The vessel was fitted with communications and navigation equipment in both wheelhouses, as listed below. After the accident, the equipment was tested by an independent electronics company, see Tests and Research section.

4.2.2.7.1. The lower wheelhouse was fitted with the following equipment: three VHF-FM marine radios (aft, port, starboard), two GPS receivers (aft, forward), satellite compass, two radars (3 and 10 cm band, port, and starboard), AIS (automatic identification system) navigation unit, echo depth sounder, and a SIMRAD 50 autopilot.

4.2.2.7.2. The upper wheelhouse was fitted with the following equipment: two VHF-FM marine radios (port, starboard), satellite compass, magnetic compass, one radar (3 cm), and an AIS navigation unit.

4.3. Vessel Maintenance.

4.3.1. *DUKW 34*. The fleet of APVs at RTDI of Philadelphia was maintained by three company mechanics and a supervisory mechanic (Fleet Maintenance Manager) at the company maintenance facility (the shop). The maintenance operations were overseen by the Philadelphia General Manager, and technical support to the Philadelphia maintenance operations (as well as other company locations) was provided by personnel located at the RTDI manufacturing facility located in Branson, Missouri.

The company had an internal website, known as “Duck Central,” that served as a repository for operational and maintenance information that was made available to employees with access to a computer. Duck Central was used to make announcements and to provide employees with access to safety and training information.

In addition, the company had implemented an electronic parts and maintenance system, known as “AssetWorks” that was used for parts inventory control and recording maintenance actions performed on the APVs.

Each APV was inspected by its assigned operator before the start of operations each day using a checklist known as the “Pre-Trip Inspection” checklist. The checklist incorporated Pennsylvania Department of Transportation inspection requirements for operation as a highway vehicle and Coast Guard inspection requirements as a waterborne vessel. According to the checklist, the pre-trip inspection included, among other items, an examination of items needed to ensure hull watertight integrity (seal “boots” and hull drain plugs), inventory and functioning of safety equipment, VHF radio, navigation and road lighting, air horn, steering and rudder, and overall cleanliness of the APV.[16] The master’s pre-trip inspection checklist did require that the underside of the APV be inspected using a mechanic’s “creeper,” but did not require that the engine compartment cover (hood) be opened to inspect any items within the engine compartment. The company required that engine compartment items be inspected by mechanics at the end of the day using the mechanics’ post-trip inspection procedures. According to the Fleet Maintenance

[16] The one-page checklist (version 3/12/2010 of the checklist, used until 4/4/10) was one page (the previous version 2/20/2010, was 2 pages in length), was titled “RTDI CAPTAIN’S/DRIVER’S PRE-TRIP INSPECTION,” included both interior and exterior items, and had space for the master to note any deficiencies, and required him to sign and date the form.

Manager,[17] no masters included an examination of the engine bay area in their pre-trip inspections. The operator was required to sign and submit the inspection form before starting operation for the day; however, the pre-tip inspection form for *DUKW 34* on the day of the accident could not be located and was not on the master's forms clipboard recovered from the APV after it was salvaged.[18]

At the end of each operating day, the APV was subjected to a "post-trip inspection," again using a checklist prepared by the company.[19] The operator was required to complete a one-page form titled "RTDI CAPTAIN'S/DRIVER'S POST-TRIP INSPECTION."[20] In addition to the master performing a post-trip inspection, at the end of each operating day, the company mechanics were required to review the operator's post-trip inspection form and to perform additional checks of the APV's mechanical systems. According to the mechanic's post-trip inspection form, the mechanic's inspection included an examination of the hull bottom, drive tube boots, tires, interior items, engine bay, prop shaft, and hour meter.[21] The form indicated that the engine bay inspection required mechanics to "check the bay area, check all fluid levels, check engine coolant, check fan belts, and check water pump for excessive play." The mechanics described the method used to check the engine coolant levels as either to check the level in the translucent overflow tank, or to remove the pressure cap on the surge tank and verify that the level in the surge tank was near the top.[22] Any significant deficiencies found during the post-trip inspections were to be corrected before the APV could be returned to service. The mechanics performing the post-trip inspection were required to note the discrepancies found and to sign the form.

On July 6, 2010, the evening before the accident, the *DUKW 34* post-trip inspection was performed by a recently hired mechanic (new-hire mechanic).[23],[24] Although he noted no deficiencies on the form for the *DUKW 34*, he did note deficiencies on three other APVs he

17 Safety Board interview of Fleet Maintenance Manager on July 15, 2010, transcript page 55.

18 The clipboard recovered from the salvaged APV contained the master's completed pre-trip inspection form for 7/6/2010. No deficiencies were noted on that form. According to the company, "standard procedure was to leave the completed Pre-Trip Inspection Forms and Post-Trip Inspection Forms in the Maintenance Shop and not carry them on the vehicle" (email from RTDI dated Dec 27, 2010). In his July 14, 2010 interview with the Safety Board, the *DUKW 34* master stated that he had performed a pre-trip inspection.

19 The company's "Captain's Operations Manual," dated 2/20/2010, required the operators to perform a pre-trip and post trip inspection. The mechanics were also required to perform a separate post trip inspection using a different form than the operator's post-trip inspection. All APVs inspected on a particular day were documented on a single 2-page form, and was titled "RTDI Maintenance Post-Trip Inspection."

20 The master's "RTDI CAPTAIN'S/DRIVER'S POST-TRIP INSPECTION" (earlier version was titled "Post-Trip Duck Inspection Form") contained 13 items that had to be checked off as being inspected, and included brakes, steering mechanisms, lighting devices and reflectors, tires, horn, windshield wipers, mirrors, coupling devices, wheels and rims, emergency equipment, trash removal and fuel. In addition, space was provided for the operator to note any deficiencies.

