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Full Mission Ship Simulation for Edgemoor Navigation Feasibility Study

Provided by
The Maritime Institute of Technology and Graduate Studies (MITAGS)

August 22 - 24, 2018

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The Maritime Institute of Technology & Graduate Studies-Pacific Maritime Institute (MITAGS-PMI) was pleased to provide this desktop and Full Mission Bridge Navigation Simulation Study.

RFP Name	**Diamond State Port Corporation "Edgemoor Site" Simulation Study**
Project Location	Port of Wilmington, Delaware
Purpose	Navigation Feasibility Study for New Terminal
Customer	Seabury Maritime PFRA, LLC 1350 Avenue of the Americas, 31st Floor New York, NY 10019
Customer Representative	Mr. Raymond Camarda, Director
Bidder Legal Name and Location	The MMP MATES Program, DBA the Maritime Institute of Technology & Graduate Studies, and the Pacific Maritime Institute (MITAGS-PMI). MITAGS-PMI 692 Maritime Boulevard Linthicum Heights, MD 21090-1952 Web: http://www.mitags-pmi.org
Bidder Description	The MM&P Mates Program is a 501(c)9 VEBA Non-profit Trusteeship. The "MATES Program" was founded by the International Organizations of Masters, Mates and Pilots and the leading U.S. Flag ship operators in 1968. Its mission is to enhance professionalism through the development and presentation of internationally recognized programs in leadership, education, training and safety for the maritime industry. MITAGS and PMI are the primary training and simulation centers for the MMP professional deck officers and pilots. Tax ID Number: 13-2577386. MD Tax Exemption Number: 31000665 Dun and Bradstreet Number: 010094977
Report Release Date	September 18, 2019
MITAGS Project Leader	Ms. Colleen Schaffer
Project Review	Mr. Glen Paine, Executive Director, MMP MATES Program
Authorized Signature	

MITAGS-PMI accepts no liability for the use of the findings, conclusions and recommendations provided by the conning pilots in this simulation study. Additionally, MITAGS-PMI cannot be held responsible for errors in the data provided by the client and other third parties used for the programming of the simulator hydrodynamic ship / tug models, and databases.

The recommendations provided within this report are for guidance. The final decision on whether it is safe to transit rests with the master of the vessel and the local pilot.

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1. BACKGROUND AND PURPOSE

The Delaware River is a major commercial maritime center on the Eastern Seaboard of the United States. A deep-draft navigation channel extends from the Delaware Capes to Port Wilmington, and the Port of Philadelphia. The river is home to numerous terminals including oil, breakbulk, roll on / roll off, and container. The navigation channels handle oil tankers up to the Suezmax class, container ships up to 14,000 TEUs, and other vessel classes.

Seabury Maritime PFRA, LLC (Seabury) is a global maritime advisory and investment banking services provider with its headquarters in New York City, New York. Seabury is advising Diamond State Port Corporation (DSPC) on the suitability of "Edgemoor Site" (North of Wilmington, DE) for a new container terminal. Containerships up to 9,300 TEUs are planned for this terminal. As part of this assessment, Seabury, DSPC, and the U.S. Army Corps of Engineers (USACOE) desire a full-mission ship navigation study to ensure that containerships are able to transit safely to the Edgemoor Terminal on a regular basis, with minimum impact on existing vessel traffic. The primary focus of the study is to determine the impact of the terminal on the ships transiting the deep-draft navigation channel.

The three-day study was conducted at the Maritime Institute of Technology and Graduate Studies (MITAGS) from August 22 to August 24, 2018.

Figure 1-1: Site location (provided by Google Earth)

1.1 OBJECTIVES

The following objectives were evaluated throughout the study:

- Demonstrate that the terminal will have minimal adverse impact on the vessels transiting inbound and outbound on the Delaware River. The preliminary plan was to have three or more pilots repeat the meeting vessel runs to demonstrate repeatability. The pilots accomplished this by repeating the same run twice under identical conditions, and rotating a third pilot in the repeated runs (Runs 13-18). ERDC onsite representatives approved this modification to the work plan. Additionally, ERDC only required the meeting runs to be repeated as they were the ones that demonstrated the impact of the proposed basin on the main navigation channel. The meeting runs used two ship simulators, conned by local pilots, integrated into one exercise. The most challenging wind and current combinations for max flood and ebb were selected (25 knots from 315° during max ebb, and 25 knots from 135° for max flood.) The final report overlaid the vessels' swept paths to illustrate channel space used during the meeting situations.
- Validate the terminal turning basin designs for handling containership ships up to 9300 TEUs on a routine basis under the River's existing environmental operating limits. .
- Provide suggestions on ways to facilitate vessel movement in and out of the terminal.
- Preliminary validation on the feasibility of a 12,000 TEU vessel to call on the terminal.

1.2 ASSUMPTIONS AND LIMITATIONS OF SIMULATION

MITAGS used the following assumptions for this study:

- The MITAGS ship models selected by the client are reflective of what is expected to call on the container terminals.
- The client provided environmental data that is sufficiently accurate for the purposes of this preliminary study.
- The primary focus of the study was ship maneuvering behavior.

The fidelity of the hydrodynamic model is dependent on the accuracy of the source data, mathematical formulas, and recommended adjustments provided by subject matter experts (captains). The model behaviors are based on the pilot card, windage, general arrangement plans, squat table, and any other data provided by the client or other sources. The model behaviors, as calculated by the simulator, are adjusted based on the consensus opinion of MITAGS and the pilots. Since the adjustments are subjective, the recommended model adjustments may vary depending on the collective experience of the testing captains and pilots at each session.

The MITAGS simulator provides a close approximation of vessel squat in shallow water. However, an adequate safety margin needs to be used in order to account for changes in squat due to vessel speeds, displacements, channel shoaling, and tidal actions.

Model behavior is highly dependent on the accuracy of the bathymetry, the current, and wind flows. In real world situations, such forces could vary significantly over the operating area. In addition, the models used in these tests were representative of vessel classes similar in size and displacement. Vessels of the same class may have significant differences in handling characteristics in real-word conditions. During berthing exercises, the simulator does not account for the forces on the fendering system due to a ship rolling in a swell.

The auto-tug feature of the simulator provided a more realistic simulation of the assist tug than vector forces, but is not as accurate as having a tug bridge integrated with the full-mission simulator.

1.3 MITAGS SIMULATION FACILITIES AND PROJECT TEAM

MITAGS used a full-mission ship simulator (FMSS) for the study (August 22 to 24, 2018). The tugs were operated using the Transas Auto-Tug® feature and operated from the console.

The MITAGS simulators are capable of providing the most realistic 360° presentation, from the perspective of a pilot / master / tug operator, in the world. The theater projection area is over twenty-four meters wide and twelve meters in height. This provides unsurpassed depth perception and visual accuracy.

Additionally, the large simulator control room had ample space for client representatives to remotely observe the entire simulation including visuals, environmental conditions, pilot orders and their effects on the vessel behavior. The full-mission shiphandling simulator met or exceeded the Det Norske Veritas (DNV) Class A standards. MITAGS-PMI is DNV-GL certified as a Maritime Training Provider. Please refer to the MITAGS-PMI Simulation Capability & Facilities Guide for further details on team member qualifications and simulation capabilities.

Figure 1-2: Bridge 1 FMSS, simulation control room, and tug bridge

The simulator was supported by an experienced in-house simulation modeling team and ship handling experts (listed below in **Table 1-1**). In addition to the Delaware Pilots, MITAGS provided an experienced maritime pilot (Captain Wayne Bailey). Captain Bailey is a retired the Delaware Pilot with over thirty years of experience. MITAGS also provided an experienced simulator operator (Captain Kujala). The simulation engineering team provided on-site simulation, hydrodynamic modeling, and engineering support during the study. USACE-ERDC provided technical oversight during the testing schedule by having ERDC personnel attend the simulations.

Table 1-1: MITAGS Support Team	
Attendees	**Position and Duties**
Mr. Glen Paine Executive Director	Responsible for overall coordination with client representatives and ensure the necessary resources are allocated to this project.
Mr. Hao Cheong Direct of Simulation Engineering	Responsible for the overall simulation technical support of project. Assisted in collection of data necessary to model the terminal, vessel under the expected environmental conditions. Served as liaison with MITAGS Simulation Engineering Staff.
Mr. Robert Weiner Naval Architect Hydrodynamic Ship Modeler	Responsible for the programming of the ship models. Also provided support for simulator projection system and maintenance during tests. Assisted in review of report.
Ms. Colleen Schaffer Coastal Engineer	Responsible for overseeing simulation project and preparing report on findings, conclusions, and recommendations with supporting data.
Captain Ken Kujala Simulator Operator	Responsible for operating the simulator during the tests.
Captain Dan Murphy Shiphandling Consultant	Responsible for validating the ship models and databases. Responsible for conning the simulated vessels and providing expertise in the handling of the models. Provided support as needed.
Captain Wayne Bailey Shiphandling Consultant and a retired Delaware Pilot	Responsible for validating the ship models and databases. Responsible for conning the simulated vessels and providing expertise in the handling of the models. Provided support as needed. Also, a conning pilot.

Table 1-2: Participants	
Attendees	**Company**
Captain David Cuff	Conning Pilot from the Delaware Pilots
Captain Robert Bailey III Conning Pilot	Conning Pilot from the Delaware Pilots
Mr. Raymond Camarda	Seabury Marine, Director
Mr. Mario Sanchez	ERDC
Mr. Timothy Shelton	ERDC

MITAGS-PMI is uniquely qualified to conduct this type of study. Our organization has over 30 years of experience in ship simulators, modeling, and is among the leading maritime training and simulation centers. The center is supported by experienced shiphandling consultants, and full-time simulation engineering staff. MITAGS has the ship / tug hydrodynamic ship models that provide the level of fidelity needed to conduct this type of study. MITAGS-PMI has a large library of vetted container ship and assist tug models. For more information on the MITAGS, please visit http://www.mitags-pmi.org, and YouTube® for videos of simulation projects at http://www.youtube.com/user/MaritimeInstitute.

2. VESSEL MODELING

Two vessel models were used in this study – *Container 29* and Maersk *Edinburgh*. The specific ship parameters are listed in **Table 2-1**. Three and four 65 ton bollard pull tugs were used with *Container 29* and the Maersk *Edinburgh*. These tugs were controlled by the simulation operator in AutoTug mode.

Each hydrodynamic model was pre-validated by the MITAGS-PMI shiphandling experts comparing the model to sea trial data, tank tests (if available), pilot / captain reports, and vessels of similar class and size. (Please see the *MITAGS-PMI Simulation Guide* for more details on model validation processes).

Table 2-1: Ship models

Parameters	9,300 TEU Container 29			12,000 TEU Maersk Edinburgh
Draft	**40 ft.**	**42 ft.**	**45 ft.**	**45 ft.**
Model Name	Container ship 29_Edgemoor			Container Maersk Edbinburg_Edgemoor
Displacement (tons)	117,229	122,960	131,643	189,360
Length (m)	299.9	299.9	299.9	366.5
Beam (m)	48.2	48.2	48.2	48.2
Trim	Even	Even	Even	Even
Engine (kW)	1 x 37,915	1 x 37,915	1 x 37,915	1 x 68,640
Propeller	Fixed pitch	Fixed pitch	Fixed pitch	Fixed pitch
Bow Thrusters	1 (3200 kW)	1 (3200 kW)	1 (3200 kW)	2 (1800 kW)

Table 2-2: Tug model

Parameters	Tug Model Z-Tech 65 t
Length (m)	30
Beam (m)	12
Trim	Even
Load Draft (m)	5
Bollard Pull	65

3. DATABASE DEVELOPMENT

3.1 BATHYMETRY

MITAGS programmed and validated a hydro-dynamically accurate geographic area database that included detailed visual scenes, RADAR, and ECDIS images. The local chart and bathymetric data were assembled to form the base layer of the database. The MITAGS Simulation Engineering Department used proprietary Transas® database modeling software to import the electronic chart display information system (ECDIS) data. This software automatically transferred the information from ECDIS into the simulator database and linked the visual and radar databases. The ECDIS data transferred included:

- Hydrographic: depth points, depth lines, depth contours, drying areas, three dimensional (3D) channel bottom. This includes a survey provided by Shell.
- Landmass: 3D terrain, DEM data, coastlines, islands, pier structures, etc.
- Navigation Aids: buoys, ranges, and lighthouses.
- Navigation Signals: color, light timing, light sector, etc.

Figure 3-1 shows the new terminal and turning basin. The entire channel was dredged to 45 ft.

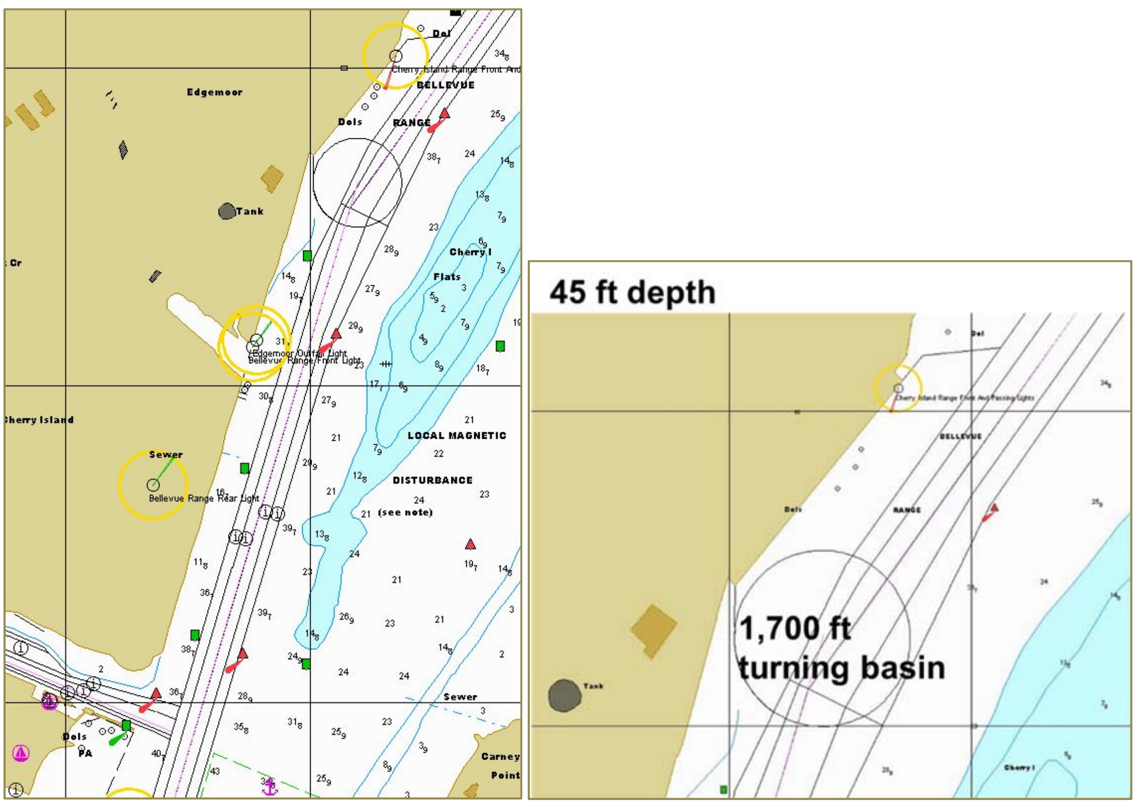


Figure 3-1: Database – 45 ft. channel and 1,700 ft. turning basin

3.2 ENVIRONMENTAL PARAMETERS

3.2.1 WIND PARAMETERS

All winds tested simulated the worst case scenarios (90°, 270°, 315°). The wind was simulated as a static wind up to 25 kts.

3.2.2 CURRENTS

Moffatt and Nichol developed a two-dimensional depth average water current model including the channel, new terminal, and turning basin areas. The current file contains 24 hours of current magnitudes and directions during a spring tide cycle.

Please note that the models are "depth averaged", meaning they are depicting the average current for the entire water column at that position. The velocity depicted will be less than what the tidal current gauges read at the surface. This is a more accurate way of simulating the currents since a large portion of the vessel's hull is experiencing the slower currents near the bottom.

For each run, a current database was imported into the simulator showing the current magnitudes and directions spatially varying. Three current conditions were used in the study including maximum flood, maximum ebb, and the last of flood transitioning to slack with each corresponding to a different time in the 24-hour current file (**Table 3-1**).

Table 3-1: Current models

Current Cycle	Time in Current File
Maximum flood	3:10 am
Maximum ebb	9:40 am
Last of flood to slack	6:26 am

Figure 3-2 and Figure 3-3 show a snapshot of the current fields at maximum flood and maximum ebb respectively.

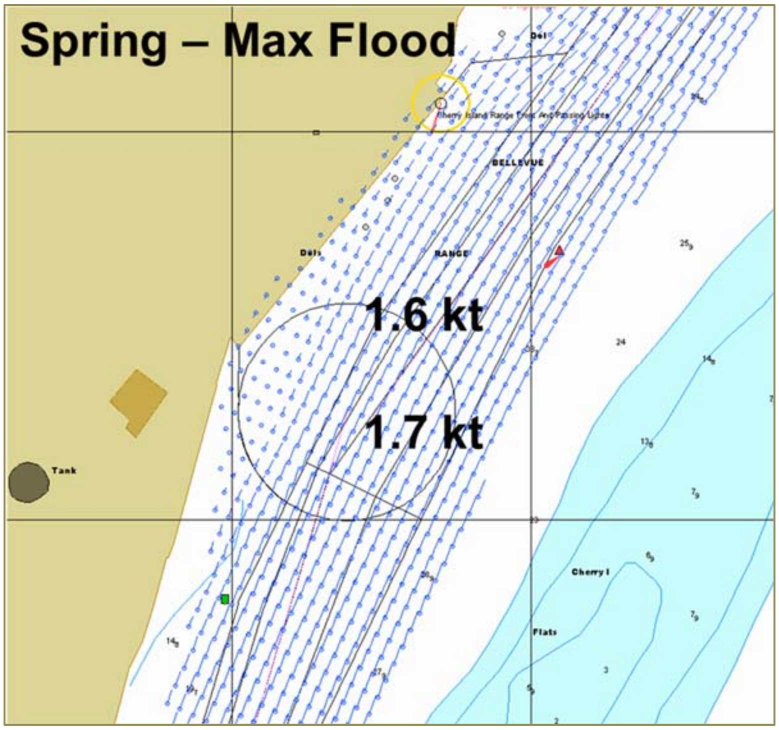


Figure 3-2: Maximum flood current field

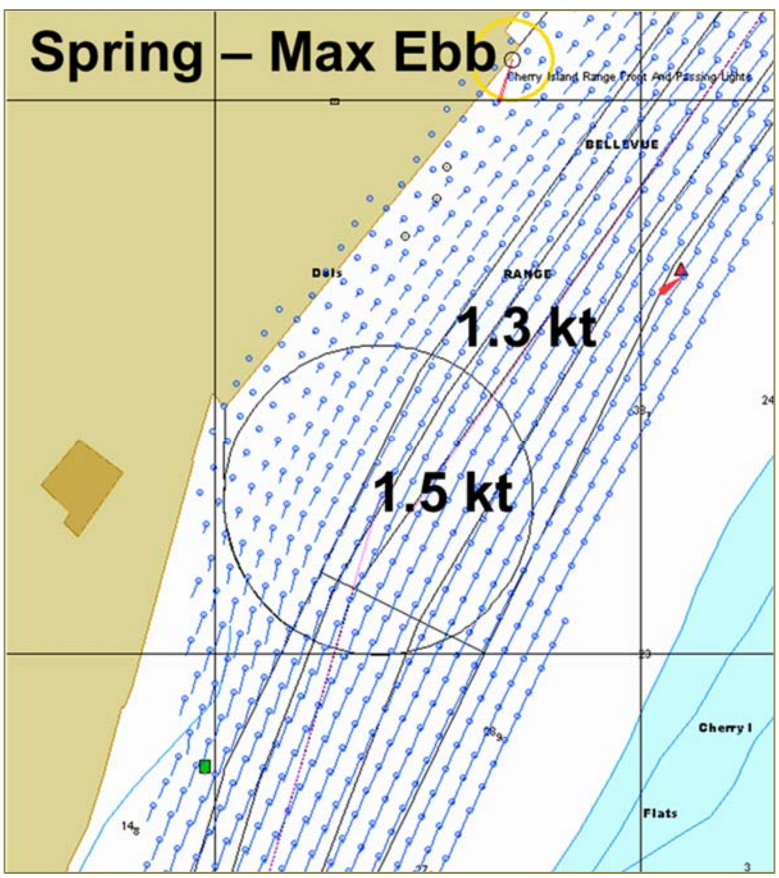


Figure 3-3: Maximum ebb current field

3.2.3 TIDES

A tide was simulated in every run as noted in the test matrix (**Table 4-1**). The tide was simulated as either a 3 ft., 5 ft., or 6 ft. tide depending on the run and ship's draft to ensure adequate underkeel clearance.

3.2.4 WAVES

A small, 0.5 m wind wave was simulated from the same direction as the wind in all of the runs.

3.3 VISIBILITY AND TIME OF DAY

Tests were conducted in clear visibility. However, the simulator operator is able to simulate rain, squalls, fog, and low-altitude clouds if needed in future simulations.

4. RESULTS

This section includes an analysis of the swept path and a summary of the pilot evaluations. Table 4-1 is the test matrix summarizing each simulation and the conditions tested. Each run was recorded and can be reviewed by the client or MITAGS.

Runs of interest to ERDC were Run 13 through Run 18. We run had two containership models meeting in the main navigation channel just off the proposed terminal basin. The tests simulated the maximum wind conditions of 25 knots, and a direction that would have the greatest impact on vessel maneuvering. (25 knots from 315° for max ebb, and 25 knots from 135° / 090° for max flood). Each condition was tested twice with a third pilot rotated into the second run to show repeatability. Runs 1 through 3 were familiarization runs.