21 The post-trip inspection form for the *DUKW 34* noted the engine hour meter (Hobbs) reading as follows: 7/6: **4678**, 7/5: **4674**, 7/4: **4669**, 7/3: **4663**, 7/2: **4656**, 7/1: not operated, 6/30:**4650**, 6/29: not operated, 6/28: not operated, 6/27: **4644**, 6/26: **4637**, 6/25: **4631**. The average daily operating time for the nine days of operation before the accident was 5.2 hours (4678-4631 = 47/9 = 5.22). After the vessel was salvaged on 7/9, two days after the accident, the engine hour meter indicated **4681.9**, indicating that it had been operated about 4 hours on the day of the accident.

22 As discussed in the Tests and Research section below, the pressure cap from the surge tank was found missing (not installed on the fill opening) during the postaccident examination of the APV.

23 The mechanic had been hired about 2 weeks before the accident and July 6th was his second workshift to which he had been assigned to perform post-trip inspections. On July 6th, the post-trip inspection form indicates that he had inspected 7 other vessels. Another mechanic was also on duty that night, and the inspection form indicates that he inspected 1 vessel during his work shift. The July 5th post-trip inspection form shows that the new-hire mechanic had inspected 5 vessels.

24 According to the Fleet Maintenance Manager (July 15, 2010 interview, transcript pages 19-28), the company hired experienced vehicle mechanics, then provided on-the-job training to teach them the unique features and inspection requirements of an APV. The Fleet Maintenance Manager said that newly hired mechanics were also given copies of the company policy and training manuals to read. The on the job training period was about 1 week for the newly hired mechanic.

had inspected on his shift. On July 5, two days before the accident, the post-trip inspection form indicated that the Fleet Maintenance Manager had inspected three APVs, including the *DUKW 34*, and one of the three APVs (*DUKW 46*, which was jointly inspected with the new-hire mechanic) did have a deficiency noted. In addition, on July 5, according to the maintenance post-trip inspection form, the new-hire mechanic had performed inspection of five APVs, and deficiencies for four of these five APVs (DUKW numbers 46, 25, 21, and 31) were noted on the inspection form. On July 4, three days before the accident, the *DUKW 34* was in service and was inspected by the Fleet Maintenance Manager, with no deficiencies noted.[25] On July 2 and 3, no deficiencies were noted for the *DUKW 34* on the post-trip inspection forms, and on July 1, the post-trip inspection form indicates that the *DUKW 34* was not operated.

According to the lead mechanic, the APVs did have occasional problems with engine high temperatures, and he described a common cause as follows:

> Usually if the boat is hot, a lot of times what they do is they accidentally trip the damper doors, and that's a two-second fix. That's probably the most [common] problem.[26]

When asked about which DUKWs had experienced temperature problems, the lead mechanic stated: [27]

> [*DUKW*] 34 was one of them, and I put thermostats in it, everything else being good, and he said that it was still running a little warm. So, I got a sending unit from a local vendor here that was the wrong one, and then we took that out and put a used one in from another water pump and put that in there, and it was still running a little hot. Then I got the correct thermostat -- or not thermostat, but a sending unit and put that in and as far as I know, it was within acceptable limits. The captain had stopped writing it up and each time I saw the gauge, it was fine.

Repairs to the APVs were documented on a company form titled "Equipment Repair Work Order." A review of the maintenance records identified the following recent work items associated with the APV:

- 5/21/10 – Replace power steering pump
- 6/6/10 – Replace thermostat, engine running hot
- 6/12/10 – R & R [Remove and Renew] left front wheel seal races and bearings
- 6/30/10 – R & R temp[erature] switch [sensor], high temp[erature] reading

Additional, more in-depth, routine maintenance and inspection of the APVs were performed principally on an operating hour-based schedule. Most major maintenance actions were performed on a 250-hour schedule. These actions covered such items as the

[25] Two mechanics inspected 15 APVs on July 5th, with 6 APVs noted as having deficiencies.
[26] Interview transcript of head mechanic, p. 17, July 14, 2010
[27] Interview transcript of head mechanic, p. 17, July 14, 2010

wheels, brakes, steering, suspension, lubrication, drive axles, struts, drive shafts, transfer cases, radiator, water pump, cooling fan, electrical system (battery, alternator, wiring), and other items. The inspection items were listed on a 9-page “250 Hour Periodic Inspection and Repair” form. According to information provided by the company, the last 250-hour inspection for *DUKW 34* was performed on 2/10.[28]

During the winter off-season, the APVs had annual maintenance and repairs periods during which major repairs, such as engine rebuilds, were performed by company mechanics.

4.3.2. *Caribbean Sea* and *The Resource*. The maintenance operations of the tug and barge were not documented during the investigation. The tug crew did not identify any operational problems during postaccident interviews, and the investigation team did not observe any operational or mechanical issues with the tug or barge during the on-scene investigation.

4.4. APV breakdown statistics.[29]

4.4.1. According to statistical information provided by the Coast Guard covering all types of APVs, APVs have an annual casualty rate approximately two times higher than other small passenger vessels.[30] The Coast Guard statistics indicated that over an 8-year period (2002 to 2009), APV’s had an annual casualty rate of 10.2 per 100 vessels, while other small passenger vessels (Subchapter T vessels) had an annual casualty rate of 5 per 100 vessels. For this same 8-year period, the average annual number of casualties was about 14.6 per year, but in 2009, the number of casualties was 24, with an increase in the number of propulsion and steering failures.

Regarding the positive changes in maintenance, historical breakdown statistics, and remedial actions taken, the RTDI’s General Manager in Philadelphia stated:[31]

> 2692s [Coast Guard Form 2692, “Report of Marine Accident, Injury or Death”]over the last several years [averaged] seven to eight…. In '09, we were at 12. We instituted several things. There are some reasons we believe why those occurred. And so we instituted several things this year prior to opening. There's a new… improved training manual provided—operations, captains, across the board. Asset work implementation systems software-based mechanics program. Resources were established. [The Senior Fleet Maintenance Manger]

[28] The form has the date listed as “2/10,” which could mean it was performed over a period of more than 1 day in Feb 2010. The form does not indicate the engine hour meter reading at the time of the inspection and was not signed by the person completing the inspection, although those items that were completed on the checklist are check marked “acceptable” or “repairs made” and initialed. Not all items on form were indicated as being inspected, either by checking or initials.

[29] Available information indicates that the *Caribbean Sea* did not experience a mechanical breakdown around the time of the accident and its breakdown statistics are not covered in this report.

[30] Coast Guard regulations at 46 CFR 4.05 require vessel operators to report certain casualties to the Coast Guard. Among the “reportable” casualties are groundings, loss of main propulsion or steering that reduces the maneuverability of the vessel, loss of life, an occurrence that materially affects a vessel’s seaworthiness, a serious injury or an occurrence causing property damage in excess of $25,000.

[31] Information was provided in reponse to interviewer’s question “what positive changes have you noticed in the maintenance” during the July 16, 2010 Safety Board interview.

> position was created. It was not there last year, and has been established this year. Bi-weekly maintenance calls that are shared by all fleet maintenance managers directed under the authority of [Fleet Operations Manager], which also that person – that position didn't exist last year. So these are the things that I would say have improved, shop performance.

According to RTDI, it has historically managed breakdowns by modifying equipment or procedures to eliminate future problems. In 2009, RTDI in Philadelphia saw a spike in on-water breakdowns (to nine), and the company took remedial actions to address the issue, including replacing components that failed, training mechanics on component rebuilds, implementing a maintenance software program, establishing RTDI bi-monthly nationwide mechanics conference calls, using an in-house maintenance website, and establishing a hierarchy of maintenance experts within the company. During the 2010 season (a partial year), the company had one casualty before the allision, which was debris caught in the rudder that self-cleared.[32]

4.5. Damage

4.5.1. *DUKW 34*. Damage to the APV was principally to the port side of the hull and the aft port side of the canopy (figures 6 and 7). The damage to the hull consisted of scrapes and indentations along the hull external support members and hull shell, and to the “Ride The Ducks” sign attached to the side of the hull. The scrapes to the “Ride The Ducks” sign were at an approximate angle of 45 degrees and they indicated the relative movement between the APV and barge during their period of contact. Damage to the canopy framing system consisted of bending and buckling of the square and rectangular steel tubing and tearing of the canopy awning, principally at the aft portion. The two aftermost port side vertical frames of the canopy were bent over approximately 45 degrees, and other support members were similarly damaged. The port side roller curtain was damaged and detached from its mountings, and the passenger-loading ladder indicated distortion and impact damage. The left front wheel was slightly displaced from its axis of rotation and a subsequent teardown examination showed that its drive axle was slightly distorted (bent).

[32] Extended information on breakdowns and the company’s response to the 2009 season’s spike in the breakdowns was provided by RTDI on Feb 14, 2010, during its review of a draft of this factual report.

Figure 6. View of damaged *DUKW 34*, photo taken after was raised from river bottom.

Figure 7. View of damage to canopy of APV from inside the cabin, looking aft.

4.5.2. *Caribbean Sea* and *The Resource*. The barge resource showed minor damage at its bow area (rake), and the *Caribbean Sea* was not damaged. The damage to *The Resource* bow consisted of contact scrapes to the “stem” and to the port and starboard side of the bow area adjacent to the stem (figure 8). The contact scrapes affected the hull coating only, and there was no sign of damage to the hull plating or interior framing.[33] According to a representative from the City of Philadelphia, the minor damage to the barge hull coating had not been repaired after the accident.[34]

[33] American Bureau of Shipping (ABS) survey report dated July 8, 2010.

[34] Email from Water Department, Operations Deputy Commissioner, dated Jan 22, 2010, states that repairs were not performed.

Figure 8. View of damage to the bow of *The Resource*. Photo by the Coast Guard.

4.6. Tests and Research

4.6.1. *Caribbean Sea*

4.6.1.1. Steering gear. A functional test and examination of the tug boat's steering system was conducted. The system was found to operate properly, and no deficiencies were noted with the mechanical or hydraulic systems associated with the steering system. The rudder slew rate from full rudder on one side to full on the other side was timed to be about 6 to 7 seconds for both hydraulic units.

4.6.1.2. *Caribbean Sea* navigation and communications equipment. An independent electronics service company conducted tests of communications and navigation equipment, and no significant deficiencies were found.[35]

4.6.2. *DUKW 34* engine and equipment examination (selected photos in appendix 2). After the accident, the engineering group performed extensive examination of the mechanical systems of the APV. Because the APV had experienced on-water mechanical problem, the examination was principally focused on determining the cause of the failure; however, it also included an examination of safety equipment. After the APV was salvaged, the status of all significant mechanical systems and switches was documented (appendix 1). In

[35] Tests of navigation and communications equipment were performed by GMT Electronics, Inc., on July 8, 2010.

addition, a more detailed examination and testing of the below listed components was done:[36]

4.6.2.1. Water pump. The water pump was removed from the engine and disassembled. No deficiencies were found with the water pump impeller other than some indication of water leakage at the lower weep hole in the case (rust stains near hole).

4.6.2.2. Batteries. The electrical charge levels of both batteries were tested. The No. 1 (forward) battery indicated 11 volts, and the No.2 (aft) battery indicated 3.5 volts.