Table 4-1: Test Matrix

Run	Ship Model	Draft (ft)	Initial Direction of Travel	Wind Speed (knot)	Wind Dir From (deg)	Start Condition	Tide (ft)	Tugs
1	Container 29 A	42	In	0	0	0	3	3 – 65 t
2	Container 29 A	42	In	0	0	Max flood	3	3 – 65 t
3	Container 29 A	42	In	15	315	Max flood	3	3 – 65 t
4	Container 29 A	40	In	25	090	Max flood	3	3 – 65 t
5	Container 29 A	42	In	25	315	Max flood	3	3 – 65 t
6	Container 29 A	42	In	25	090	Max flood	3	3 – 65 t
7	Container 29 A	42	Out	25	315	Max ebb	3	3 – 65 t
8	Container 29 A	42	Out	25	90	Max ebb	3	3 – 65 t
9	Container 29 A	42	In	25	270	Last of flood to slack	3	3 – 65 t
10	Container 29 A	45	In	25	315	Max flood	5	3 – 65 t
11	Container 29 A	45	In	25	270	Max flood	5	3 – 65 t
12	Container 29 A	45	In	25	000	Max flood	5	3 – 65 t
Meeting Vessel Runs 13-18								**Pilots**
13	Container 29 A	42	In	25	315	Max ebb	5	WB / RB
	Container 29 A	42	Out					
14	Container 29 B	40	In	25	315	Max ebb	5	DC / RB
	Container 29 B	42	Out					
15	Container 29 B	45	In	25	135	Max flood	5	WB / RB
	Container 29 B	42	Out					

Table 4-1: Test Matrix								
Run	Ship Model	Draft (ft)	Initial Direction of Travel	Wind Speed (knot)	Wind Dir From (deg)	Start Condition	Tide (ft)	Tugs
16	Container 29 B	45	In	25	135	Max flood	5	WB / DC
	Container 29 B	42	Out					
17	Container 29 B	45	In	25	90	Max flood	5	DC / WB
	Container 29 B	42	Out	25	90			
18	Container 29 B	45	In	25	90	Max flood	5	DC / RB
	Container 29 B	42	Out	25	90			
Single Model Runs Continued Below								
19	Edinburg B	45	In	25/20	90	Max flood	6	4 – 65 t
20	Edinburg B	45	In	20	90	Max flood	6	4 – 65 t
21	Edinburg B	45	In	20	315	Max flood	6	4 – 65 t
22	Edinburg B	45	Out	20	315	Max ebb	6	4 – 65 t
23	Edinburg B	45	Out	20	90	Max ebb	6	4 – 65 t
24	Edinburg C	45	In	25	90	Max flood	6	4 – 65 t
25	Container 29 B	45	In	25	315	Max flood	5	3 – 65 t
26	Container 29 B	45	In	25	90	Max flood	5	3 – 65 t
27	Container 29 B	45	In	25	135	Max flood	5	3 – 65 t
28	Container 29 B	45	In	25	225	Max flood	5	3 – 65 t
29	Edinburg C	45	In	20	0	Last of flood	6	3 – 65 t

4.1 SWEPT PATH ANALYSIS

In this section, combinations of various swept paths are plotted. Figure 4-1 shows the general layout of each swept path figure. The light gray channel represents the existing channel while the solid white line represents the proposed turning basin and Edgemoor terminal.

Figure 4-2 shows all of the inbound runs. Figure 4-3 shows all of the outbound runs; it also shows all of the runs conducted using the maximum ebb current. No maximum ebb currents were used during inbound runs. Figure 4-4 shows all of the runs conducted with a maximum flood current. Figure 4-5 and Figure 4-6 split the inbound runs (with maximum flood current) by the tested wind direction. Figure 4-7 shows all of the runs tested with wind from 315° while Figure 4-9 shows the runs where the wind was from 90°.

A series of passing vessel runs were conducted. Six runs (Run 13 through Run 18) were conducted with two containerships meeting close to the terminal basin in the main navigation channel. These passing runs each used a maximum flood current with 25 kts. from 135°, or 90°, and max ebb with 25 knots from 315°. As per ERDC representative's request, meeting runs repeated twice, with a third pilot in the second run to show repeatability. Figure 4-7, Figure 4-8, and Figure 4-9 show the three different wind regimes tested. During these runs, the ships transited within the channel limits and had adequate passing distance between the vessels. As the vessels passed, there was a minimum of 290 ft. between them in all of the passing runs. In Run 13 to Run 18, the distance at passing was 360 ft., 425 ft., 290 ft., 390 ft., 375 ft., and 345 ft. respectively. No adverse effects were indicated during the passing vessel runs. In fact, the pilots indicated the addition of this terminal basin reduced the bank effect making navigation safer.

Individual swept paths for each run are available in Appendix B. Each run is shaded according to its time throughout the run where dark red represents the beginning of the run (time = 0 sec) and dark blue represents the end of the run. The colors and corresponding times in between are shown on the legend. Tug 1, Tug 2, Tug 3, and Tug 4 are represented by the yellow, red, green, and turquoise tugs in the figures. The swept paths are plotted at 45 second intervals.

The passing runs are available in Appendix C.

Figure 4-1: Existing channel (gray) with new Edgemoor Terminal (solid white line)

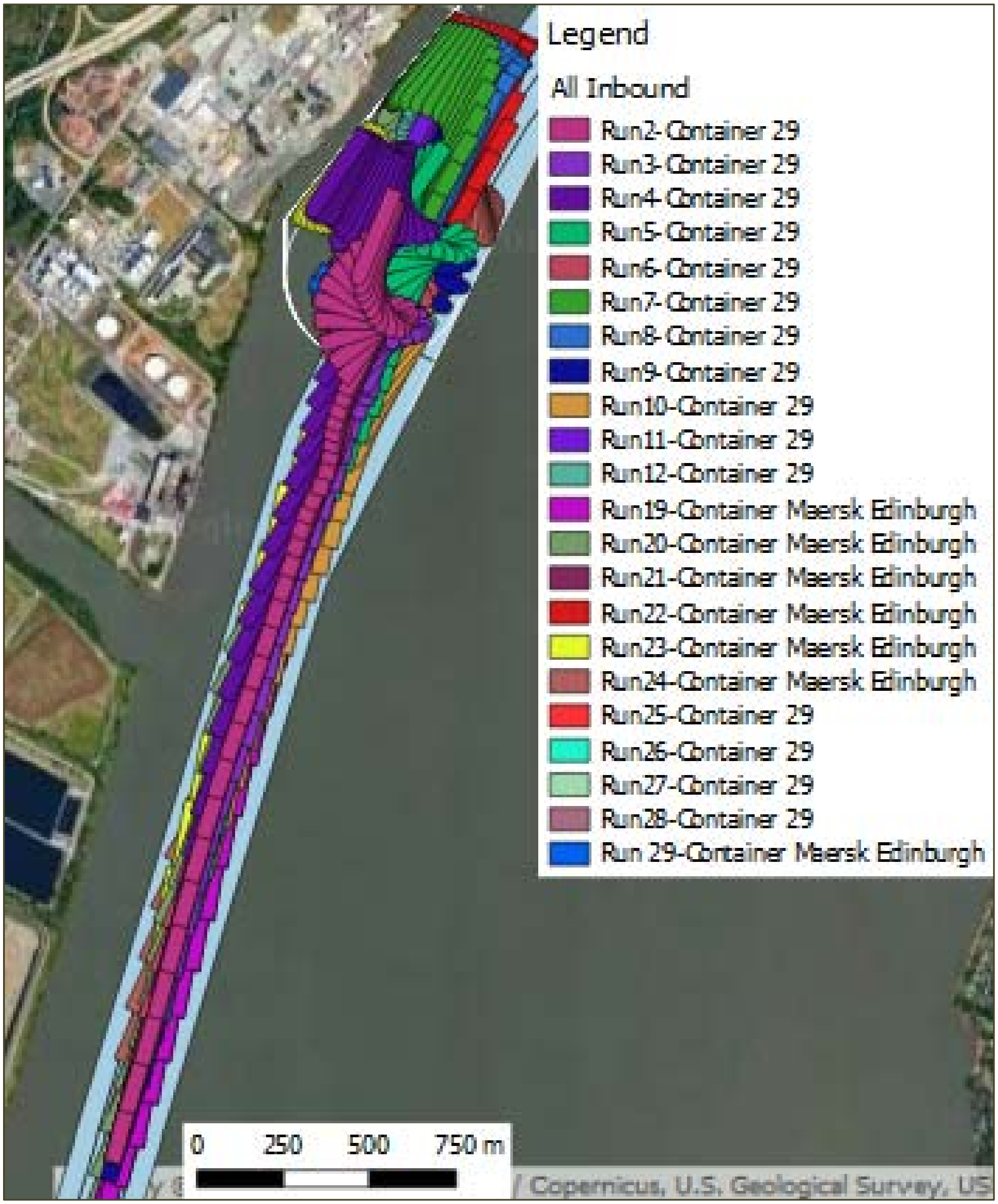


Figure 4-2: Summary of all inbound runs

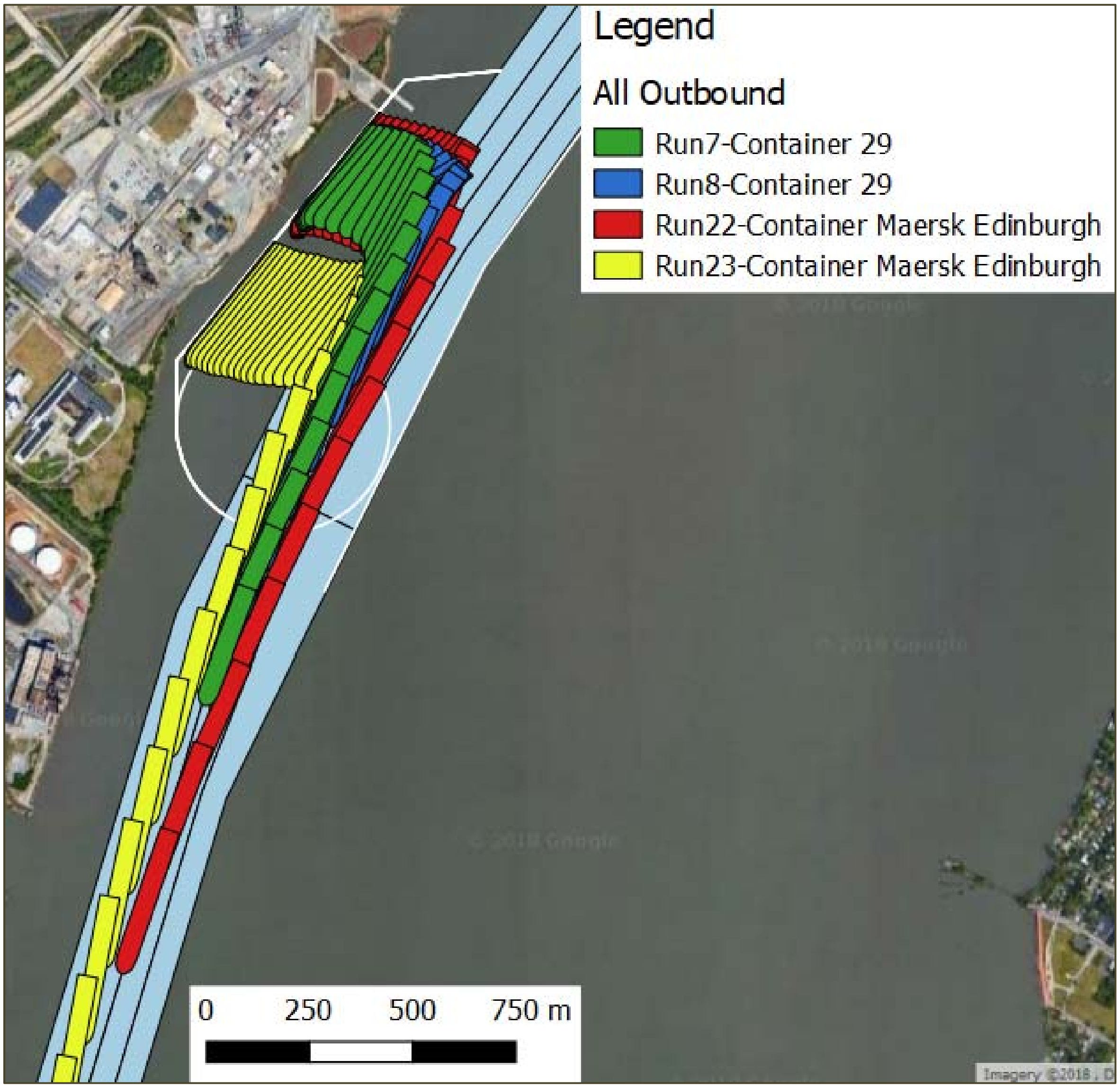


Figure 4-3: Summary of all outbound runs and also all maximum ebb current runs

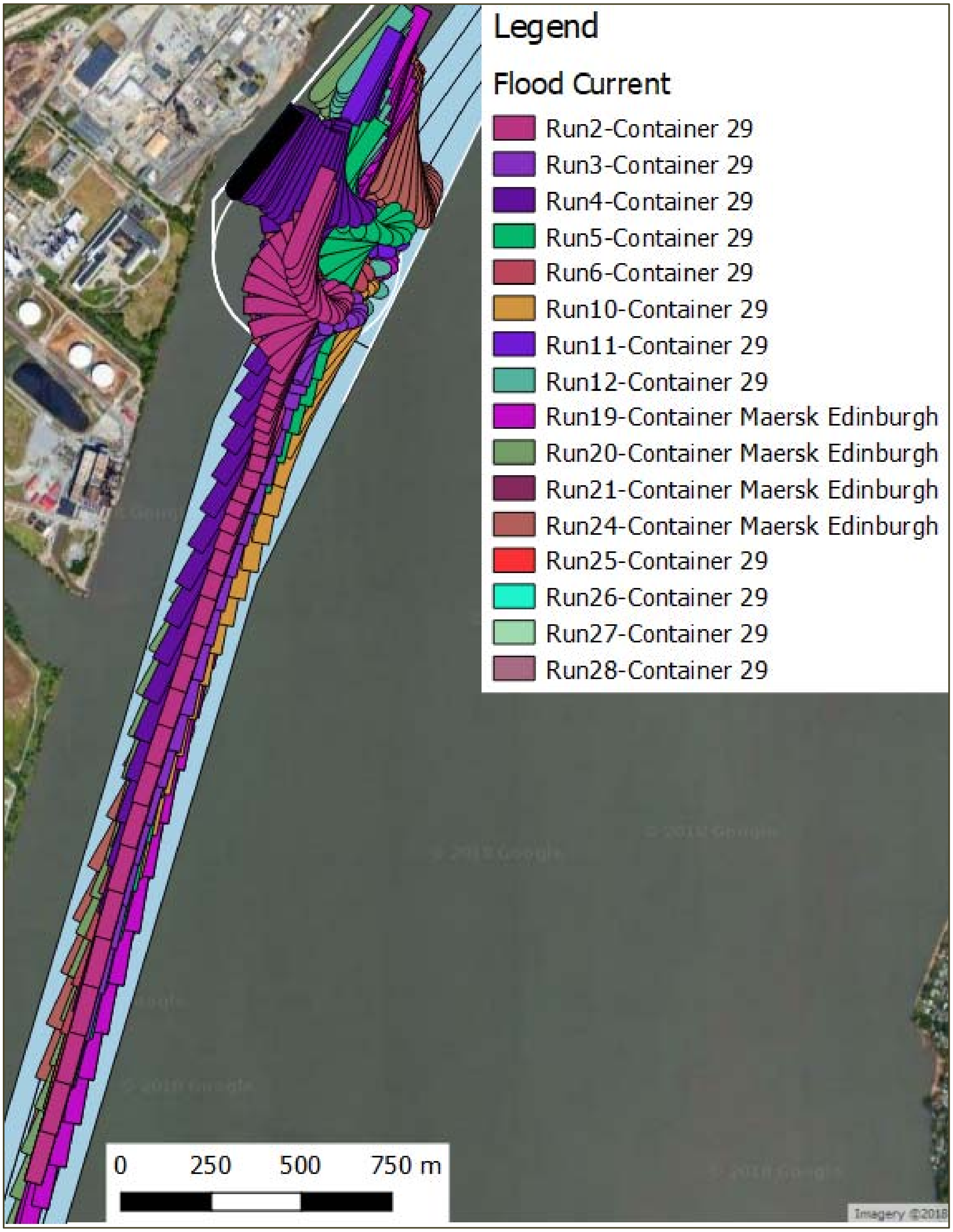


Figure 4-4: Summary of all inbound runs under maximum flood currents

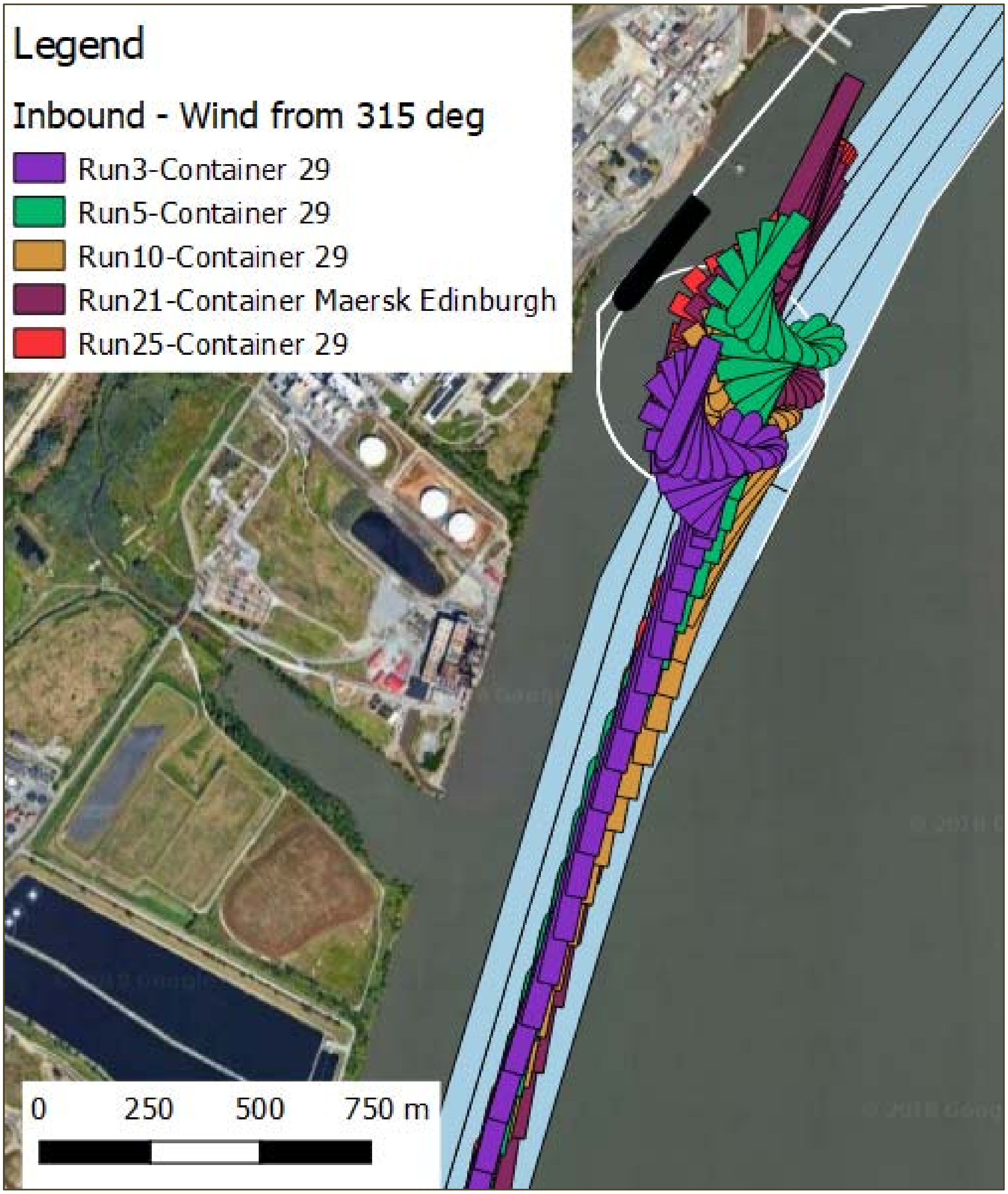


Figure 4-5: Summary of all inbound runs with wind from 315°

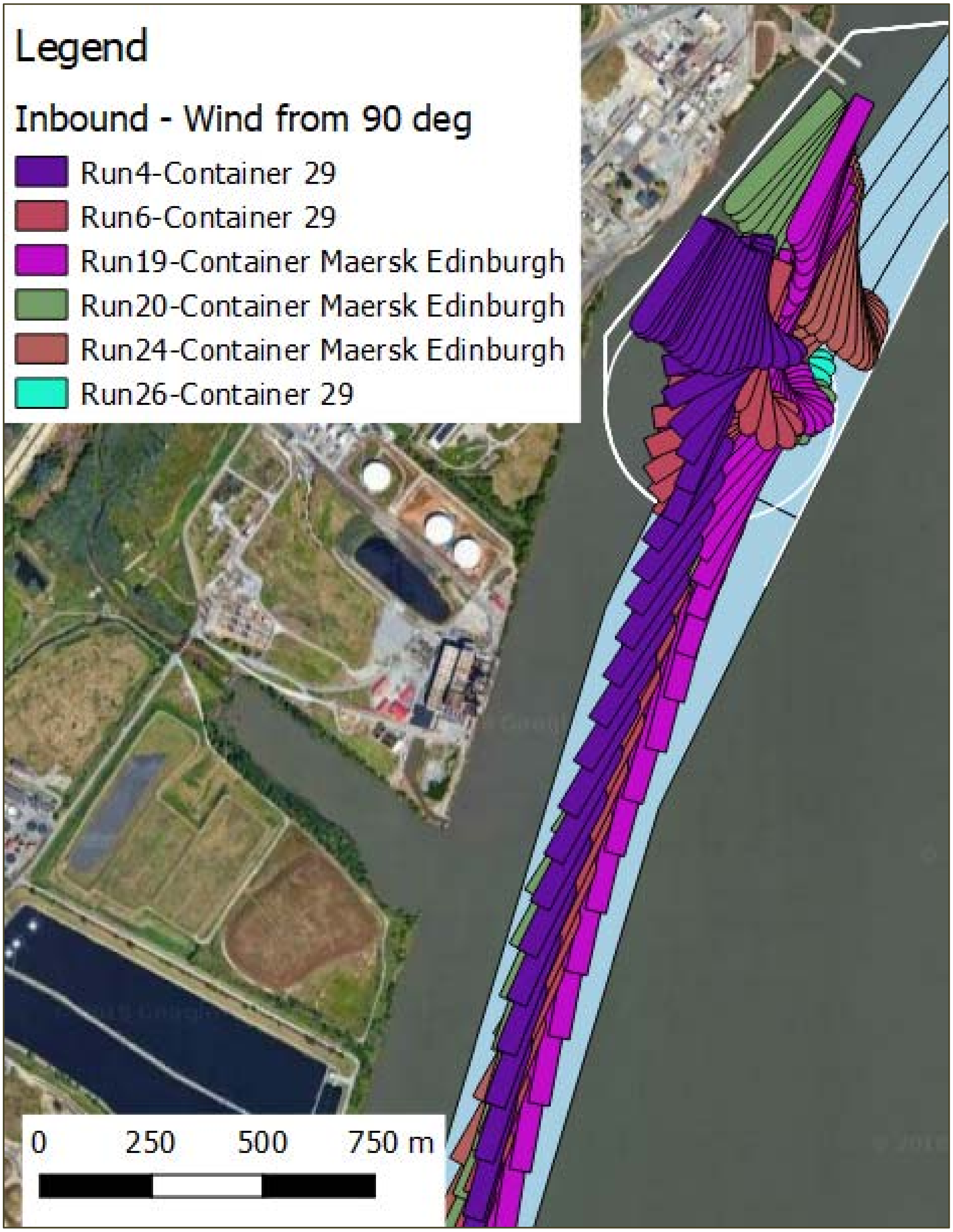


Figure 4-6: Summary of all inbound runs with wind from 90°

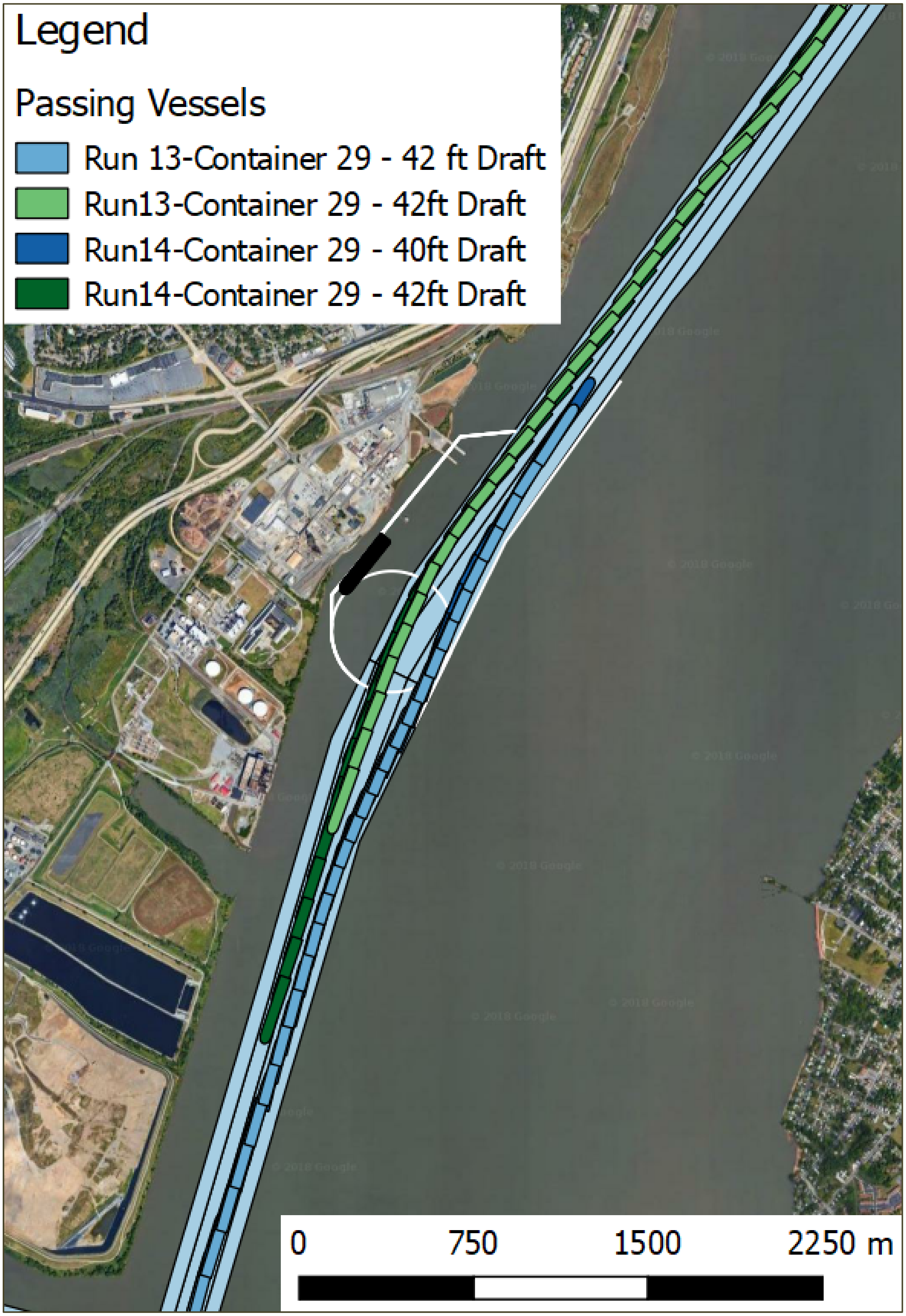


Figure 4-7: Passing vessels – maximum flood current, 25 kts wind from 315°

Figure 4-8: Passing vessels – maximum flood current, 25 kts wind from 135°

Figure 4-9: Passing vessels – maximum flood current, 25 kts wind from 90°

4.2 PILOT EVALUTATIONS

After each run, the pilots filled out an individual run questionnaire. A summary of the evaluation is presented in Table 4-2 while the full comments are shown in Appendix C. There are no evaluations for Run 1 to Run 3 as they were familiarization runs. One column ranks tug configuration and reserve capacity on a scale of 1 to 10 with 10 being equivalent to most adequate. The overall difficulty was also assessed on a scale of 1 to 10 with 10 being the most difficult. The last column of the table shows the overall safety ranking. This value is also on a 1 to 10 scale with 10 being the safest scenario possible. Both the river and docking pilots completed the surveys.

The average tug configuration and reserve capacity was 5.1 (10 = most adequate). The average overall difficulty was 5.7 (10 = most difficult), and the average safety ranking was 5.4 (10 = most safe).

Table 4-2: Pilot Ratings

Run	Tug Reserve Capacity	Overall Run Difficulty	Overall Run Safety	Run	Tug Reserve Capacity	Overall Run Difficulty	Overall Run Safety
1	--	--	--	19	2	9.5	2
2	--	--	--	20	3	8	4
3	--	--	--	21	5	8.5	5
4	5	6	6	22	8	2	8
5	6	7	5	23	3.5	7.5	4
6	7	6	5	24	2	10	1
7	7	3	9	25	6	5	5
8	3	8	5	26	7.5	7	5
9	5	7	4	27	6	5	5
10	5	8	4	28	6.5	6	5.5
11	4	6	4	29	--	--	--
12	5	5	8				
Meeting Runs in the Main Navigation Channel (13-18)							
13	--	2.5	8.5				
13	--	5	5				
14	--	2.5	8				
14	--	5	5				
15	--	5.5	5.5				
15	--	5	5				
16	--	5.5	5				
16	--	--	2.5				
17	--	2	8.5				
17	--	--	--				
18	--	3	9				
18	--	5	5				

5. CONCLUSION SUMMARY

The purpose of this study was to validate the design of the Edgemoor Terminal and turning basin. Throughout the study, 29 runs were completed including 19 inbound, 4 outbound, and 6 passing vessel runs. In all of the runs, the ships transited within the channel limits including the existing and proposed terminal limits as shown in Figure 5-1.

Figure 5-1: Summary of all runs

5.1 PILOT RECOMMENDATONS

With the Delaware Pilots, the following recommendations were determined from this study

5.1.1 ENVIRONMENTAL CONDITIONS:

The current environmental limitations apply:

- Wind 20 kts or less
- High tide for inbound transits

5.1.2 DESIGN CONSIDERATONS

The design should consider deepening the red hatched area to provide additional maneuvering space as the inbound vessels turn in the turning basin.

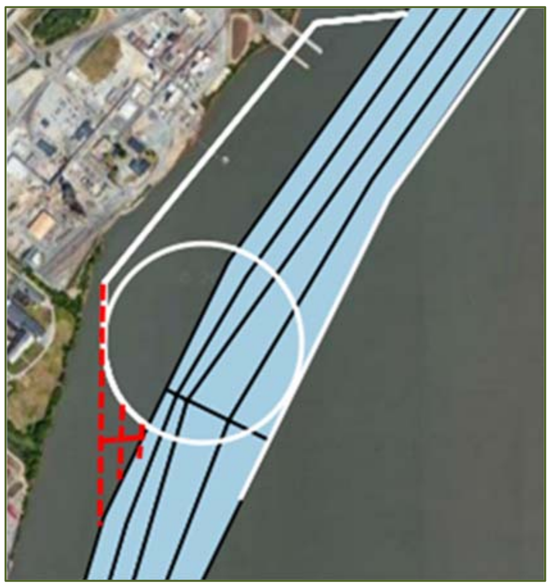


Figure 5-2: Deepening considerations for inbound approach to turning basin

5.1.3 PASSING VESSELS:

- Of the 6 passing vessel tests, the distance between the vessels when passing ranged from 290 ft. to 425 ft. allowing safe passing distances.
- No adverse effects occurred; the addition of the Edgemoor Terminal and resultant deepening, reduces the bank effect in the channel adjacent to the terminal making navigation safer.

5.1.4 FUTURE CONSIDERATIONS

- Berthing procedures, tug power required, and emergency procedures will be developed in future simulation studies.

The simulation results indicated the proposed Edgemoor Terminal would have minimal impact on ships as they transit the existing navigation channel.

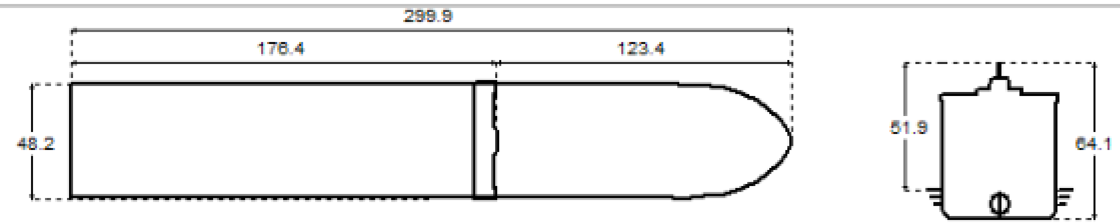
APPENDIX A – PILOT CARDS

PILOT CARD

Ship name	Container ship 29 Edgemore_A 3.0.6.1 *			Date	21.08.2018
IMO Number	9674529	Call Sign	9HA3731	Year built	2014
Load Condition	40'				
Displacement	117229 tons		Draft forward	12.2 m / 40 ft 1 in	
Deadweight	112619 tons		Draft forward extreme	12.2 m / 40 ft 1 in	
Capacity			Draft after	12.2 m / 40 ft 1 in	
Air draft	51.95 m / 170 ft 10 in		Draft after extreme	12.2 m / 40 ft 1 in	

Ship's Particulars

Length overall	299.95 m	Type of bow	Bulbous
Breadth	48.2 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9.48 / 9.48		



Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 1	Number of bow thrusters	1
Maximum angle	35	Power	3200 kW
Rudder angle for neutral effect	0.21 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	15 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	668.6 s	19.29 cbls	Advance	4.33 cbls
HAH to HAS	629.6 s	13.94 cbls	Transfer	2.26 cbls
SAH to SAS	659.6 s	7.96 cbls	Tactical diameter	5.22 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 37915.31 kW	Propeller type	FPP
Astern power	85 % ahead	Min. RPM	10
Time limit astern	N/A	Emergency FAH to FAS	144.5 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	22.2	35759	78	1.08
"FAH"	17.6	18240	62	1.08
"HAH"	14.2	9774	50	1.08
"SAH"	10	3550	35	1.08
"DSAH"	6.3	1017	22	1.08
"DSAS"	-4.2	1533	-22	1.08
"SAS"	-6.8	5625	-35	1.08
"HAS"	-9.6	15840	-50	1.08
"FAS"	-12	29788	-62	1.08

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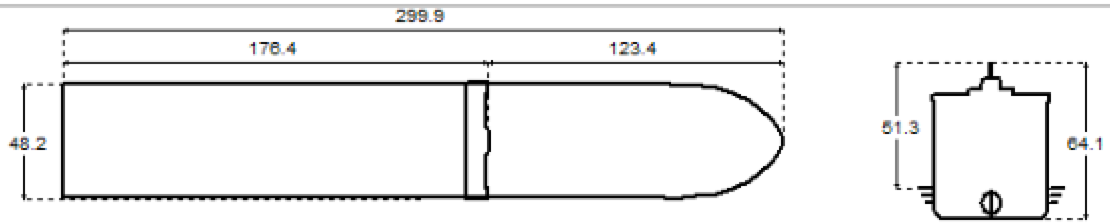
PILOT CARD					
Ship name	Container ship 29 Edgemore_A 3.0.6.1 *			Date	21.08.2018
IMO Number	9674529	Call Sign	9HA3731	Year built	2014
Load Condition	42'				
Displacement	122960.53 tons		Draft forward	12.8 m / 42 ft 1 in	
Deadweight	112619 tons		Draft forward extreme	12.8 m / 42 ft 1 in	
Capacity			Draft after	12.8 m / 42 ft 1 in	
Air draft	51.35 m / 168 ft 10 in		Draft after extreme	12.8 m / 42 ft 1 in	

Ship's Particulars			
Length overall	299.95 m	Type of bow	Bulbous
Breadth	48.2 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9.48 / 9.48		



Steering characteristics			
Steering device(s) (type/No.)	Normal balance rudder / 1	Number of bow thrusters	1
Maximum angle	35	Power	3200 kW
Rudder angle for neutral effect	0.21 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	15 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	632.6 s	17.9 cbls	Advance	4.09 cbls
HAH to HAS	608.6 s	12.83 cbls	Transfer	2.26 cbls
SAH to SAS	687.6 s	8 cbls	Tactical diameter	4.99 cbls

Main Engine(s)			
Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 37915.31 kW	Propeller type	FPP
Astern power	85 % ahead	Min. RPM	10
Time limit astern	N/A	Emergency FAH to FAS	111.5 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	22.2	36409	78	1.08
"FAH"	17.6	18576	62	1.08
"HAH"	14.2	9943	50	1.08
"SAH"	10	3613	35	1.08
"DSAH"	6.3	1036	22	1.08
"DSAS"	-4.2	1603	-22	1.08
"SAS"	-6.8	5912	-35	1.08
"HAS"	-9.6	16670	-50	1.08
"FAS"	-12	31365	-62	1.08

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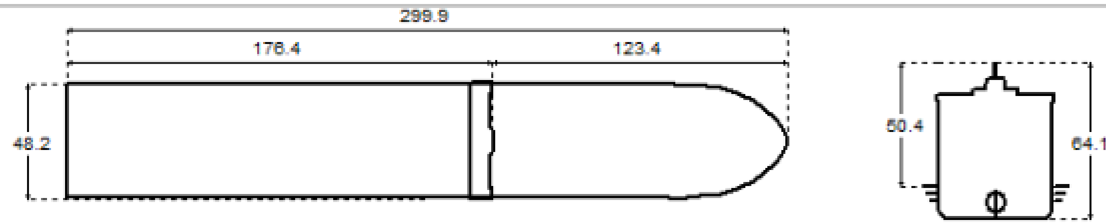
PILOT CARD

Ship name	Container ship 29 Edgemore_A 3.0.6.1 *			Date	21.08.2018
IMO Number	9674529	Call Sign	9HA3731	Year built	2014
Load Condition	45'				
Displacement	131643 tons		Draft forward	13.7 m / 45 ft 0 in	
Deadweight	112619 tons		Draft forward extreme	13.7 m / 45 ft 0 in	
Capacity			Draft after	13.7 m / 45 ft 0 in	
Air draft	50.45 m / 165 ft 11 in		Draft after extreme	13.7 m / 45 ft 0 in	

Ship's Particulars

Length overall	299.95 m	Type of bow	Bulbous
Breadth	48.2 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	9.48 / 9.48		



Steering characteristics

Steering device(s) (type/No.)	Normal balance rudder / 1	Number of bow thrusters	1
Maximum angle	35	Power	3200 kW
Rudder angle for neutral effect	0.2 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	15 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	640.6 s	17.95 cbls	Advance	4.13 cbls
HAH to HAS	619.6 s	12.76 cbls	Transfer	2.28 cbls
SAH to SAS	719.6 s	8.26 cbls	Tactical diameter	5.01 cbls

Main Engine(s)

Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 37915.31 kW	Propeller type	FPP
Astern power	85 % ahead	Min. RPM	10
Time limit astern	N/A	Emergency FAH to FAS	98.3 seconds

Engine Telegraph Table

Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"FSAH"	22.2	36778	78	1.08
"FAH"	17.6	18751	62	1.08
"HAH"	14.2	10043	50	1.08
"SAH"	10	3645	35	1.08
"DSAH"	6.3	1042	22	1.08
"DSAS"	-4.2	1642	-22	1.08
"SAS"	-6.8	6065	-35	1.08
"HAS"	-9.6	17115	-50	1.08
"FAS"	-12	32228	-62	1.08

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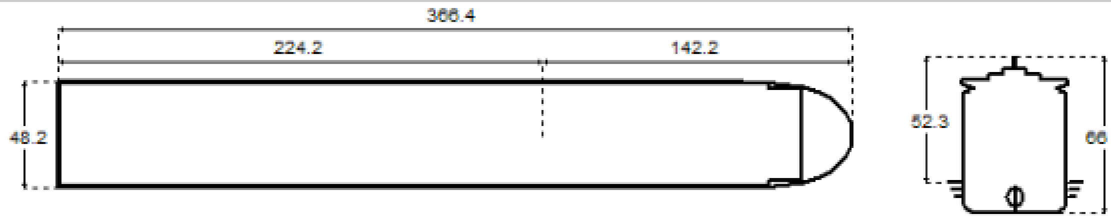
PILOT CARD

Ship name	Container Maersk Edinburgh_Edgemore_B 3.0.39.1 *			Date	21.08.2018
IMO Number	N/A	Call Sign	N/A	Year built	2010
Load Condition	45'				
Displacement	189360.8 tons		Draft forward	13.7 m / 45 ft 0 in	
Deadweight	126493 tons		Draft forward extreme	13.7 m / 45 ft 0 in	
Capacity			Draft after	13.7 m / 45 ft 0 in	
Air draft	52.3 m / 172 ft 0 in		Draft after extreme	13.7 m / 45 ft 0 in	

Ship's Particulars

Length overall	366.45 m	Type of bow	Bulbous
Breadth	48.2 m	Type of stern	Transom
Anchor(s) (No./types)	2 (PortBow / StbdBow)		
No. of shackles	14 / 14		(1 shackle =27.5 m / 15 fathoms)
Max. rate of heaving, m/min	15 / 15		



Steering characteristics

Steering device(s) (type/No.)	Becker's rudder / 1	Number of bow thrusters	2
Maximum angle	35	Power	1800 kW / 1800 kW
Rudder angle for neutral effect	0.18 degrees	Number of stern thrusters	N/A
Hard over to over(2 pumps)	27 seconds	Power	N/A
Flanking Rudder(s)	0	Auxiliary Steering Device(s)	N/A

Stopping			Turning circle	
Description	Full Time	Head reach	Ordered Engine: 100%, Ordered rudder: 35 degrees	
FAH to FAS	515.6 s	10.53 cbls	Advance	5.41 cbls
HAH to HAS	666.6 s	10.19 cbls	Transfer	2.11 cbls
SAH to SAS	821.6 s	9.99 cbls	Tactical diameter	5.26 cbls

Main Engine(s)

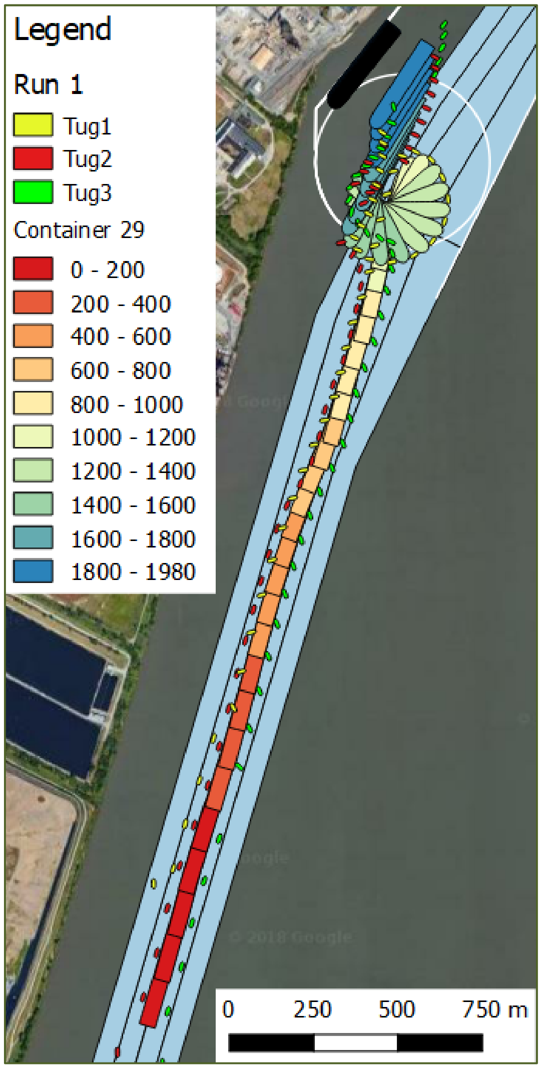
Type of Main Engine	Low speed diesel	Number of propellers	1
Number of Main Engine(s)	1	Propeller rotation	Right
Maximum power per shaft	1 x 68640 kW	Propeller type	FPP
Astern power	28 % ahead	Min. RPM	25
Time limit astern	N/A	Emergency FAH to FAS	19.2 seconds