4.6.2.3. Radiator. After the APV was salvaged from the river, it was noted that the pressure cap, normally fitted to the surge tank, was missing. The pressure cap was subsequently found in the lower part of the engine compartment, and it and the surge tank fill neck were noted to be undamaged. The pressure cap was tested and was shown to open at 11 to 13 psi. The pressure cap was rated at 13 psi.[37]

A sample of the coolant in the radiator was collected from the bottom of the radiator through the drain valve, and the sample was tested for antifreeze content. Using a basic float type specific gravity tester, it was found that the coolant freeze protection level was –15° F. Testing of the same sample with a more precise refractometer indicated that the coolant freeze protection level was at +3° F.

During the teardown inspection of selected engine components, the radiator was removed from the engine and its top cover (header) was removed, which exposed the ends of the heat exchanger tubes. A water flow test of the radiator was normal, and no significant deficiencies were noted with the radiator.

4.6.2.4. Thermostats. The APV was fitted with two thermostats, both fitted at the top front of the engine. The thermostats served to control the flow of cooling water to the radiator and to maintain cooling water sytem temperature near its design operating temperature. The thermostats were tested in a pot of gradually heated water. They were found to begin opening at 160° F and were fully open at 170° F. The thermostats were rated to open at 160° F.

4.6.2.5. Keel cooler. A water flow test through the keel cooler and hoses indicated that no significant blockage existed. No deficiencies were found with the keel cooler or the tubing connecting it to the engine cooling water system.

4.6.2.6. VHF radio. The VHF radio was not tested because it had been submerged in water for an extended time after the accident. During testing of the same model radio on another RTDI APV, it was found that when power was

[36] Examination of certain *DUKW 34* components was done after the APV was salvaged, while the engineering team was on-scene, postaccident (July 9 to July 15), and other follow on examinations were performed after the vessel had been transported to the RTDI facility in Branson, Missouri, (September 1 and 2)

[37] The saturation temperature of water at 11 psi (gage) is about 242° F. Online steam properties at http://www.efunda.com/materials/water/steamtable_sat.cfm.

secured to the radio, the channel section reverted to channel 16, regardless of the channel setting before power was shut off.

4.6.2.7. Engine and heads. The engine cooling system was pressure tested at 15 psi for 30 minutes, and a pressure drop of about 1 psi was noted after 30 minutes. The engine heads were removed from the engine and were sent to a specialist repair shop for examination. The heads indicated some minor warping and no cracks.[38]

4.6.2.8. Radiator/engine ventilation system. The air ventilation dampers for the engine compartment were examined and tested. After the accident, it was found the port side fire damper door was in the closed position, and the starboard side damper was open. It was noted that the manual closure lever was installed near the floor adjacent to the position of drivers left foot. As noted in the vessel maintenance section, the company lead mechanic stated that a common cause of engine overheating problems was the result of inadvertent activation of the engine cooling air [fire] damper. The damper was spring–loaded, and tripping of the damper was initiated by pulling upward on a trip lever. The damper was held in the open position against spring force through use of a 2-stage latch, similar to a automobile door latch. The force needed to trip the damper was measured and found to be about 3 pounds when latched in the first-stage position and about 12 pounds when latched in the second-stage position. The trip lever travel distance needed to cause activation (opening) of the latch (and closure of the damper) was about 0.5 inch.

4.6.2.9. Engine compartment examination. The engine compartment was examined for evidence of fire/smoke damage. All electrical wiring, belts, and hoses were in good condition, and no evidence of fire or smoke was found in the engine compartment. In addition, no sign of smoke/fire damage was found at the electrical wiring panels inside the cabin, near the master’s operating station, or in the area below the passenger cabin deck boards.

4.6.2.10. Air horn. The air horn was tested, and it failed to operate. It was noted that the power supply to the air compressor passed through the ignition switch such that the air horn could not be operated if the ignition switch was in the off position. The air horn trumpet and compressor were cleaned and inspected. Some sediment was found on the trumpet diaphragm. After disassembly and cleaning, the horn was retested, and it functioned properly.

4.6.2.11. Trial runs. In an attempt to simulate a potential scenario that could have led to the occurrence of conditions similar to those observed by the *DUKW 34* master before the accident,[39] The engineering group performed two sets of trial runs of a similar RTDI APV. The first trial run was performed in Philadelphia on July

[38] The heads were examined at Reilly Auto Parts of Springfield, Missouri, on September 7, 2010. The examination found that “both heads warped between .005 - .007 [inch], no cracks when magna-fluxed with valves in head, 6 intake valves and 4 exhaust valves are not pulling good vacuum, recommend valve job.”

[39] In his July 14, 2010, Safety Board interview, the *DUKW 34* master stated the he observed dense white smoke in the forward part of the passenger compartment, near his operating station. The appearance of this smoke, which he believed to be from an onboard fire, prompted him to shut down the main engine and anchor the APV.

14th. The trial run was intended to closely duplicate the conditions present on the day of the accident. The APV was loaded with additional weight to simulate the load conditions at the time of the accident,[40] and the pressure cap from the engine cooling system was removed. The route taken during the trial run was similar to the route taken by the *DUKW 34* on the day of the accident, with on-land trips preceding the water on-water portion of the trial.[41] A major difference between the trial and the accident day conditions was that the ambient air temperature at the time of the trial was about 77° F, as opposed to an air temperature in excess of 100° F on the day of the accident. The engine water temperature was observed throughout the trial, and the highest on-land temperature was about 180° F and the highest on-water temperature was about 165° F.