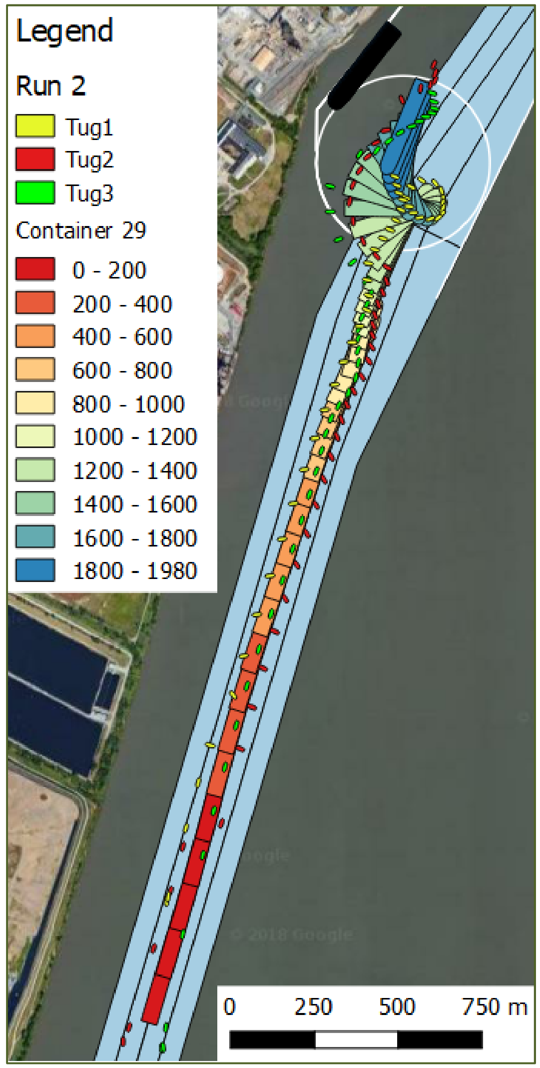
Engine Telegraph Table

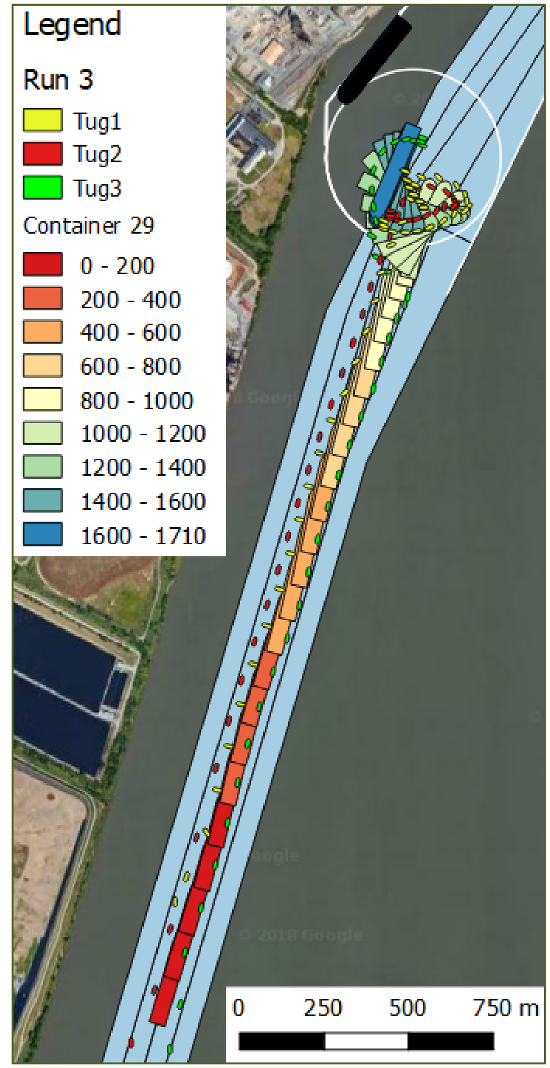
Engine Order	Speed, knots	Engine power, kW	RPM	Pitch ratio
"100%"	25.2	66581	102	1.03
"80%"	16.6	18870	67	1.03
"60%"	12.6	8323	51	1.03
"40%"	10.1	4324	41	1.03
"20%"	7.7	1869	31	1.03
"-20%"	-4.8	1904	-31	1.03
"-40%"	-6.3	4404	-41	1.03
"-60%"	-7.9	8477	-51	1.03
"-80%"	-10.3	19219	-67	1.03
"-100%"	-10.3	19219	-67	1.03

APPENDIX B – SWEPT PATHS AND AVAILABLE PILOT EVALUATION COMMENTS FOR INDIVIDUAL RUNS

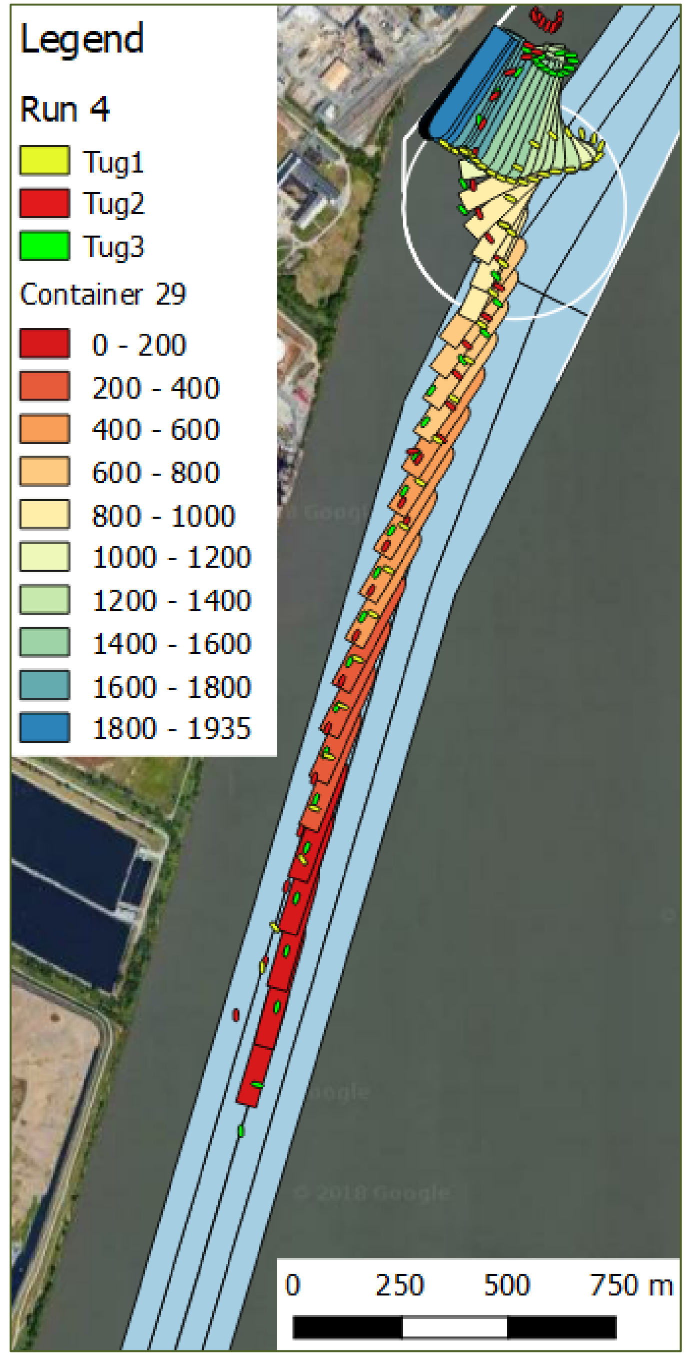
Individual swept paths for each run are available in Appendix B. Each run is shaded according to its time throughout the run where dark red represents the beginning of the run (time = 0 sec) and dark blue represents the end of the run. The colors and corresponding times in between are shown on the legend. Tug 1, Tug 2, Tug 3, and Tug 4 are represented by the yellow, red, green, and turquoise tugs in the figures. The swept paths are plotted at 45 second intervals.



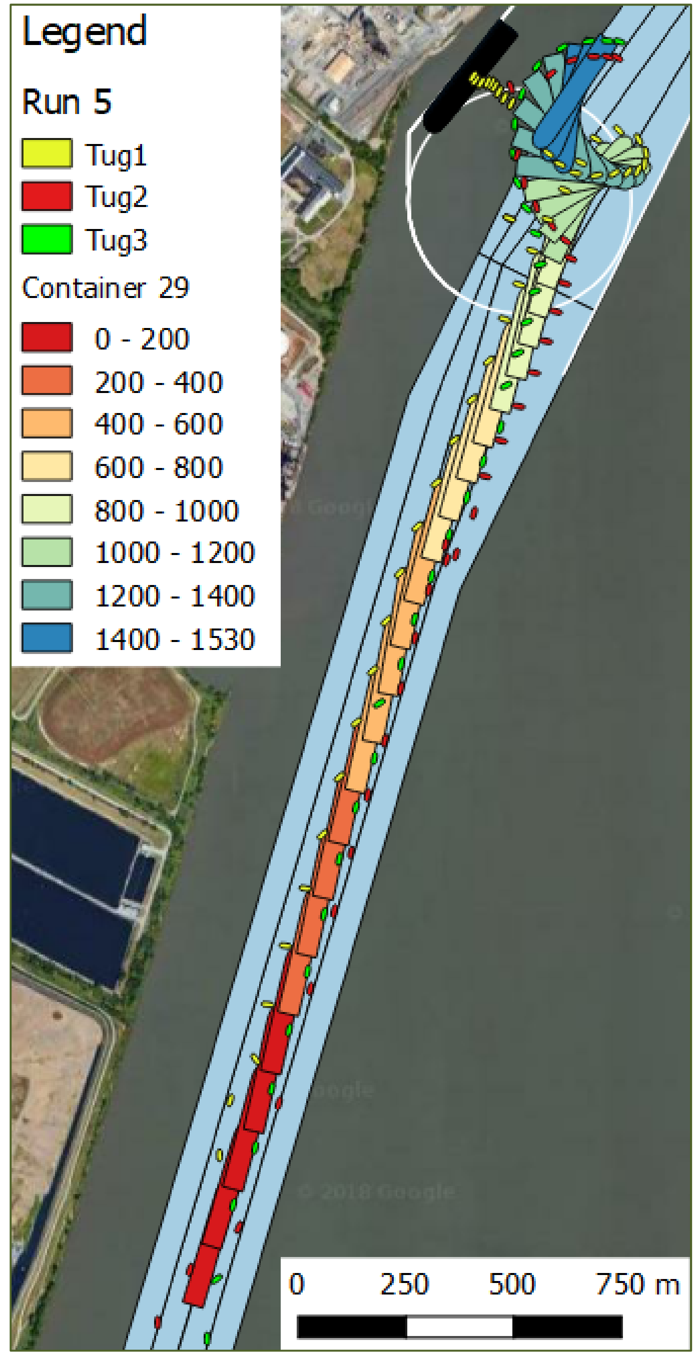




	Run	4
	Captain	David Cuff
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	Roughly 10°, speed was maintained; would use minimum 3 tugs
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes, very realistic, vessel handled just like real conditions; vessel reacted to commands as predicted
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	5
8.	Qualifiers to tug rating	use 50 t minimum
9.	Difficulty rating	6
10.	Overall safety	6
11.	Safety qualifier	Would require 4 tugs with wind over 25 kts especially out of the east



	Run	5
	Captain	Dana Gray
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	3 or 4°
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	Stay a little more left
7.	Tug configuration and reserve capacity?	6
8.	Qualifiers to tug rating	
9.	Difficulty rating	7
10.	Overall safety	5
11.	Safety qualifier	



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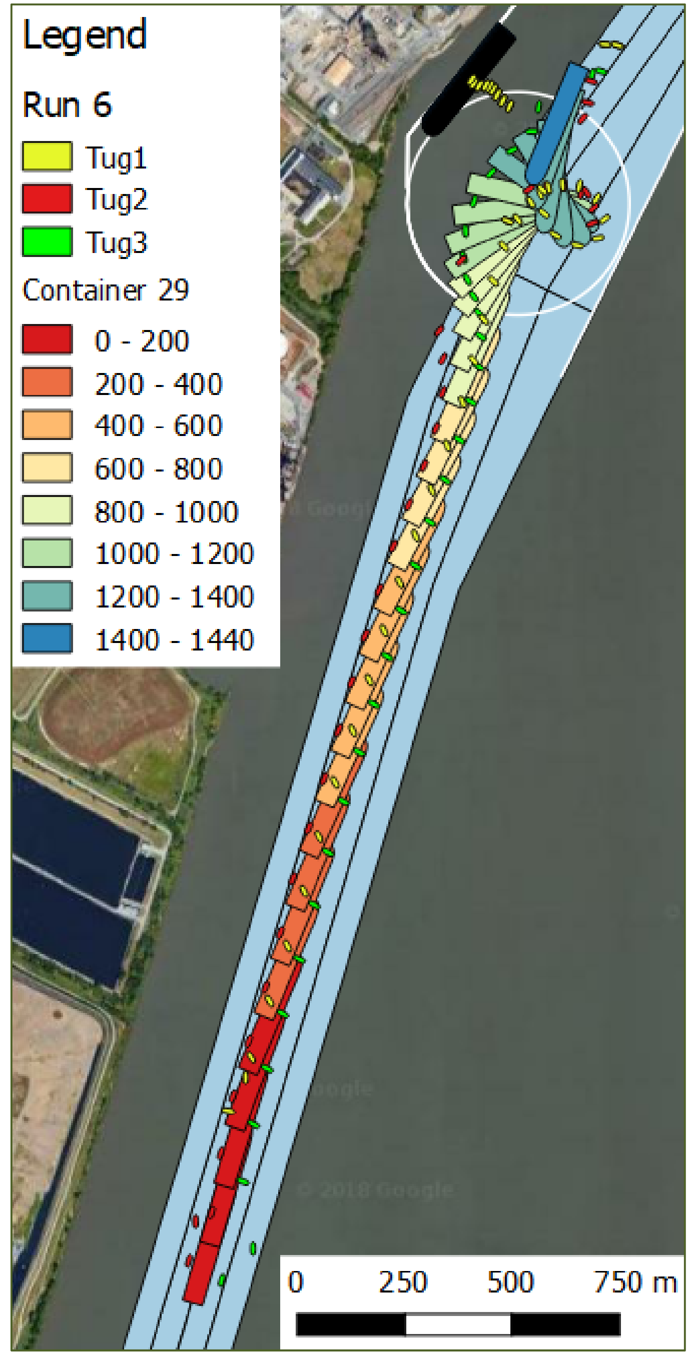
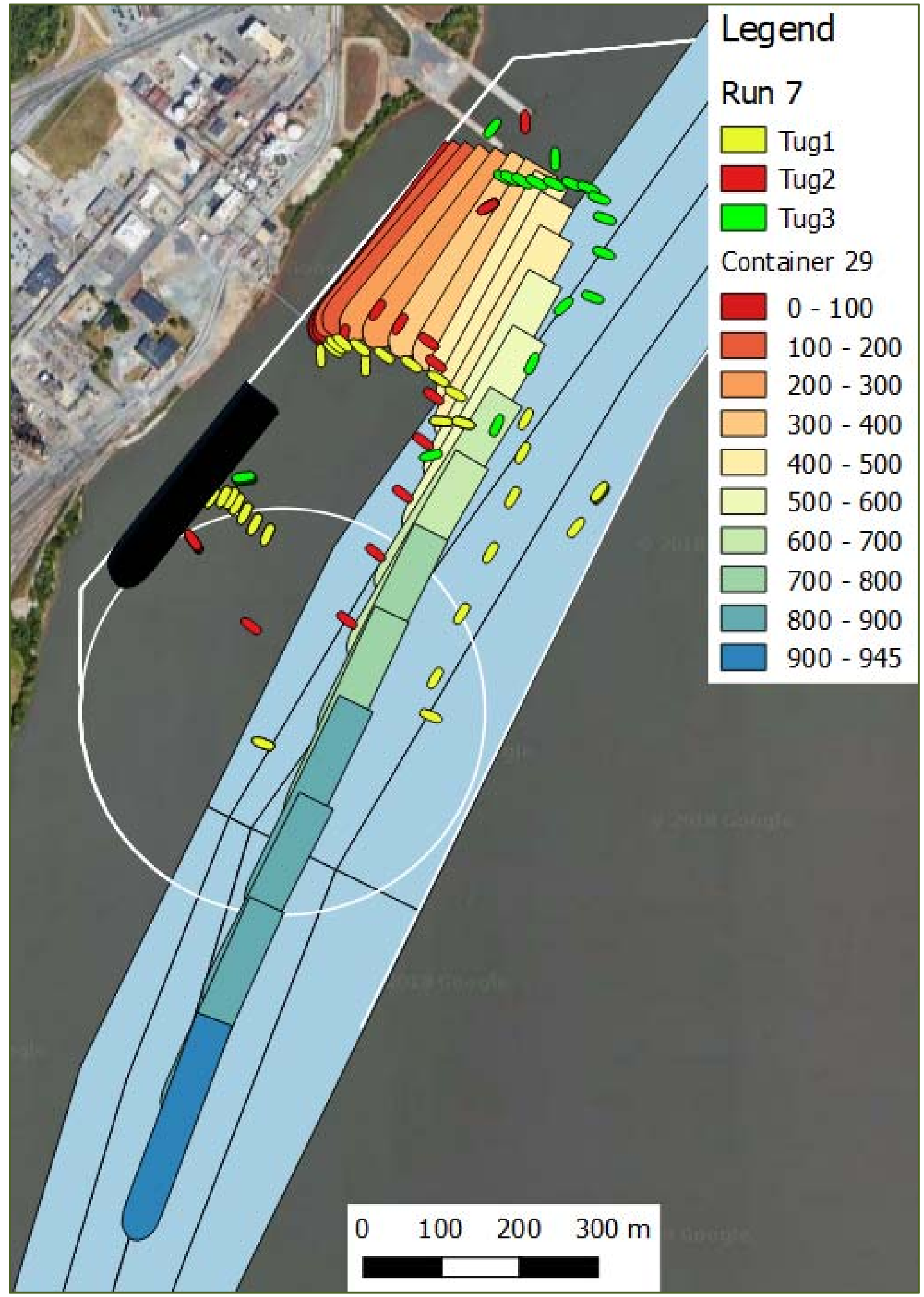
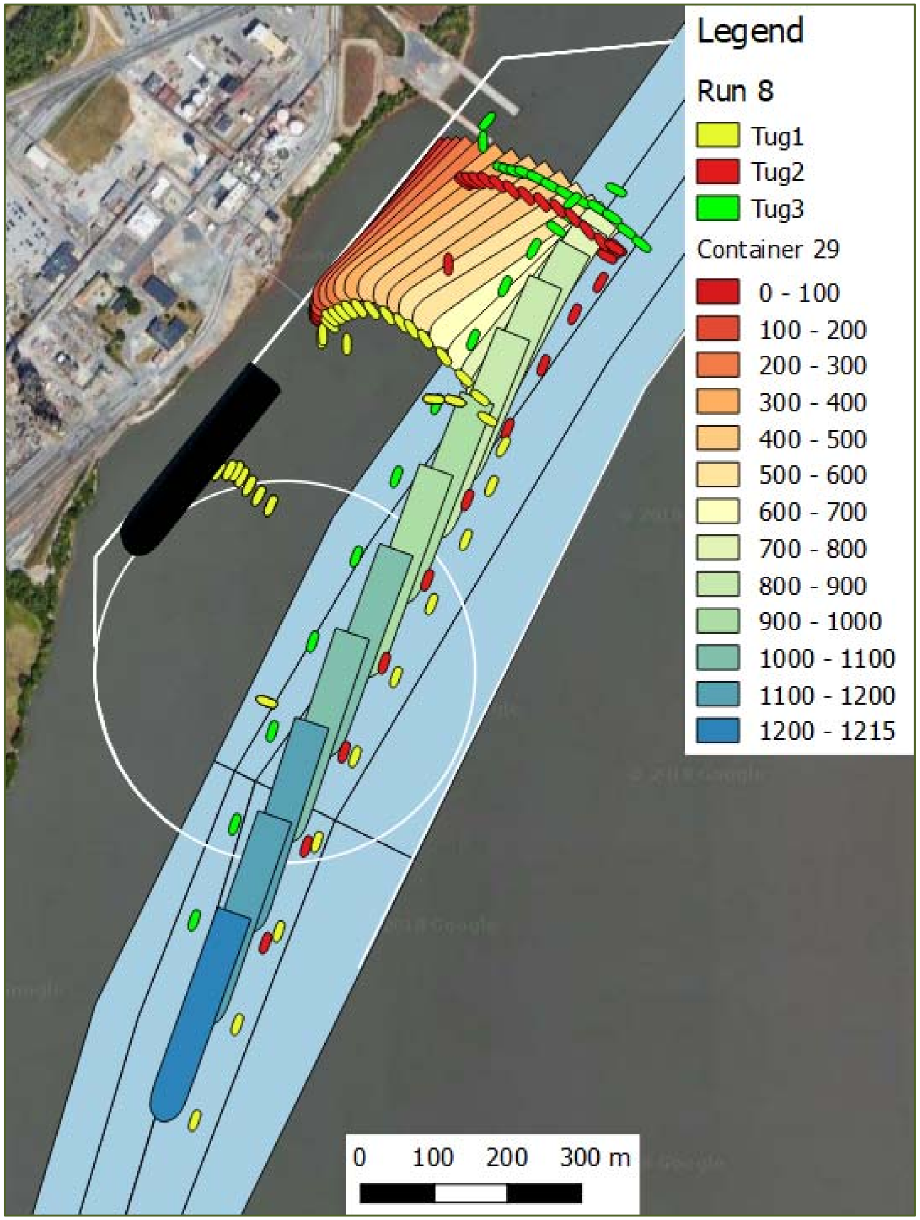
	Run	6
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	10°, 3/4 kts
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	Yes
7.	Tug configuration and reserve capacity?	7
8.	Qualifiers to tug rating	3 tugs needed with 25 kts; 2 needed on bow to overcome wind
9.	Difficulty rating	6
10.	Overall safety	5
11.	Safety qualifier	



	Run	7
	Captain	David Cuff
1.	Successfully made transit?	Yes, with wind off of the dock, this assisted moving into the channel. I would do this with 2 tugs.
2.	Average drift angle and minimum speed to offset environments	N/A at sailing.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes, wind and current assisted. Would be different if wind were on dock.
4.	Ship model react as expected with environment?	Yes, very realistic, slow to respond like real time.
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	7
8.	Qualifiers to tug rating	Could be done with 2 tugs with wind off the dock.
9.	Difficulty rating	3
10.	Overall safety	9
11.	Safety qualifier	If vessel at lower berth maybe make aft boat through transom, when ebb tide or NW wind.