The second trial was performed in Branson, Missouri, on September 1 and 2, with a similar RTDI APV. In this trial run, the pressure cap was removed from the radiator surge tank, and the port side fire damper was closed after the engine cooling water temperature had stabilized. The trial consisted of only on-road travel[42] and no attempt was made to match the trial load to the passenger load on the *DUKW 34* at the time of the accident. At the time of the trial, the ambient air temperature was about 72° F. The engine cooling water temperature was observed to increase to about 220° F after about 10 minutes of on-road travel. Steam was seen around the engine compartment when the engine water temperature reached 220° F (figures 9 and 10).

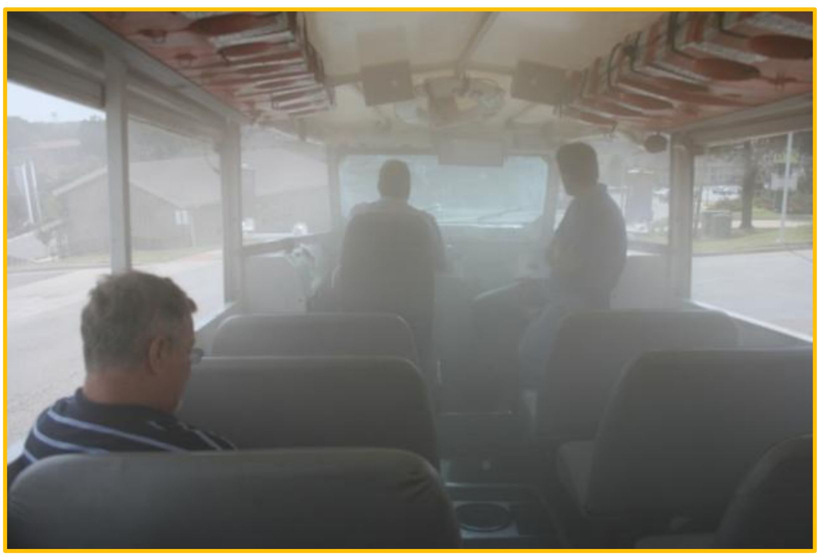

Figure 9. View of steam resulting from engine cooling water temperature about 220 degrees F, pressure cap removed.

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[40] Sand bags, totaling 4700 pounds, were loaded aboard the APV to supplement the weight of the trial observers. The total passenger and sand bag weight was 6580 pounds.

[41] Poor weather conditions (rain and lighting) prevented entry into the water immediately after the on-land portion of the third trip, so the additional time was spent driving and waiting on-land before entry into the water could be made on the third trip.

[42] The on-road trip was from the RTDI maintenance facility at Branson, Missouri, to the parking lot near the location where the on-water portion of the local APVs would normally begin. The on-road trip involved a higher number of elevation changes because of the terrain (more “hilly”) than the normal on-road trip in Philadelphia.

Figure 10. View of steam from engine compartment with engine temperature of about 220 degrees F, pressure cap removed.

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4.6.3. Postaccident Certificate of Inspection (COI) inspection. After the accident, the Coast Guard member of the engineering group, who also was one of the Coast Guard inspectors normally assigned to perform COI and post-damage inspections of Philadelphia APVs, conducted a small passenger vessel inspection of the APV using the standard Coast Guard inspection booklet. Although many of the systems could not be demonstrated to operate properly, likely because of water damage sustained in the accident,[43] the inspection did verify operation of certain systems and did identify several deficiencies unrelated to the accident. For example, the double row roller drive chain for the (Higgins) bilge pump was found to be improperly postioned on the pump's drive sprocket – only one-half of the roller chain was on the double row sprocket. In addition, the fan in one of four cabin heater blowers was found damaged (melted and distorted), apparently as the result of an electrical or mechanical failure in the blower at some time before the accident.

4.7. Postaccident Action[44]

4.7.1. Coast Guard.

4.7.1.1. Immediately after the accident, RTDI voluntarily suspended its operations and shortly thereafter, the Coast Guard issued inspection deficiency reports to all operational RTDI APVs in Philadelphia.[45] The Coast Guard action,

[43] According to the Coast Guard inspectors report dated July 15, 2010, the following equipment was inoperative: VHF marine radio, fuel vapor detector, bilge alarm, air horn, heat detector audible alarm, and electric bilge pumps, In addition, some safety equipment was missing from the vessel, such as lifejackets, portable lights, stern light, anchor and rope, and gas tank label.

[44] The information contained in the section came principally from the respective parties to the Safety Board's investigation and has not been verified by the NTSB.

[45] The inspection requirement dated July 16, 2010, was issued to each of the remaining 14 operational APVs in the Philadelphia fleet. By the form CG-835, the Coast Guard required that "Vessel not authorized to operate in the Delaware River with passengers. Any proposals regarding new route must be submitted & approved by the cognizant OCMI."

effectively prevented RTDI from immediately resuming APV operations in Philadelphia.[46]

4.7.1.2. In response to the inspection requirements issued after the accident, RTDI submitted a revised Operations Plan to the Coast Guard that was approved on August 27, 2010. The plan added provisions that eliminated the waterway interaction with deep draft vessels by adding processes that improved safety, communications and assistance efforts to disabled vessels.

4.7.2. Ride The Ducks International.

4.7.2.1. Immediate actions. Immediately following the accident, RTDI suspended operations at all its locations and initiated a review of safety and operational procedures. In addition, the company held training classes for all masters, operators, and mechanics, company-wide. All operations were suspended for at least 2 days while every APV at each of its operating locations underwent a full inspection of engine compartment, fire-fighting systems, and safety equipment. According to RTDI, only a few minor (non-safety) discrepencies were found and they were corrected immediately.

4.7.2.2. Safety equipment. A full review and inspection of all onboard safety equipment was conducted. RTDI repositioned some safety equipment (including the distress flag and anchor ball, now pre-mounted on poles and held in place by quick-release clips) for better visibility and accessibility to the master.