	Run	8
	Captain	Dana Gray
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	N/A
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	3
8.	Qualifiers to tug rating	was max for 3 tugs with environment.
9.	Difficulty rating	8
10.	Overall safety	5
11.	Safety qualifier	



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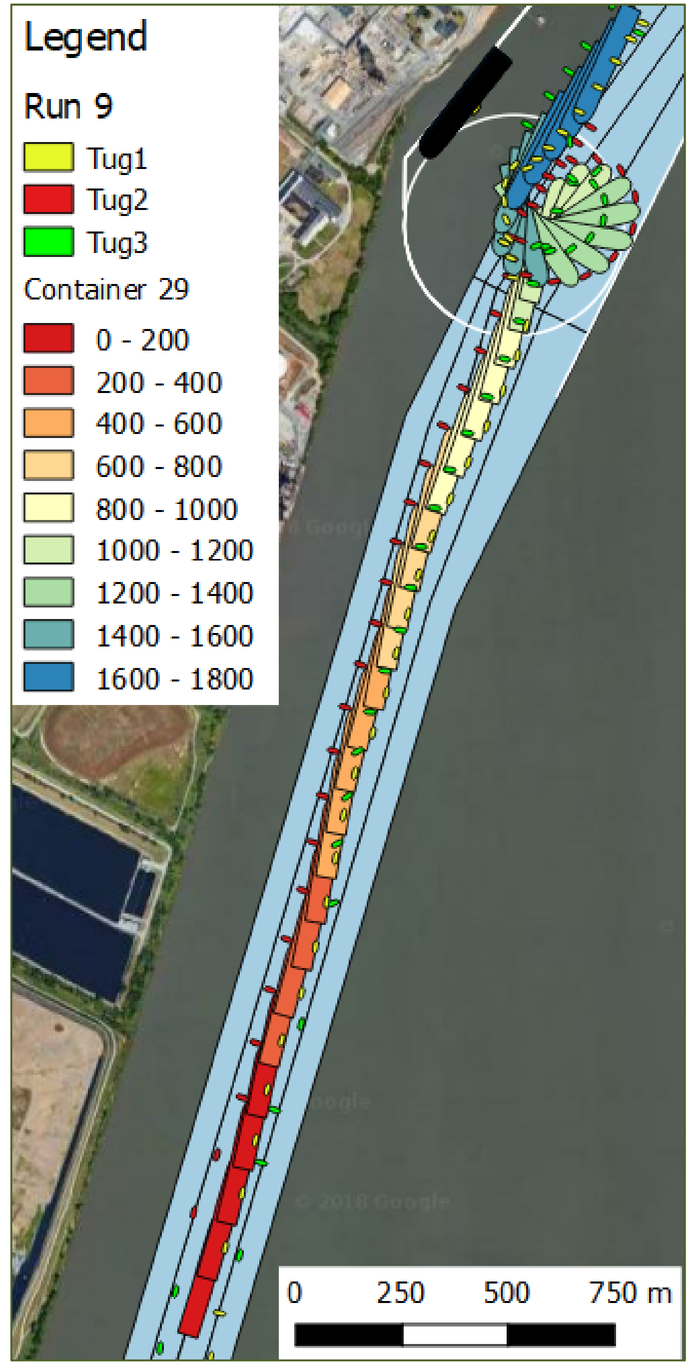
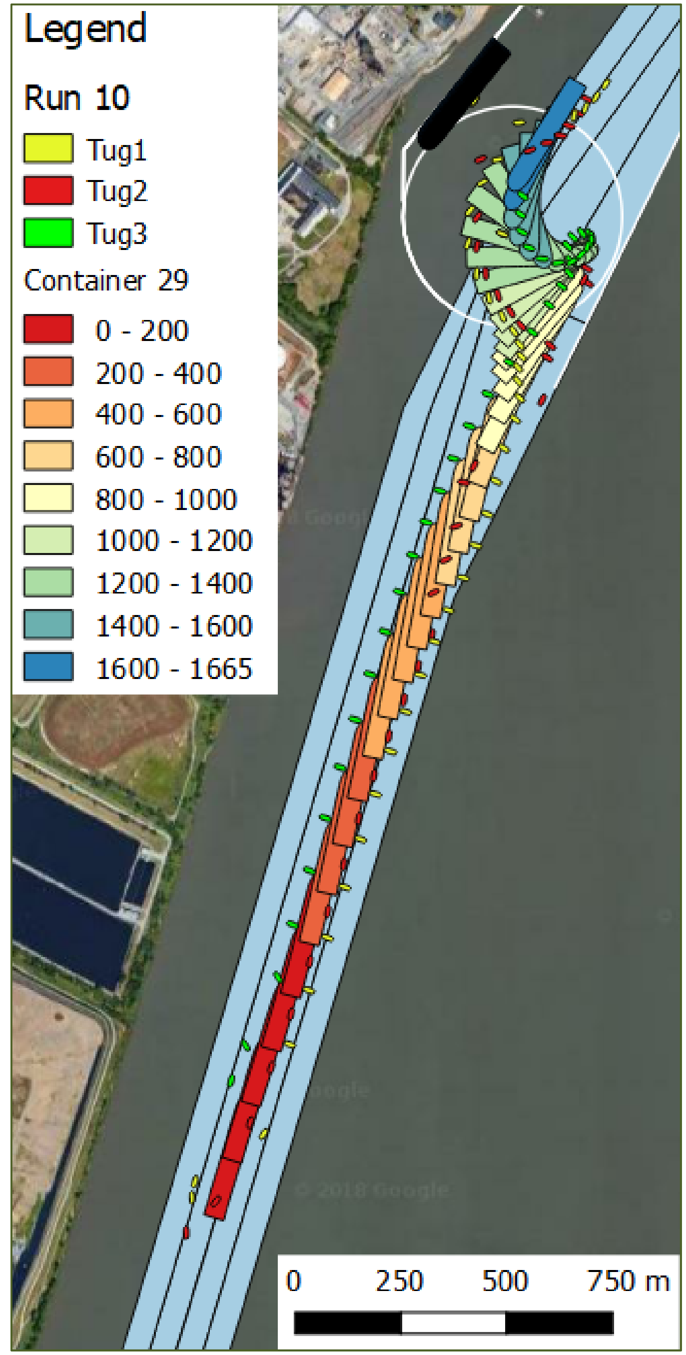
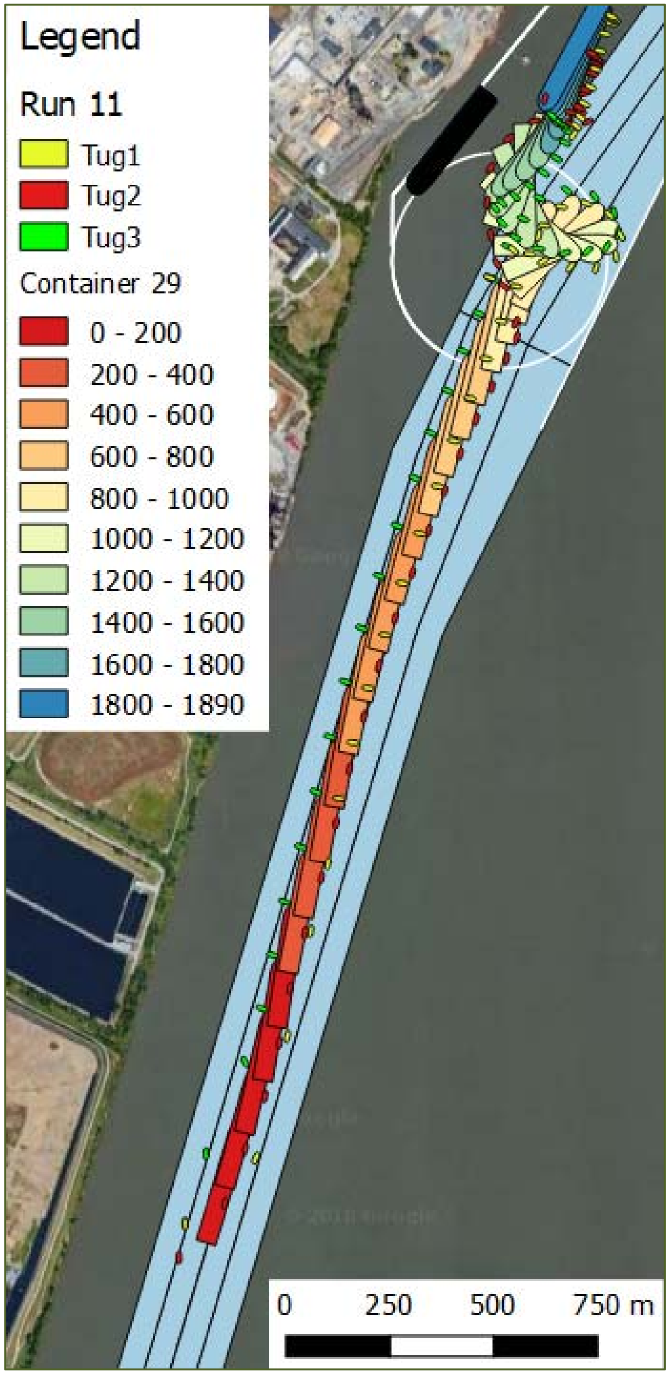
	Run	9
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	6-8°, 3/4 kts.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	No, would have expected sternway sooner with full astern but it worked out.
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	Would create sternway sooner.
7.	Tug configuration and reserve capacity?	5
8.	Qualifiers to tug rating	3 tugs necessary with wind; 4 tugs would be necessary for berthing with wind off dock.
9.	Difficulty rating	7
10.	Overall safety	4
11.	Safety qualifier	Wind limits 25 kts.



	Run	10
	Captain	
1.	Successfully made transit?	Yes, wind at 315° (NW) and 45 ft. draft required 3 tugs.
2.	Average drift angle and minimum speed to offset environments	Roughly 10° depending on speed.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes, any more wind might require more tugs.
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	Yes, would have started more left of center and worked over using the wind.
7.	Tug configuration and reserve capacity?	5
8.	Qualifiers to tug rating	Maneuver with high winds might require 3 or 4 tugs.
9.	Difficulty rating	8
10.	Overall safety	4
11.	Safety qualifier	Loaded ship, high wind, max flood requires strong (minimum 65 t bollard pull) tugs.



	Run	11
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	5°, 5 kts
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	4
8.	Qualifiers to tug rating	With wind would have 4th tug.
9.	Difficulty rating	6
10.	Overall safety	4
11.	Safety qualifier	25 kts max.



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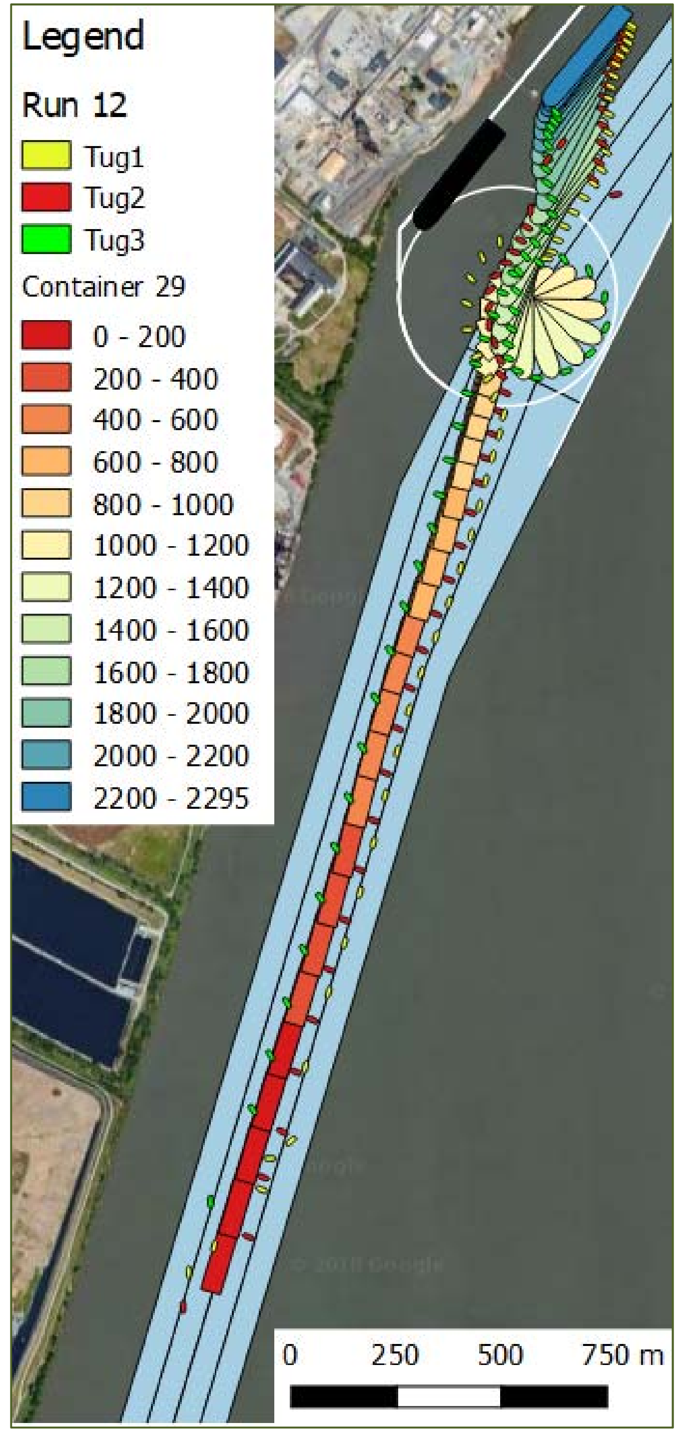
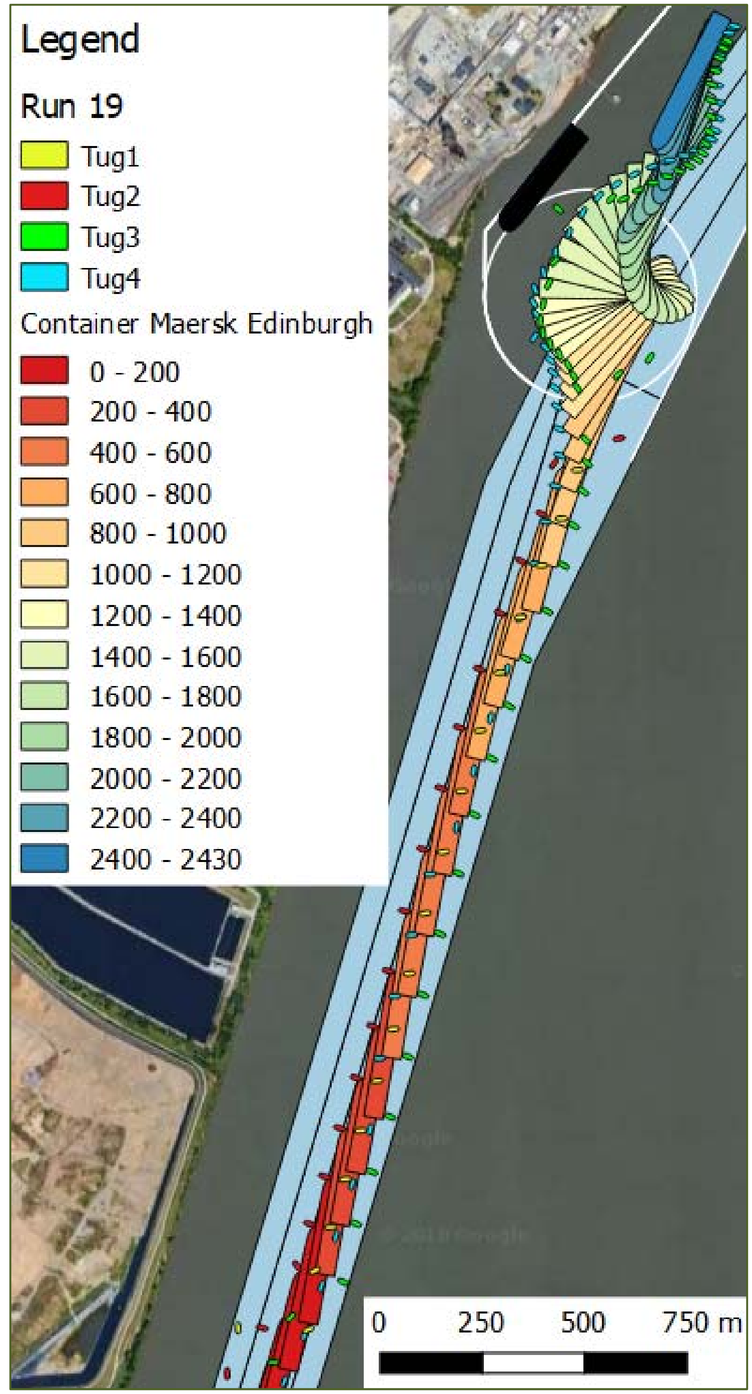
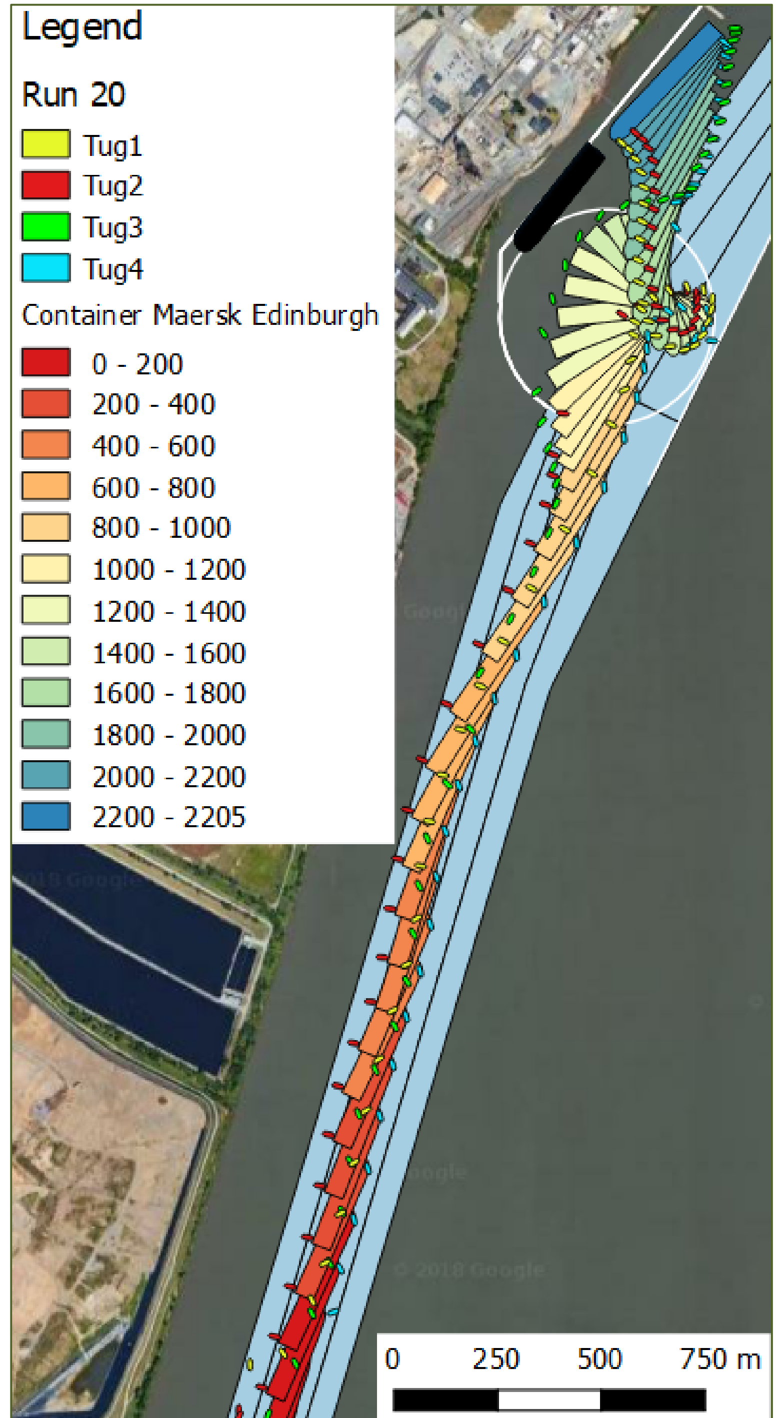
	Run	12
	Captain	David Cuff
1.	Successfully made transit?	Yes, simulated being late for tugs and losing current. Worked very well.
2.	Average drift angle and minimum speed to offset environments	Max ebb current, 4 kts no set.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes, very good reaction.
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	6
8.	Qualifiers to tug rating	NA worked very well.
9.	Difficulty rating	5
10.	Overall safety	8
11.	Safety qualifier	Very realistic simulation. This is a very strong occurrence on the river.