4.7.2.3. Horns: The fixed air horn electrical supply arrangement was modified to allow operation of the horn regardless of position of the engine ignition switch. In addition, a second hand-held air horn was added and mounted in the cockpit away from the masters station.

4.7.2.4. Radios: All RTDI APVs were outfitted with hand-held VHF radios in addition to the previously existing hard-wired dash-mounted radio, to provide maritime communication redundancy and monitoring capability. RTDI affirmed and clarified communication procedures both internally and with Coast Guard for both APVs and the response boat in the event of an on-water incident. Radios and horns were evaluated for effectiveness. Radio procedures were enhanced, including a requirement for two VHF radios at each location. At one of its operating locations, RTDI installed radio repeaters at appropriate locations to enhance radio communication.

4.7.2.5. Safety briefing: RTDI standardized and re-scripted the complete pre-water-entry safety briefing for all its operating locations to include, among other things, a standardized formal live demonstration of how to put on a personal flotation device. The safety briefing planned was to be translated into multiple

[46] According to RTDI management, the City of Philadelphia took no action against their permits, but expressed a preference that RTDI not resume operations on the Delaware River, and expressed a preference for RTDI to resume operations on the nearby Schuylkill River. RTDI's formal request to operate on the on the Schuylkill River was later denied by the City of Philadelphia.

languages and made available onboard for passengers in the 2011 operating season.

4.7.2.6. Response boat: RTDI purchased a custom-built, dedicated response boat to maintain line-of-sight of the entire Delaware River operating area during the entire water portion of the APV tours and to provide coordination and rapid assistance when necessary. This boat was outfitted with VHF radios and an automatic identification system (AIS), and was to be manned by a licensed master.

4.7.2.7. Waterways management: RTDI joined the Maritime Exchange, Marine Advisory Committee and USCG Auxiliary to improve communication with other river users and to receive local notice of pertinent river conditions and planned vessel activity. RTDI consulted with third-party marine consultants, participated in safety conferences and solicited industry partners for marine safety. RTDI formed mutual-aid pacts with local marine operators and held meetings with vessel operators' leadership in all of their operating locations to improve their awareness of each other's routes and intentions. RTDI also coordinated with other industry members and organizations to increase awareness of these issues.

4.7.2.8. Route: A route study of each operating location was conducted with managers and operations personnel. Masters were encouraged to attempt to make landfall if at all possible while handling any water emergency, as appropriate.

4.7.2.9. Procedures review. RTDI conducted a review of all manuals, forms, and procedures. Focus and intent was to clarify procedures and facilitate training. All locations contributed to content particular to their operations and any differences were briefed.

4.7.2.10. Safety management system (SMS). RTDI compared the company safety procedures and other directives with the Safety Management System (SMS) used by other operators. RTDI concluded that its existing processes were more comprehensive and were aligned with other Herschend Family Enterprises Corp (HFEC) properties,therefore making internal reporting easier and clearer. However, in the interest of clarity in the marine industry, RTDI began translating their procedures, processes, and safety systems into the SMS-type format. Additionally, RTDI began working with the Passenger Vessel Association (PVA) to assist other passenger vessels with the same task, as RTDI will be the first in the industry to adopt this system.

4.7.2.11. Audits. Audits (including paperwork procedures, daily operations, OSHA compliance, driver safety, and mechanical procedures) of all locations were conducted by an outside engineering firm. Multi-day site visits were made with the audit team, the Director of Fleet Operations, the Safety Specialist, and a senior member of RTDI Fleet Operations/Maintenance. According to RTDI, results were positive and any deficiencies found were corrected on the spot.

4.7.2.12. Engine bay attention signs. RTDI installed caution signs on the underside of all APV engine bay hoods to ensure safety and service completion are highlighted.

4.7.2.13. Training program: The 2011 training program for operations personnel, masters, deckhands, safety representatives, and mechanics was reviewed. According to RTDI, significant improvements were made, including stronger requirements for each department to enhance development and internal promotion.

4.7.2.13.1. Masters/deckhands. Masters and deckhands will complete bridge resource management and situational awareness training, and company compliance training in addition to their safety training, emergency procedures training, driver's training, and training in U.S. Coast Guard requirements.

4.7.2.13.2. Mechanics. All mechanics will enter training to achieve appropriate National Institute for Automotive Service Excellence (ASE) certifications.

4.7.2.13.3. Operations personnel. Operations personnel will engage in FEMA Crisis Management training. The Safety Director has already completed this course and will also attend the Coast Guard's Crisis Management Course.

4.7.2.13.4. Training aids. Visual and/or tactile training aids are being developed for more comprehensive operator education of the propulsion and steering systems.

4.7.2.13.5. New hires. Enhanced "new-hire" mechanic and master training was established.

4.7.2.14. Personnel actions: A former safety specialist promoted to the position of Safety Director has reviewed all procedures for the 2011 operating season and has made site audit visits of all RTDI locations. Additionally, RTDI named a specific "safety representative" at each location to be a forward point of contact for any safety issues.

4.7.2.14.1. The proficiency levels of mechanics that had the most contact with APV before the accident were evaluated. One mechanic did not possess competencies and commitment that met the standards of RTDI. He was given additional training in both technical and professional areas. He did not progress satisfactorily and his employment was terminated.

4.7.3. K-Sea Transportation.

4.7.3.1. Training seminars. Held training seminars for vessel crewmembers where duty distraction was stressed.

4.7.3.2. Policy reviews. Reviewed various safety policies, including cell phone policy, watchstanding policy, and others. K-Sea updated its cell phone policy to prohibit use of personal cell phones while on duty.

4.7.3.3. Safety review. K-Sea hired a consultant to observe the company's movement of the barge and to make safety recommendations.

4.7.3.4. Contract modification. The city modified its contract with K-Sea to required that the tug boat be opereated from the upper wheelhouse when towing a light barge.

3/7/2011

X T. K. Roth-Roffy

Thomas K. Roth-Roffy, P.E.
Engineering Group Chairman

Appendix 1. Report of Findings from Initial Examination of *DUKW 34*

The following observations were made by the engineering group after the APV was salvaged and set on shore at the Coast Guard Sector Delaware Bay facility on July 9, 2010 (figure 9).

Operating Station and Passenger Cabin

Item	Condition found
Ignition switch	Off
Drive gear selector	Neutral
Port vent door closure	shut (up position)
Starboard vent door closure	open (down position)
Main engine hood	closed, handle deployed
Battery switch (fire wall)	position 2 (#2 battery on)
CO2 main bottle	not energized
CO2 portable by driver	not energized
CO2 portable at stern	not energized
Engine kill switch (CO2 activated)	up, not deployed
Fire detector audible	switch off
Cabin heater valves in bilge and eng comp	Closed
Choke	closed position
Hand throttle	Closed
Navigation lights	Off
Head lights	Off
Fuel pump switch	main on
Doom lights switch	Off
Mileage odometer	028322
Engine hours	4681.9
Higgins pump:	chain drive attached
Pull handle propulsion selector (by left side of master chair)	set on propeller
Emergency break:	Off
300 amp fuse:	intact/installed
Batter cover (cabin):	Installed
Side curtains release (p/s):	intact, not pulled
3 fire buckets	in place
Road side emergency equipment locker	Intact
Life rings over master position	in place, stern attached but deployed during salvage
Wheel chair (ADA)	not used
PFDs on board (not necessarily in place)	8 adult, 23 children
Red knob starboard side fwd door latch	closed, door open
First aid kit	on board
Mariner radio hand mike	Free
Passenger mirror	Attached
VHF radio antenna	Intact

Kenwood stereo remote control	Installed
AED (Defib) kit	in place
Stern passenger ladder	Closed
Stern and side doors	closed, sealed
Shaft propeller stern tube seal	intact, double clamped
Normally on switch (by prop/road drive yoke)	Intact
Rudder cables (primary/aux)	intact. APV partially maneuvered to move to maintenance facility
Aux steering handle	in place
Side curtains:	in rolled position p/s

Engine Bay Status

Item	Status
Radiator cap	Missing
All belts	in place
Radiator fan/shroud	in place
Engine oil dip stick	in place
Battery	in place, leads attached and covered
300 amp fuse	Intact
Heat sensor stbd side wall	in place
Vapor detector starboard	in place
Headers	Wrapped
Steering pump cap	in place
Keel cooler valves	port open
Heater valves starboard	Closed
Distributor and plug leads	Attached
Flex fuel lines	Intact
Eng comp fuel shut off	pull in open position
Emer hood closure	Intact
Fwd bow hatch door	closed and latched
Engine hatch rubber seals	Attached

Exterior Walk around

Item	Status
Stbd side fuel fill cap	in place
2 emer towing bridles	in place
Exhaust guard	in place
Bow mirror	Intact

Full passenger load stern markers	Attached
3 rudders and prop	Intact

Plaques and certificates observed:

- Op blower 3 min
- Emergency drills
- COI (Mar 12, 2014)
- Oil discharge
- Marine distress
- Emergency vent pull p/s
- Emergency hood closure
- Fuel shut off valve labeled
- Heat sensor box
- High water bilge alarm
- Emergency comp heat sensor box
- High water alarm
- Discharge of garbage
- Fire suppression instructions
- CO2 warning
- Windshield down
- PA Omnibus (5-11) OB-75610 (license plate)
- PA 3930 CS (state boat registration)
- PD Dot Certificate (# 233700), expires Dec 31, 2010
- PD Dot Certificate (#300538), expires Mar 31, 2012

Appendix 2. Photographs

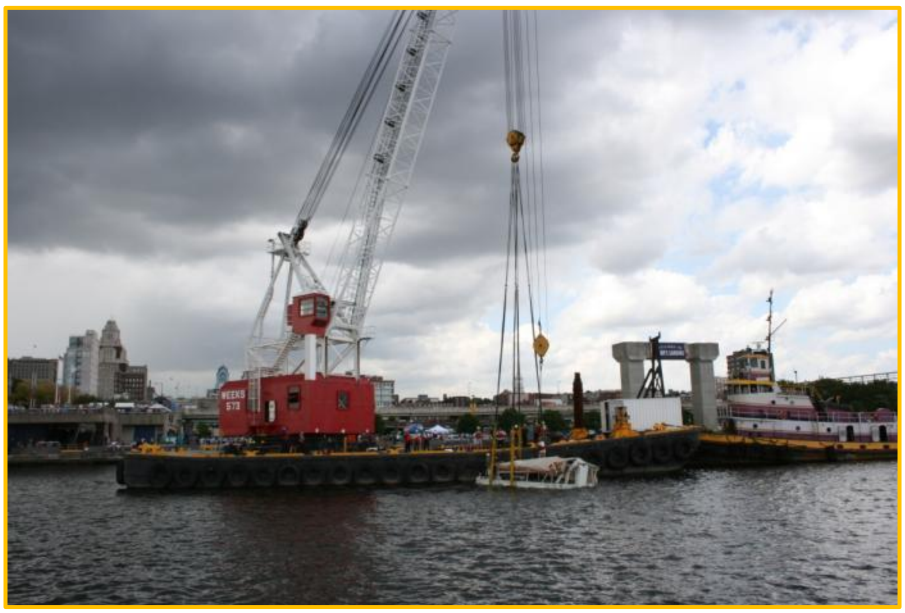

Figure A-2- 1. Salvage operation - *DUKW 34* being raised from river bottom.