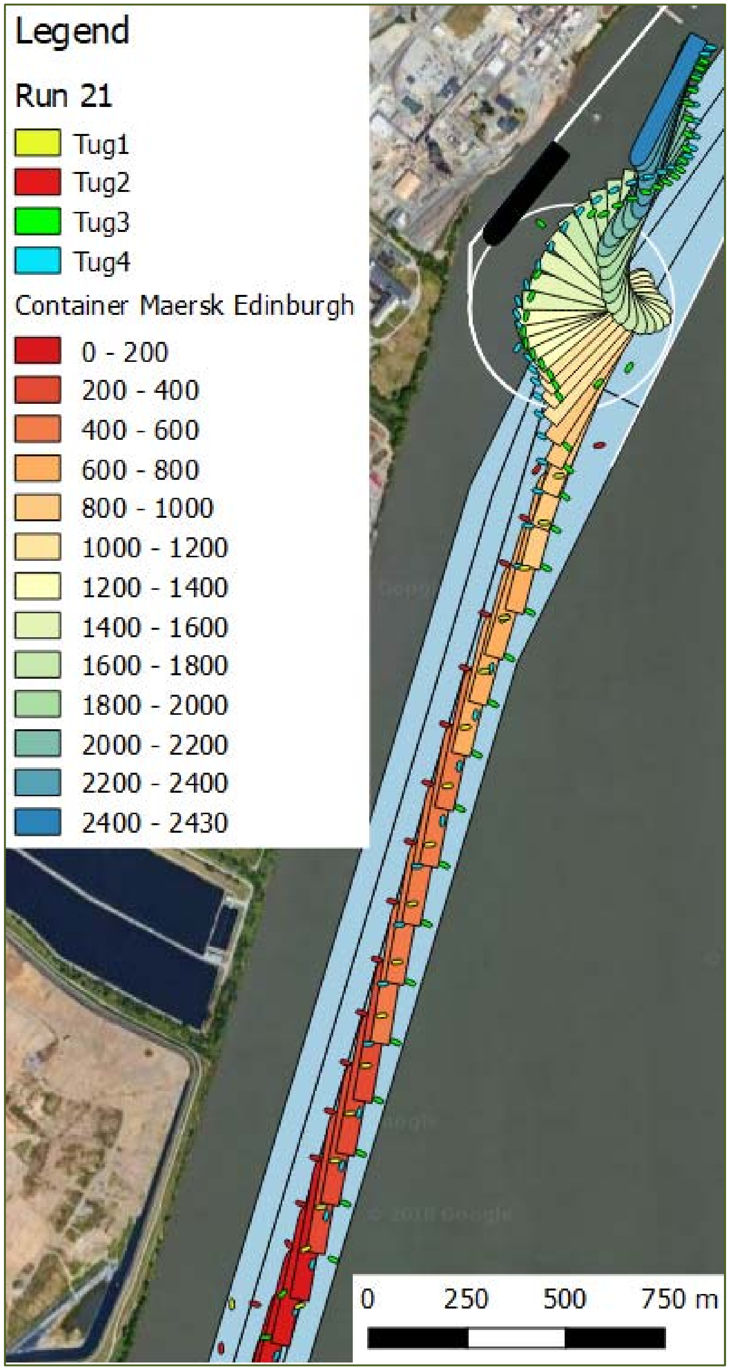
	Run	19
	Captain	David Cuff
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	10-15° (too much for size of vessel).
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	No, wind was too high directly on the beam.
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	Yes, more tugs, more horsepower or abort the transit/docking.
7.	Tug configuration and reserve capacity?	2
8.	Qualifiers to tug rating	Tugs were insufficient with amount and direction of wind.
9.	Difficulty rating	9.5
10.	Overall safety	2
11.	Safety qualifier	Not advised with amount of wind directly on beam.



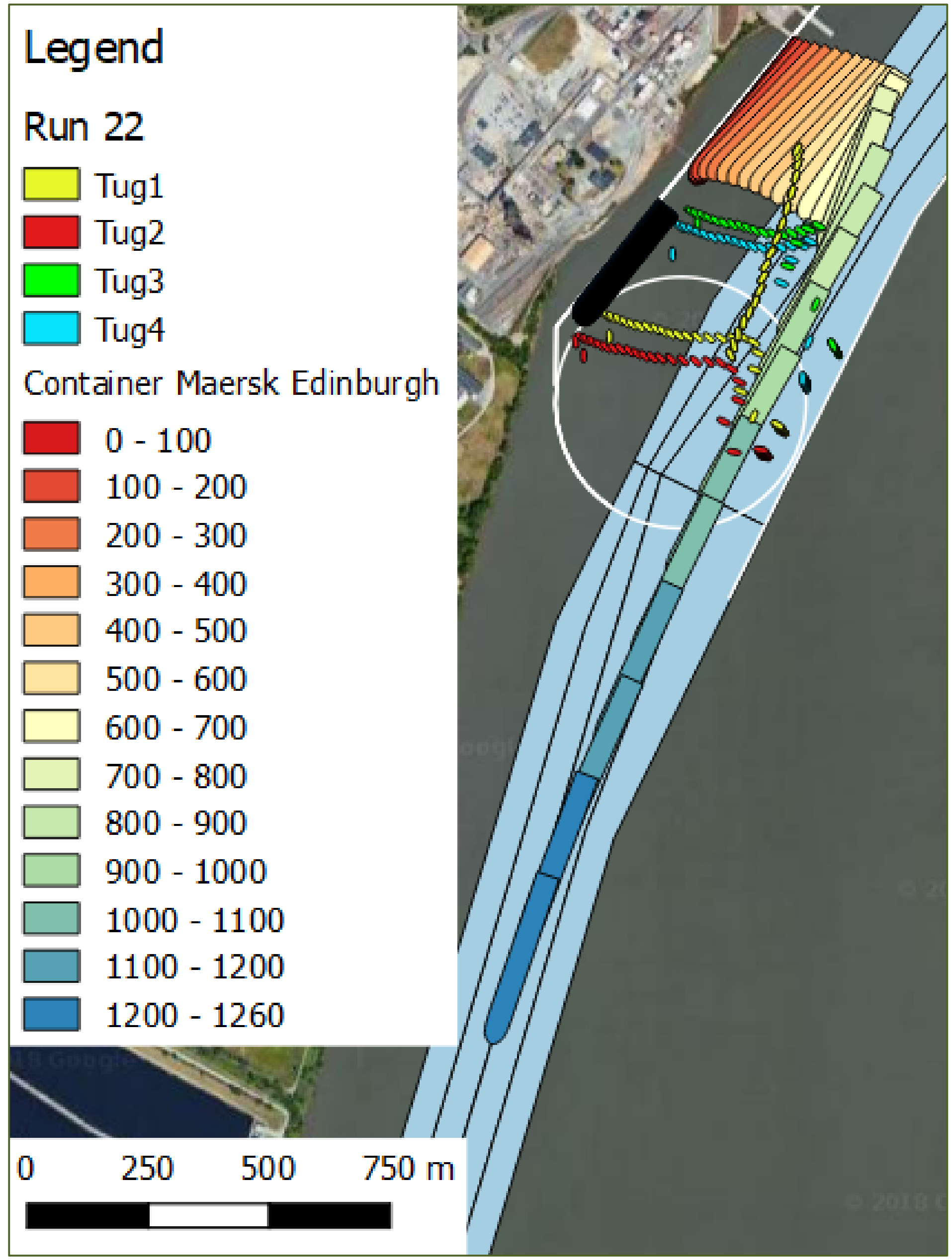
	Run	20
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	10°, 5-6 kts.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	3
8.	Qualifiers to tug rating	Tugs were running at 100% with limited functionality at certain times during transit.
9.	Difficulty rating	8
10.	Overall safety	4
11.	Safety qualifier	20 kts wind limit.



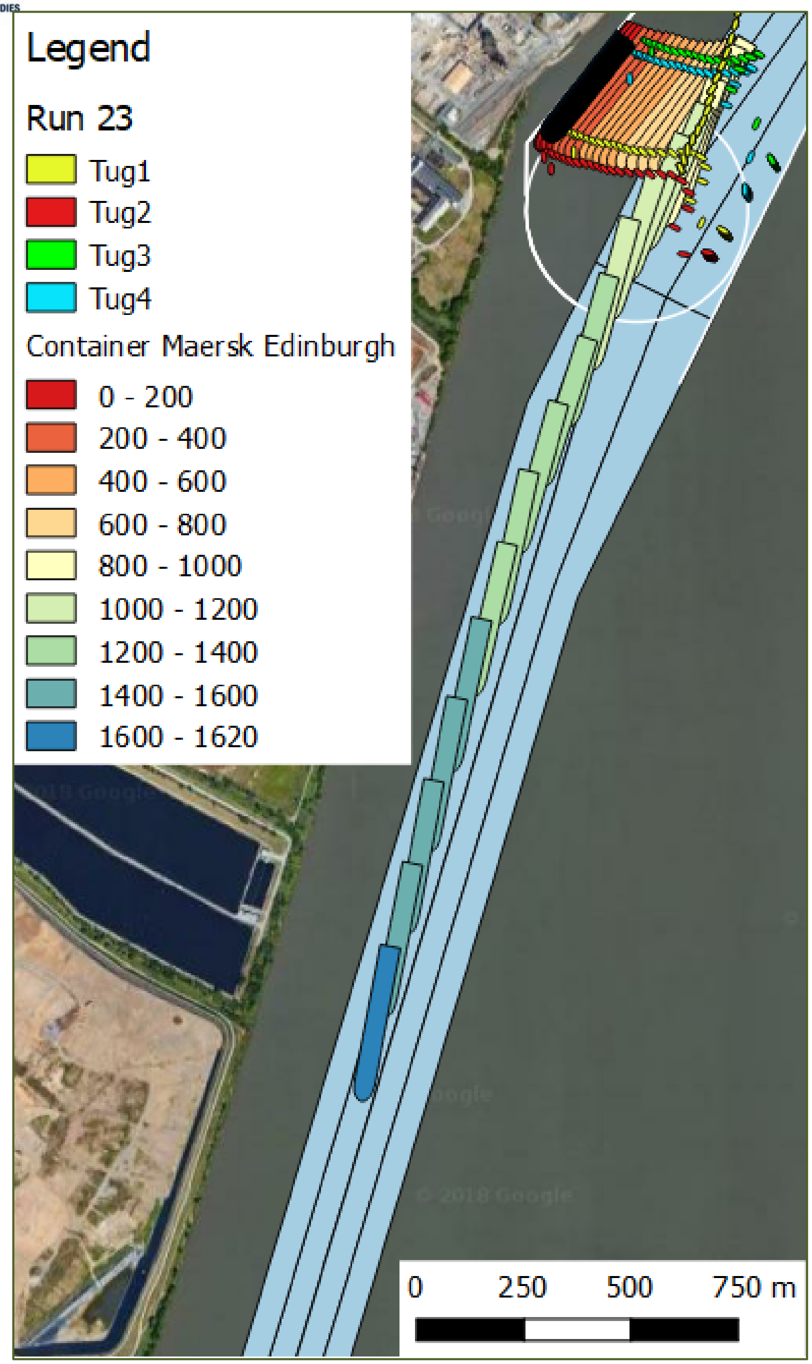
	Run	21
	Captain	David Cuff
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	3-5 sometimes, 7°.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes, needed 4 tugs to dock.
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	5
8.	Qualifiers to tug rating	
9.	Difficulty rating	8.5
10.	Overall safety	5
11.	Safety qualifier	Strong wind needs 4 tugs over 20 kts.



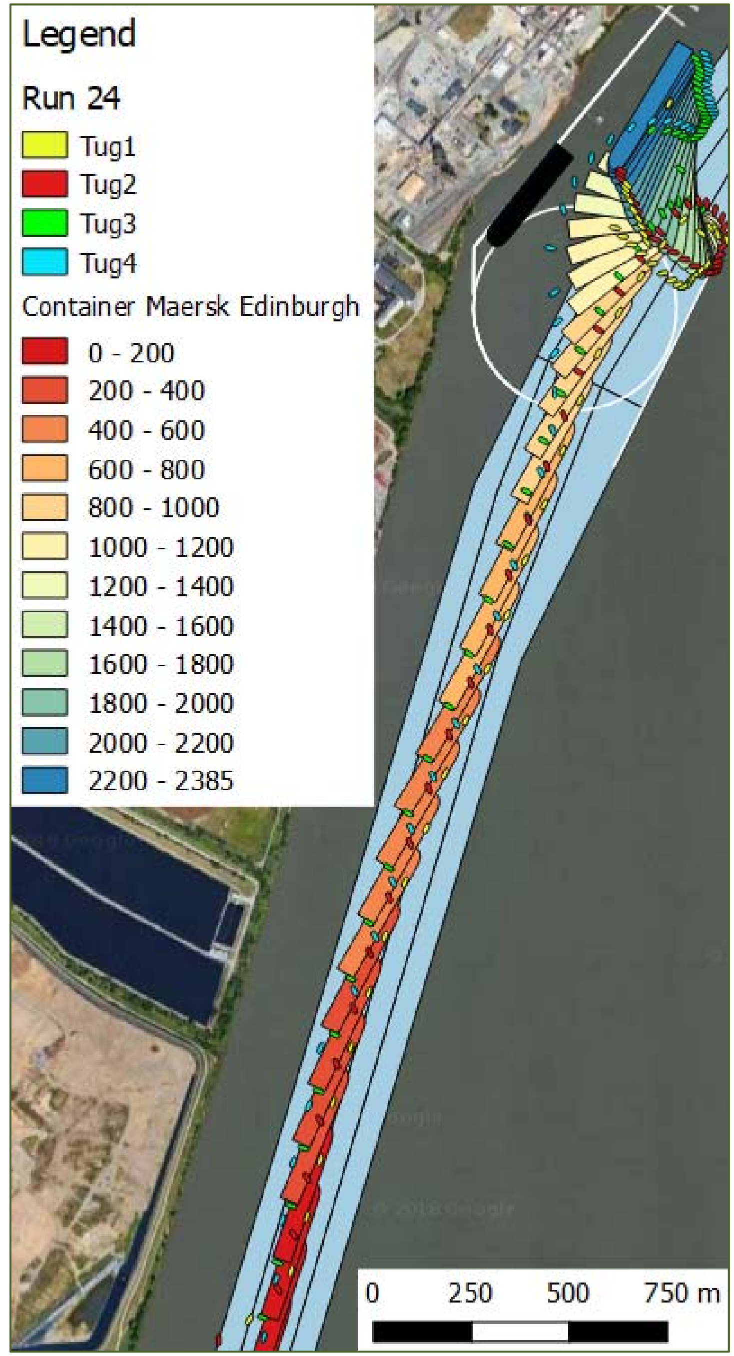
	Run	22
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	3-4 kts.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	8
8.	Qualifiers to tug rating	Wind off the dock 2 tugs needed.
9.	Difficulty rating	2
10.	Overall safety	8
11.	Safety qualifier	Ideal conditions.



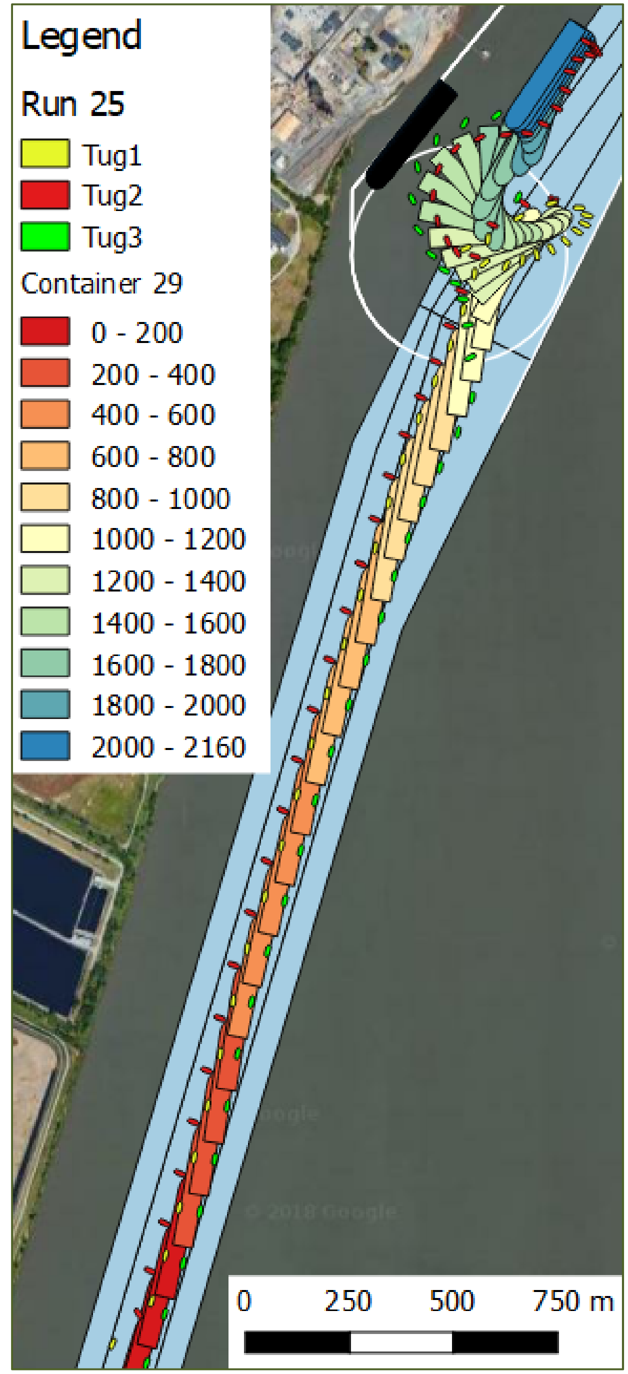
	Run	23
	Captain	Wayne Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	Yes, at or close to maximum allowable.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	3.5
8.	Qualifiers to tug rating	Tugs were operating at maximum capacity coming off berth. No reserves available.
9.	Difficulty rating	7.5
10.	Overall safety	4
11.	Safety qualifier	20 kts of wind was the most that safe operating conditions could be done in. The shoal at the bottom of the turning circle/area was in play and could have become an issue to maneuver around.



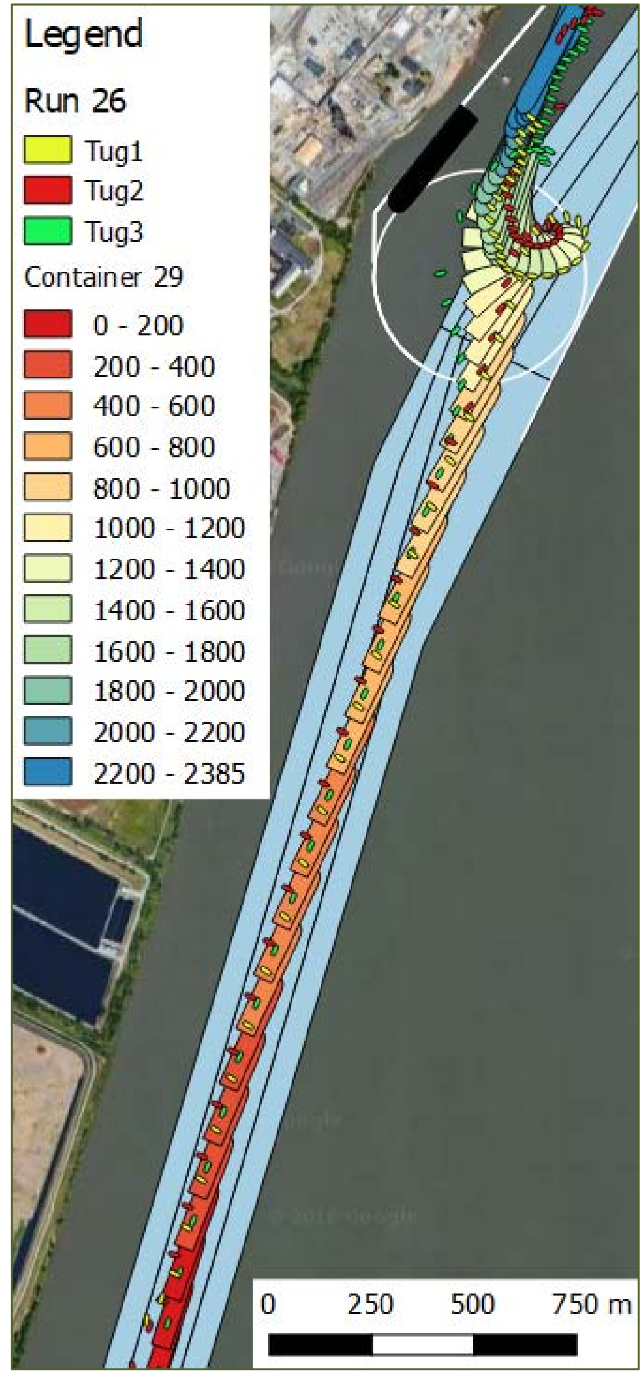
	Run	24
	Captain	Wayne Bailey
1.	Successfully made transit?	Transit was completed. Drift angle excessive by a large amount.
2.	Average drift angle and minimum speed to offset environments	Drift angle 13° at 5.5 kts
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes, but there was nothing in reserve.
4.	Ship model react as expected with environment?	Yes, but wind response after turning the vessel was a bit less than expected. Also flood current effect felt weak.
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	Yes, I would not make this transit in this vessel in these conditions.
7.	Tug configuration and reserve capacity?	2
8.	Qualifiers to tug rating	I used these tugs to maximize their efficiency and barely controlled the vessel. Greater bollard pull is needed.
9.	Difficulty rating	10
10.	Overall safety	1
11.	Safety qualifier	The ship in winds greater than 20 kts should not attempt this transit and maneuver. Without tugs, excessive angles to the wind were needed to remain on track.