Figure A-2- 2. Initial examination of *DUKW 34* on day of salvage. Photo by the Coast Guard.

Figure A-2- 3. View of forward part of engine compartment, *DUKW 34*. Gold arrow indicates missing pressure cap at surge tank**.**

Figure A-2- 4. Examination of radiator from *DUKW 34*. Gold arrow shows water hose connected to lower end of radiator for water flow test.

Appendix 3. Wastewater Processing Technical Description[47]

The Northeast Water Pollution Control Plant is a secondary treatment facility. At a capacity of 210 million gallons/day (420 MGD wet weather) it is the largest of Philadelphia's three wastewater treatment plants. It treats domestic and industrial wastewater from the northeast section of the city and from some of the surrounding suburbs 24 hours/day.

Under the Clean Water Act, the City of Philadelphia is mandated to treat the wastewater to certain standards as dictated in their National Pollution Discharge Elimination System (NPDES) permit. While there are many parameters which must be met in their NPDES permit, the two primary parameters are 5 day carbonaceous biochemical oxygen demand (CBOD5) and suspended solids- essentially the pollutants that are to be kept out of the Delaware River.

Wastewater treatment is a biological and physical process. Ideal conditions are created for the bacteria to help clean up the wastewater and then settle the solids out. Those solids are called "sludge" or "biosolids."

The treatment process is as follows:

1) Preliminary Treatment.
   a) removal of trash (plastic bottles, leaves, branches, snack containers, cans, and what not) through bar screens
   b) removal of inorganics called "grit", basically sand, through detritor basins (a settling tank)
2) Primary Treatment- easily settled organic solids are settled out and collected at the bottom of the tanks. These solids are primary sludge and average 3 - 5% solids. This sludge is pumped to anaerobic digesters. What floats on the tanks (oils & greases known as "scum") is also removed and pumped to scum concentration tanks.
3) Secondary Treatment.
   a) Aeration Tanks- bacteria are fed air and kept in suspension as they flow through the process eating the pollutants and getting fatter
   b) Final Sedimentation Tanks- the bigger fatter bacteria/solids settle and are collected at the bottom of the tanks. These solids (secondary sludge) are typically less than 1% and are pumped to sludge thickening tanks prior to being pumped to the anaerobic digesters. There are also oils & greases, albeit not as much, which float on the top of the tanks and are pumped to the scum concentration tanks.
4) Disinfection- the effluent from the final sedimentation tanks is disinfected w/ sodium hypochlorite prior to discharge to the Delaware River .

The solids train:

As previously mentioned, secondary sludge needs to be thickened. At Northeast, this occurs in Dissolved Air Floatation Tanks. Suffice it to say that they thicken the sludge to an average of 3 - 4 % solids. This thickened secondary sludge meets up w/ the primary sludge and is pumped to the anaerobic digesters. The digesters stabilize the sludge by taking advantage of two types of bacteria- acid formers and methane formers. The methane formers eat the acid formers and produce methane gas (about 60-65% methane, the rest being CO2, H2S, etc). The methane is used as fuel for the boilers that heat some buildings as well as maintain the digester temperatures at approximately 98 degrees F. The detention time in the digesters is about 18 days while it takes approximately 6-8 hours to get from the influent of the plant to the river. Digested sludge (now at 2-3% solids) is fed to 1 of 2 storage tanks (sludge transfer tanks) from which the sludge is pumped to the barge. While pumping the tankerman for the towing company monitors the levels in the barge and insures that the barge fills as it should and of course does not get over filled. The barges transport about 900,000 gallons of sludge to PWD's Biosolids Recycling Center (BRC) pier 6-7 times per week. The pumps on the barge are used to pump out the sludge to 1 of 3 storage tanks at BRC.

From these tanks sludge is pumped to centrifuges which dewaters it to around 30% solids. This material, sludge cake, is land applied in controlled agricultural applications in PA, MD & VA, used in strip mine reclamation and

[47] This information was provided by the Deputy Commissioner, Operations, City of Philadelphia Water Department, in an email dated August 30, 2010.

sometimes land filled. As part of the upgrade of the Northeast Plant, the City decided in the early 1980's to centralize the sludge dewatering process in southwest Philadelphia. Northeast Plant is in a residential community with homes literally at its front gate. Sludge processing can be quite odorous so moving it down to southwest Philadelphia away from residents seemed to be a good idea. Barging, trucking and a pipeline were evaluated as possible methods to transport the sludge. Barging was determined to be the most cost effective and environmentally responsible solution. Thus, 2 barges were designed and constructed. The solids that enter the City's wastewater treatment plants go one of two places, out to the river or to BRC. For obvious reasons the City's goal is to get as much to BRC as possible. When we cannot barge on a regular basis, there are problems on the river which delay transporting a barge to or from Northeast or problems with the towing company or barges which preclude moving the barges, the City has to get creative in storing the solids at the treatment plant in a way that does not cause them to washout to the river. Because the treatment plant has to take whatever flow gets to it, this can be quite challenging when it rains and the flows drastically increase. Methods the City employed in July included letting the sludge levels in the primary tanks build up more than usual and thereby pumping less often to the digesters. With the warm water and ambient air temperatures, this caused the sludge to turn more septic, which in turn caused odor problems in the community. The treatment plant also put some out of service tanks in service to spread the load. The secondary sludge concentrations were also increased. This put us in a very precarious position, especially if it rained. The condition of Dissolved Air Floatation tanks degraded causing solids to be recirculated to the head of the plant, further contributing to the odor problem. The sludge transfer tanks were operated at higher elevations than normal to increase storage. This caused some back ups in the digesters. These various techniques of "hiding" solids can only occur for so long. The City was able to deal with the flow problems through good fortune and the creativity and resourcefulness of those overseeing the treatment process.