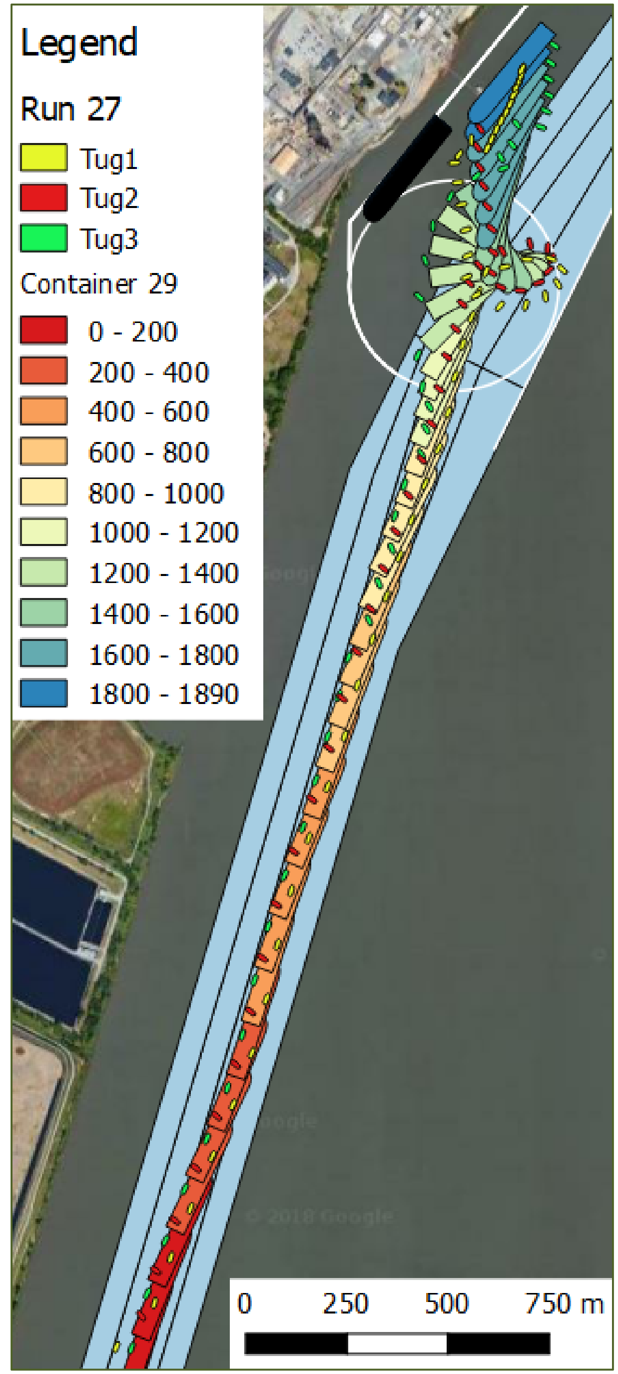
	Run	25
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	3-5° with slow speeds below 5 kts.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	6
8.	Qualifiers to tug rating	3 tugs.
9.	Difficulty rating	5
10.	Overall safety	5
11.	Safety qualifier	Limit of 25 kts - extra tug for safety with winds above 20 kts.



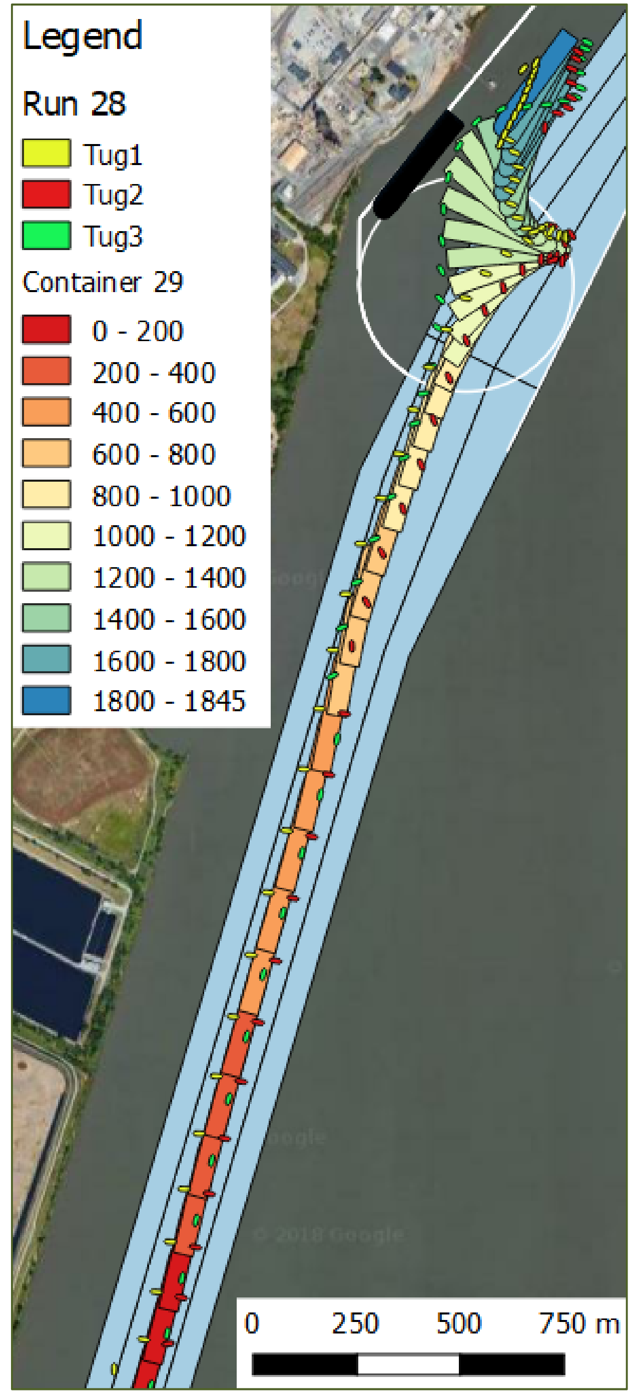
	Run	26
	Captain	Wayne Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	5° at 5.5 kts; high but reasonable.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes, all 3 tugs were needed.
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	7.5
8.	Qualifiers to tug rating	Control was safely maintained with 3 tugs. Only 2 tugs was not enough.
9.	Difficulty rating	7
10.	Overall safety	5
11.	Safety qualifier	25 kts of wind is the maximum that this vessel should be in for this transit/maneuver.

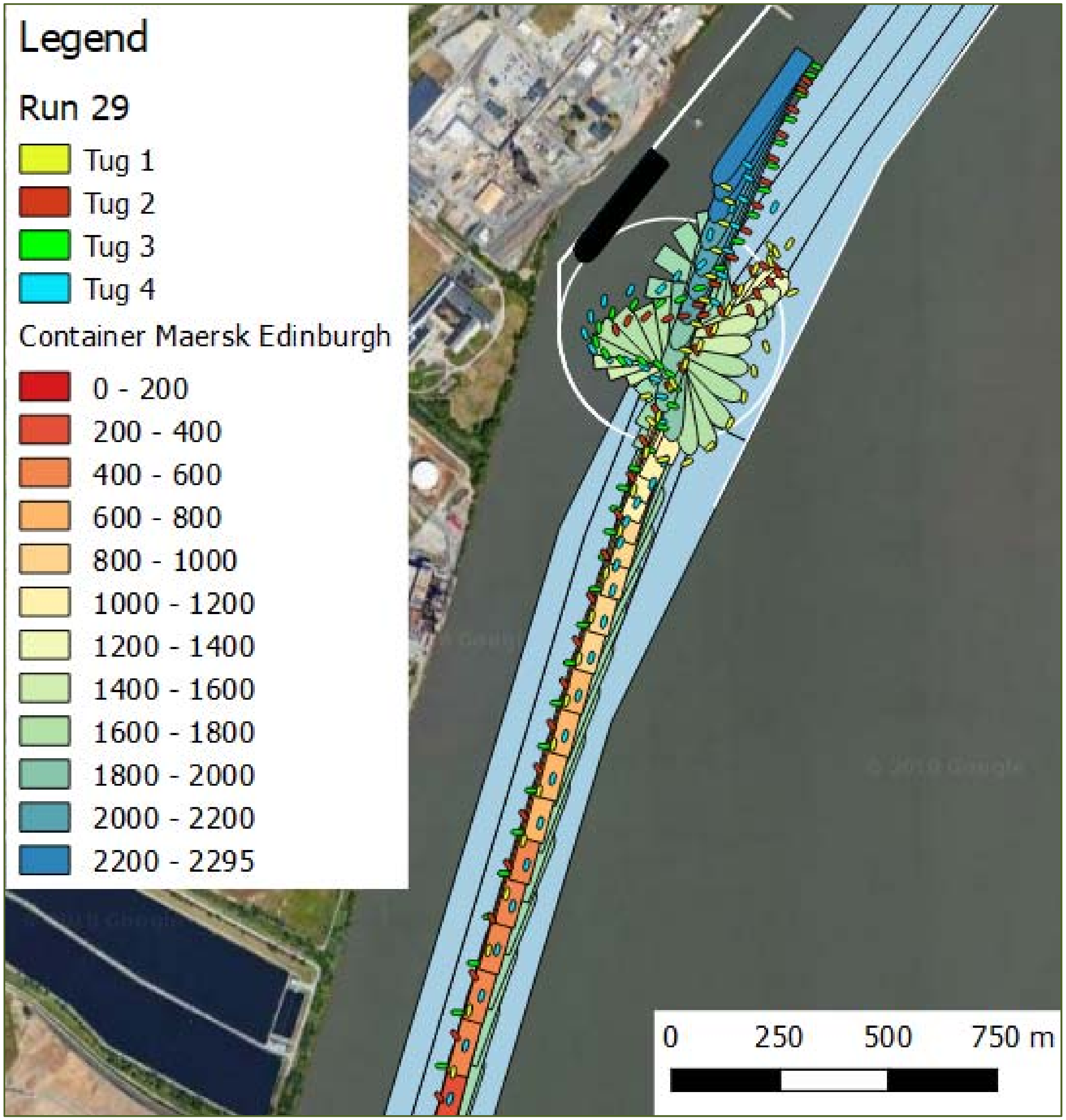


	Run	27
	Captain	Robert Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	2-4°, 5 kts.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	6
8.	Qualifiers to tug rating	
9.	Difficulty rating	5
10.	Overall safety	5
11.	Safety qualifier	25 kts limit.



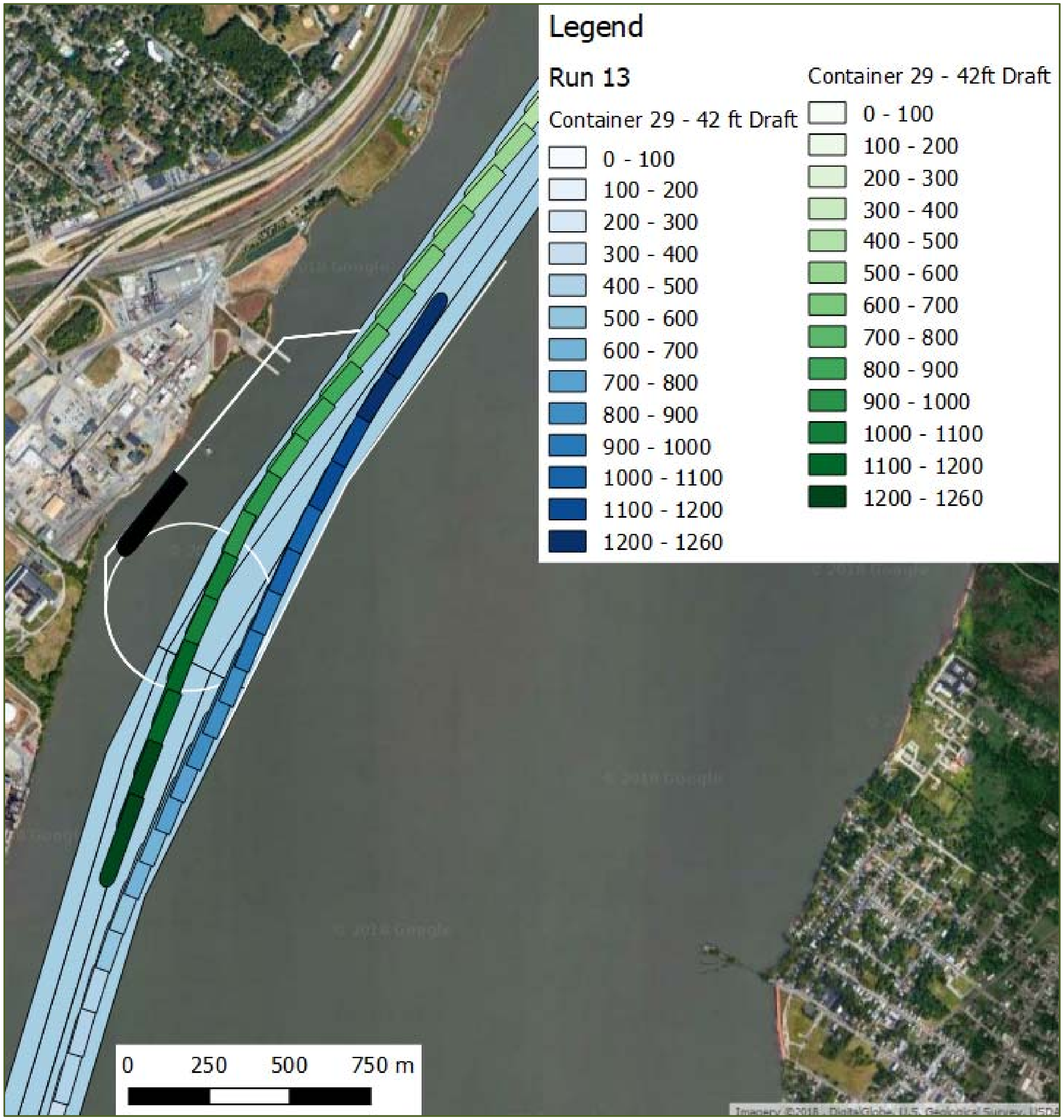
	Run	28
	Captain	Wayne Bailey
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	Drift angle less than 2°, 4 kts.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Yes
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	6.5
8.	Qualifiers to tug rating	3 tugs needed in 25 kt wind.
9.	Difficulty rating	6
10.	Overall safety	5.5
11.	Safety qualifier	Winds greater than 25 kts will be a problem for this vessel and transit.




Legend
Run 29
Tug 1
Tug 2
Tug 3
Tug 4
Container Maersk Edinburgh
0 - 200
200 - 400
400 - 600
600 - 800
800 - 1000
1000 - 1200
1200 - 1400
1400 - 1600
1600 - 1800
1800 - 2000
2000 - 2200
2200 - 2295
0
250
500
750 m

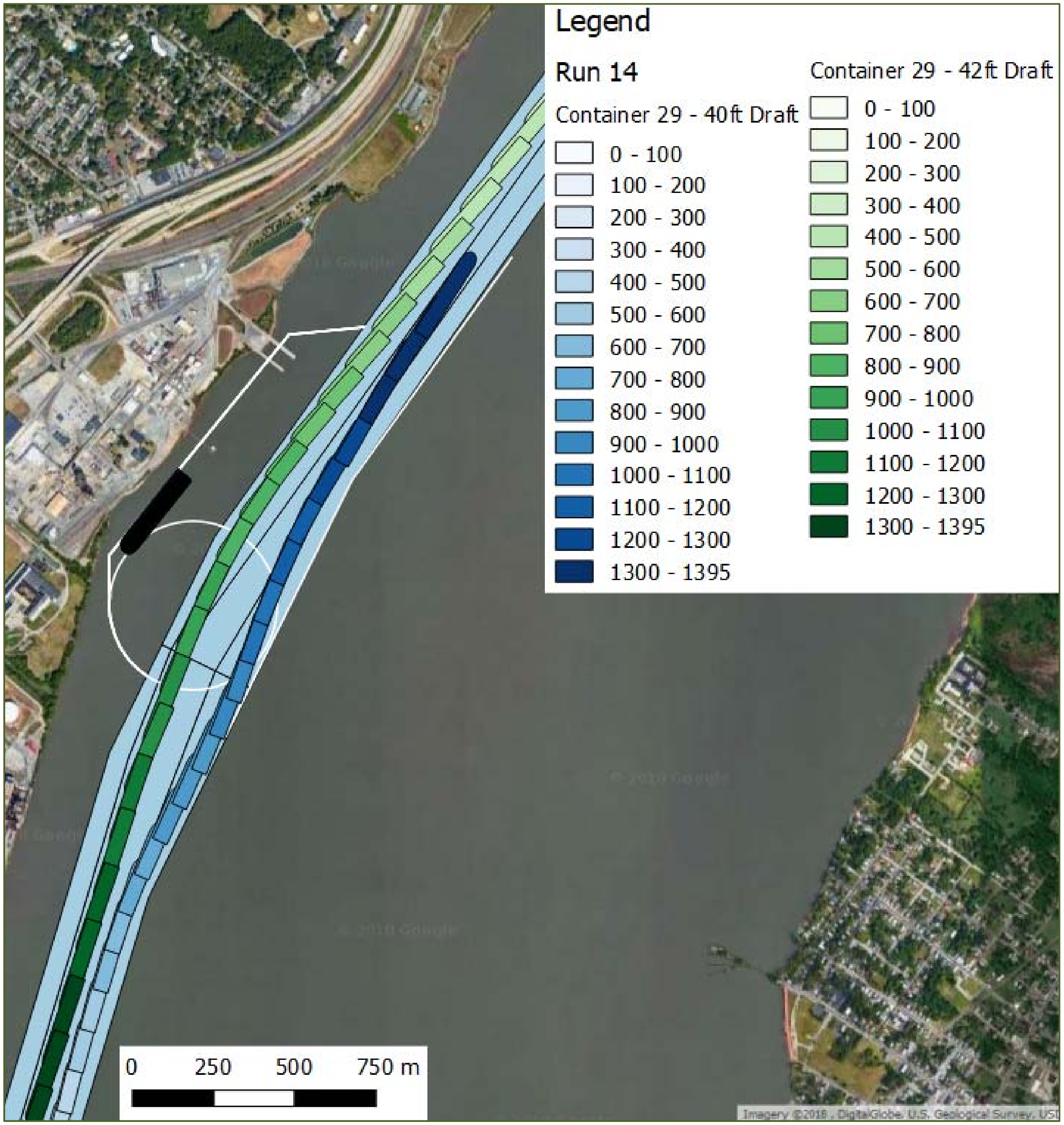
	Run	13	13
	Captain	Wayne Bailey	Robert Bailey
1.	Successfully made transit?	Yes	Yes
2.	Average drift angle and minimum speed to offset environments	nil	2°, 5 kts
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	not applicable	Yes, NA
4.	Ship model react as expected with environment?	Yes	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes	Yes
6.	Would you modify transit plan?	No	No
7.	Tug configuration and reserve capacity?	Does not apply	NA
8.	Qualifiers to tug rating		
9.	Difficulty rating	2.5	5
10.	Overall safety	8.5	5
11.	Safety qualifier	The presence of the facility increases the room available to the outbound vessel and I feel it increases safety in this intersection.	25 kts limit

(Swept paths next page)


Legend
Run 13
Container 29 - 42 ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1260
Container 29 - 42ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1260
0 250 500 750 m

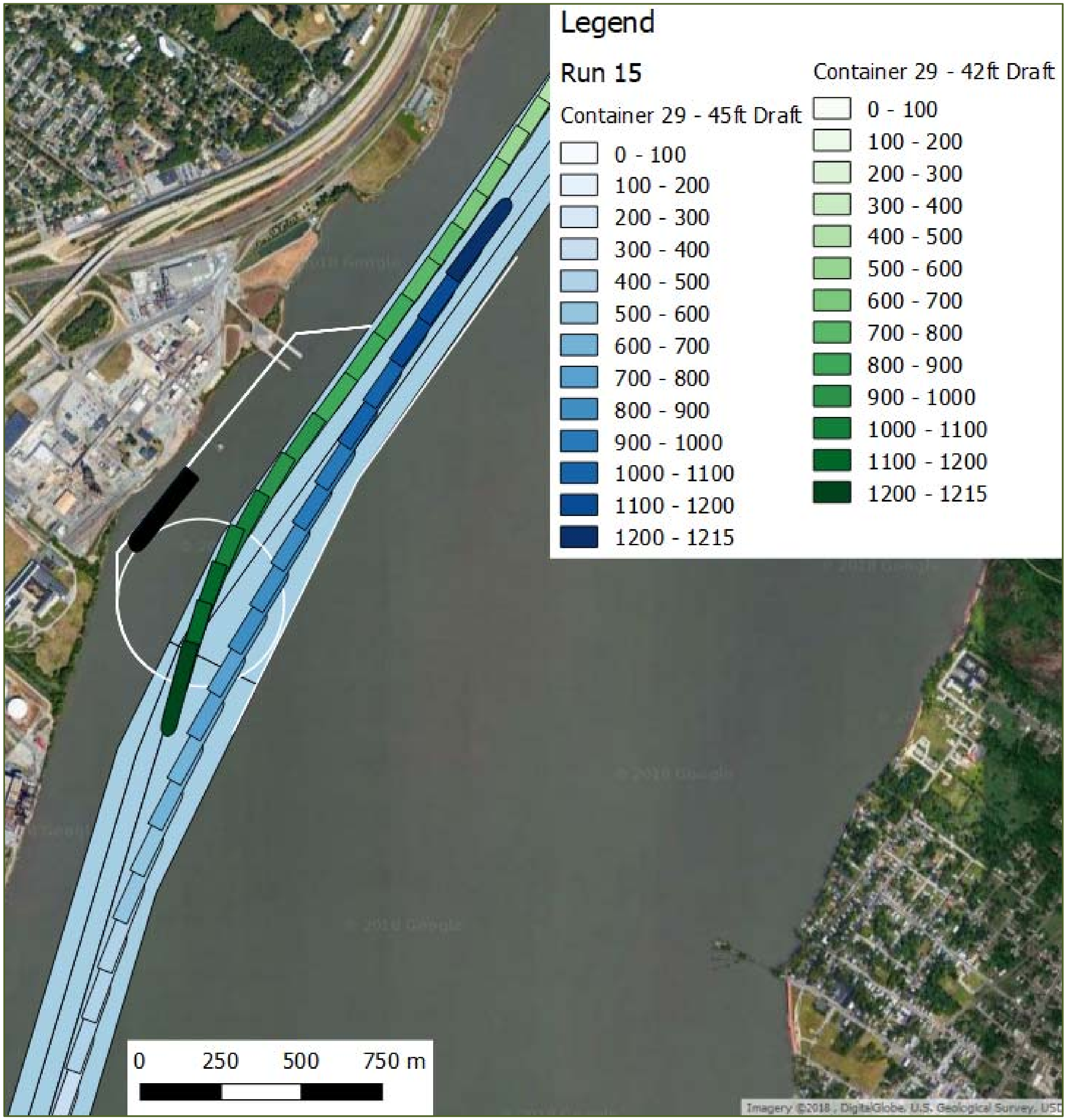
	Run	14	14
	Captain	David Cuff	Robert Bailey
1.	Successfully made transit?	Yes	Yes
2.	Average drift angle and minimum speed to offset environments	Roughly 2 - 4° due to NW wind	2°, 5 kts
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	NA	NA
4.	Ship model react as expected with environment?	Yes	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes	Yes
6.	Would you modify transit plan?	No	No
7.	Tug configuration and reserve capacity?	NA	NA
8.	Qualifiers to tug rating		
9.	Difficulty rating	2.5	5
10.	Overall safety	8	5
11.	Safety qualifier	used 20° rudder but kept control of the vessel and was able to safely pass berth with another vessel there	25 kts limit

(Swept paths next page)


Legend
Run 14
Container 29 - 40ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1300
1300 - 1395
Container 29 - 42ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1300
1300 - 1395
0 250 500 750 m

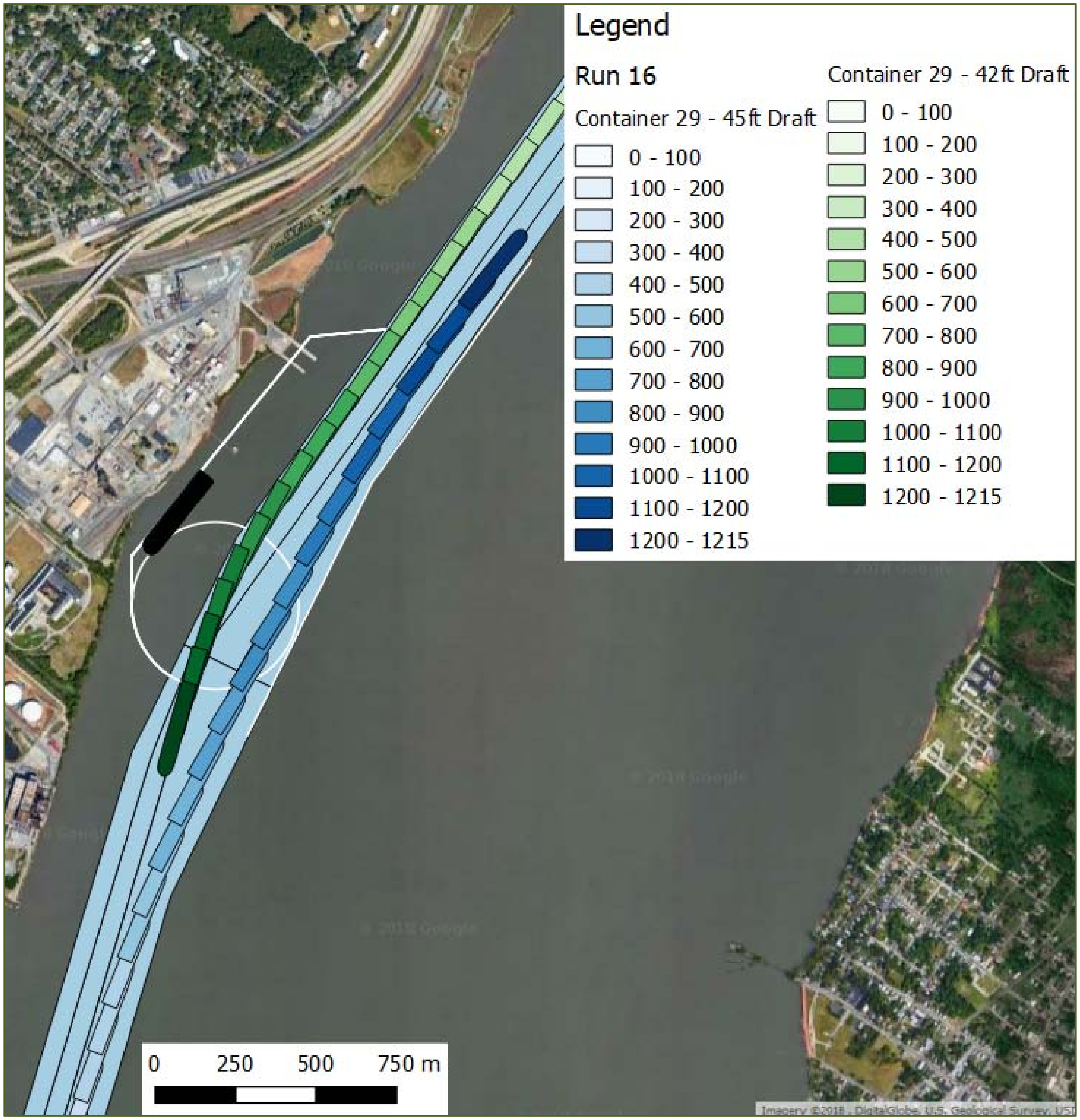
	Run	15	15
	Captain	Wayne Bailey	Robert Bailey
1.	Successfully made transit?	Yes	Yes
2.	Average drift angle and minimum speed to offset environments	Yes	2°, 4.8 kts
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Does not apply	NA
4.	Ship model react as expected with environment?	Yes	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes	Yes
6.	Would you modify transit plan?	No	No
7.	Tug configuration and reserve capacity?	Does not apply	NA
8.	Qualifiers to tug rating		
9.	Difficulty rating	5.5	5
10.	Overall safety	5.5	5
11.	Safety qualifier		Avoid transits above 25 kts

(Swept paths next page)

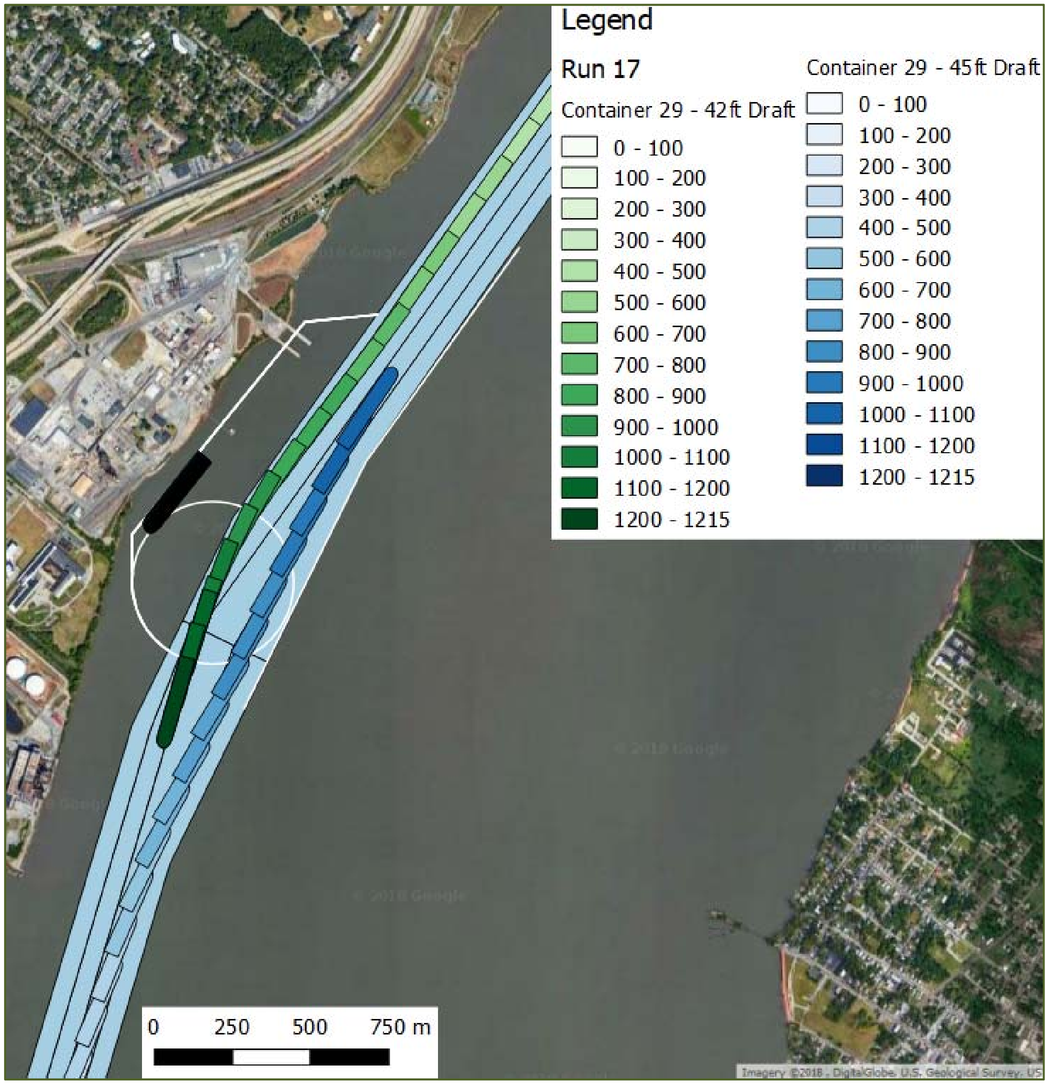

Legend
Run 15
Container 29 - 45ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1215
Container 29 - 42ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1215
0 250 500 750 m

	Run	16	16
	Captain	Wayne Bailey	David Cuff
1.	Successfully made transit?	Yes	Yes
2.	Average drift angle and minimum speed to offset environments	Nil	2-4° with SE wind
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	Does not apply	NA
4.	Ship model react as expected with environment?	Yes	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes	Yes
6.	Would you modify transit plan?	No	No
7.	Tug configuration and reserve capacity?	Does not apply	NA
8.	Qualifiers to tug rating		
9.	Difficulty rating	5.5	
10.	Overall safety	5	2.5
11.	Safety qualifier		Normal meeting situation

(Swept paths next page)


Legend
Run 16
Container 29 - 45ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1215
Container 29 - 42ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1215
0
250
500
750 m

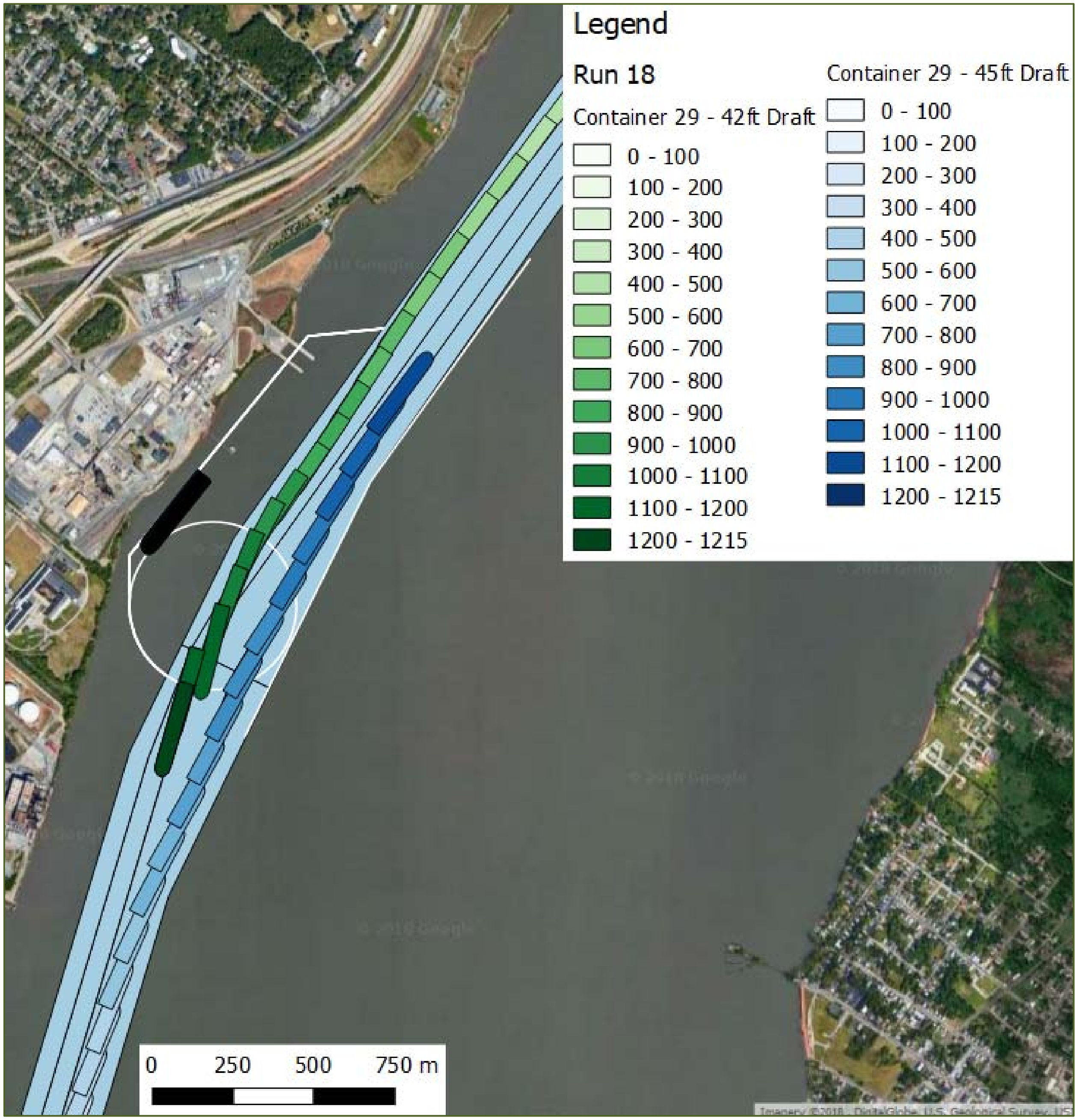
	Run	17
	Captain	David Cuff
1.	Successfully made transit?	Yes
2.	Average drift angle and minimum speed to offset environments	1-2°, depending on vessel speed.
3.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	NA
4.	Ship model react as expected with environment?	Yes
5.	Maintain acceptable distance from shoals and terminal?	Yes
6.	Would you modify transit plan?	No
7.	Tug configuration and reserve capacity?	NA
8.	Qualifiers to tug rating	
9.	Difficulty rating	2
10.	Overall safety	8.5
11.	Safety qualifier	very safe real conditions.



(Second Pilots Run Comments Not Available)

	Run	18	18
	Captain	David Cuff	Robert Bailey
12.	Successfully made transit?	Yes	Yes
13.	Average drift angle and minimum speed to offset environments	2-3°, sometimes 5 depending on speed.	2°, 5 kts.
14.	Successfully complete berthing / unberthing evolutions? If not, what were limiting factors?	NA	NA
15.	Ship model react as expected with environment?	Yes	Yes
16.	Maintain acceptable distance from shoals and terminal?	Yes	Yes
17.	Would you modify transit plan?	No	No
18.	Tug configuration and reserve capacity?	NA	NA
19.	Qualifiers to tug rating		
20.	Difficulty rating	3	5
21.	Overall safety	9	5
22.	Safety qualifier		225 kt limits.

(Swept paths next page)


Legend
Run 18
Container 29 - 42ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1215
Container 29 - 45ft Draft
0 - 100
100 - 200
200 - 300
300 - 400
400 - 500
500 - 600
600 - 700
700 - 800
800 - 900
900 - 1000
1000 - 1100
1100 - 1200
1200 - 1215
0 250 500 750 m

APPENDIX D – MODEL CHANGES

Note, there were 2 model changes throughout the study. The 9,300 TEU ship model (*Containership 29*) was adjusted from the A model version to the B version to experience less roll angle. The 12,000 TEU ship model (*Edinburg)* was modified from the B version to the C version also to experience less roll as per the Pilots' request.

Edgemoor Participants

Left to Right (Front Row)

1. Hao Cheong, MITAGS-PMI Director of Simulation Engineering
2. Colleen Schaffer, MITAGS-PMI Coastal Engineer

Left to Right (Back Row)

1. Raymond Camarda, Director Seabury Marine
2. Ken Kujala, MITAGS-PMI Simulator Operator
3. Wayne Bailey, MITAGS-PMI Shiphandling Consultant
4. Robert Bailey III, Delaware Pilots
5. Timothy Shelton, ERDC
6. Glen Paine, MITAGS-PMI Executive Director

MITAGS-PMI
MARITIME INSTITUTE OF TECHNOLOGY & GRADUATE STUDIES
PACIFIC MARITIME INSTITUTE

APPENDIX E – MITAGS-PMI INFORMATION

The Maritime Institute of Technology and Graduate Studies (MITAGS) and the Pacific Maritime Institutes (PMI) are non-profit, continuing education centers for professional mariners. The Institutes provide training for both civilian and military mariners at every level of their career.

MITAGS Location and General Facility Description

MITAGS is located less than five (5) miles from the Baltimore-Washington International Thurgood Marshall Airport (BWI). Complimentary shuttle links the campus with the airport, BWI Amtrak Rail, Baltimore Light Rail, and regional bus services. It is also near major tourist destinations; including Baltimore, Annapolis, and Washington, DC.

The MITAGS campus encompasses over forty (40) acres. The 300,000 square-feet facilities include:

- On campus hotel with 232 hotel rooms (3-STAR equivalent). Hotel and conference facilities approved by the International Association of Conference Centers (IACC).
- 500-seat dining facility, 250-seat auditorium, pub, and store.
- Indoor swimming pool, jogging / walking trails, Nautilus® Fitness Room.
- Maritime Museum.
- ECDIS, Stability, LNG Cargo and Engine Room Training Software.
- Emergency Medical Lab.
- 16-station networked computer Lab.
- Two, 360° Transas Full-Mission Shiphandling Simulator integrated with three 300° and one 120° Tug Bridge Simulators.
- 8-Ship Radar, Automatic Radar Plotting Aids (ARPA), and Electronic Chart Display and Information Systems (ECDIS) Simulators.
- Global Maritime Distress and Safety Systems (GMDSS) Communications Lab.
- Vessel Traffic System (VTS) Watchstander Training Lab.

PMI Location and General Facility Description

The Pacific Maritime Institute (PMI) is a subsidiary of MITAGS in Seattle, Washington. PMI is located approximately twenty (20) minutes from Seattle Tacoma (SEA-TAC) International Airport. Their waterfront facility is positioned directly within the Maritime Technology and Career Center. PMI offers the following onsite technology and training support facilities:

- 240° DNV Class A Full-Mission Bridge Simulator.
- Two 300° Full-Mission Tugboat Simulator.
- 6-Radar/Automatic Radar Plotting Aids (ARPA) Simulators.
- Two Electronic Chart Display and Information Systems (ECDIS)/Electronic Navigation Labs.
- Global Maritime Distress and Safety Systems (GMDSS) Communications Lab.
- 2-Simulation Debriefing Rooms and 12 conference / classrooms.

Aerial Photograph of MITAGS Campus and Location Diagram

Wilmington

October 1, 2019

Mr. Eugene Bailey
Diamond State Port Corporation
820 N. French Street
Wilmington DE 19801

RE: Edgemoor Navigation Feasibility Study

Dear Gene:

GT USA Wilmington reviewed the information in Duffield Associates March 12, 2019 correspondence related to the navigation feasibility study performed for the Edgemoor Port Project.

GT USA Wilmington attended the simulation performed by MITAGS-PMI in August 2018 and has worked with The Diamond State Port Corporation design team in evaluation the site for development.

Based on our review, it is our opinion that the simulated port is consistent with the landside development that GT USA is developing with DSPC and GT USA and is in agreement that the modifications to the channel footprint address the recommendations in the simulation report. We look forward to continuing to the development of this project in conjunction with DSPC.

Respectfully,

Eric R. Casey
Chief Executive Office

ERC/jam
cc: Randall Horne

GT USA Wilmington, LLC

Port of Wilmington, 1 Hausel Road, Wilmington, DE 19801-5852
Phone: (302) 472-7678 | Fax: (302) 472-7740

WILMINGTON TUG, INC.

December 30, 2019

Mr. Eugene Bailey
Diamond State Port Corporation
820 N. French Street
Wilmington DE 19801

RE: Edgemoor Navigation Feasibility Study

Dear Mr. Bailey

Wilmington Tug, Inc. reviewed the information in Duffield Associates' March 12, 2019 correspondence related to the navigation feasibility study performed for the Edgemoor Port Project.

Based on our review of the simulation, the simulated tug service appears consistent with our experience and expectations with the berthing of a 13,000 TEU ship on the Delaware River. It appears the modifications to the channel footprint address the recommendations in the report.

Wilmington Tug supports the development of the new port with the proposed configuration.

Sincerely,

Christopher Rowland
President

P.O. Box 389
New Castle, Delaware 19720
Phone: (302) 652-1666
Fax: (302) 652-1672
www.wilmingtontug.com